COL334 Minor

Anish Banerjee

TOTAL POINTS

40 / 50

QUESTION 1

Link-layer 13 pts

1.1 Transmission time 1 / 1

✓ **- 0 pts** *10^(-4) ms*

- 1 pts Incorrect

1.2 Count of Wavelengths 1 / 1

✓ **- 0 pts** *80*

- 1 pts Incorrect

- 1 pts Not attempted.

1.3 Size of wavelength 1 / 1

✓ **- 0 pts** *30m*

- 1 pts Incorrect

- 1 pts Not attempted.

1.4 Transmission rate 1 / 1

✓ **- 0 pts** *8Mbps*

- 1 pts Incorrect

- 1 pts Not attempted.

1.5 Packet error 3 / 3

✓ **- 0 pts** *Correct 0.16*

- 1 pts Packet error rate = 1 - probability that no bit gets corrupted = 1 - (1-p)^n = pn

- 1 pts Over 4 links, overall packet error rate = 4pn

- 1 pts 4*0.00005*1000*8 = 0.16

1.6 Latency 1 / 2

- 0 pts Correct - 3.24 ms

✓ **- 1 pts** *Transmission delay = 3.2 ms*

- 1 pts Propagation delay = 0.04 ms

1.7 Transmission frequency of different routers 2 / 2

✓ **- 0 pts** *Correct: No*

- 1 pts If B transmits to C at channel 1, this will cause interference at A.

- 1 pts A will not be able to hear the transmission from S.

1.8 Spectral utilization 1 / 2

✓ **- 0 pts** *Correct: [1 2 3 1] and 33.3%*

- 1 pts C->D is the closest link at which a frequency can be reused since only now will the S->A transmission will not see any interference.

✓ **- 1 pts** *For the overall system, 3 channels are needed for e2e simultaneous transmission.*

QUESTION 2

Proxy Server 4 pts

2.1 IP address restriction 1 / 1

✓ **- 0 pts** *Network (lowest layer at which IP addresses are seen)*

- 1 pts Incorrect

2.2 Drop UDP data 0 / 1

- 0 pts Network (IP header contains next protocol type field)

✓ **- 1 pts** *Incorrect*

2.3 Allow only HTTP data 0 / 1

- 0 pts Transport (port is needed)

✓ **- 1 pts** *Incorrect*

2.4 Filter out .jpg images 1 / 1

✓ **- 0 pts** *App layer (Resource url can be used)*

- 1 pts Incorrect

QUESTION 3

CDN 12 pts

3.1 Transaction diagram (TCP, HTTP, and DNS) 3 / 3

✓ **- 0 pts** *Correct*

- 1 pts Client requests DNS server for IP address of www.nytimes.com and www.nytimes.akamai.com

- 1 pts 3-way TCP handshake

- 1 pts HTTP redirection and content in response to a GET

3.2 Key benefit of CDN 0.5 / 1

- 0 pts Lower latency, higher throughput

✓ **- 1 pts** *Incorrect.*

+ 0.5 *Point adjustment*

3.3 Transaction diagram (with connection keep-alive) 2 / 2

✓ **- 0 pts** *Correct*

- 1 pts Base first, all files on the same TCP connection.

- 1 pts Each file then separately.

3.4 Trace web page 1 / 1

✓ **- 0 pts** *Correct*

- 0.5 pts At this point, the client knows the objects to be downloaded.

- 0.5 pts Pipelining: Client can send many requests in one go. Server keeps servicing these requests one by one.

3.5 Advantages of modified HTML standard 2 / 3

- 0 pts Correct

✓ **- 1 pts** *Avoid head of line blocking*

- 0.5 pts Different objects could be coming over different connections.

- 1 pts Loss on one TCP connection will not affect other TCP connections.

- 0.5 pts Will result in more fine grained sharing of the available bandwidth across multiple TCP connections.

3.6 Disadvantage of modification in 3.5 1 / 2

- 0 pts Correct

✓ **- 0.5 pts** *Can cause unfairness*

✓ **- 0.5 pts** *Client 1 reduces to R/2*

Client 2: > R/2

- 1 pts Yes, HTTP/2 provides some interleaving advantage and fairness across multiple clients.

