The primary functions of a packet-switched network are Packet Interpretation, Packet Construction, Packet Transmission.

A network protocol may do the following: Specify the time between sending information, Specify the whether or not information is sent, Specify actions taken upon message receipt, Specify the order of messages sent and received, Specify actions taken upon message transmission, Specify the form of messages sent and received.

Total utilization: 5 users, 3 -> 92%, 2 -> 8% Answer: 58.4%

Host A to Host B: L = 14MiB, R = 67.1Gps, 18 users, setup time = 53.2ms. Answer: 84.7ms

VoIP: a = 53 Kbps, R = 3 Mbps, L = 127 bytes, d = 705.8km, s = 2.5x10^8m/s Answer: 22.33ms

82 packets entering queue, L = 7 MiB, R = 1.5 Gbps. Queueing delay of packet 27? Answer: 1017.8ms

1 router between Host A and Host B. R = 8.3Mbps, L = 1KiB, s = 2.7x10^8m/s, d = 120.4km. Answer: 2.42ms

R = 18Mbps, X file (1MiB), Y file (340KiB). X gets it first.Time when File Y is finished transmitting. Answer: 0.62 sec

Application data is payload at the transport layer.

In the Internet protocol stack, the Application Layer is responsible for assembling user data to be sent.

In Internet protocol stack, if a data transfer is connection-oriented, it is implemented at the Transport Layer.

OSI Layering Model: 7) Application, 6) Presentation, 5) Session, 4) Transport, 3) Network, 2) Link, 1) Physical

Internet Layering Model: 5) Application, 4) Transport, 3) Internet 2) Network, 1) Physical

TCP protocol transport-layer services: Reliable data transmission, flow control, connexion-oriented service, congestion control.

Application layer protocols: SSH, Telnet, FTP, DNS, POP3

#46901 -> little-endian: 0x35B7, big-endian: 0xB735, network communication requires big-endian.

SSH port: 22

FTP port: data 20 control 21

SMTP port: 25

HTTP port: 80

Proxy server: L = 5 MiB, R = 3.51 Mbps, Response time between proxy and origin 9 seconds. Answer: 11.95 sec

Connection setup 3.2 ms, including RTT. 23 additional imagines. How much longer non-persistent vs persistent? Answer: 73.6 ms

8 additional images. How many requests for non-persistent and persistent? Answer: 18, 10

HTTP implements caching by use of a conditional GET.

HTTP implements a conditional GET using if-modified-since.

An HTTP server does not maintain client states.

Complete email communication:
Alice uses her user agent to compose message and sent to Bob's email address.
Alice's user agent sends message to her mail server; message placed in message queue.
Client side of SMTP opens TCP connection with Bob's mail server.
SMTP client sends Alice's message over the TCP connection.
Bob's mail server places the message in Bob's mailbox.
Bob uses his user agent to read the message.

A server-side piece of data which is used to keep track of transactions between a client and server is not called a cookie.

How much longer for non-persistent vs persistent: Connection setup 4.1 ms. 19 additional images. Answer: 78 ms

In the Internet protocol stack, the Application Layer is responsible for finding the destination IP address.

Application-level protocol specify:
Message Semantics, Message Fields and Structure, Messages response rules, Message sending rules, Types of messages exchanged.

For demultiplexing, a UDP socket is identified by destination address and destination port.

For demultiplexing, a TCP socket is identified by source and destination address and port.

A client application sends a request to a server application at port 80 on a remote server. The server responds to the client's address at a port number assigned by the client's OS; this number is not used directly by the client application, but is sent to the sever along with the original request.

Both UDP and TCP protocol uses a 16-bit 1's complement of the 1's complement sum to compute the checksum.

The transport layer manages communications from process to process.

The network layer managers communications from host to host.

A simple checksum can not detect all 2-bit errors.

A simple checksum can detect some 2-bit errors.

The UDP protocol provides error detection.

Maximum TCP header size is 60 bytes.

Minimum TCP header size is 20 bytes.

Max and min UDP header size is 8 bytes.

The TCP countdown timer is used to implement reliable data transmission.

Pipelining is intended primarily to increase network utilization.

Fields in the TCP header: Header Length/Data Offset, Checksum, Destination Port, Sequence Number, Source Port, Window Size.
Arrival of segment that partially or completely fills in a gap in received data. Immediately send ACK, provided the segment starts at the lower end of gap.

