Name_____ Student ID_____ Department/Year_____

1st Examination

Introduction to Computer Networks (Online)
Class#: EE 4020, Class-ID: 901E31110
Fall 2022

10:20-12:10 Thursday
October 13, 2022

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, 3pt) Below are a variety of devices on the Internet today. Which part of the Internet do they belong – (a) edge, (b) access network, or (c) core?
   (1) Cable modem (1pt)
   (2) IXP router (1pt)
   (3) Bitcoin node (1pt)

Sample Solution:

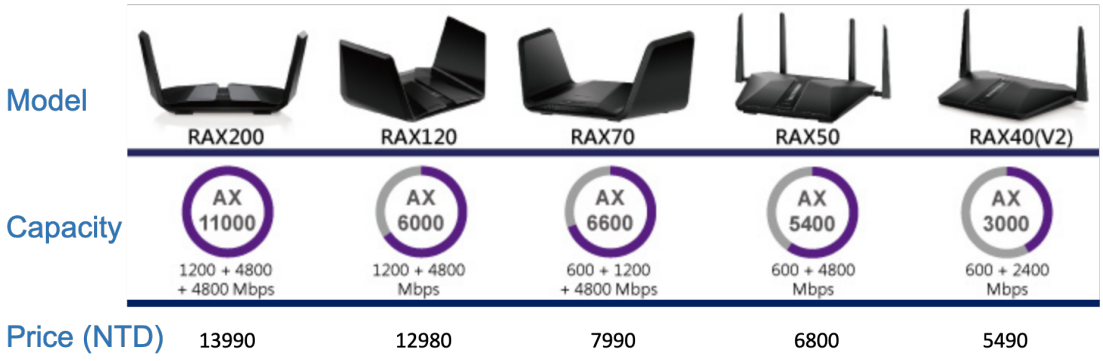
   (1) (b) or (a)
   (2) (c)
   (3) (a)

2. (ch12, 3pt) For each of access networks below, tell whether the bandwidth use (from the customer end to the ISP's office) is (a) dedicated or (b) shared?
   (1) Ethernet (1pt)
   (2) WiFi (1pt)
   (3) ADSL (1pt)

Sample Solution:

   (1) (a) or (b), depending on the Ethernet switch used
   (2) (b)
   (3) (a)

3. (ch12, 4pt) WiFi access network has evolved rapidly from WiFi4 WiFi5, to WiFi6. They operate on the IEEE 802.11n, 802.11ac, and 802.11ax standard respectively. For WiFi6, the theoretical maximum capacity is 10.8Gbps. In practice, we see WiFi6 Access Points (APs) for sale at a wide range of capacity and prices. Below is Netgear's WiFi6 AP lineup.



Ashley is running a streamer share space. Each tenant is offered 300Mbps uplink bandwidth, guaranteeing an 8K 60fps HDR live stream. To allow the tenants to stream from a variety of backgrounds, the plan is to upgrade the WiFi AP so all tenants can stream 300Mbps live from anywhere in the share space with no cables attached. Grading policy: no points without a sensible justification.

(1) Aiming at minimizing the expense and in the meantime satisfying 15 streamers, which WiFi6 AP in the above lineup should Ashley purchase?
(2) Justify your answer in (1). (2pt)
(3) Going for the lowest price per Mbps and in the meantime satisfying 15 streamers, which WiFi6 AP in the above lineup should Ashley purchase?
(4) Justify your answer in (3). (2pt)

Sample Solution:

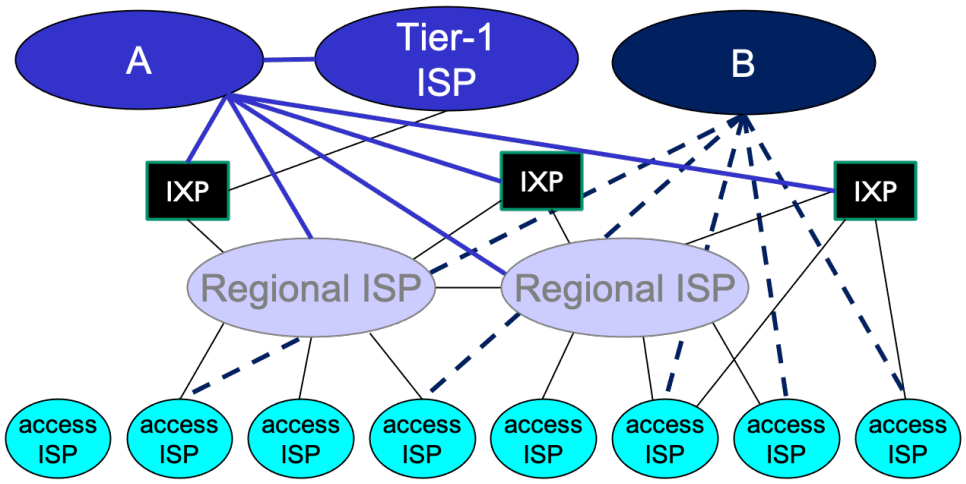
(1) RAX50
(2) RAX50 is the cheapest providing >4500Mbps capacity.
(3) RAX70
(4) Among RAX200, RAX120, RAX70 and RAX50 satisfying the capacity demand, RAX70 costs the least (1.21NTD) per Mbps

