**Units:** Speed -K = 103, M=106, G=109; Size – K =210, M = 220, G = 230; 8 bits in a byte; b for bits and B for bytes; 1 Mib = 128KiB, 1 Mib = 220 = 1048576 b = /210 = 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

**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 mediumprimary 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.

**Propagation Delay:** proportional to the rate of travel of electrons through the transmission medium. Also the time spent in transit between nodes in network.

**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.**

**Interoperability:** protocol that allows multiple protocols to work together.

**HTTP:** users port 80 on TCP, it is addressable by its uniform resource locator, it is stateless so the server maintains no info about past client requests.

**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 = 1612, Unique IP = 216, 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 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 106, packet size is 3 KiB**. d = 141600m, s = 2.7x108, 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 108, 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) + (593/2.5x108) + (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 109, L = 10x220x8. 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\*210\*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\*106)\*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. Consider: 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

**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\*220\*8/(2.01\*106) = 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.