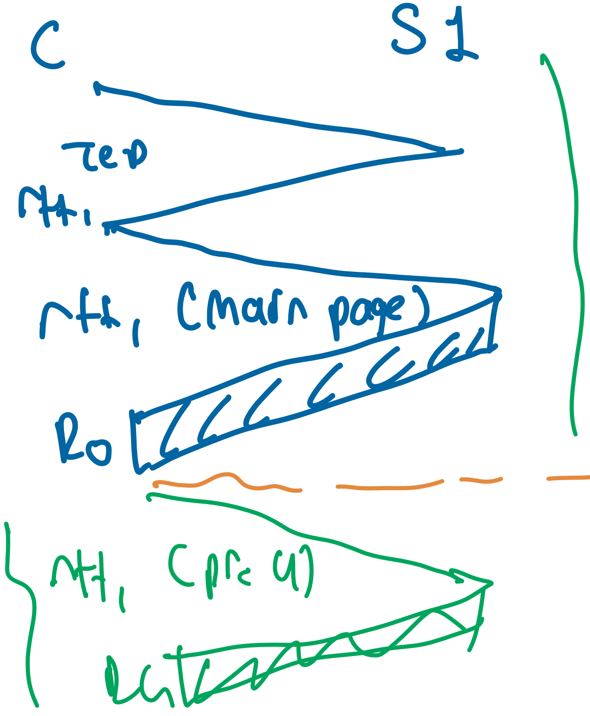
1) Fill in the blank.

The concept of "service access point" of OSI reference model is named as ~~port~~ ________________ in TCP/IP.

port number

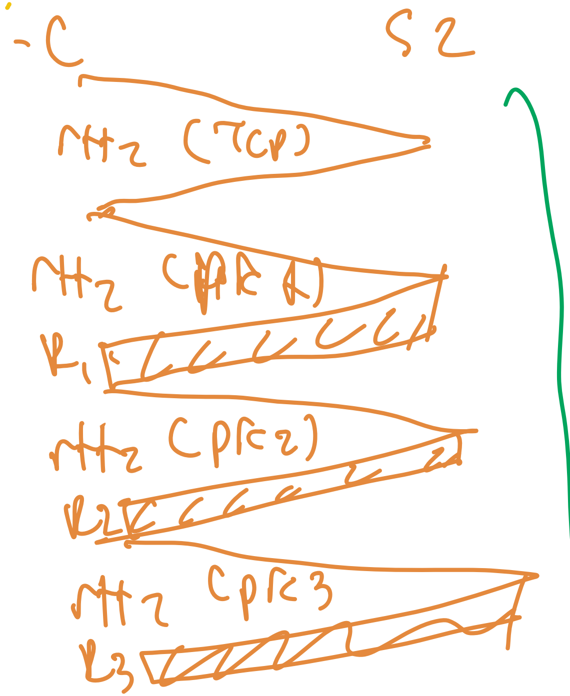
3) Which application layer protocol(s) among the following ones work in session manner such that several messages are exchanged back and forth during the application run? Mark all that apply.

~~Nonpersistent HTTP~~ SMTP ~~FTP data connection~~ telnet



2) Suppose you use HTTP to retrieve a web page from a server (say *server*1). At the end of this web page, there are references to 3 pictures from another server (say *server*2). First the web page is downloaded from *server*1; then the pictures are downloaded from *server*2.

rtt_1 and rtt_2 denote the round trip times between the client and the HTTP servers *server*1 and *server*2, respectively. R_0 denotes the transmission time of the web page, and R_1, R_2, and R_3 denote the transmission times of the pictures. How much time elapses between the initiation of the first TCP connection and reception of all 4 objects (web page and 3 pictures), if persistent HTTP is used without pipelining?



