Name_______________ Student ID____________________ Department/Year___________

# 1st Examination

Introduction to Computer Networks (Online)
Class#: EE 4020, Class-ID: 901E31110
Spring 2024

10:20-12:10 Wednesday
March 27, 2024

**Cautions**

1. There are in total 100 points to earn. You have 90 minutes to answer the questions. Skim through all questions and start from the questions you are more confident with.
2. Use only English to answer the questions. Misspelling and grammar errors will be tolerated, but you want to make sure with these errors your answers will still make sense.

1. (ch11, 2pt) Consider these devices on the Internet today. Tell the part of the Internet each of them belongs – (a) edge or (b) core?
    (1) The PA workstation (1pt)
    (2) A router in the Internet backbone (1pt)

Sample Solution:

(a) (b)

2. (ch12, 4pt) Consider these access network technologies: (a) DSL, (b) Cable Modem, (c) FTTH, (d) Ethernet, and (e) WiFi. Tell which of them shares the bandwidth among multiple subscribers (from the subscriber end to the ISP's office) and which of them dedicates the bandwidth to the subscriber. Grading policy: -1pt per wrong choice till 0pt.
    (1) Dedicated bandwidth (2pt)
    (2) Shared bandwidth (2pt)

Sample Solution:

(1) (a)(c) or (a)(c)(d)
(2) (b)(d)(e) or (b)(e)

Ethernet can be shared or dedicated.

3. (ch13, 2pt) Recall the packet switching and circuit switching principle, select the keywords that are characteristics of a circuit switched network. (a) Reservation, (b) Contention, (c) Guaranteed bandwidth, (d) Packet drop, (e) Statistical multiplexing. Grading policy: -1pt per wrong choice till 0pt.

Sample Solution:

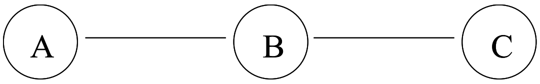
(a)(c)

4. (ch13, 4pt) Between packet switching and circuit switching, which of the principles would you choose for a network that transmits the following kind of data and why? Grading policy: no pts without a sensible argument.
    (1) Long video streams (2pt)
    (2) Short messages (2pt)

Sample Solution:

Take your pick and justify.

5. (ch13, 8pt) Consider a simple network as follows. 12P bits of data need to be sent from node A, through node B, to node C. Link A-B and link B-C are identical. The link bandwidth is R bits per second. The link speed is S meter per second. The length of the link is D meters. Assume the packet header containing necessary information to deliver any amount of data from A to C is P bits. And the queuing and processing delays are negligible.




(1) What is the transmission delay sending P bits over link A-B? (1pt)
(2) What is the propagation delay sending data over link A-B? (1pt)
(3) Let's send the 12P bits in 2 equal parts. 6P bits in each part. Each part is sent in a packet. The total number of bits in a packet to send is then 7P bits (including the P bits necessary for the packet header). The two packets are sent back-to-back (i.e., in the pipelined fashion). What is the total delay (in terms of R, P, S, or D) for all the data to arrive at C? Grading policy: must show derivation for the pts. (2pt)
(4) Let's send the 12P bits in 3 equal parts. 4P bits in each part. Each part is sent in a packet. The total number of bits in a packet to send is then 5P bits (including the P bits necessary for the packet header). The three packets are sent back-to-back (i.e., in the pipelined fashion). What is the total delay (in terms of R, P, S, or D) for all the data to arrive at C? Grading policy: no pts without the derivation for Problem 5-3. (1pt)
(5) Let's send the 12P bits in 6 equal parts. 2P bits in each part. Each part is sent in a packet. The total number of bits in a packet to send is then 3P bits (including the P bits necessary for the packet header). The six packets are sent back-to-back (i.e., in the pipelined fashion). What is the total delay (in terms of R, P, S, or D) for all the data to arrive at C? Grading policy: no pts without the derivation for Problem 5-3. (1pt)
(6) What is the optimal number of parts to break the 12P data to minimize the total delay and why? Grading policy: no pts without a sensible argument. (2pt)

Sample Solution:

(1) P/R
(2) D/S
(3) 21P/R + 2D/S

Queuing and processing delay = 0 (assumed negligible)

Propagation delay = 2D/S (fixed)

Transmission delay = 7P/R for the 1st part of the data to arrive at the 1st hop + 7P/R to the 2nd hop + 7P/R for the 2nd part (pipelined) to arrive. Total=21P/R

(4) 20 P/R + 2D/S

Transmission delay = 2* 5P/R for the 1st part to travel 2 hops + 2* 5P/R for the 2nd and 3rd parts to arrive = 20P/R

(5) 21 P/R + 2D/S

Transmission delay = 2* 3P/R for the 1st part to travel 2 hops + 5* 3P/R for the 2nd and 3rd parts to arrive = 21P/R

(6) 3 or 4 parts. The delay sending the data in 4 equal parts is the same as in 3 equal parts. And the delay sending the data in more than 4 equal parts ends up higher.