QUESTION 4

File download 8 pts

4.1 Probability of sending new lilne 1 / 1

✓ **- 0 pts** *Probability of sending a new line = (N-xi)/N*

- 1 pts Incorrect

4.2 Expected waiting time 4 / 4

+ 0 pts Incorrect/Unattempted

✓ **+ 1 pts** *Expected value = pi*1 + pi*(1-pi)*2 + pi*(1-pi)^2*3.....*

✓ **+ 1 pts** *n-1 initial draws sent old lines and nth draw sent a new line*

✓ **+ 1 pts** *S = 1/x*

✓ **+ 1 pts** *wait time wi = N/(n-xi)*

4.3 Total expected waiting time 2 / 3

- 2 pts Total expected waiting time = N/(N-0) + N/(N-1) + N/(N-2) + ...

✓ **- 1 pts** *Approximately N*(lnN + c) units of time*

- 3 pts Incorrect or Not attempted

- 0 pts Correct

QUESTION 5

Short-answer questions 13 pts

5.1 Reason for minimum frame size requirement by Ethernet 1 / 1

✓ **- 0 pts** *Collision detection*

- 1 pts Incorrect/Unattempted

5.2 IP address 127.0.0.1 1 / 1

✓ **- 0 pts** *localhost/loopback address*

- 1 pts Incorrect/Unattempted

5.3 Unique IP address of each router? 1 / 1

✓ **- 0 pts** *False*

- 1 pts Incorrect

5.4 Can SMTP read email despite encrypted transmission? 1 / 1

✓ **- 0 pts** *True*

- 1 pts Incorrect

5.5 Contact whom on network switch? 1 / 1

✓ **- 0 pts** *DHCP*

- 1 pts Incorrect

5.6 ARP operates on UDP? 1 / 1

✓ **- 0 pts** *False*

- 1 pts Incorrect

5.7 Why is 700 Mhz spectrum considered prime property? 0.5 / 1

- 0 pts The frequency is high enough to achieve a good transmission rate but low enough to penetrate walls and get around obstacles.

✓ **- 0.5 pts** *Partially correct*

- 1 pts Incorrect/Unattempted

5.8 Protocol used by ping 1 / 1

✓ **- 0 pts** *ICMP*

- 1 pts Incorrect/Unattempted

5.9 Latency (Starlink N/W) = Latency (terrestrial fibre optic)? 0 / 1

- 0 pts True

✓ **- 1 pts** *Incorrect/Unattempted*

5.10 User tracking used by Ad networks like Doubleclick **0 / 1**

- **0 pts** Third party cookies

✓ **- 1 pts** *Incorrect*

5.11 Does TCP transmit data at a constant rate? **1 / 1**

✓ **- 0 pts** *False*

- **1 pts** Incorrect

5.12 NIC to MAC address relation **1 / 1**

✓ **- 0 pts** *True*

- **1 pts** Incorrect/Unattempted

5.13 Error detection scheme to detect bursty bit errors **1 / 1**

✓ **- 0 pts** *CRC: Cyclic Redundancy Check*

- **1 pts** Incorrect
- **0.25 pts** Full Form Missing

gradescope

COL334/672: Semester 2023-24-1

Minor exam: 120 minutes, closed-book.

Name: ANISH BANERJEE

Entry number: 2021CS10134

Needless to say, please explain your answers. Zero marks will be awarded if you just state an answer without any explanation. Use the roughwork sheets to work out your answers and write them out neatly in the main answer sheets.

As a student of IIT Delhi, I will not give or receive aid in examinations. I will do my share and take an active part in seeing to it that others as well as myself uphold the spirit and letter of the Honour Code.

Signature: Anish Banerjee

Q1 (out of 13)	
Q2 (out of 4)	
Q3 (out of 12)	
Q4 (out of 8)	
Q5 (out of 13)	
Total (out of 50)	

1. Answer the following link-layer related questions:

a. The transmission rate on a wireless link is 10Mbps. What is the bit-time to transmit one bit? 1Mbps = 10^6 bits per sec. Give your answer in ms.

