Units: Speed - K = 10^3, M=10^6, G=10^9; Size – K =2^{10}, M = 2^{20}, G = 2^{30}; 8 bits in a byte; b for bits and B for bytes; 1 Mib = 128KiB, 1 Mib = 2^{20} = 1048576 b = /2^{10} = 1024 Kib = 128 KiB
Network: a system for connecting computers using a single transmission technology.
Internet: A system for connecting multiple networks, each of which may use a transmission technology that is a different form. Inet core is packet switched.
Network protocol: rules that define format/order of messages sent/received among network hosts, and actions taken on that message.
RFC: public DB containing adopted networking/internetworking standards.
IETF: Internet Engineering Task Force, produce tech docs that influence internet.
Network Edge: Hosts and applications, clients and servers | end system/hosts (ex. comp)
Network Core: interconnected routers, network of networks. Circuit switched network
TCP (Transmission control protocol): Connection oriented, handshake, reliable, in order, flow control, congestion control. Used by: HTTP, FTP, TELNET, SMTP
UDP (User Data Protocol): not connection oriented, fast, no handshake, unreliable data transfer, no flow control, no congestion control. Used by: Streaming media, teleconferencing, DNS.
Multiplexing: In terms of physical media it is merging multiple comms into same medium.
Statistical Multiplexing: adaptive sharing of the transmission medium in packet-switched networks; based on whether or not host has data to transmit, which prevents resources from being wasted by idle host.
Frequency Division Multiplexing (FDM): Share trans medium by dividing links bandwidth among multiple hosts.
Time Division Multiplexing (TDM): Share trans medium by circuit switching in equal time slices.
Circuit switched network: network has a dedicated circuit through which information is transmitted. If there are multiple users, the network resource is divided into chunks.
Packet switched network: sends information in "chunks" through a network on shared medium primary functions are: packet transmission, packet interpretation, packet construction.
Bits per seconds (bps): used for network bandwidth and transmission rate.
Access network: allows a host to connect to the internet.
Throughput: end to end speed (over a period of time) in bps on a path between 2 hosts.
Processing Delay: time spent processing header info, checking bit errors, deciding out port link.
Queueing Delay: time spent waiting for the transmission medium to become available.
Transmission Delay: proportional to the rate at which the receiving node can interpret the electronic signal. Also the time spent being placed on transmission medium. D=L/R
Propagation Delay: proportional to the rate of travel of electrons through the transmission medium. Also the time spent in transit between nodes in network. D=d/s
Physical Media: In a network it is the chain between sender and receiver pairs. Analog signals relating to bits propagate over/through the physical media.
Guided media: twisted pair copper wire, coax cable; **Unguided:** wireless
Internet Protocol Stack: Start at application and work down, send, receive, start at physical and work way back up.
1. Application: Supporting network applications. Determines destination IP, supports network apps, decides which data will be sent. Types: **HTTP:** Used for communication of hosted info on web; **FTP:** Used to transfer files without web interface; **SSH**; **Telnet; SMTP/IMAP/POP3**: Email; **DNS:** Domain name resolution (google.com to ip); **SCCP:** VoIP. Must specify message fields & structures, message sending rules, types of messages exchanged, message response rules, message semantics.
2. Transport: Process-Process data transfer (TCP, UDP)
3. Network: Routing of datagrams from source to destination (IP, Routing protocols)