6. (ch14, 11pt) `ping` provides another way to investigate the round-trip time (RTT) to a remote machine. The way it works is very simple – sending a request to the remote machine and the remote machine sending back a response. By calculating the difference in the timestamp of the request and response, `ping` shows the measured RTT on the screen. Using the `–c` flag, one can limit the number of request-response probes.

   Let's `ping` to `k.root-servers.net`, `l.root-servers.net`, and `m.root-servers.net`. These 3 root DNS servers are located in Amsterdam, Los Angeles, and Yokohama respectively. Let's see which one is the best for NTU's local DNS server to send queries to.

   (1) Login to the PA workstation with your exam account. Create a directory "exam1" and move to the directory. (2pt)

   (2) `ping` to `k.root-servers.net` and create a file `k.txt` to contain the output as follows. You should see 5 RTT measurements in the output file. Leave the file there for grading. (2pt)

   ```
   $ ping -c 5 k.root-servers.net > k.txt
   ```

   (3) Tell the average RTT from the PA workstation to `k.root-servers.net` according to `k.txt`. (1pt)

   (4) `ping` to `l.root-servers.net` and create a file `l.txt` to contain the output and leave the file there for grading. (1pt)

   (5) Tell the average RTT from the PA workstation to `l.root-servers.net` according to `l.txt`. (1pt)

   (6) `ping` `m.root-servers.net` and create a file `m.txt` to contain the output and leave the file there for grading. (1pt)

   (7) Tell the average RTT from the PA workstation to `m.root-servers.net` according to `m.txt`. (1pt)

   (8) Suppose you are hired to configure NTU's local DNS server, which root DNS server would you choose to send queries to and why? (2pt)

Sample Solution:

Will check what the .txt files in your exam1 directory say

7. (ch15, 3pt) The Internet protocol stack consists of 5 layers: (a) application layer, (b) transport layer, (c) network layer, (d) link layer, (e) physical layer. Tell which layer the following protocols belong to.
   (1) WiFi (1pt)
   (2) SSL (1pt)
   (3) BGP (1pt)

Sample Solution:

(d) (a) (c)

8. (ch21, 2pt) Between the two communication models, client-server and peer-to-peer, which one do you prefer and why? (2pt)

Sample Solution:

Take your pick and justify.

9. (ch21, 2pt) Based on what you have learned about (a) communication model, (b) IP address, (c) port number, (d) transport layer protocol, tell which of these will be necessary to uniquely identify the following entities.
   (1) A host (1pt)
   (2) A process (1pt)

Sample Solution:

(1) (b)
(2) (b)(c)

One does not need to know the communication model, nor the transport layer protocol to uniquely identify a host or a process on the Internet.

10. (ch21, 4pt) Based on what you have learned about (a) TCP, (b) UDP, and (c) TLS, which of them address(es) the following QoS requirement better than the others.
    (1) Data integrity (1pt)
    (2) Timing (1pt)
    (3) Throughput (1pt)
    (4) Security (1pt)

Sample Solution:

(1) (a)(c)

TCP and TLS address the data integrity requirement equally well.

(2) (b)

UDP allows lower delay in general. There's no need of connection setup delay (unlike TCP and TLS is based on TCP).

(3) (b)

UDP allows a higher throughput in general. There's no connection setup. There are less control bits to send.

(4) (c)

TLS is the only one addressing the security issue.

11. (ch22, 4pt) Below are 3 messages intercepted by a packet sniffer between a pair of web client and server. Tell which protocol and type of message they could be: (a) HTTP request, (b) HTTP response, (c) HTTPS request, (d) HTTPS response.