A Go-back-N type retransmission protocol will retransmit all un-ACK'd segments upon a countdown timer interrupt.

The TCP sequence numbers are used to implement reliable data transmission.

Flow control is intended to keep TCP sender from overwhelming a receiver's buffer.

#3642, P: 287 bytes, Q: 427 bytes, R: 493 bytes. The sequence number on segment Q is 3930.

Window size is 5729 bytes, 1005 byte segment. R = 32 Mbps, prop delay is 32 ms. Utilization is 1.9% U = x*(L/R)/(RTT + L/R) RTT = 2*prop delay

A Selective Repeat type retransmission protocol will retransmit one segment at a time upon a countdown timer interrupt.

A Cumulative acknowledgement scheme, a received ACK indicates all the segments prior to the ACK'd segment were received.

UDP header: Length, Source Port, Checksum, Destination Port.

TCP three way handshake is used to implement a connection.

Arrival of in-order segment with expected sequence number. One other in-order segment waiting for ACK transmission. Immediately send single cumulative ACK, ACKing both in-order segments.

Most packet switches use store and forward transmission.

The TCP protocol does not provide error detection and correction.

Describes reliable data transfer: the ability to send and receive information that you are reasonably sure is what was sent, without losing any information.

EstimatedRTTnew = (1-a)EstimatedRTTprev + a*SampleRTTrecent

Closing a TCP Connection:
Client sends segment with FIN bit set
Server sends ACK of received segment
Server sends segment with FIN bit set
Client sends ACK of received segment

What is the total utilization of a circuit-switched network, accommodating five users with equal bandwidth share, and the following properties:

- Three users each using 92% of their bandwidth share
- Two users each using 8% of their bandwidth share

Give answer in percent, with one decimal place (normal rounding) and no percentage sign (e.g. for 49.15% you would enter "49.2" without the quotes).

58.4000

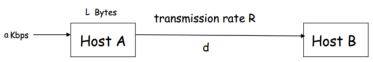
How long does it take to send a 14 MiB file from Host A to Host B over a circuit-switched network, assuming:

- Total link transmission rate = 67.1 Gbps.
- Network is TDM, with 18 permitted users, each with an equal time slot size.
- A link connection requires a setup time of 53.2 ms.

Your answer should be in **milliseconds** (ms) with one decimal place, and without the unit (e.g. "140.6" without the quotes)

84.7000

Voice over IP (VoIP)



Given the attached image, and:h

- Host A converts analog to digital at a = 53 Kbps
- Link transmission rate R = 3 Mbps
- Host A groups data into packets of length L = 127 bytes
- Distance to travel d = 705.8 km
- Propagation speed s = 2.5 x 10^8 m/s
- Host A sends each packet to Host B as soon as it gathers a whole packet.
- Host B converts back from digital to analog as soon as it receives a whole packet.

How much time elapses from when the first bit starts to be created until the conversion back to analog begins? Give answer in milliseconds (ms) to two decimal places, normal rounding, without units (e.g. 1.5623 ms would be entered as "1.56" without the quotes)

22.3300

Suppose there are 82 packets entering a queue at the same time. Each packet is of size 7 MiB. The link transmission rate is 1.5 Gbps. What is the queueing delay of packet number 27 (in milliseconds, rounded to one decimal place, e.g. 0.01234 seconds would be entered as "12.3")

1017.8000

For the following question, proper hexadecimal format is (0xYYYY) where Y will range in (0-9) or (A-F). Only proper formats will be accepted.
Suppose that we send a DNS request with ID #46901.

1. What is the little-endian representation (hexadecimal)?
   0x35B7
2. What is the big-endian representation (hexadecimal)? 0xB735
3. Which representation is required for network communication? (Enter "1" or "2" without quotes) 2

Assume a TCP sender is continuously sending 1005-byte segment. If a TCP receiver advertises a window size of 5729 bytes, and with a link transmission rate 32 Mbps an end-to-end propagation delay of 32 ms, what is the utilization? Assume no errors, no processing or queueing delay, and ACKs transmit instantly. Also assume the sender will not transmit a non-full segment. Give answer in percentages, rounded to one decimal place, without units (e.g. for an answer of 10.43% you would enter "10.4" without the quotes).

