Name_____ Student ID_____ Department/Year_____

1st Examination

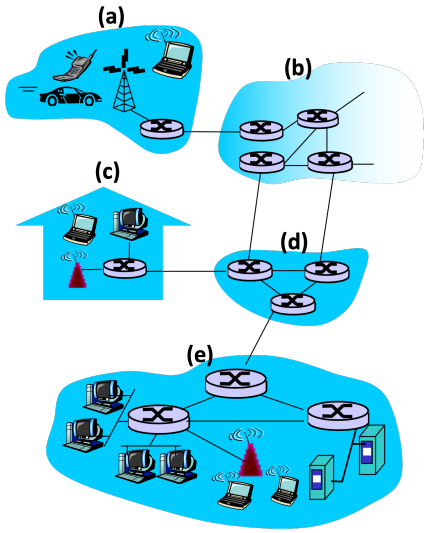
Introduction to Computer Networks (Online)
Class#: EE 4020, Class-ID: 901E31110
Spring 2023

10:20-12:10 Wednesday
March 29, 2023

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, 5pt) Consider a micro-Internet consisting of 5 subnets, namely (a), (b), (c), (d) and (e) as labeled below.



(1) Which subnets are classified as the Internet core? (1pt)
(2) Which subnets are classified as the Internet edge? (1pt)
(3) Which subnet is described as a mobile network in the lecture? (1pt)
(4) Which subnet is described as an institutional network in the lecture? (1pt)
(5) Which subnet is described as a home network in the lecture? (1pt)

Sample Solution:

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

2. (ch12, 4pt) Consider these devices on the Internet today. Tell the part of the Internet each of them belongs – (a) edge, (b) access network, or (c) core?
   (1) DNS root server (1pt)
   (2) FTTH modem (1pt)
   (3) Smart toaster (1pt)
   (4) Router connecting NTU to TANET (1pt)

Sample Solution:

(1) (a)

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

3. (ch13, 4pt) Tell the tradeoff of sending small vs. large packets in a packet switched network.
   (1) What is the benefit of sending small packets? (2pt)
   (2) What is the benefit of sending large packets? (2pt)

Sample Solution:

(1) shorter file transfer time. When the packet size is small, the time to store and forward the first packet will be short. The subsequent packets will follow in a pipelined way, which do not add more store-and-forward time. This allows a shorter file transfer time overall.
(2) lower packet header overhead. There are two parts in a packet -- the header that contains the control info and the payload that contains the actual data the networked applications are sending to each other. The packet header size is fixed. Using a larger packet size gives a higher proportion of bits for data.

4. (ch13, 2pt) Why does a packet switched network need to store and then forward a packet?

Sample Solution:

In a packet switched network, packets are forwarded over routers towards the destination. The forwarding function depends on the destination address (and potentially other info in the packet) which a router won't see until storing the packet.

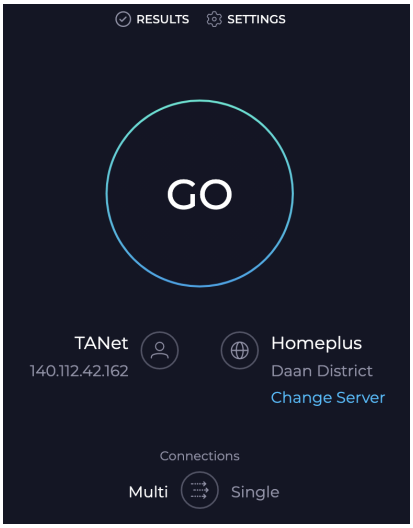
5. (ch14, 4pt) These terms are used to evaluate the performance of a network – (a) end-to-end delay, (b) round-trip delay, (c) queuing delay, (d) propagation delay, (e) transmission delay, (f) packet losses, (g) packet loss rate, (h) bit error rate, (i) throughput, and (j) link speed. Tell the term the following descriptions are referring to.
   (1) L/R, where L is the packet size and R is the link bandwidth.
   (2) The percentage of the packet dropped among all packets sent.
   (3) The maximum amount of data to arrive at the destination within a time interval.
   (4) The amount of time a packet takes to travel from the data source to the final

destination.