(1) (1pt)

```
GET /whatever.html HTTP/1.1
Host: 127.0.0.1:11999
User-Agent: curl/7.54.0
Accept: */*
…
```

(2) (1pt)

```
HTTP/1.1 200 OK
Date: Mon, 27 Jul 2009 12:28:53 GMT
Server: Apache/2.2.14 (Win32)
Last-Modified: Wed, 22 Jul 2009 19:15:56 GMT
Content-Length: 88
…
```

(3) (2pt)

```
.......L........._3..0.0o...~'....N.......i......6.../5.g....|#.z..Q..a
....e1...x/..
…
```

Sample Solution:

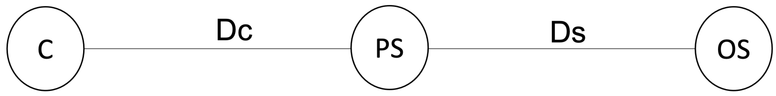
(1) (a)

(2) (b)

(3) (c)(d)

Message (3) is HTTPS for sure but one can't be sure if it's an HTTPS request or response.

12. (ch22, 6pt) Consider the following network.




A client (C) downloads a Web page of 1 base html and 3 reference objects from the origin server (OS). In that, the base html and reference objects are all in OS. Assume the transmission time is negligible and the one-way delay between C and PS is Dc and the one-way delay between PS and OS is Ds. Derive the response time downloading the Web page in terms of Dc and Ds in the following HTTP connection modes. Grading policy: no pts without a sensible derivation.

(1) Non-persistent connection without parallel connection. (2pt)
(2) Non-persistent connection with 3 parallel connections. (1pt)
(3) Persistent connection without pipelining. (2pt)
(4) Persistent connection with pipelining. (1pt)

Sample Solution:

(1) 2RTT (for the base) + 3 * 2RTT (for 3 ref obj) = 8RTT = 16Ds+16Dc (RTT=2Ds+2Dc)
(2) 2RTT (for the base) + 2RTT (for 3 ref obj at once) = 4RTT = 8Ds+8Dc
(3) 2RTT (for the base) + 3RTT (for 3 ref obj one after another) = 5RTT = 10Ds+10Dc
(4) 2RTT (for the base) + RTT (for 3 ref obj at once) = 3RTT = 6Ds+6Dc

13. (ch22, 6pt) Continue from Problem 12. The client (C) is configured to download the Web page via the proxy server (PS) instead. Assume all Web pages contain 1 base html and multiple reference objects and all HTTP connection are persistent with pipelining. Derive the response time in terms of Dc and Ds under these 2 conditions. Assume the connection keep-alive time is infinitely long for simplicity. Grading policy: no pts without a sensible derivation.

(1) Downloading 2 different Web pages not yet cached on the proxy server. (3pt)
(2) Downloading a Web page not yet cached on the proxy server and then downloading the same page again. (3pt)

Sample Solution:

(1) 10Dc+10Ds
    2Dc to setup a TCP connection to PS
    1Dc to request the base obj from PS

4Ds to fetch the base obj from OS

1Dc to return the base obj to C

Time to download the 1st page's base obj = 4Dc+4Ds

For the ref objs of the 1st page and next page's base and ref objects, each requires 1RTT between C and OS as none of the objects are cached.

Time to download the 1st page ref objs and 2nd page = 3* (2Dc+2Ds) = 6Dc+6Ds

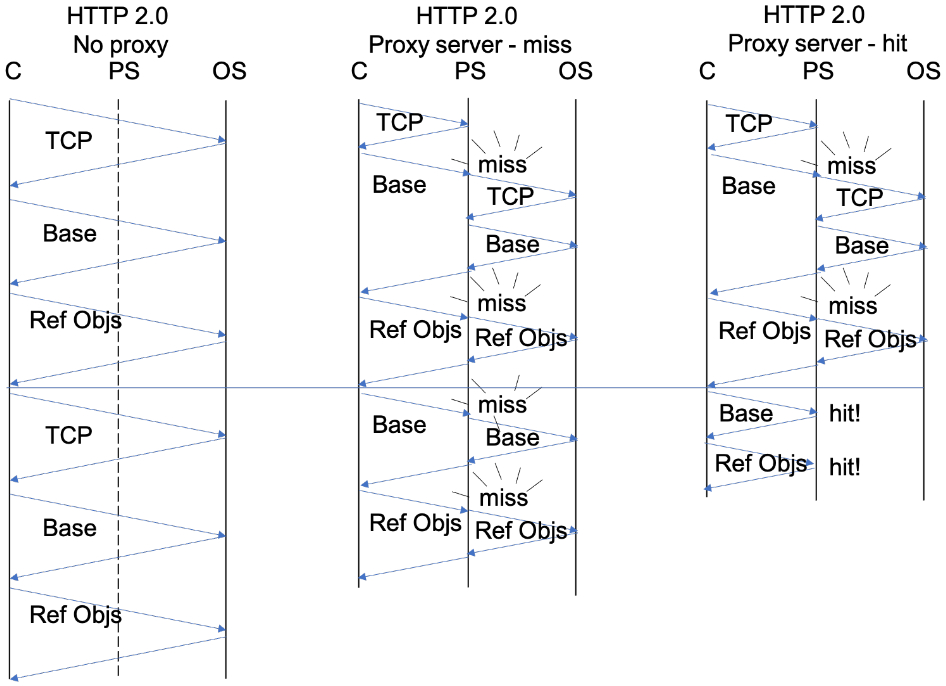
Altogether 10Dc+10Ds.