Total: $2rtt_1 + R_0 + 4rtt_2 + R_1 + R_2 + R_3$

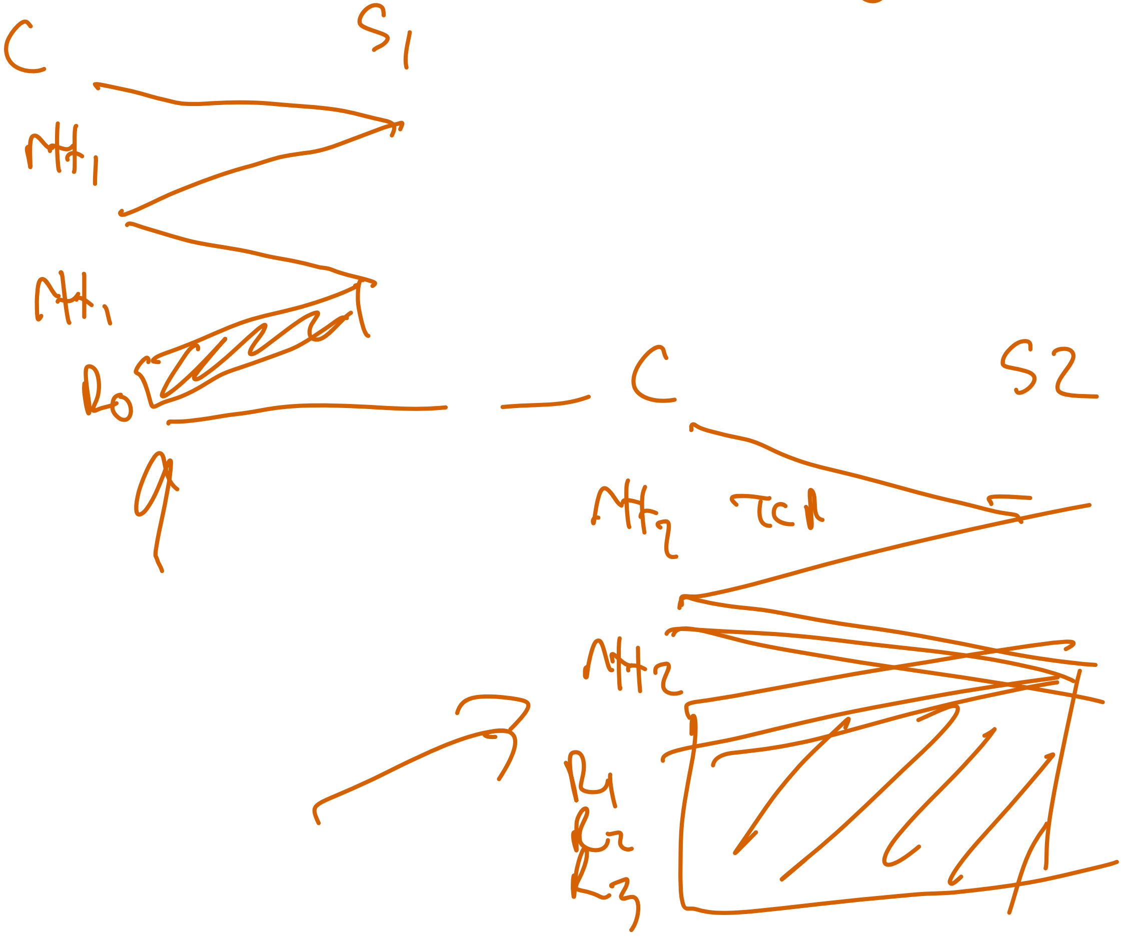
No overlap back-to-back

Extra: 4th pic (R_4) from server 1

Total: $2rtt_1 + R_0 + \max(rtt_1 + R_4,\ 4rtt_2 + R_1 + R_2 + R_3)$

overlap

Extra: w/ pipelining



$$2RTT_1 + R_0$$
$$+$$
$$2RTT_2 + R_1 + R_2 + R_3$$

4) Suppose you are a system administrator responsible for email server setup and DNS configuration for the domain guzelbalik.com. You set up three alternative incoming SMTP servers for the users of @guzelbalik.com domain with names lufer.guzelbalik.com, hamsi.guzelbalik.com, palamut.guzelbalik.com. The corresponding IP addresses of these SMTP servers are 173.11.76.4, 173.11.76.5 and 173.11.76.6, respectively. Write down the necessary DNS RRs:

(i) to define these servers as the incoming SMTP servers of guzelbalik.com domain users

MX

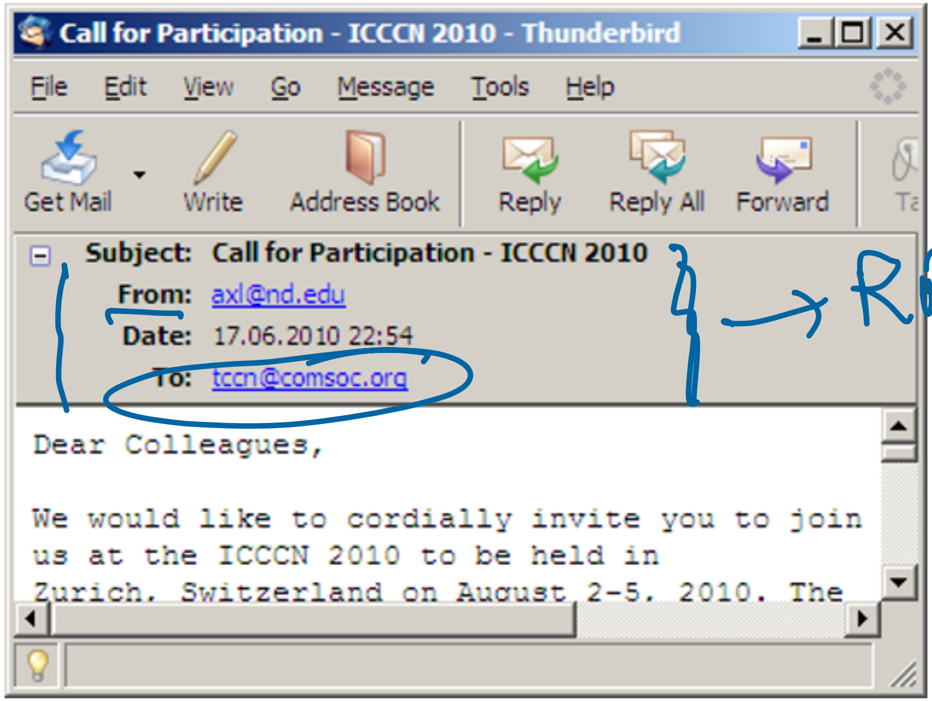
guzelbalik.com 86400 IN MX lufer.guzelbalik.com
guzelbalik.com 86400 IN MX hamsi.guzelbalik.com
guzelbalik.com 86400 IN MX palamut.guzelbalik.com

(ii) to define these servers' IP addresses.

A

lufer.guzelbalik.com 86400 IN A 173.11.76.4
hamsi.guzelbalik.com 86400 IN A 173.11.76.5
palamut.guzelbalik.com 86400 IN A 173.11.76.6

5) Suppose that your email address is *aliveli@sabanciuniv.edu* and you receive the following message. What can be said for the values of `MAIL FROM:` and `RCPT TO:` commands of the sender's SMTP protocol run for the delivery of this email?



RFC 822 header

MAIL FROM:
any valid email address

RCPT TO:
aliveli@sabanciuniv.edu

6) (Zincirlikuyu – Avcılar metrobüs completes the boarding process of all of its 200 passengers in 150 seconds. The travel time from Zincirlikuyu to Avcılar is 60 minutes. What are the **transmission rate** and **propagation delay** of this operation? Give appropriate units for these values as well.

prop. delay → travel time

$T_{prop} = 60$ minutes

trans. time (total) → 150 seconds for 200 passengers

$$\text{trans. rate} = \frac{200 \text{ pass}}{150 \text{ seconds}} = \frac{4}{3} \text{ pass/sec}$$

7) Hosts A and B communicate via a modified datagram packet switched network. The system is modified such that rather than waiting for the reception of a whole packet, an intermediate switching node begins forwarding as soon as it receives the header of a packet.

In this network, there are **two intermediate switching nodes** between A and B. Processing and propagation delays are negligible.

a) Considering the following notation, derive the formulation for the duration between beginning of transmission at node A and ending of reception at node B.

