1. True or False

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F F 1. The BW x Delay product is the maximum # of bits/sec that can fill the "pipe"

F F 2. In cable access, several users share the same cable. Hence Medium Access Control procedures are required on both the uplink and the downlink to prevent collisions.

T ~~F~~ F 3. In a virtual-circuit packet-switched network, a packet switch maintains state information for each connection passing through the switch.

T T 4. A modem controls the speed at which data bits can be transmitted but the bandwidth determines the maximum speed at which the data bits can be sent

F F 5. ADSL and cable modem access providers must install a modem in their offices for each individual subscriber unlike the case of dial-up connections where the modems are located at the user sites only

F F 6. An odd parity can detect all even number of errors but it can't detect odd number of errors

100011
100101

F F 7. Full Duplex transmission always require 4 wires, i.e. two pairs, since it implies that both sides can transmit simultaneously

F ~~T~~ F 8. Two distinct web pages say http://www.usc.edu/exam.html and http://www.ucla.edu/grade.html can be sent over the same persistent TCP connection

T T 9. A router is a node that can forward packets that are not explicitly addressed to itself.

T ~~F~~ T 10. In the Internet terminology, a node is any device, including hosts and routers, which runs an implementation of TCP/IP

T T 11. A packet is a protocol data unit that exists at the network layer and comprises of an IP header and a payload

F F 12. Both TCP and UDP provides one-to-one and ~~one-to-many~~ communications services. The difference is that TCP provides connection-oriented reliable service while UDP provides connectionless unreliable service.

F F 13. ~~HTML pro~~tocol transfers files that make up pages on the world wide web

T ~~F~~ T 14. ARP is a protocol used to resolve the "next hop IP address" to its MAC address.

T F 15. ARP request frame is broadcasted over the shared access network

T T 16. A process C running in a server has a port number of 30. Two hosts A and B each send a UDP datagram to host C with destination port number 30. Both of these datagrams will be directed to the same socket.

F T 17. An application creates a stream socket or datagram socket by specifying two items namely the IP address of the host and the port number of the application along with the ~~Network~~ protocol.

T F 18. Two 4 sockets form a bi-directional communications path between two applications

T T 19. Private organizations "Intranets" that do not need an Internet connection can use the same network address as other public networks

T T 20. In Statistical TDM, the number of time slots in each frame is less than the number of input lines to the MUX.

F F 21. A DHCP server must be located on every network to assign IP addresses to DHCP clients on that network

T T 22. If a computer has multiple Network Interface Cards, The DHCP process must occur separately over each interface to obtain a separate dynamically assigned IP address for each interface.

T T 23. Applications using UNIX Sockets allow users to specify destination hosts by their names or IP addresses.

T ~~F~~ F 24. A message broken into long packets suffer longer end-to-end transfer delay than a message broken into shorter packets not ~~necessary~~ necessary

one packet

F F 25. Synchronous TDM is most useful when the peak rate of the information source is much higher than its average rate

F T 26. In T1, the synchronization rate is 1 bit/frame 24 1.544M

F F 27. To be able to recover the analog signal from its sample, the sampling period has to be at ~~least~~ twice the highest frequency component in the signal being sampled

2. Fill in the Plank

$3 \times 2 \times 2$

a. A television channel is 5MHz wide. It is sampled at the ~~2x~~ Nyquist rate and quantized into 4 levels and encoded. The resulting bit rate is ~~20~~ 20 Mbps

b. Suppose a 1 Mbps adapter card sends into a channel an infinite stream of 1's using Manchester coding. The signal emerging from the adapter will have signaling rate of 2M transitions/sec

~~0.5M~~ 2M

c. Bit stuffing procedure is performed on the following binary sequence: 110111111101111110110101. The resulting pattern is 11011111011011111001101 01

110111110110111110011010 1

d. A signal is to be transmitted over a channel with bandwidth of 1MHz. The Signal to Noise ratio on this channel is 20 dB. The maximum bit rate that can be reliably transmitted over this channel is 6.658 Mbps.