4. (ch13, 2pt) Recall the packet switching and circuit switching principle, select the phrases that are characteristics of a circuit switched network. (a) call reject, (b) reservation, (c) idle, (d) packet drop, (e) call setup. Grading policy: -1pt for each wrong selection till 0pt.

Sample Solution:

(a)(b)(c)(e)

5. (ch13, 4pt) Take a look at the network below. Grading policy: no points without a sensible justification.
   (1) Is A more likely a tier-1 ISP or a content provider network?
   (2) Justify your answer in (1). (2pt)
   (3) Is B more likely a tier-1 ISP or a content provider network?
   (4) Justify your answer in (3). (2pt)



Sample Solution:

(1) Tier-1 ISP
(2) It connects mostly to high-level ISPs (tier-1 ISP, IXPs and regional ISPs)
(3) Content provider network
(4) It connects to only access ISPs

6. (ch14, 2pt) Recall the 4 components of nodal delay – (a) processing delay, (b) queuing delay, (c) transmission delay, and (d) propagation delay. Grading policy: -1pt for each wrong selection till 0pt.
   (1) Which one is (relatively speaking) negligible?
   (2) Which one is constant given the transmission distance?
   (3) Which one can be calculated given the packet size?
   (4) Which one can go infinitely long when the router buffer is full?

Sample Solution:

(1) (a)
(2) (d)
(3) (c)
(4) (b)

7. (ch14, 11pt) `traceroute` allows investigation of the route to reach a remote machine. The way it works is very simple – sending 3 requests to each of the routers along the way to the remote machine. One can see the number of hops it takes to reach the remote machine and the round-trip time to each of the routers on the way.

Let's `traceroute` to NCU, NCHU, and NCKU's Web servers. These 3 universities are located in northern, central, and southern Taiwan respectively. Let's see if the remote machines that are geographically closer take also a shorter route.

(1) Login to the PA workstation with your exam account. Create a directory "exam1" and move to the directory. (1pt)
(2) `traceroute` to www.ncu.edu.tw and create a file `ncu.txt` to contain the output as below. You should see the route to reach www.ncu.edu.tw and 3 RTTs from the source to each of the routers in the middle. Leave the file there for grading (1pt).

```
$ traceroute www.ncu.edu.tw > ncu.txt
```

(3) Tell the number of hops from the PA workstation to reach www.ncu.edu.tw. (1pt). Grading policy: 1pt given when the ncu.txt file exists and the data support your answer.
(4) `traceroute` to www.nchu.edu.tw and create a file `nchu.txt` to contain the output and leave the file there for grading (1pt).
(5) Tell the number of hops from the PA workstation to reach www.nchu.edu.tw. (1pt). Grading policy: 1pt given when the nchu.txt file exists and the data support your answer.
(6) From ncu.txt and nchu.txt, do you see the machine geographically closer to the PA workstation travel a shorter route? (1pt) Grading policy: 1pt given when the ncu.txt and nchu.txt files exist and the data support your answer.
(7) `traceroute` to www.ncku.edu.tw and create a file `ncku.txt` to contain the output and leave the file there for grading (1pt).
(8) Tell the number of hops from the PA workstation to reach www.ncku.edu.tw. (2pt). Grading policy: 2pt given when the ncku.txt file exists and the data support your answer.
(9) From ncu.txt, nchu.txt and ncku.txt, do you see the machine geographically closer to the PA workstation travels a shorter route? (2pt) Grading policy: 2pt given when the ncu.txt, nchu.txt and ncku.txt files exist and the data support your answer.