(2) 10Dc+6Ds

Same as (1) to get the 1st base obj and the ref objs. Total= 6Dc+6Ds

2nd download is a cached page. Total = 4Dc to get the base and the ref objs.

Altogether 10Dc+6Ds.




14. (ch24, 4pt) Network Utopia is a new company. For the potential customers to find the company web site or to email the sales, the network admin needs to set up the web server and mail server. In addition, the admin needs to set up the authoritative DNS server and install a number of DNS records properly as well. Tell for each of the DNS records below, which server it is supposed to be installed. (a) the web server, (b) the mail server, (c) the authoritative DNS server, or (d) a DNS registrar.

(1) (networkutopia.com, dns1.networkutopia.com, NS) (1pt)

(2) (dns1.networkutopia.com, 212.212.212.1, A) (1pt)

(3) (www.networkutopia.com, 212.212.212.2, A) (1pt)

(4) (networkutopia.com, mail.networkutopia.com, MX) (1pt)

Sample Solution:

(d)(d)(c)(c)

15. (ch24, 4pt) A local DNS server is often configured to cache the hostname-IP mappings for some time T.
    (1) Tell the issue of setting T to a long duration. (2pt)
    (2) Tell the issue of setting T to a short duration. (2pt)

Sample Solution:

(1) It will take a long time for a revised hostname-IP mapping to take effect.
(2) There will be a higher amount of DNS query/reply traffic from the local DNS server to the other servers in the DNS server network.

16. (ch25, 4pt) In BitTorrent, the “rarest first” algorithm is used to determine the video chunks to download and the “optimistically unchoke” algorithm is used to change peers randomly.
    (1) What is the reason behind using the “rarest first” algorithm? (2pt)
    (2) What is the reason behind using the “optimistically unchoke” algorithm? (2pt)

Sample Solution:

(1) To ensure there’s a good number of copies of each chunk in a torrent. Or to avoid rare chunks to go extinct.
(2) To allow new peers opportunities to contribute. Or to allow peers who are in need of download bandwidth to contribute.

17. (PA2, 14pt) Please go on the PA workstation and work under the exam1 directory for this problem set. Create the exam1 directory if you have not yet done so. Grading policy: pts for latter sub-problems will be given only when the formers are completed.
    (1) You should see a text file in your home directory unix-test.txt. Move the file to the exam1 directory. (1pt)
    (2) Make a copy of unix-test.txt and name it new-test.txt in your exam1 directory. (1pt)
    (3) Develop exam1-p17-1.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the file size on screen. (3pt)
    (4) Develop exam1-p17-2.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the exact file on screen. (3pt)
    (5) Develop exam1-p17-3.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the file characters by capitalizing the English alphabets on

screen. (3pt)

(6) Develop exam1-p17-4.go such that it (1) prompts the user for a filename, (2) reads the file, (3) prints the file characters by capitalizing the English alphabets to a new file named whatever.txt. (3pt)

Sample Solution:

Whatever that works.

18. (PA3, 16pt) Please go on the PA workstation and work under the exam1 directory for this problem set. Create the exam1 directory if you have not yet done so. Grading policy: pts for latter sub-problems will be given only when the formers are completed.

(1) Develop exam1-p18-1.go such that it connects to the server running on port 11991 and then close the connection. (3pt)

(2) Develop exam1-p18-2.go such that it connects to the server running on port 11992, sends “50\n” (a number in 1-100) and then closes the connection. (3pt)

(3) Develop exam1-p18-3.go such that it connects to the server running on port 11993, sends “50\n” (a number in 1-100), prints the response from the server, and then closes the connection. (4pt)

(4) Run your exam1-p18-3.go again. Send another number in 1-100, say “80\n” this time. Tell the response from the server. (3pt)

(5) Run your exam1-p18-3.go again. Send yet another number in 1-100 until you figure out what the server on port 11993 is doing. Tell what the server on port 11993 is doing. (3pt)

Sample Solution:

Whatever that works.