CS305 Assignment 01

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Q1

Explain the five-layer Internet protocol stack. Please include the following details:

• What are the five layers?
• What is the functionality or description of each layer?
• What are the typical protocols of each layer (if any)?

Layer	Functionality	Typical Protocols
Application	Supporting network applications	FTP(end-to-end file transmission), SMTP(e-mail), HTTP(Web page)
Transport	Process-process data transfer	TCP, UDP
Network	Routing of datagrams from source host to destination host	IP, routing protocols
Link	Data transfer between neighboring network elements	Ethernet, 802.111, PPP
Physical	Bits on the wire	twisted-pair copper wire protocol, coaxial cable protocol, fiber protocol

Q2

Answer the following questions:

(a) What type of applications is TCP better suited for? Any application examples?

(b) What type of applications is UDP better suited for? Any application examples?

Protocol	Type of Application	Application Example
TCP	Connection-oriented, reliable transport	E-mail, remote terminal access, Web, file transfer, streaming multimedia, Internet telephony
UDP	Connectionless, unreliable data transfer	Streaming multimedia, Internet telephony

Q3

Consider a packet of L bits sending from the source to destination through a K-hop path. That is, there are K − 1 routers between the source and destination. Suppose each link has a transmission rate of R bits per second (bps), and the propagation delay is d for each hop.

(a) Consider a packet switching network. Suppose there is no nodal processing delay and queuing delay. What is the end-to-end delay?

$$\begin{aligned} d_{end-to-end} &= K(d_{trans} + d_{prop}) \\ &= K(\frac{L}{R} + d) \end{aligned} \tag{1}$$

(b) Consider a circuit switching network. Suppose the circuit setup time is τ seconds. Links in the network use frequency division multiplexing (FDM), where the associated frequency band is divided into F subbands, each being allocated to a user (or circuit). [Hint: As a result, the transmission rate allocated to each user (or circuit) is R/F.] What is the end-to-end delay?

$$\begin{aligned} d_{end-to-end} &= K(d_{trans} + d_{prop}) \\ &= \tau + K(\frac{LF}{R} + d) \end{aligned} \tag{2}$$

(c) Consider a packet switching network with L = 1000 bits, K = 2, R = 20 Mbps, d = 10μs. There are two packets sent one after the other, and there are no other packet in the system. Let the nodal processing delay at the router be 5μs. We ignore the nodal processing delay at the source and destination. Compute the time required to send both packets from the source and destination. [Note: In our lecture, we set $1Kbit = 10^3 bits$ and $1Mbit = 10^6 bits$.]

$$\begin{aligned} d_{end-to-end} &= K(d_{trans} + d_{prop}) + (K-1)d_{proc} \\ &= K(\frac{L}{R} + d) + \frac{L}{R} + (K-1)d_{proc} \\ &= 2(\frac{1000bits}{20 \times 10^6 bits/s} + 10\mu s) + \frac{1000bits}{20 \times 10^6 bits/s} + 5\mu s \\ &= 175\mu s \end{aligned} \tag{3}$$

Q4

Consider a set of packets, each with a size of 10 Mbits and a queue. These packets arrive at the queue with certain patterns defined in (a) and (b), waiting for transmission. The transmission rate is 10 Mbps.

(a) Suppose there is one packet arrival every second. What is the average queuing delay of these packets?

Every second there is a packet arrive and transmitted, so the average queuing delay = 0.

(b) Suppose K packets arrive simultaneously every K seconds. What is the average queuing delay of these packets?

For the i^{th} K packets and the $(i+1)^{th}$ K packets, there are 0 queuing delay, so we only have to consider the queuing delay within each K packets. The 2^{nd} packet need to wait 1s for the 1^{st} packet to be transmitted, and the i^{th} packet need to wait $(i-1)^{th}$ seconds for the first $i-1$ packets to be transmitted.

So their avarage queuing delay is $\frac{K-1}{2}$.

(c) What are the traffic intensity of the scenarios considered in (a) and (b)? Any insights?

Let L denotes packet length, λ denotes packets per second, R denotes transmission rate.

$$\begin{aligned}\text{traffic intensity} &= \frac{L\lambda}{R} \\ &= \frac{10Mbpp \times 1pps}{10Mbps} \\ &= 1\end{aligned} \tag{4}$$

Although their traffic intensity are the same, it leads to different queuing delay.

Q5

(a) Is this message an HTTP request message or an HTTP response message?

It is an HTTP response message because it has start line and response headers.

(b) Does this message corresponds to a non-persistent or a persistent connection? Explain the idea of persistent connection.

It is a persistent connection. HTTP/1.1 protocol often use persistent protocol and its' connection information is "Keep-Alive".

In persistent connection, server leaves connection open after sending response. Subsequent HTTP messages between same client/server sent over open connection. Client sends requests as soon as it encounters a referenced object. Server closes a connection when it isn’t used for a certain time. As little as one RTT for all the referenced objects.

(c) There is one formatting mistake in this message. What is this mistake?

There is no blank line between header and message body.

(d) Why do we need the header of “Last-Modified”? Consider from the perspective of proxy server.