Sample Solution:

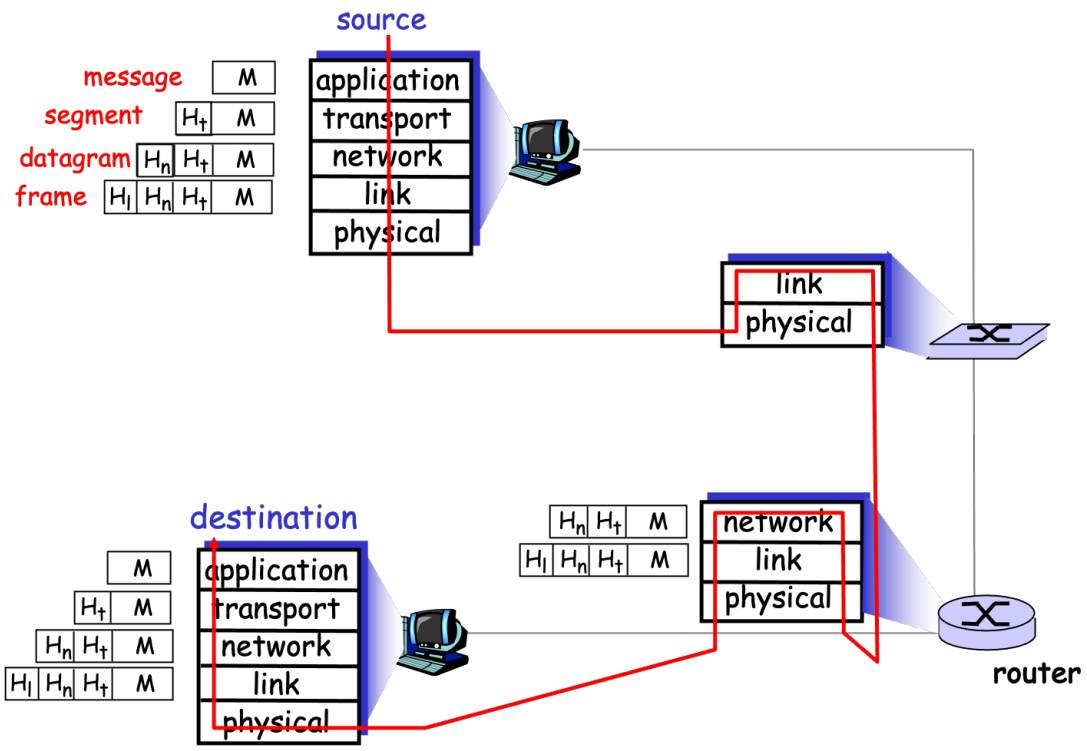
Will check on the PA workstation
Points for (3)(5)(8) will be credited when they are consistent with the outcome of (2)(4)(7)
Points for (6) will be credited when (2)-(5) are complete.
Points for (9) will be credited when (2)-(8) are complete.
(8) The last entry in ncku.txt ends with "!Z", which means the ICMP are turned off by the admin. The number of hops to www.ncku.edu.tw can't be determined.
(9) can't be sure if farther machines connect consistently with longer routes.

8. (ch15, 3pt) Consider the following protocols and tell which of the 4 layers they belong to – (a) application Layer, (b) transport Layer, (c) network Layer, (d) link Layer. Grading policy: -1pt for each wrong selection till 0pt.
   (1) ARP
   (2) UDP
   (3) DHCP
   (4) TLS

Sample Solution:

(1) (d)
(2) (b)
(3) (c) or (a)
(4) (a) or (b)

9. (ch15, 4pt) The picture below illustrates the life of an Internet packet – from the source, through a (link layer) switch, a (network layer) router, and finally the destination. Going downwards at the source, the headers (H_t, H_n, H_l) are added to the message (M) at the corresponding layer, providing information for processing per layer. Going upwards at the destination, each header is examined per layer, the packet is processed according to the protocol rules at the layer, and eventually the header is removed before the remaining packet is passed up a layer for further processing.



Tell which layer each of the actions below takes place – (a) transport layer, (b) network layer, (c) link layer, (d) physical layer, (e) none of the above. Grading policy: -1pt for each wrong selection till 0pt.

(1) Adding the H_t at the source?

(2) Adding the H_n at the source?

(3) Examining the H_l at the switch?

(4) Examining the H_n at the switch?

(5) Removing the H_l at the router?

(6) Adding the H_n at the router?

(7) Removing the H_t at the destination?

(8) Adding the H_n at the destination?

Sample Solution:

(1) (a)

(2) (b)

(3) (c)

(4) (e)

(5) (c)

(6) (e) (In the router, the stack goes only to the network layer. The H_n was not removed and therefore no need to be added back)

(7) (a)

(8) (e)

10. (ch21, 6pt) MapleStory is an ancient online game that allows diverse game plays. One can (a) shop/trade in the market, (b) chill/hang out with online friends, or (c) join a multi-guild event battling a uber mob for rare treasures. Grading policy: no pts without sensible explanation.

