Review

CSC317 Computer Networks

06 October 2016

1. A course in history often begins with a study of the more distant past and concludes with a study of more recent events. Professor Herder might begin the term by talking about events in the year 1300 A.D. and finish up in the fourth week by talking about what the world was like in 1700 A.D. She and her students move forward in time.

   Our course, like the course in history, has direction.

   (a) The authors of our textbook presented us with a division of functionality and responsibilities in the network. In this abstraction, the network is a stack. With respect to the layers of the network, in which direction are we moving?

   (b) The authors of our textbook presented us with a conceptual model of the network's layout. In this simplified view, they made a distinction between the network edge and the network core. With respect to this picture of the organization of the physical components of the network, in which direction are we moving?

2. The Internet is a network of networks. It spans the globe. The Interplanetary Internet Project (http://www.ipnsig.org/) aims to extend the Internet throughout the solar system.

   List some of the media through which data on the Internet travels.

3. Suppose that two people share a channel with statistical multiplexing and that both parties (in this particular case) communicate over the channel for equal amounts of time. Although time division multiplexing could also give them equal shares, they might strongly prefer statistical multiplexing. Explain.

4. Draw a tree that relates these concepts:

   - circuit switched network
   - datagram network
   - frequency division multiplexed networks
   - packet switched network

- telecommunications networks
- time division multiplexed networks
- virtual circuits network

5. What do each of the letters in equation **??** represent?
6. What does P represent in equation **??**?
7. In equation **??**...
   (a) Which value might be different for different packets (in the same system)?
   (b) Which value depends upon the distance that packets travel?
   (c) Which value depends upon the physical medium through which the packets travel?
   (d) Which values depend on the size of the packets?
   (e) Which values might depend upon how information a packet carries and how complex the encoding of that information is?
8. In equation **??**...
   (a) What does a represent?
   (b) What will happen if the inequality holds?
9. Let's suppose that we want to send B bits on some path through a network and that we will divide B bits into n packets of B/n bits each. Ignore queueing, processing, and propagation delays. Consider only the transmission delay. Choose symbols to represent the number of links on the path and the transmission rate of the switches.
   (a) Compose an expression that models the end-to-end delay.
   (b) What is the effect of increasing n?
10. How are HTTP and HTML related?
11. How are SSL and TCP related?

1

1. Reorder the items in the second column of this table to make features and purposes match.

features	**purpose**
acknowledgement	detect errors in packets
checksum	detect loss of packets
negative acknowledgement	detect duplicate packets
sequence number	receiver tells sender it has received error-free packet
timer	receiver tells sender it has not received error-free packet
window, pipelining	enable simultaneous flight of multiple packets

$$d = \frac{NL}{R} \tag{1}$$

$$d = \frac{L \cdot (N + P - 1)}{R} \tag{2}$$

$$d = d_{processing} + d_{queueing} + d_{propagation} + d_{transmission} \tag{3}$$

$$\frac{La}{R} > 1.0 \quad ? \tag{4}$$

Figure 1: Equations from Chapter 1 of Kurose and Ross.

2. A TCP connection is not a virtual circuit. Why not?

3. How many segments do two processes exchange during the opening of a TCP connection?

4. TCP provides "full duplex service." What does that mean?

5. TCP does not provide "multicasting" service. What does that mean?

6. What is the typical length of the header in a TCP segment?

7. The MSS constrains the size of a TCP segment. What is the MSS?

8. TCP is a protocol for communication between two processes. Which process takes the first step in establishing a TCP connection? The client process or the server process?

9. In general, would you expect the sequence numbers of segments that are sent one immediately after the other to be consecutive numbers?

10. What happens when segments arrive out of order during communication with the TCP protocol?

11. TCP computes timeouts by estimating the time required for a packet to make a roundtrip between sender and receiver. The computation involves a weighted average.

    (a) Write a mathematical expression for the weighted average of two numbers.

    (b) The weighted average will be the average of which two numbers?

12. For what kind of increasingly important services is TCP splitting especially advantageous?

2

1. What are some reasons for preferring UDP over TCP for some applications?

2. Identify several applications that may use the UDP transport protocol.

3. The first 4 bytes of a TCP segment header contain the the same kind of information as the first 4 bytes of a UDP segment header. What do both kinds of headers contain in the first 4 bytes?

4. What is the "end to end" principle? Where does it find application in the transport level?

5. Is reliable communication a concern only in the design of protocols that operate at the transport level?

6. The authors of our textbook showed us methods for sending data reliably from a sender to a receiver. How does this one way communication relate to the way that TCP works?