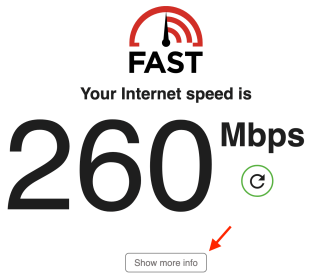
Sample Solution:

(1) (e)
(2) (g)
(3) (i)
(4) (a)

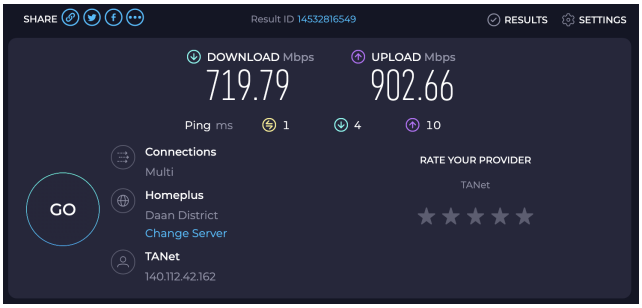
6. (ch14, 10pt) There are Web services that test a user's Internet speed. The result shows typically the download and upload speed. Let's try two such speed test services out.
   (1) Go to the speedtest.com site: https://www.speedtest.net/. Click 'GO' in the middle of the page. Let the test complete. Upload the screenshot of your test result. (2pt)

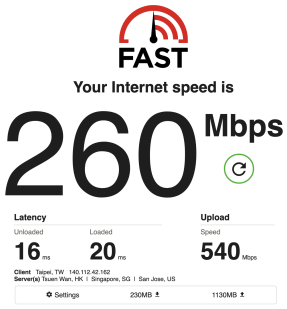


   (2) Go to the fast.com site here: https://fast.com/. The speed test should start automatically. When it is done, click Show more info (see pic below) to see the result in detail. Upload the screenshot of your test result. (2pt)



(3) Below are the results from polly's trial. Do you see your Internet speed different between the two speed tests as well? (1pt)





(4) Google up how the speed test works. Give the URL where you find clues. (1pt)

(5) Think through the clues and provide your interpretation of how the speed test works. (2pt)

(6) How can the user's Internet speed be different using one test vs. another (at least in polly's case)? (2pt)

Sample Solution:

(1) We'll check the pic you've uploaded.

(2) We'll check the pic you've uploaded.

(3) Just yes or no depending on your test results.

(4) Whatever you find online that's relevant.

(5) Send files of certain sizes and record the delay to complete the transfers. Divide the file size by the transfer time and repeat for a number of times for an average (after excluding the extreme samples in some tests).

(6) Depending on the exact destination/server the files are sent, the delay from the user and the server load may vary.

7. (ch15, 6pt) Internet protocols are sorted into layers and people refer to this as a layered service model.

(1) Give 1 benefit of the layered model. (1pt)

(2) Give 1 drawback of the layered model. (2pt)

(3) We used air travel as an example of the layered model. Give another example that operates in the layered model. (1pt)

(4) Justify your example. (2pt)

Sample Solution:

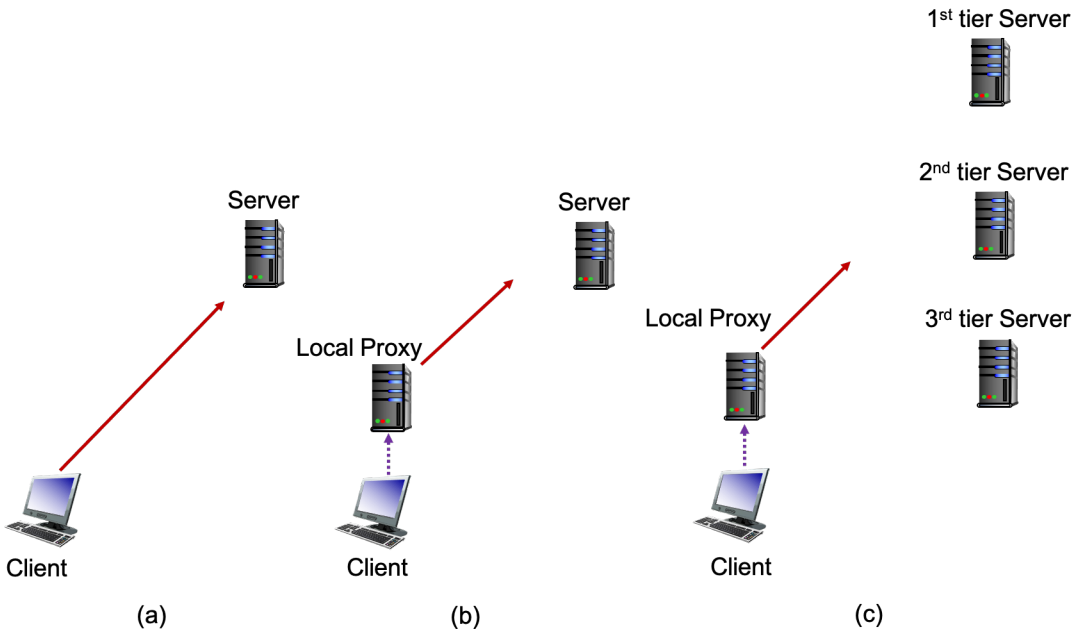
(1) ease of management, lowered communication overhead

(2) Sub-optimal performance/efficiency, hard to debug inter-layer errors
(3) Think of one.
(4) Justify your example.