(a) Trading in the market

(b) Hanging out for group pictures

(c) Battling a uber mob

(1) Would you use TCP or UDP for (a) kind of game play and why? (2pt)
(2) Would you use TCP or UDP for (b) kind of game play and why? (2pt)
(3) Would you use TCP or UDP for (c) kind of game play and why? (2pt)

Sample Solution:

Take your pick and justify.

11. (ch22, 3pt) Web proxy caches a copy of the web pages requested. However, some of the pages might be modified at the source server. The client accessing the pages from the same Web proxy will miss the most up-to-date copies. Propose a solution such that the clients will always receive the most up-to-date copies from the proxy.

Sample Solution:

Whatever works.

12. (ch22, 9pt) Consider these connection modes one can implement in HTTP –
    (a) non-persistent + no parallel connections
    (b) non-persistent + 4 parallel connections
    (c) persistent connection without pipelining + no parallel connections
    (d) persistent connection without pipelining +2 parallel connections
    (e) persistent connection with pipelining + no parallel connections
    (f) persistent connection with pipelining +2 parallel connections

    Let's download a Web page of 1 base html and 4 reference objects. In that, the base html is in one server, 2 of the reference objects in another server, and the remaining 2 reference objects in yet another server. Assume the transmission time is negligible and the RTT to these 3 servers are the same for simplicity. Grading policy: no pts without sensible derivation or justification. pt for (7) granted when (1)-(6) are answered correctly.
    (1) Tell the response time in RTT using mode (a). (1pt)
    (2) Tell the response time in RTT using mode (b). (1pt)
    (3) Tell the response time in RTT using mode (c). (1pt)
    (4) Tell the response time in RTT using mode (d). (2pt)
    (5) Tell the response time in RTT using mode (e). (1pt)
    (6) Tell the response time in RTT using mode (f). (2pt)
    (7) Among the 6 modes, which one would you use and why? (1pt)

Sample Solution:

(1) 2RTT for the base. 4*2RTT for each of the subsequent ref objects. Total = 10RTT

(2) 2RTT for the base. 2RTT for 4 parallel connections to get 4 ref objects at once. Total = 4RTT

(3) 2RTT for the base. 2RTT+RTT for two objects in one server. 2RTT+RTT for the other two objects in another server. Total = 8RTT

(4) 2RTT for the base. 2RTT+RTT for the objects in two other servers. Total = 5RTT

(5) 2RTT for the base. 2RTT for two objects in one server. 2RTT for the other two objects in another server. Total = 6RTT

(6) 2RTT for the base. 2RTT for the objects in two other servers. Total = 4RTT

(7) Take your pick and justify.

13. (ch22-24, 8pt) Recall these application-layer protocols mentioned in the lectures or used for the PA assignments: (a) HTTP, (b) HTTPS, (c) FTP, (d) SMTP, (e) POP3, (f) IMAP, (g) DNS, (h) ssh. Grading policy: 2pt per subproblem. -1pt for each wrong selection till 0pt.

(1) Which of them pull(s) data from the server end? (2pt)

(2) Which are(is) stateful? (2pt)

(3) Which communicate(s) out of band? (2pt)

(4) Which send(s) encrypted data? (2pt)

Sample Solution:

(1) (a)(b)(c)(e)(f)(g)(h)

(2) (c)(f)

(3) (c)

(4) (b)(h)

14. (ch23, 6pt) Email messages are ASCII readable as well. Just like how telnet is useful debugging Web server configuration, we can try EE department's email server out – `cc.ee.ntu.edu.tw`.

(1) Log in to the PA server with your username and password. Go to the `exam1` subdirectory. telnet to the email server by this command as below:

```
telnet cc.ee.ntu.edu.tw 25
```

From the output, tell the IP address of `cc.ee.ntu.edu.tw`. (1pt)

(2) Type up the following line by line. Hit the enter key at the end of each line. The

points will be awarded when the TA receives the email. (5pt)

```
HELO blahblahblah
MAIL FROM: <your ntu email address>
RCPT TO: r11921098@ntu.edu.tw
RCPT TO: pollyhuang@ntu.edu.tw
RCPT TO: <your ntu email address>
DATA
To: r11921098@ntu.edu.tw
From: <your gmail address>
Subject: Exam #1 <your student ID>

If this works, it means anyone learning about the existence of
cc.ee.ntu.edu.tw can spoof as someone else easily.
.
QUIT
```

Sample Solution:

We'll check our emails.