7. What does `udt_send()` denote in the diagrams that illustrate the algorithms rdt1.0 to rdt3.0?

8. List four problems that we encountered and solved in our study of reliable data transfer at the transport layer.

9. How does TCP measure $SampleRTT$?

10. Let $s_0, s_1, s_2, s_3, \ldots, s_n$ be successive samples of the round trip time for packets exchanged between two processes.

    Let $e_0, e_1, e_2, e_3, \ldots, e_n$ be successive estimates of the expected or average round trip time.

    Let α be a number in the interval $[0.0, 1.0]$. This is the "weight" used in computing the weighted average of the previous estimate and the most recent sample.

$$
\begin{aligned}
e_n &= (1-\alpha)e_{n-1} + \alpha s_n \\
e_0 &= s_0 \\
e_1 &= (1-\alpha)s_0 + \alpha s_1 \\
e_2 &= (1-\alpha)[(1-\alpha)s_0 + \alpha s_1] + \alpha s_2 \\
&= (1-\alpha)^2 s_0 + (1-\alpha)\alpha s_1 + \alpha s_2 \\
e_3 &= (1-\alpha)[(1-\alpha)^2 s_0 + (1-\alpha)\alpha s_1 + \alpha s_2] + \alpha s_3 \\
&= (1-\alpha)^3 s_0 + (1-\alpha)^2 \alpha s_1 + (1-\alpha)\alpha s_2 + \alpha s3
\end{aligned}
$$

    (a) What will be the first term in the expression for e_4?

(b) What will be the first term in the expression for e_n?

(a) e_4 =??
(b) e_n =??

11. The authors compared TCP's method of controlling congestion to the behavior of a child. What is the similarity?

12. List several costs of congestion.

3

1. Find links to short video recordings of talks or interviews with experts in the fields of computer networks. I suggest that you begin your search with the names Vint Cerf, Tim Berners-Lee, Bob Kahn, Danny Hillis, and perhaps our very own George Strawn.

2. The transport layer is about the movement of segments between processes. What is the network layer about?

3. Assemble these words in a $2x2$ table:

   - a single router
   - all routers
   - forwarding
   - routing

4. Chapter 4 has three parts. Identify the sections of the chapter that make up each part.

   - network layer functions
   - forwarding
   - routing

5. What is the primary role of a router?

6. The authors show a truncated protocol stack next to each router in Figure 4.1. In what way are these protocol stacks truncated?

7. A router's forwarding table associates values found a datagram's header with output links. What kind of information might the router take from a datagram's header and use to find the output link?

8. A relationship between forwarding and routing is found in the answer to the question: how is a forwarding table filled? Explain.

9. Describe the distinction between forwarding and routing by an analogy with a long trip taken by automobile.

10. Handshaking is not a part of IP but it is a part of some other network layer protocols. Give an example.

11. How do the authors distinguish routers from switches?

12. Write a list of services that we might want in our network by rewriting the list found on page 311 without using the words "guarantee," "delivery," "bandwidth," or "jitter."

13. We have used different words to name packets at each level of the Internet protocol stack. Yet another word is used to name packets in ATM networks. What is that word?

14. What are CBR and ABR?

15. What distinguishes a datagram network from a virtual circuit network?

16. What might cause packets to be lost?

17. What is a principal purpose for which virtual circuit networks were developed?

18. What is a principal purpose for which datagram networks were developed?

19. The authors tells that the Internet is built on a model that is an inverse of the model upon which the telephone system was built. How so?

20. Although we have just one connection to the Internet at our house, my wife and I are both able to use the Internet at the same time. How do the right Web pages get to her computer and my computer?

21. How do firewalls and intrustion detection systems differ?

22. Identify a principle that has been violated in the design of NAT?

23. When did the Swedish people switch from driving on the left side of the roads to driving on the right side of the roads? (Find the answer on the Web.) What might we call such a special day? How might this idea relate to our choice of a network layer protocol?

4

1. What is "forward error correction?" In particular, what does the word "forward" signify in this phrase?

2. Which bytes are summed in computing checksums for...

   (a) TCP and UDP segments?

(b) IP datagrams?

3. There are two types of network links.

   (a) How will we refer to a system with a single sender and a single receiver?

   (b) How will we refer to a system with many senders and receivers communicating through a shared channel?