10^{-4} ms = 0.0001 ms [1]

Explanation:

Transmission Rate = No. of ~~bytes~~ bits written in 1 sec = 10^7 bits

Time to write 1 bit = $\frac{1}{10^7}$ sec = $\frac{1}{10^4}$ msec

b. Continuing from the above, amplitude shift keying is used for modulation, at a signal frequency of 800MHz. How many wavelengths does 1 bit stretch over?

80 [1]

Explanation:

Time period = $\frac{1}{f} = \frac{1}{800 \times 10^6}$ sec

# of wavelengths for 1 bit $= \frac{0.0001 \text{ ms}}{1/800 \times 10^6 \text{ sec}} = 80$

c. Continuing from the above, if the propagation speed is 3 x 10^8 m/s, what is the physical distance over which 1 bit is stretched? Give the answer in m (meters).

30m [1]

Explanation:

$c = \nu\lambda$ $\quad 3\times10^8 = 800\times10^6\,\lambda$ $\quad \lambda = \frac{3}{8}$ m $\quad$ bit length $= 80\lambda = 30$m

d. Continuing from the above, 4B/5B is used as an encoding scheme with NRZI. What is the effective transmission rate? Give your answer in Mbps.

8Mbps [1]

Explanation:

Transmission of 5 bits is equivalent to 4. Effective rate $10\text{Mbps} \times \frac{4}{5}$

e. Continuing from the above, a packet of size 1000 bytes travels over a network of 4 long-distance wireless links:

Source (S)------Router A------Router B-----Router C-----Destination (D)

If the bit error rate on a link is 0.000005, what is the packet error rate for the end to end transmission from the source to the destination? Assume no other source of packet or bit errors during the transmission.

0.16 [3]

Explanation:

Packet error rate for each link $= 8\times1000\times0.000005 = 0.04$

Thus for all the 4 links it will get added $4\times0.04 = 0.16$

f. Continuing from the above, what is the one-way latency for the packet to travel from the source to the destination? Assume zero node processing delays, and no queueing delays either. The physical span for each link is 3km (1km = 1000m). The nodes follow a store and forward method. Give the answer in ms.

4.04 msec [2]

Explanation:

Total ~~transmission~~ propagation delay $= 4\times\frac{d}{c} = \frac{4\times3\times10^3}{3\times10^8} = 4\times10^{-5}$ sec $= 4\times10^{-2}$ msec

Assume that the routers have the same R

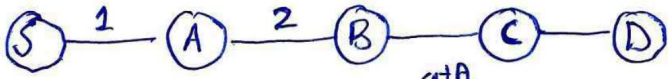
Total transmission delay $= \frac{4L}{R}$ $\quad \frac{4\times1000\times8}{8\times10^6} = 4\times10^{-3} = 4$ms

$R_{eff} = 8$Mbps

g. Continuing from the above, assume that only adjacent nodes are within one another's range, ie. the source node's transmission can only be heard by router A and does not interfere at any other node, similarly a transmission by router A can be heard by the source and router B only, and so on. Each of the routers have two NICs that can communicate on different non-interfering frequency channels at the same time. Therefore, while S is transmitting to A on frequency channel 1, A can be transmitting to B at frequency channel 2, B can be transmitting to C at frequency channel 3, and C and be transmitting to D at frequency channel 4. The spectral utilization in this case can be said to be 1/4, i.e. 25%. To improve spectral reuse, can B transmit to C at frequency channel 1, i.e. the same frequency at which S is sending to A?

No [2]

Explanation:



This may cause interference at A, so B should not use channel 1 for transmission

If now B uses frequency channel 1, then A will hear that frequency too (since A is hearing on channel 1)

h. Continuing from the above, what frequency channel assignment to the links can achieve the highest spectral utilization? Write your answer against the links below and also give the highest spectral utilization:

1 2 3 1

Source (S)------Router A------Router B-----Router C-----Destination (D) [1]

50% (spectral utilization) [1]

Explanation:

Channel 1 will be used by S→A and C→D

Utilization = $\frac{2}{4}$ = 50%. Others have utilization of 25%.