15. (ch24, 8pt) DNS's server end is a 3-level, tree-like distributed database. The root servers at the highest level, the TLD servers at the 2nd, and the authoritative servers at the bottom level. The root servers track where the TLD servers are. The TLD servers track where the authoritative servers are. In addition to the database, there's a cache called the local DNS server that tracks the root servers and sometimes the TLD servers to redirect the RR entry queries.

    The RR entries and the special entries to allow access to the root and TLD DNS servers are stored at different DNS servers. Tell for each of the entries below, where they might be stored (temporarily or permanently): (a) root, (b) TLD, (c) authoritative, and (d) local DNS server.

    (1) Special root server entry: (b.root-servers.net, 199.9.14.201) (1pt)
    (2) Special TLD server entry: (com, a.gtld-servers.net) (1pt)
    (3) Special TLD server entry: (tw, a.gtld-servers.twnic.tw) (1pt)
    (4) RR entry: (netutopia.com, smtp.netutopia.com, MX) (1pt)
    (5) RR entry: (smtp.netutopia.com, 212.212.212.2, A) (1pt)
    (6) RR entry: (netutopia, dns1.netutopia.com, NS) (1pt)
    (7) RR entry: (dns1.netutopia.com, 212.212.212.1, A) (1pt)

(8) RR entry: (www.netutopia.com, 212.212.212.3, A) (1pt)

Sample Solution:

(1) (d)
(2) (a)(d)
(3) (a)(d)
(4) (c)(d)
(5) (c)(d)
(6) (b)(d)
(7) (b)(d)
(8) (c)(d)

16. (PA2, 10pt) Please go on the PA workstation and work under the exam1 directory for this problem set. Grading policy: pt for latter sub-problems will be given only when the formers are completed.
    (1) You should see two text files in your home directory – win-test.txt and unix-test.txt. Move the two files to the exam1 directory. (1pt)
    (2) Develop exam1-p16-1.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the file size on screen. (1pt)
    (3) Develop exam1-p16-2.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the exact file on screen. (1pt)
    (4) Develop exam1-p16-3.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the file character by character where all 'e' characters are printed in the capital form – 'E'. (2pt)
    (5) Develop exam1-p16-4.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the file character by character where all '\n', an unprintable character called line feed, is printed using a string of 5 characters –"<LF>\n" instead. (3pt)
    (6) Extend exam1-p16-4.go to exam1-p16-5.go such that it prints '\r', another unprintable character called carriage return, as a string of 5 characters –"<CR>\r" instead. (1pt)
    (7) Test your exam1-p16-5.go using win-test.txt and unix-test.txt and tell the difference between the output. (1pt)

Sample Solution:

Whatever that works.

17. (PA3, 14pt) Please go on the PA workstation and work under the exam1 directory for this problem set. Grading policy: pt for latter sub-problems will be given only when the formers are completed.
    (1) Develop exam1-p17-1.go such that it connects to the server running on port 11991 and then close the connection. (1pt)
    (2) Develop exam1-p17-2.go such that it connects to the server running on port 11992, sends "<your student ID>\n" and then closes the connection. (1pt)
    (3) Extend exam1-p17-2.go to exam1-p17-3.go such that it connects to the server running on port 11993, sends "<your student ID>\n", prints the response from the server, and then closes the connection. (1pt)
    (4) Extend exam1-p17-3.go to exam1-p17-4.go such that it connects to the server running on port 11993, prompts the user for the student ID, sends the ID in one line (+'\n' at the end of the message), prints the response from the server, and then closes the connection. (2pt)

    You should see the response from the server on port 11993. It says it is a Bulls and Cows game engine. In the game, the player guesses a 4-digit number. Each digit is a number in 0-9 and there's no repeating digits. The game engine responses with #B#C. #B tells the # of digits being correct and at the right position. #C tells the # of digits being correct but at the wrong position. The game ends when 4B0C response is accomplished.
    (5) Extend the code to exam1-p17-5.go such that it connects to the server running on port 11993, prompts the user for the student ID, sends the ID in one line (+'\n' at the end of the message), prints a line of response from the server. Continue to prompt the user for a 4-digit number, sends the number in one line (+'\n' at the end of the message), receives a line of message from the server, prints the line of message on screen, and then closes the connection. (2pt)
    (6) To complete the game, extend the code to exam1-p17-6.go such that it repeatedly prompts the user for another 4-digit number, sends the number in one line (+'\n' at the end of the message), receives a line of message from the server until the server response is 4B0C. (4pt)
    (7) Run exam1-p17-6.go and play the game until 4B0C. Tell the final 4-digit number that gives 4B0C. (3pt)

Sample Solution:

Whatever that works.