"Last-Modified" allows proxy server to track when the resource was last modified so that it can update cache only when there is a new "Last-Modified" time. As a result, it can substantially reduce the response time for a client request, particularly if the bottleneck bandwidth between the client and the origin server is much less than the bottleneck bandwidth between the client and the cache. Also, it can substantially reduce traffic on an institution’s access link to the Internet.

Q6

Consider the following figure with an institutional network connected to the Internet. There are a set of objects, each with a size of 1 Mbits. Suppose the institution’s browsers has an average request rate of 10 requests per second, and all those requests are sent to the origin servers.

The average response time is determined as follows:

$$\text{Average Response Time} = \text{Internet Delay} + \text{Average Access Delay}$$

- **Internet delay is the round trip time between router A and the origin server. It is equal to 2 seconds.**
- **Average access delay is the delay from Router A to the institution router. The transmission rate of the access link is 20 Mbps. The average access delay is equal to Δ/(1 − Δβ), where Δ is the average time required to transmit an object over the access link (i.e., the transmission delay of an obejct); β is the arrival rate (in requests per second) at the access link.**

- **Note: The delays over other links, e.g., local area network (LAN) delay, are regarded as zero. Answer the following questions:**

(a) Derive average response time of the system.

$$\begin{aligned}
\Delta &= \frac{1Mbits}{20Mbps} \\
&= 0.05 \\
\text{Average Response Time} &= \text{Internet Delay} + \frac{\Delta}{1-\Delta\beta} \\
&= 2 + \frac{0.05}{1-0.05\times 10} \\
&= 2.1s
\end{aligned} \tag{5}$$

(b) Suppose there is a cache installed in the institutional LAN. Compute the hit rate x ∈ [0,1] that leads to an average response time that is less than 1 second.

$$\begin{aligned}
x\times(0s)+(1-x)\times(2s+\frac{\Delta}{1-\Delta\beta(1-x)}) &< (1s) \\
x &> 0.516
\end{aligned} \tag{6}$$

Q7

Suppose you click a web page within your Web browser, and your local DNS server has stored the related resource records. Let RTT_0 denote the round trip time (RTT) between your host and your local DNS server. On the web page you visit, there are an HTTP basic file and 12 referenced objects. Let RTT_1 denote the RTT between the local host and the Web server. The HTTP basic file has a size of L Mbit, and each referenced object has a size of L Mbit. The transmission rate is R Mbps. Compute how much time elapses from when you click the link until your web browser receives the objects.

(a) Non-persistent HTTP with no parallel TCP connections?

$$\begin{aligned}
\text{total time} &= N(RTT_0 + RTT_1 + \text{HTML transmission time}) \\
&= RTT_0 + 13(2\times RTT_1 + \frac{L}{R})
\end{aligned} \tag{7}$$

(b) Non-persistent HTTP with the browser configured for 4 parallel connections?

$$\begin{aligned}
\text{total time} &= RTT_0 + (\frac{N}{P}+1)(2\times RTT_1 + \text{HTML transmission time}) \\
&= RTT_0 + 4(2\times RTT_1 + \frac{L}{R})
\end{aligned} \tag{8}$$

(c) Persistent HTTP? Note that in this case, if a client knows the URLs of its requested referenced objects, the client can send requests of referenced objects back-to-back without waiting for the responses.

$$\begin{aligned}
\text{total time} &= RTT_0 + 2\times RTT_1 + N(\text{HTML transmission time}) \\
&= RTT_0 + 2\times RTT_1 + \frac{L}{R} + RTT_1 + \frac{12L}{R} \\
&= RTT_0 + 3\times RTT_1 + \frac{13L}{R}
\end{aligned} \tag{9}$$

Q8

(a) Explain the differences between HTTP and SMTP.

HTTP	SMTP
Pull	Push
ASCII in header	ASCII in header and body
Each object encapsulated in its own response message	Multiple objects sent in one message
Persistent connections and non-persistent connections	Persistent connections

(b) Can HTTP be used as a mail access protocol? Why?

Yes. There are currently a number of popular mail access protocols, including Post Office Protocol—Version 3 (POP3), Internet Mail Access Protocol (IMAP), and HTTP. When a recipient wants to access a message in his mailbox, the e-mail message is sent from Bob's mail server to Bob's browser using the HTTP protocol.

(c) Can we place the receiver's mail server at the receiver's PC? How about placing the sender's mail server at the sender's PC?

No. If the receiver's mail server is at the receiver's PC, the receiver's PC would have to remain always on in order to receive new mail.

No. The receiver's mail server may fail so that the sender's PC may need to repeatedly send the message until success.

Q9

Suppose you want to register your domain name exmple.com with a TLD server, you need to provide the TLD server with the information of your authoritative DNS server:

- **The hostname of your authoritative DNS server is dns.example.com.**
- **The IP address of your authoritative DNS server is 200.200.200.[last-two-digits-of-your-SID]. Note that [last-two-digits-of-your-SID] should be fill in with the last two digits of your own student ID. Answer the following questions:**

Answer the following questions:

(a) At which TLD server you need to register the information of your authoritative DNS server?

com DNS server.