4. Link: Data transfer between neighboring network elements (PPP, Ethernet)
5. Physical: Carries actual signals between devices (cable, wireless)
Why layers? Protocols can be tested independently. Maintenance only affects one level. can update protocol as long as input/output stay the same. Complications of intermeshed type of host and data is lessened.
Encapsulation: As a packet is being constructed and passed down to the next layer of the internet protocol stack, a new header is added.
Application Data: The payload (non-header portion) of transport layer.
ISO Protocol Stack: Application, presentation, session, transport, network, link, physical. presentation allows app to interpret meaning of data. session: synchronization, check pointing, recovery of data exchange.
Virus is designed to destroy files and cause computer to malfunction. **Spyware** is software that acts like a server. Once installed a client can request info from host.
Botnet is a group of computers all controlled for a common objective. (DDos).
DDOS (Distributed Denial of Service): attack that floods inet with traffic.
Packet sniffing: Looking at packet somewhere along the route. Attacker can see all data.
IP spoofing: Sending info into network with false IP.
Process: A program that is running on a host
IP Address & Port(Process): Info needed to identify process on remote host. aka **socket**. A paired set of sockets is a **connection.** | IP Range 0-255 |
Interoperability: protocol that allows multiple protocols to work together.
HTTP: users port 80 on TCP, it is addressable by its uniform resource locator URL, it is stateless so the server maintains no info about past client requests. No state preserved
Persistent HTTP: The ability to send multiple objects over a single TCP connection.
Cookie: A client side history of transactions between client and server using HTTP.
FTP: client/server protocol. It maintains the states: current directory, earlier auth, limit on concurrent connections. Uses two connections: 1st is for commands 2nd is for files.
Email: 3 components: user agent (email client), mail service, and email protocol. Requires push protocol to send messages to recipient's service provider. pull protocol is so recipient can download message from mail service. SMTP(Push), IMAP(Pull) – maintain on server, POP3(PULL)-2 modes DL to client, delete from server & DL and delete from server
Unique Hardware Addresses = 16^{12}, Unique IP = 2^{16}, IP #s can be 0 – 255.
De-multiplexing: TCP socket identified by source IP and Port and dest IP and Port; UDP socket identified by dest IP and Port.
Reserved Ports: FTP 20, FTP Control 21, SSH 22, HTTP 80
TCP protocol uses a 16-bit, 1's complement of the 1's compliment sum to compute checksum. **UDP protocol** uses a 16-bit, 1's complement of the 1's compliment.
Simple checksum: can detect 1 bit errors but not all 2 bit errors.
Selective repeart: keep timer for each un ack seg. When protocol calls for retrains, it will send un ack segs independently instead of bulk.
Fast retransmission: retransmitting a missing seg before the countdown timer expires.
Reliable data transfer (RTD): The ability to guarantee that a transmitted message was received and it was received without errors. Aspects include: error detection, receipt ack, timing, fairness, message sequencing, usage fairness. This is wht TCP sequence #s are for. Tradeoffs: added overhead, possible delays due to ack, more congestion because of acks
TCP Header: min size is 20B due to 5 4B rows. 60B max because header length field is only 4b which has a max value of 15. Contains: source port, dest port, seq #, header lenth/data offset, windows size, checksum **UDP header:** min 8B, max 8B. Contains Checksum, dest port, source port, length. **TCP Countdown timer:** Used in RDT to determine if packet drop. TCP will retrans a packet and restart timer.