4. What problem does a multiple access protocol solve?

5. What are the 3 kinds of multiple access protocol?

6. What are the authors' purposes in showing us three methods detecting errors?

7. What is the relationship between the size of the generator G and the number r of extra bits that are attached to the data in a cyclic redundancy check?

8. To what are the authors referring when they use the word "collision" in Chapter 5?

9. Identify advantages and disadvantages of TDM and FDM.

10. Where will we find an especially important application of CDMA?

11. Where is the randomness in a random access protocol?

12. The "CS" and the "CD" in CSMA/CD correspond to which two rules that we all know how to use in conversation?

13. Why is the ALOHA system called "ALOHA?"

14. Why do the authors describe the Slotted ALOHA and ALOHA systems?

15. When we speak of the efficiency of a random access protocol, what do we mean?

16. Solve problem P8 on page 504 of our textbook.

5

1. Estimate the time required to send a signal and receive an acknowledgement over the length of the longest fiber optic cable in the world.

2. The following initials represent which words?

   ABR -

   ACK -

AIMD -
API -
ARP -
ARPA -
ATM -
BGP -
CBR -
CRC -
CSMA/CD -
DHCP -
DHT -
DNS -
DoS -
FDM -
FSM -
FTP -
GBN -
HTML -
HTTP -
ICMP -
IETF -
IMAP -
IP -
ISP -
JPEG -
JSON -
LAN -
MAC -
MSS -
MTU -
MVC -
NACK -
NAT -
NSF -
OSPF -

P2P -

POP3 -

RFC -

RIP -

RTT -

SCP -

SSH -

SMTP -

SR -

TCP -

TDM -

TLD -

TTL -

UDP -

URI -

URL -

VC -

VPN -

XML -

W3C

3. On page 183, Marc Andreessen names an actress among the people who influenced him. Who was she?

4. On page 754, Steven Bellovin identifies what he believes is the principal cause of insecurity on computer networks. What is it?

5. Read what each of these experts has to say about the future of computer networks. Drawing from their wisdom, compose two or three paragraphs that describe what we might might expect.

    - Leonard Kleinrock (See page 181)
    - Van Jacobson (See page 302)
    - Vinton Cerf (See page 432)
    - Simon Lam (See page 512)
    - Deborah Estrin (See page 585)
    - Henning Schulzrinne (See page 669)
    - Jennifer Rexford (See page 787)

6

1. What are the five layers of the Internet's protocol stack?
2. How does the Internet's protocol stack differ from the OSI model?
3. A TCP connection is not a virtual circuit. Why not?
4. What do the DNS, ARP, and NAT protocols have in common?
5. What criteria might you use to evaluate a code for the detection and/or correction of errors?
6. Where did we find application for the following mathematics?
   (a) graphs
   (b) trees
   (c) finite state machines
   (d) weighted averages
7. FLAG is the Fiber-Optic Link Around the Globe. It is a fiber optic cable whose length is $28,000$ kilometers. That is 28 million meters. Let us round that number and say that the length is approximately $3 \cdot 10^7$ meters. The speed of light is approximately $3 \cdot 10^8$ meters per second.
   (a) Compute a lower bound for the RTT of a signal that travels between a sender and a receiver at opposite ends of this cable?
   (b) We made a similar calculation during our discussion of reliable data transfer. At that point, we put aside "stop-and-wait" protocols and turned our attention of "pipelined" protocols. Why?
8. Here are 3 characteristics of the distance-vector routing algorithm.

   What do each of these words mean?
   (a) asynchronous
   (b) distributed
   (c) iterative
9. Define these distinctions between
   (a) static versus dynamic
   (b) load-sensitive versus load-insensitive
10. How might considerations of policy and performance differ in the design of intra-AS and inter-AS routing algorithms?

11. What do each of the terms in the Bellman-Ford equation denote?

$$d_x(y) = \min_v(c(x,v) + d_v(y))$$

(a) $d_x(y)$?

(b) $c(x,v)$?

(c) $d_v(y)$?

12. Ethernet is a CSMA/CD network. How does that make an Ethernet like a conversation among several or many polite human beings who are seated around a dinner table?

13. Since its invention forty years ago, Ethernet technology has evolved. Identify one of the ways in which the technology has changed.

14. Choose and respond to just one of the four following directives.

    - Identify a person who made a significant contribution to the development of the technology of computer networks.
    - Identify an organization that had an important role in the development of the technology of computer networks.
    - Identify an important event in the history of computer networks.
    - Identify a prediction for the future development of computer networks that experts have made.