(b) A Type NS and a Type A record are needed to be inserted into the TLD server. What are these records?

1. (example.com, dns.example.com, NS)
2. (dns.example.com, 200.200.200.44, A)

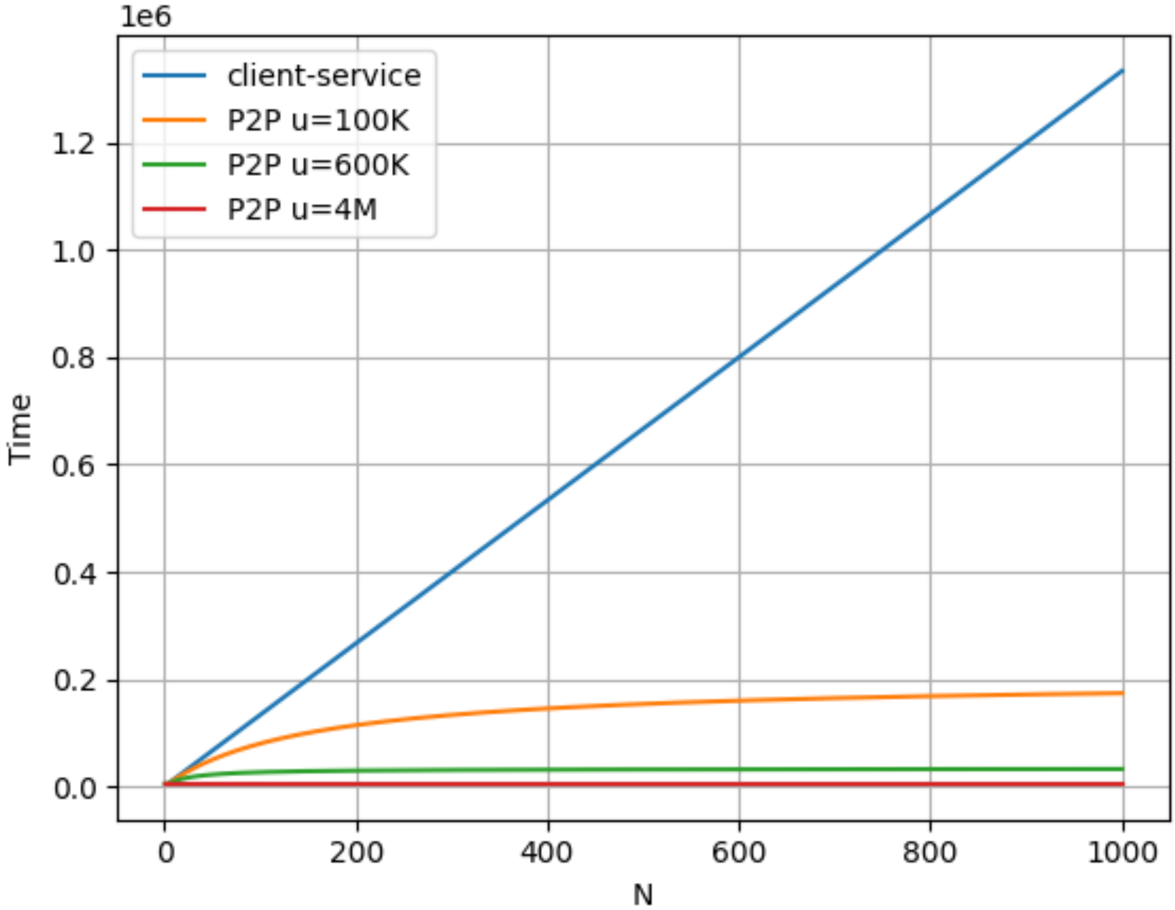
Q10

Consider a server distributes a file of F = 20 Gbits to N peers. The server has a upload rate of us = 15 Mbps. Each peer has a upload rate of u Mbps and a download rate of d = 4 Mbps. Please plot or draw the following curves with x-axis corresponding to N (ranging from 1 to 1000) and y-axis corresponding to the minimum distribution time.

(a) Client-server distribution;

(b) P2P distribution with u = 100 Kbps, 600 Kbps, 4 Mbps, respectively.

$$\begin{aligned} D_{cs} &= max\{\frac{NF}{u_s}, \frac{F}{d_{min}}\} \\ &= max\{\frac{N \times 20G}{15M}, \frac{20G}{4M}\} \\ D_{P2P} &= max\{\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\} \\ &= max\{\frac{20G}{15M}, \frac{20G}{4M}, \frac{N \times 20G}{15M + N \times u}\} \end{aligned} \tag{10}$$



(c) Based on (a) and (b), which one is better in terms of reducing the distribution time, P2P or client-server? Why? How does u affect the distribution time?

P2P is better in terms of reducing the distribution time.

For the client-server architecture, the distribution time increases linearly and without bound as the number of peers increases. However, for the P2P architecture, the total upload rate increases with the total file size.

The larger the u is, the less the distribution time. When u is large enough, the bottleneck becomes downloading time.