8. (ch21, 6pt) There are four QoS requirements an application designer needs to consider before selecting a transport layer service. They are (a) delay, (b) loss, (c) throughput, and (d) security. Tell for each of the following application, which QoS requirement you think is the most important and why.
   (1) Which of the QoS requirements is the most important for online banking (e.g., eTrade) and why? (2pt)
   (2) Which of the QoS requirements is the most important for short video sharing (e.g., Tiktok) and why? (2pt)
   (3) Which of the QoS requirements is the most important for hostname to IP address lookup (i.e., DNS) and why? (2pt)

Sample Solution:
Take your pick and justify.

9. (ch22-24, 4pt) These are the major design choices of an application layer protocol – the architecture, the socket type, and the message formats. Among the 3 system architectures we have observed so far (depicted below) – (a) client-server model without expansion, (b) client-server model with client-end expansion, (c) client-server model with both client- and server-end expansion, which one is used by the following protocols:



(1) HTTP with proxy server (1pt)

(2) FTP (1pt)

(3) SMTP (1pt)

(4) DNS (1pt)

Sample Solution:

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

10. (ch22-24, 4pt) Continue from Problem Set 9 and consider the 3 system architectures again – (a) client-server model without expansion, (b) client-server model with client-end expansion, (c) client-server model with both client- and server-end expansion.

(1) Tell 1 benefit of client-side expansion from (a) to (b). (2pt)

(2) Tell 1 benefit of server-side expansion from (b) to (c). (2pt)

Sample Solution:

(1) Whatever that makes sense. E.g.:

--Caching to reduce delay and bandwidth consumption

-- Lowering server load

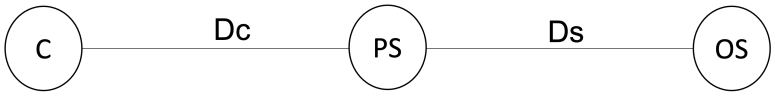
--Aggregating data to send in bulk to reduce the (TCP) connection setup overhead

(2) Whatever that makes sense. E.g.:

--Load balancing to allow the system to grow/scale while keeping the response/service time under control

--Providing flexibility to assign roles to the various servers so the architect can co-optimize the data search/retrieval and data upload/update time

11. (ch22, 4pt) Consider the following network.



A client (C) downloads a Web page of 1 base html and 4 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 pt without sensible derivation.
(1) Non-persistent connection without parallel connection. (1pt)
(2) Non-persistent connection with 4 parallel connections. (1pt)
(3) Persistent connection without pipelining. (1pt)
(4) Persistent connection with pipelining. (1pt)

Sample Solution:

(1) 2RTT (for the base) + 4 * 2RTT (for 4 ref obj) = 10RTT = 20Ds+20Dc (RTT=2Ds+2Dc)
(2) 2RTT (for the base) + 2RTT (for 4 ref obj at once) = 4RTT = 8Ds+8Dc
(3) 2RTT (for the base) + 4RTT (for 4 ref obj one after another) = 6RTT = 12Ds+12Dc
(4) 2RTT (for the base) + RTT (for 4 ref obj at once) = 3RTT = 6Ds+6Dc

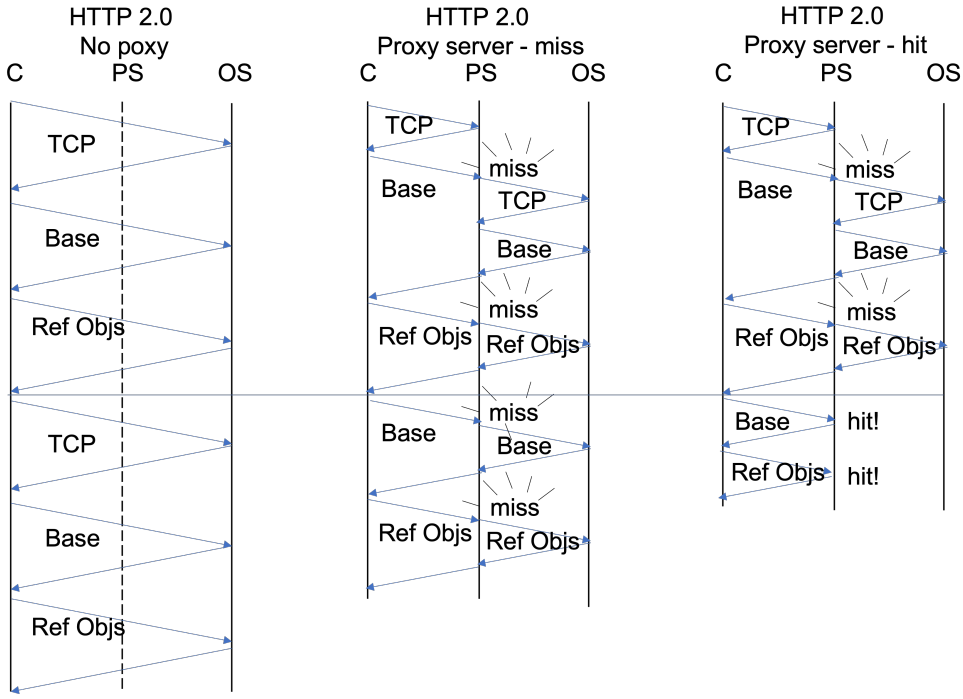
12. (ch22, 6pt) Continue from Problem Set 11. The client (C) is configured to download the Web page via the proxy server (PS) instead. Assume all Web pages contain 1 base html and multiple reference objects and the HTTP connection is persistent with pipelining.