2. Suppose a firewall is running on a proxy server to filter out packets that match a particular pattern. At what lowest layer of the network stack would the firewall be operating to be able to apply the following filters? [4]

a. Allow only a particular IP address range: Network Layer

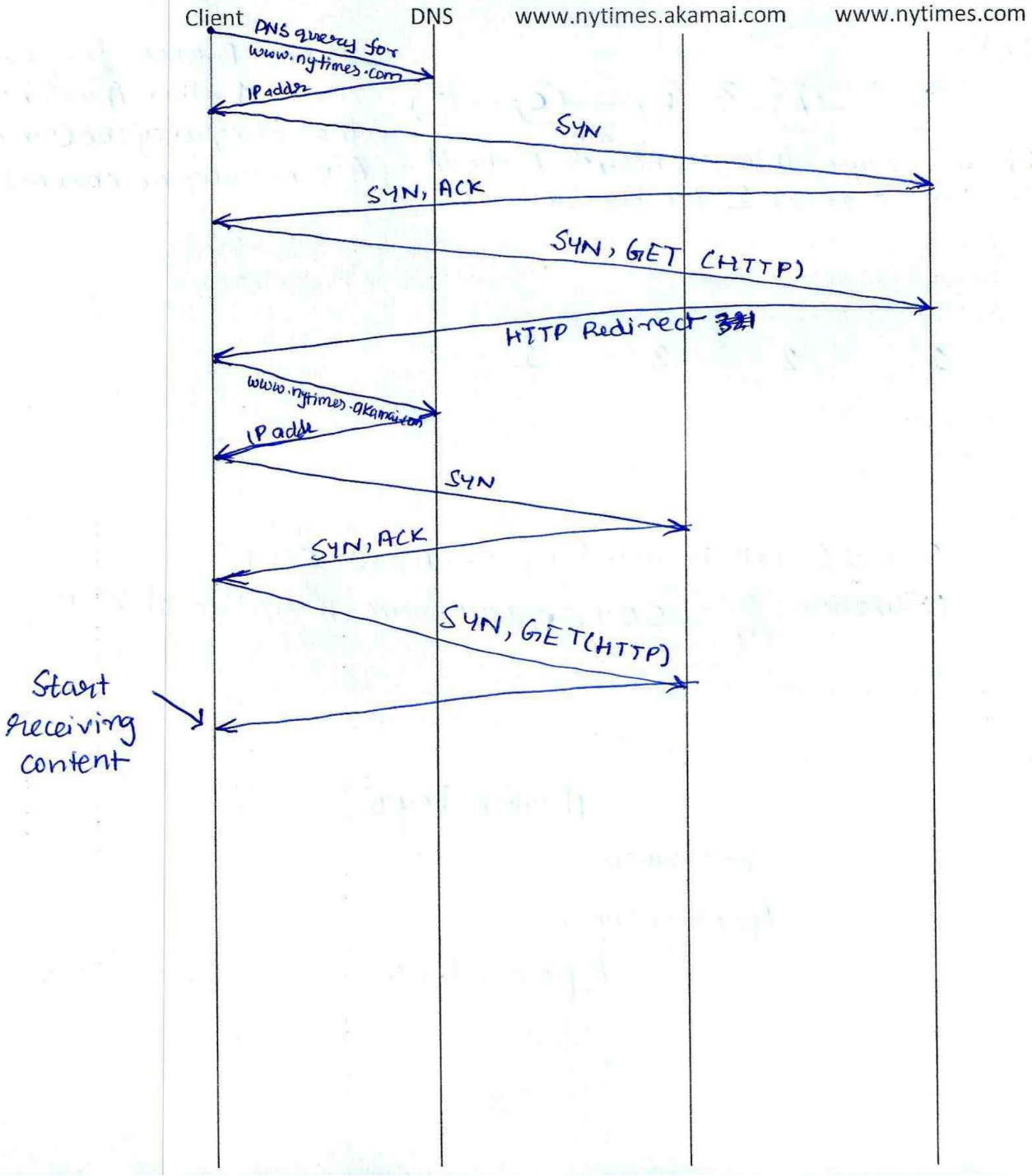
b. Drop UDP data: Transport layer

c. Allow only HTTP data: Application layer

d. Filter out all .jpg images in web pages: Application layer

3. Akamai is a CDN (Content Delivery Network) provider. It places its content servers inside the networks of regional ISPs. An ISP like Airtel may have an Akamai server inside its network, and similarly Reliance may also have an Akamai server inside its network.