1.9000

Suppose there are 3 routers in sequence between Host A and Host B, all of which use store-and-forward routing. What is the total end-to-end delay for a packet originating from Host A with destination Host B, under the following conditions.

Each of the link transmission rates are 6.3 Mbps

The total distance from Host A to Host B along its path of transmisison is 154.1 km

The speed of propagation through the transmission medium is is 2.7 x 10^8 m/s

The packet size is 4 KiB

Remember that you must also uplink from Host A to the first router. Give answer in milliseconds, rounded to 1 decimal place, without units (e.g. for 0.12345 seconds you would enter "123.5" without the quotes).

21.4000

A client in a network with a proxy server requests a 5 MiB file from an internet server, fakeservername.com. The network's proxy server has a 3.51 Mbps connection to fakeservername.com. The average response time between the network's proxy server and the internet origin server (including RTT) is 9 seconds for a small "header-only" HTTP request/response. The file requested by the client is currently in the proxy server cache, but the proxy server relays the client's request to the internet server with "if-modified since".

Assume that transmissions between the proxy and the origin servers are stream (not packets) at fullbandwidth, with negligible propagation delay.

How much time is saved if the file has not been modified? (Give answer in seconds, without units, rounded to two decimal places, so for an answer of 1.4233 seconds you would enter "1.42" without the quotes.)

11.9500

Given a link with a maximum transmission rate of 18 Mbps. Only two computers, X and Y, wish to transmit starting at time t = 0 seconds. Computer X sends ***fileX*** (1 MiB) and computer Y sends ***fileY*** (340 KiB), both starting at time t = 0.

- Computer X gets the transmission medium first, so Computer Y must wait.
- For the following calculations, assume maximum transmission rate during transmission.
- Suppose that entire files are sent as a stream (no packets, no multiplexing).

At what time (t = ?) would *FileY* finish transmitting?

Give answer in seconds, without units, and round to two decimal places (e.g. for an answer of 12.4567 seconds you would enter "12.46" without the quotes)

0.6200

A client's browser sends an HTTP request to a website. The website responds with a handshake and sets up a TCP connection. The connection setup takes 3.2 ms, including the RTT. The browser then sends the request for the website's index file. The index file references 23 additional images, which are to be requested/downloaded by the client's browser.

Assuming all other conditions are equal, how much longer would non-persistent HTTP take than persistent HTTP? (Give answer in milliseconds, without units, rounded to one decimal place. For an answer of 0.01005 seconds, you would enter "10.1" without the quotes.)

73.6000

A client's browser sends an HTTP request to a website. The website responds with a handshake and sets up a TCP connection. The connection setup takes 2 sec, including the RTT. The browser then sends the request for the website's index file. The index file references **8** additional images, which are to be requested/downloaded by the client's browser. How many requests (including the initial request) must be sent by the browser...

1. With non-persistent HTTP? 18 requests
2. With persistent HTTP? 10 requests

HostA has established a TCP connection with HostB in a remote network. HostA is sending segments to HostB. Assume we have configured TCP, somehow, to ACK every segment (no ACKing every other segment). Assume that the timeout is the same for all packets. HostB's "window size" is 20000 bytes. HostB has already received and acknowledged everything sent by HostA's application up to and including byte #4774. HostA now sends segments of the same application data stream in order:

P: 254 bytes
Q: 295 bytes
R: 273 bytes

What is the sequence number on segment R?

5324.0000

HostA has established a TCP connection with HostB in a remote network. HostA is sending packets to HostB. Assume we have configured TCP, somehow, to ACK every segment (no ACKing every other segment). Assume that the timeout is the same for all packets. HostB's "window size" is 20000 bytes. HostB has already received and acknowledged everything sent by HostA's application up to and including byte #2830. HostA now sends segments of the same application data stream in order:

P: 182 bytes
Q: 213 bytes
R: 347 bytes

Suppose segments P, Q, and R arrive at Host B in order. What is the acknowledgment number on the segment sent in response to segment P?

3013.0000

Compute the one's complement sum of the following two numbers. Give answer in 8-bit binary, zero-padded to 8 bits if necessary, with no spaces (e.g. 00101000).

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10010110
10011100
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110011.0000