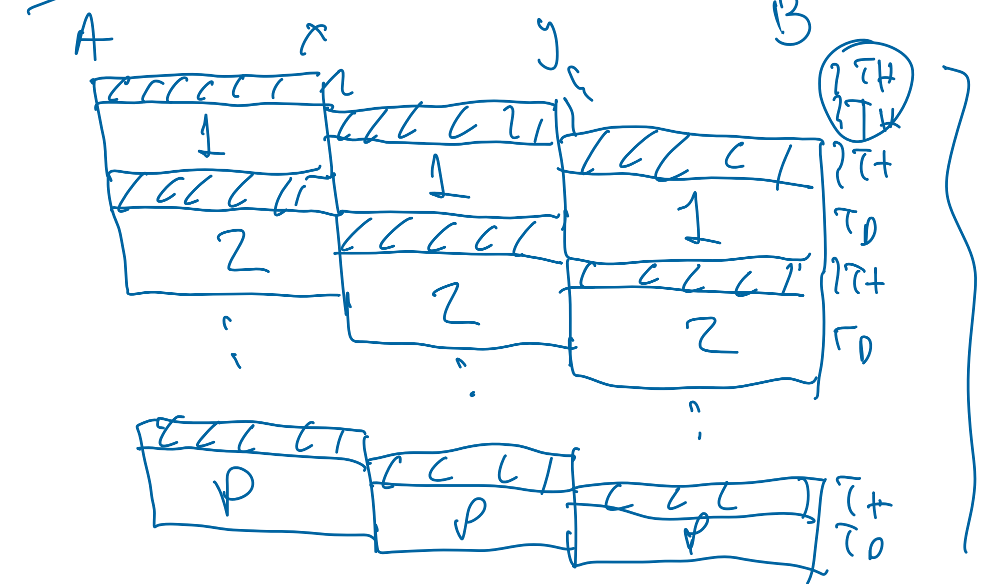
R	Transmission rate of A and switching nodes (in bps)
L_h	Length of header of one packet (in bits)
L_d	Length of the data part of one packet excluding the header (in bits)
P	Number of packets

$$T_H = \frac{L_H}{R}$$

$$T_D = \frac{L_D}{R}$$

T_H : header's trans. time

T_d : data trans. time



$$\underbrace{P \times (T_H + T_D) + 2T_H}_{\text{Total time}}$$

$$\text{Total} = P \times \left(\frac{L_H}{R} + \frac{L_D}{R}\right) + 2 \times \frac{L_H}{R}$$

7b) Suppose node A will send a file of length 100 Kbits to B using this network. Transmission rate is 50 Kbps and header length is 200 bits. What is the optimal number for *P* that minimizes the duration formulated in part (a) of this question? What is the duration with this optimal *P* value?

$$L_D = \frac{100{,}000}{P}$$

$$\text{Total} = P \times \left(\frac{200 + \frac{10^3}{P}}{50 \times 10^3} \right) + 2 \times \frac{200}{50 \times 10^3}$$

$$= P \times \left(\frac{2 + \frac{10^3}{P}}{500} \right) + \frac{4}{500}$$

$$\text{Total time} = \frac{2P}{500} + 2 + \frac{1}{125}$$

Since time is linear with P $\Rightarrow$ $P = 1$

$$\text{Time} = \frac{2}{500} + 2 + \frac{1}{125} = \frac{1006}{500}\ \text{s.} = 2.012\ \text{s.}$$

8) Consider you are running a CSMA/CD network at 32 Mbps over a broadcast medium where one-way propagation delay is 10 microseconds. There are 100 stations in this network. Each station transmits a frame at each slot with a certain probability. Here assume that the probability of transmitting a frame during a slot is the same even after collisions. Thus, binary exponential backoff algorithm is not used.

a) What is the minimum frame size for this network?

You have to listen to the channel during transmission for max RTT.

RTT = 2 × Tprop one-way prop. delay

= 10 μsec × 2 = 20 μsec

= 20 × 10^{-6} s.