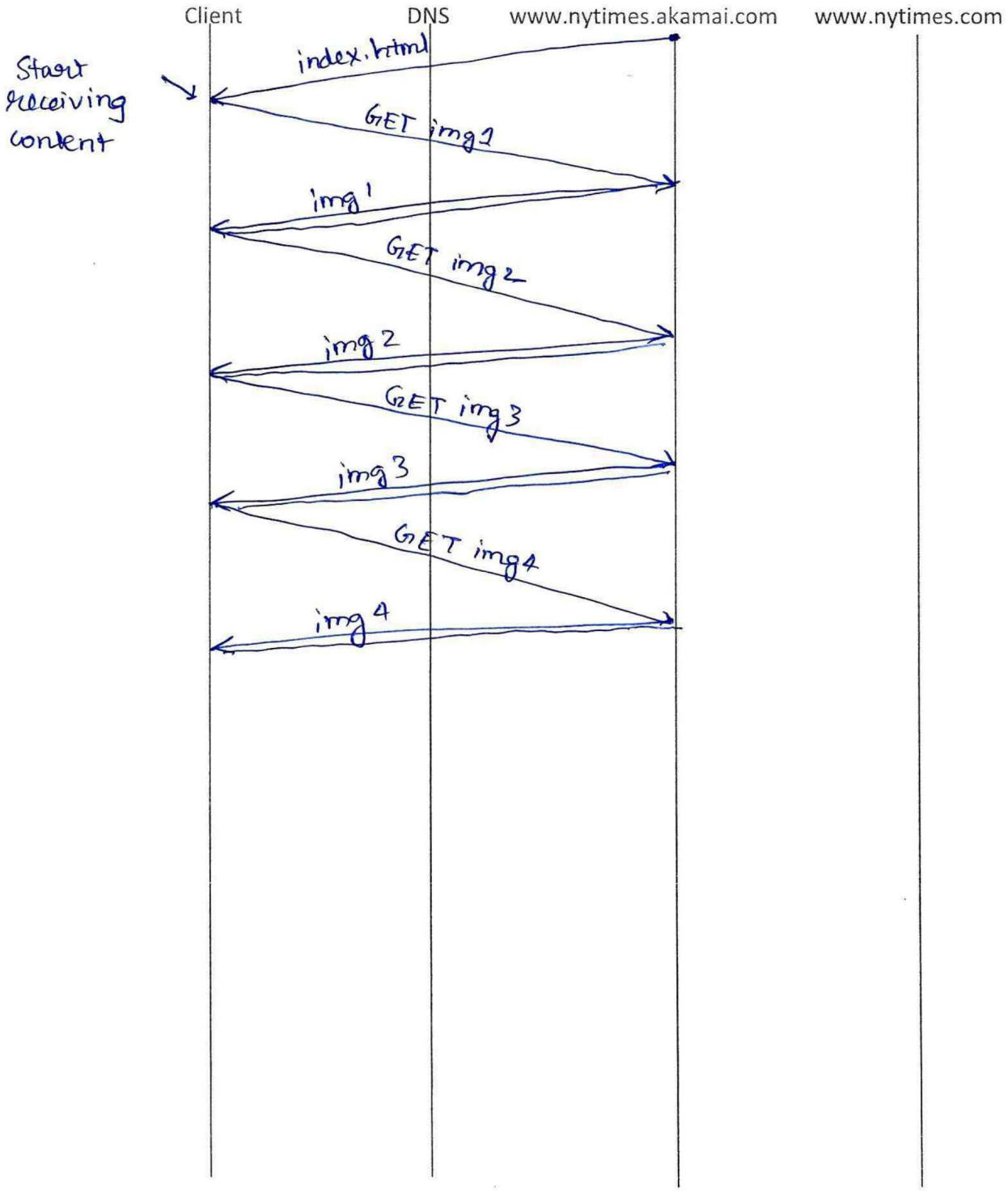
a. Suppose a content provider like NYTimes wants to use Akamai. It does this by responding to the very first HTTP GET request to www.nytimes.com, with a redirection to www.nytimes.akamai.com. The client will then use DNS to resolve www.nytimes.akamai.com, and since Akamai would have populated DNS servers to return the IP address for the Akamai CDN server that is closest to the client, therefore after the DNS resolution the client will be able to connect to the closest Akamai server to get the content. Trace out the TCP connection establishment, HTTP, and DNS requests, to the point where you actually start receiving content. [3]