Derive the response time in terms of Dc and Ds under these 2 conditions. Grading policy: no pt without 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 (or 12Ds+12Ds if two Web page downloads are beyond keep-alive time)

(2) 10Dc+6Ds (or 12Dc+6Ds if two downloads are beyond keep-alive time)



13. (ch24, 12pt) One can find the IP address of a host using this Unix command – `dig`. Below is an example looking up www.google.com's IP address. One can see from the QUESTION SECTION the DNS query, and from the ANSWER SECTION the DNS reply. The IP address of www.google.com is clearly 142.251.42.228. One can also see from the SERVER line that 140.112.2.2 is the DNS server providing the reply through port 53. Grading policy: pts will be granted when the answers match the stored output.

```
$ dig www.google.com
; <<>> DiG 9.10.6 <<>> www.google.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 49261
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1400
;; QUESTION SECTION:
;www.google.com.                IN   A
```

```
;; ANSWER SECTION:
www.google.com.         11   IN   A    142.251.42.228

;; Query time: 0 msec
;; SERVER: 140.112.2.2#53(140.112.2.2)
;; WHEN: Tue Mar 28 16:22:14 CST 2023
;; MSG SIZE  rcvd: 59
```

(1) Log on the PA server. Go to your exam1 directory. Create the exam1 directory if you have not yet done so. Execute the following command. Leave `www-ntu.txt` in the directory for grading. (3pt)

```
$ dig www.ntu.edu.tw > www-ntu.txt
```

(2) Tell the IP address of `www.ntu.edu.tw`. (1pt)

(3) Execute the following command. Leave `dns-ntu.txt` in the directory for grading. (2pt)

```
$ dig dns.ntu.edu.tw > dns-ntu.txt
```

(4) Tell the IP address of dns.ntu.edu.tw. (1pt)

(5) How many authoritative DNS servers are there for ntu.edu.tw and why so you think so? (3pt)

(6) Can you tell also the IP address of ntu3.ntu.edu.tw and what is your clue? (2pt)

Sample Solution:

We'll check the *-ntu.txt files in your exam1 directory.

14. (PA2, 15pt) 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: pt for latter sub-problems will be given only when the former ones 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-p14-1.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the file size on screen. (2pt)
    (3) Develop exam1-p14-2.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the exact file on screen. (3pt)
    (4) Develop exam1-p14-3.go such that it (1) prompts the user for a filename, (2) reads the file and (3) prints the file character by character except for '\r'. (3pt)
    (5) Develop exam1-p14-4.go such that it (1) prompts the user for a filename, (2) reads the file, (3) prints the file character by character except for '\r', and (4) append a '\n' at the end of last line if there isn't a '\n' already. (4pt)
    (6) Test your exam1-p14-4.go using win-test.txt and compare the output to unix-test.txt and tell if you see any difference. (2pt)

Sample Solution:

Whatever that works.

15. (PA5, 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: pt for latter sub-problems will be given only when the former ones are completed.
    (1) Develop exam1-p15-1.go such that it connects to the server running on port 11991 and then close the connection. (3pt)
    (2) Develop exam1-p15-2.go such that it connects to the server running on port 11992, sends “hello!\n” and then closes the connection. (3pt)
    (3) Develop exam1-p15-3.go such that it connects to the server running on port 11993, sends “hello!\n”, prints the response from the server, and then closes the connection. (4pt)
    (4) Run your exam1-p15-3.go again and send “what?\n” this time. Tell the response from the server. (2pt)
    (5) Run your exam1-p15-3.go again and send an arbitrary string until you figure out what the server on port 11993 is doing. Tell what the server on port 11993 is doing. (2pt)

Sample Solution:

Whatever that works.