Sample Calc questions

1. What is the total utilization of a circuit-switched network, accommodating 10 users with equal bandwidth, with the following users: 4 using 100%, 2 using 60%, 4 using 0%.
Answer: 4(1)(.10) + 2(.6)(.10) + 4(0)(.1) = .52 = 52%

2. 4 Routers in sequence from A to B using *store and forward*. What is total end to end delay? Each link has trans rate of 8 Mbps, distance from A to B 169km, prop through medium is 2.7 x 10^6, packet size is 3 KiB. d = 141600m, s = 2.7x10^8, R = 8000000, L = 3 = 24576. (169000/2.7x10^8) + 5*(24576/8000000) = 15.985 = 16.0 ms

3. Image and Host A converts analog to digital at a = 57Kbps, R = 1Mbps, L = 38 bytes, d = 593 km, s = 2.5 x 10^8, Host A sends each packet to B as soon as it gather whole packet. How much time elapses from when the first bit starts to be created until the conversion back to analog begins? (38*8/57000) + (593/2.5x10^8) + (38*8/1000000) = 8.01 ms

4. How long to send 10 MiB file from A to B over circuit switched network assuming: trans rate = 42 Gbps, network is TDM with 6 users, link setup takes 93.4 ms? R = 42/6 x 10^9, L = 10x2^{20}x8. Answer = L/R * 1000 + 93.4 = 105.4

6. There are 58 packets entering a queue at the same time. Each packet is 207 KiB. The trans rate is 1 Gbps. What is the queueing delay for packet 20?
(L(n-1)/R) = ((207*2^{10}*8)*19)/1000000) = 32.2

7. Link has max trans of 91.7 Mbps. Two comps, X and Y, wish to transmit at t = 0 seconds. X send file (11MiB) Y sends file (416KiB). Statistical multiplexing is used, packet payload = 1000B and Header = 24B. Ignore processing and queueing delays. Assume partial packets are padded so they are the same size. Assume alternating packet transmission and X transmits first. At what t will File Y finish? File Y = 416KiB = 426 packets. Packets are 8192b including header, 8000b just data. Will send 852 total packets until Y finishes. (852*8192)/(91.7*10^6)*1000 = 76.1 ms.

8. Suppose that we send a DNS request with ID #38959
38959/16 = **2434 R 15** /16 = **152 R 2** /16 = **9 R 8** /16 = R9
Little endian = 0x2F98, Big endian = 0x982F, network uses big endian.

9. http://oregonstate.edu/admissions/sites/all/themes/doug_fir/images/osu-tag.png
Hostname = oregonstate.edu,
Path name = /admissions/sites/all/themes/doug_fir/images/osu-tag.png,
URL = http://oregonstate.edu/admissions/sites/all/themes/doug_fir/images/osu-tag.png,
TLD = EDU

9. Connection setup takes 5.5ms including RTT. The browser sends req for websites index file. The index file ref 21 additional images, which are requested and downloaded by client. How much longer is non persistent compared to persistent?
5.5ms * 21 images = 11.5 ms.
Persistent = 1x for image. Persistent is 2x calls for image. (P – 12, NP-22)

10. A client in a network with a proxy servers req a 6MiB file. The proxy has a 2.01 Mbps connection. The average response time between the networks proxy and the internet origin server including RTT is 7.6 second. Assume trans between proxy and origin are stream. How much time is saved if the file has not been modified?
6*2^{20}*8/(2.01*10^6) = 25.04 seconds

11. Give the ones compliment sum of 10000001 and 10000001. 00000011 (Just add)

12. Ones compliment of 01101001 is 10010110**. flip 1s and 0s.**

13. Server X is running xbox live on port #3072. Client A is running app on port 1796 to request xbox live. Client B is using port 2076. IPs: server X 201.164.10.123, A 128.193.11.113, B 128.193.45.227. The connection for B is identified by sock endpoints

	IP Address	Port
Client B	201.164.10.123	3072
Server X	128.193.45.227	2076

14. Assume TCP sender is cont sending 1154 byte segment. TCP receiver has 6477B window and trans rate 17Mbps end to end with prop delay 18.3ms. What is utilization?
6477/1154=5.61 = 5 packets. L/R = 1154*8/17000000 * 1000 = .543ms; RTT = 2*18.3 = 36.6. Since we have 5 segments (5*.543)/37.14 * 100 = 7.3% utilization.