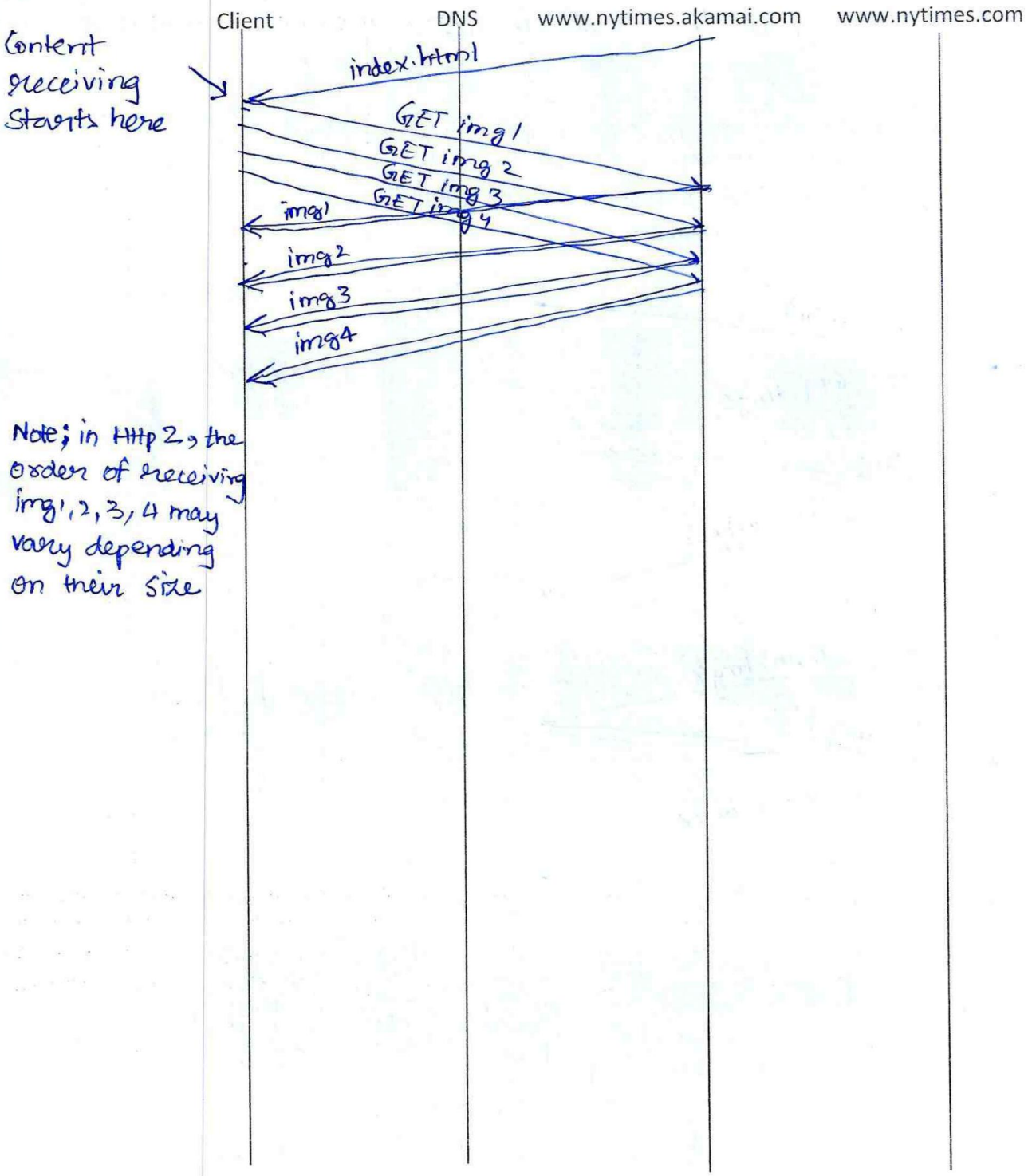
b. What is the key benefit of using content delivery networks? [1]