Min frame size = RTT × 32 Mbps

= $20 \times \cancel{10^{-6}} \times 32 \cancel{\times 10^{6}}$ = 640 bits

8b) Assuming that the frame size is fixed to 6400 bits and the average number (a.k.a. expected value) of collisions for each successful transmission is given as 4, what is the utilization of this network?

$$U = \frac{T_{trans}}{T_{trans} + T_{prop} + \underline{T_{contention}}}$$

$(T_{collision}: \text{time spent for collisions})$

$$T_{trans} = \frac{\cancel{6400}^{2}}{\cancel{32} \times 10^{6}} = 2 \times 10^{-4}\,s = 200\ \mu sec$$

$$T_{contention} = \underbrace{slot\_time}_{2 \times T_{prop}} \times \underbrace{E[collisions]}_{\text{given as } 4}$$

$$= 2 \times 10 \times 4 = 80\ \mu sec$$

$T_{prop} = 10\ \mu sec$

$$U = \frac{200}{200 + 10 + 80} = \frac{200}{290} = \frac{20}{29}$$

9) Two stations are communicating via a link that uses error-free sliding window protocol. What are the minimum values for the window size in order to have maximum utilization in the following cases?

$a = \frac{D}{T}$

$U = \begin{cases} 1 \\ \frac{W}{2a+1} \end{cases}$

$W \geq 2a+1$

$W < 2a+1$

(a) the propagation delay is equal to the transmission delay.

$D = T \Rightarrow a = 1$

$W \geq 2a+1$

≥ 3

$\boxed{W = 3}$

(b) the propagation delay is 1/5 of the transmission delay.

$D = \frac{1}{5} \times T \Rightarrow \frac{D}{T} = \frac{1}{5} \Rightarrow a$

$W \geq 2a+1$

$\geq 2 \cdot \frac{1}{5} + 1 \Rightarrow W \geq 1.4$

$\boxed{2}$

$\text{Total} = 2D + T$

$U = \frac{T \times W}{2D+T}$

$T \times W = 2D + T$

$W = \frac{2D+T}{T} = 2a+1$

CSMA/CD 10 Mbps Tprop = 15 μsec.

200 stations Frame size = 10000 bits

a) What's the optimal prob. for a station to transmit during a slot for max. util?

max util → p equally likely among 200 stations

$$p = \frac{1}{200}$$

b) What's max util?

$$U = \frac{T_{trans}}{T_{trans} + T_{prop} + T_{contention}}$$

$$T_{trans} = \frac{10000}{10 \times 10^6} = \frac{10^4}{10^7} = 10^{-3} s = 1 \text{ ms.}$$

$$T_{prop} = 15 \mu sec = 0.015 \text{ ms.}$$

$$T_{contention} = \underbrace{2 \times T_{prop}}_{slot} \times E[\text{collisions}]$$

A: prob. of no collision on the slot

$$= 2 \times 0.015 \times \frac{1-A}{A}$$

$$E[\text{collisions}] = \sum_{i=0}^{\infty} i \times \Pr(i \text{ slots in collision, w/ first ok})$$

$$= \sum_{i=0}^{\infty} i \times (1-A)^i \times A$$

$$= \sum_{i=1}^{\infty} i \times (1-A)^{i-1} \times (1-A) \times A$$

$$= (1-A) \times A \sum_{i=1}^{\infty} i \times (1-A)^{i-1}$$

$$= (1-A) \times \cancel{A} \times \frac{1}{A^{\cancel{2}}}$$

$$= \frac{1-A}{A}$$

$$A = \binom{200}{1} \frac{1}{200} \times \left(1 - \frac{1}{200}\right)^{199}$$

$$p = \frac{1}{200}$$

$$= \cancel{200} \times \frac{1}{\cancel{200}} \left(\frac{199}{200}\right)^{199} \simeq \underline{0.369} \nearrow A$$

$$T_{cont} = 2 \times 0.015 \times \left(\frac{1 - 0.369}{0.369}\right) \simeq 0.0513 \text{ msec.}$$

$$U = \frac{1}{1 + 0.015 + 0.0513} \simeq \underline{\underline{0.936}}$$