Network Edge: End Systems / Hosts (smartphones, computers, servers, peers, etc.
Network Core: Interconnection devices (routers, switches, associated network cards, etc
Components of TCP: Connection-orientation w a 3-way connection-setup handshake, reliable in-order data transfer, flow control, congestion control
Components of UDP: Connection-less, unreliable data transfer, no flow/congestion cntl
Network w/ Dedicated Circuit for sending info: Circuit-switched
Network that sends info in chunks: Packet-switched
Units for Network Bandwidth: bits per second | Units for Transmission: bps
Network Resources in a circuit-switched network to allow multiple users to utilize the network: the network resources is divided into chunks
Diff (TDM/FDM): T divides bandwidth into chunks of time, F divides avail into freq bands
Three func of a packet-switched network: pack construction, transmission, interpretation
Faster? Circuit vs packet (depends) | Average Delay = L(N-1)/2R
Causes of congestion in a packet-switched network: packet delay / loss, jitter
Avg Throughput: Rate at which bits are actually transferred between sender and receiver
End Delay = (processing + queueing + transmission + propagation) delays
Role of Physical Media in access networks: link between sender/receiver pairs
Benefit of Broadband bs baseband cabling: Broadband -> utilize a greater freq range
Five Layers of IP stack: Physical, Data-Link, Network, Transport, Application
App Layer responsibilities: determine destination IP address, support network applications, decide which data which will transit the internet
7 Layers ISO stack: Physical, Link, Network, Transport, Session, Presentation, Application
Client App comms with server app after connection: Sending data into the conn socket
App Protoc: Type of msgs exchanged, msg syntax/semantics, rules for msg send/response
14 objects over a single TCP connection is Persistent
Client-side history of transactions between client and server using HTTP: Cookie
Goal of Caching in HTTP: To keep inof requests from going to the goal server
SMPT sends additional types of objects via MIME (multipurpose mail extension)
SMTP, POP3, and IMAP are pull protocols. DNS uses UDP
Internet name's highest-priority component: right-most component
Transmission Rate: Max # of bits/seconds a transmission device can push onto a medium
End-To-End Delay: Sum of times for processing, queueing, transmission, prop delay
propagation speed: rate at which data travels through a transmission medium
TDM-based network: circuit-switched | False – Udp is connection-oriented
Circuit-switched network, if a user is allowing available bandwidth to be idle: silent period
App level protocol implementing web browser would use TCP as transport layer protocol
A server-side piece of data which is used to keep track of transactions between a client & server is called a cookie – FALSE. | 90.09 Mbps = 90090 Kbps | 43 MiB = 360710144 bits
Week5: The network layer manages communications from host to host
If I want to be fair about my usage of internet resources, I would use the TCP protocol.
Suppose that 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 operating system; this number is not used directly by the client application, but is sent to the server along with the original request.
False - The TCP protocol provides error detection and correction.
The TCP countdown timer is used to implement reliable data transmission .
Retransmitting a missing segment before the segment's countdown timer expires is called: fast retransmission | TCP header fields: Sequence Number, destination port, source port, Header Length/Data Offset, checksum, window size
A Selective Repeat -type retransmission protocol will retransmit one segment at a time upon a countdown timer interrupt | 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 in-order delivery.
START: HostA has established a TCP connection with HostB in a remote network. HostA is sending packets to HostB, and HostB immediately acknowledges every packet. Assume that the timeout is the same for all packets. HostB's "window size" is 2000 bytes. HostB has already received and acknowledged everything sent by HostA's application up to and including byte #140. HostA now sends packets of the same application data stream in order: P (50 Bytes), Q (60 Bytes), and R (100 Bytes).
a. What are the sequence numbers on packets P, Q, and R? P: 141 Q: 191 R: 251
b. Suppose that packets P, Q, and R arrive in order at HostB. What are the acknowledgement numbers in the ACK's for packets P, Q, and R? P: 191 Q: 251 R: 351
c. Suppose that packet Q arrives at HostB before packet P. What is the acknowledgement number in the ACK for packet Q? If packet P arrives after packet Q (but before packet R), what is the acknowledgement number in the ACK for packet P?
Q: 141 (still expecting packet P) | P: 251 (cumulative ACK for P and Q)
d. Suppose that packet P is lost, but packets Q and R are received. What is the acknowledgement number in the ACK for packet R? R: 141 (still expecting packet P)