Distributed content delivery networks help to reduce latency to the end users

c. Assume the web page structure is as follows: a base index.html file which refers to 4 images to be downloaded from www.nytimes.akamai.com. Complete the transaction diagram from where you left off in part (a), with connection keep-alive but without HTTP pipelining being used. [2]



d. Now trace the same web page download request with connection keep-alive and HTTP pipelining being used. [1]



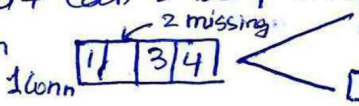
e. Suppose a modification is made in the HTML standard which allows multiple sources to be specified in the base index.html from where subsequent objects could be

downloaded. For example, this is how the web page could indicate that 1.jpg can be downloaded from either of www.nytimes.com or www.nytimes.akamai.com:

In this case, the client could open multiple TCP connections, to www.nytimes.com and www.nytimes.akamai.com and fetch different objects from different connections. Give at least two advantages of such a setup and when would these advantages be realized. [3]

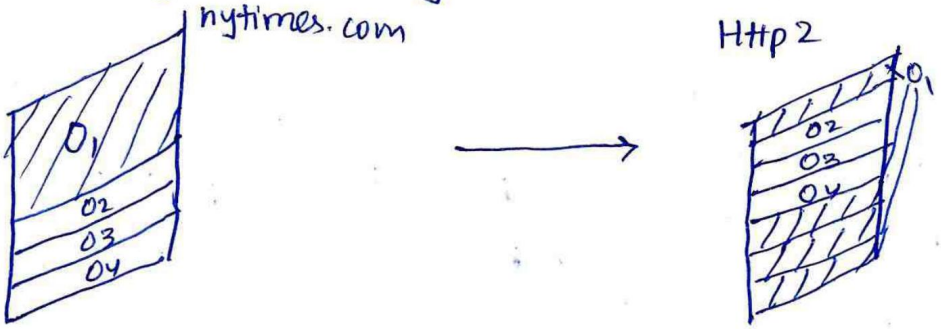
① Since TCP follows the principle of "additive increase and multiplicative decrease", whenever a packet gets dropped, it reduces the rate of that connection. Suppose we had only one TCP connection with rate R. If packet is dropped rate becomes $R/2$. But if we had 2 conns each with $R/2$ and packet is dropped in 1st, rate becomes $\frac{1}{2}\cdot\frac{R}{2}+\frac{R}{2}$ $= \frac{3R}{4} > \frac{R}{2}$

② keeping separate buffers for diff. TCP connections will help to speed up when a packet is dropped. Since TCP follows in-order transfer, until packet 2 is received, 3 and 4 can't be passed to app. layer. But with multiple connections, they can



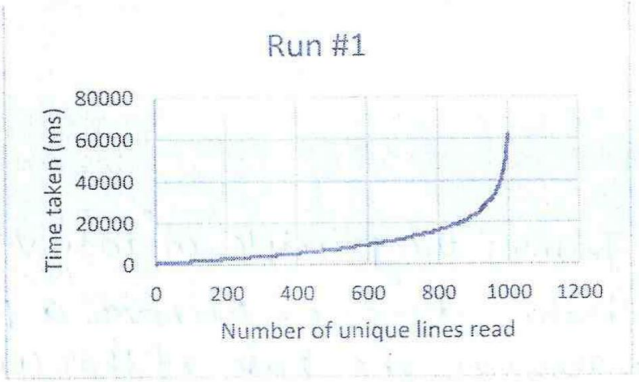
f. In part (e) above, give one disadvantage of such a setup. Does HTTP/2 address this issue? [2]