True - A simple checksum can detect all 1-bit errors.
False - A simple checksum can detect all 2-bit errors.
When it comes to pushing data into the internet, UDP is the more effective protocol.
When it comes to reliable data transmission, TCP is a more effective protocol.
For demultiplexing, a UDP socket is identified by: <destination address, destination port>
For demultiplexing, a TCP socket is identified by: <source address, source port, destination address, destination port> | In a Selective acknowledgement scheme, a received ACK indicates only that the ACK'd segment was received.
The TCP three-way handshake is used to implement a connection
Pipelining is intended primarily to increase network utilization.
The TCP sliding window is used to implement flow control .
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.
Arrival of segment that partially or completely fills in gap in received ata. = Immediately send ACK, provided that segment starts at the lower end of gap.
Arrival of in-order segment with expected sequence number. All data up to expected sequence number already acknowledged. = Delayed ACK. Wait up to 500ms for arrival of another in-order segment. If next in-order segment does not arrive in this interval, send an ACK. | Select the proper equation for calculating EstimatedRTT =
ERTT(new) = (1-alpha)ETT(prev) + alpha x SampleRTT(recent)
Week 4: The DNS application-layer protocol utilizes the UDP transport-layer protocol.
False - HTTP implements caching by use of a UDP check. & FTP is implemented over a single TCP connection.
If I want to be sure I don't overwhelm the receive host with too much information, I would use the TCP protocol.
False - It is acceptable to create two TCP connections on the same server/port doublet from the same client with different port numbers. | If I want to be reasonably sure the recipient received my transmitted information, I would use the TCP protocol.
If I were going to implement a lossy VoIP connection, I would use the UDP protocol.
W3: What transport-layer services are provided by the base UDP protocol? None
In the internet, an application-level protocol implemeting live-streaming video would most likely utilize UDP as its transport-layer protocol.
In a peer-to-peer architecture, no one host is always on, but hosts may connect amongst themselves in an on-demand fashion. | The reserved port for SMTP is port 25.
False - FTP is implemented over a pair of UDP connections. (or single HTTP connection)
True - FTP is implemented over a pair of TCP connections.
If an HTTP server requires 2 TCP connections to send 2 objects, this is an example of non-persistent HTTP. | If an HTTP server can send 2 objects over a single TCP connection, this is an example ofpersistent HTTP. | HTTP implements caching by use of a conditional GET.
The DNS application-layer protocol utilizes the UDP transport-layer protocol.
The HTTP application-layer protocol utilizes the TCP transport-layer protocol.
The IMAP/POP3 application-layer protocols utilizes the TCP transport-layer protocol.
False - There is a single, central DNS server. | In the internet, an application-level protocol implemeting web browsing would most likely utilize TCP as its transport-layer protocol.
In the Internet protocol stack, if a data transfer is connection-oriented, it is implemented at the Transport Layer. | Application data is the payload at the transport layer
Merging multiple communication streams into the same media is called multiplexing
A FDM-based network is a circuit-switched network
A TDM-based network is a circuit-switched network
False - In store-and-forward transmission, a packet switch may being transmitting the *first* bits of packet before it has finished receiving that the *last* bits of the packet.

Email Process:

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
If I were to send information into the internet with your IP address listed as the sender IP, I would be spoofing my IP address. | If your computer becomes infected, you may be enrolled in "botnet(s)" and used in "DDoS attack(s)" against other hosts
A paired IP address and port number is called a socket
In a peer-to-peer architecture, no one host is always on, but hosts may connect amongst themselves in an on-demand fashion.
In a hybrid client-server/P2P architecture, one host is always on, and other hosts may connect and be handed off amongst themselves by this first host.
Protocol interoperabilityallows multiple protocols to work together.
W1: Propagation Delay is proportional to the rate of travel of electrons through the transmission medium, whereas Transmission Delay porportional to the rate at which the receiving node can interpret the electronic signal.
True - Most packet switches use store-and-forward transmission.
False - A connection-oriented protocol in a packet-switched network guarantees a dedicated line - similar to how a circuit-switched network works.