We may still face the disadvantage of HoL blocking in one connection. Suppose 4 objects are requested to www.nytimes.com and 4 to www.nytimes.akamai.com. If the first objet to www.nytimes is big, then other objects will be queued behind it

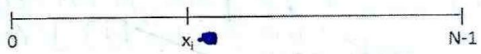


Http 2 mitigates HoL blocking and helps to speed up this by breaking O_1 into pieces and not necessarily transmitting in order

4. In Assignment-2, our experiments brought up graphs such as the following for the time taken for a single client to receive a given number of unique lines, against the maximum number of unique lines to be received (1000 in this case). We will now try to derive this theoretically, step by step.



a. Without loss of generality, it can be assumed that the server has pre-decided the order in which it would send unique lines. Therefore, for any SENDLINE request, the random choice the server would have to make is whether to send a line it has already sent, or advance to the next line that it should send. At time *i*, assume the server has sent x_i unique lines, out of *N* maximum unique lines it has to send. This can be represented graphically as follows. What is the probability p_i that the server will send a new line at this point in response to a SENDLINE request? The server makes a draw from a uniformly random distribution that produces a number between 0..N-1. [1]



$Pr[\text{server sends a new line}] = \frac{N - x_i}{N} = p_i$

b. Now calculate the expected value of the waiting time at this point, to receive a new line, i.e. after how many SENDLINE requests is the server likely to send a new line. Hint: The chance of waiting for n units of time would be $(1-p_i)^{n-1}p_i$. Explain why, and then calculate the expected value w_i as the waiting time at point *i*. [4]

Prob. that server sends unique line after k tries

$P[K = k] = (1-p_i)^{k-1} p_i$ k-1 failures and last one success

$$E[K] = \sum_{k=1}^{\infty} k(1-p_i)^{k-1} p_i = p_i \sum_{k=1}^{\infty} k(1-p_i)^{k-1} = p_i \frac{1}{(1-(1-p_i))^2} = \frac{1}{p_i}$$

Thus expected # of tries (waiting time)

$w_i = \frac{C}{p_i} = \frac{NC}{N - x_i}$ where C is the time for 1 request

c. The total expected waiting time to receive all N unique lines would then be $w_0+w_1+...+w_{N-1}$. Simplify this using the expressions obtained above. You may need to use the harmonic series sum: $1+1/2+1/3...+1/N$ = approximately $\ln N + c_1$, where $c_1 \sim 0.577$ as $N \to \infty$. [3]

Total time:

$$\mathbb{E}[w_0 + w_1 + \cdots w_{N-1}] = \mathbb{E}[w_0] + \mathbb{E}[w_1] \cdots \mathbb{E}[w_{N-1}]$$

$$c\left(\frac{N}{N-0} + \frac{N}{N-1} + \frac{N}{N-2} + \cdots \frac{N}{1}\right)$$

$$= Nc\left(1 + \frac{1}{2} + \frac{1}{3} + \cdots \frac{1}{N}\right)$$

$$\approx Nc\,(\ln N + c_1) \qquad c_1 \sim 0.577$$

5. Short-answer questions:

a. Ethernet requires a minimum frame size to ensure Collision detection [1]

b. The IP address 127.0.0.1 refers to localhost [1]

c. Each router has one unique IP address. True/false? False [1]

d. Even when using transport layer security for SMTP connections, so that your data transmission is encrypted, SMTP servers can still read your email. True/false?
True [1]

e. When you switch to a new network, you typically contact a DHCP server to get an IP address in this network. [1]

f. ARP operates on UDP. True/false? False [1]

g. The 700MHz spectrum is considered prime property because it is the best for transmitting data as it doesn't get deflected easily by obstacles [1]

h. Ping uses the ICMP protocol. [1]

i. The latency for data transmission over the Starlink network is expected to be similar to that over a terrestrial fibre optic network. True/false? False [1]

j. Ad networks like Doubleclick use cookies to track users across different websites. [1]

k. TCP transmits data at a constant rate. True/false? False [1]

l. A device with two NICs will have two MAC addresses. True/false? True [1]

m. Which error detection scheme is useful to detect bursty bit errors? CRC
Cyclic Redundancy Check [1]