$C = B \log_2 1 + SNR$ 6.66 $\log_{10} SNR = 2$ $SNR = 100$

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e. Assume a voice channel occupies a bandwidth of 4 KHz. We need to multiplex (using FDM) 10 such voice channels. The guard band between adjacent channels is 100 Hz. The required bandwidth is 40.9k Hz

900+4M 40900

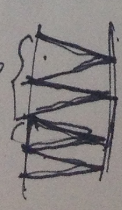
f. Real-Time voice is sent from host A to host B over a packet network. Host A converts analog voice to 64Kbps bit stream on the fly (on the fly means as the voice is generated). Host A then groups the bits into 48 Byte packets. Host A is connected to host B via a link with transmission rate of 1 Mbps and propagation delay of 2 msec. As soon as host A gathers a packet, it sends it to host B. As soon as host B receives the entire packet it converts the bits back to an analog signal. The time elapsed from the moment the first bit is generated till the moment the first bit is decoded is 8.384×10^{-3} sec.

8.384×10^{-3}

$$\frac{48 \times 8}{64K} + \frac{48 \times 8}{1M} + 2m =$$

g. Suppose within your web browser, you click on a link to obtain a web page. The IP address of the associated URL is cached in your machine (i.e. no need for DNS). Denote by RTT the round trip time between your machine and the server. Assume that the web page consists of a base html file + three small images (ignore all transmission times). The time (in terms of RTTs) elapsed from the time the user click on the link till the time the client receives the entire web page for each of the following is

2RTT



8 RTTs

4 RTTs

- Nonpersistent HTTP: 8 RTTs
- Nonpersistent HTTP with parallel connections: 4 RTTs
- Persistent HTTP with pipelining: 3 RTTs

3 RTTs

h. Consider a Packet of 1000 Bytes originating at node A and destined to node B via Router R (hence a total of two links A-----R-----B). Assume the propagation speed on each link is 2.5x10[8] m/sec Assume that the transmission rate over each link is 1 Mbps. Assume that the store and forward router introduces 1 msec processing delay. Assume the length of the first link is 4000 Km; the length of the second link is 1000 Km. The end- to-end delay is 0.023 0.037 seconds. Now suppose the router does not store and forward but transmits the bits immediately upon their arrival. The end-to-end delay in this case is 0.021 0.036 seconds. 0.028

$\frac{1000\times8}{1M} + 1ms + \frac{1000\times8}{1M} + \frac{4000+1000\,km}{2.5\times10^8\,m/s}$

i. Consider transmitting a packet from host A to hosts B and C. Hosts A and B are located on the same network while host C is located on a second network connected to the first one via a router. Assume All ARP tables (in hosts and router) are empty. Let x denote the time (in seconds) to transmit the packet. Let y denotes the time (in seconds) elapsed from the beginning of transmitting an ARP query until receiving an ARP response. Ignoring propagation delay, the total time it takes to forward the packet from A to B is x+y x+y seconds. The total time it takes to forward the packet from A to C is 2(x+y) 2(x+y) seconds

j. A 30 Mbits MP3 file is sent from a source host to a destination host over a 10-channel TDM link of 10 Mbps. The MP3 is sent over one of these channels. Assume that the propagation speed is 2 * 10[8] meters/sec, and the distance between source and destination is 10,000 km. The end-to-end delay is 30.05 seconds 30.05

$\frac{10000\times10^3}{2\times10^8} + \frac{30M}{1M}$

Part 3: Error Detection:

An FCS error detection mechanism is used over a communications link. The message bit sequence is 10011101. An FCS generator pattern of 1001 is used to generate the FCS sequence.

a) How many FCS bits are generated? What are they? What is the transmitted bit sequence? Identify the FCS bits in that sequence. Show details of your work.

b) Suppose the channel introduces the following error pattern 10011000001, what would the received pattern be and what would the receiver decision be? Prove your answer (no credit without proof)

a) 3

```
          10001100
1001 ) 10011101000
       1001
       00001
       00000
        0011
        0000
         0110
         0000
          1101
          1001
          01000
           1001
            10
            00
           100
```

$\boxed{100}$

10011101100
FCS

b)

```
          10001001
1001 ) 10011000001
       1001
       0001
       0000
        0010
        0000
         0100
         0000
          1000
          1001
           0010
           0000
            0100
            0000
             1001
             1001
              000
```

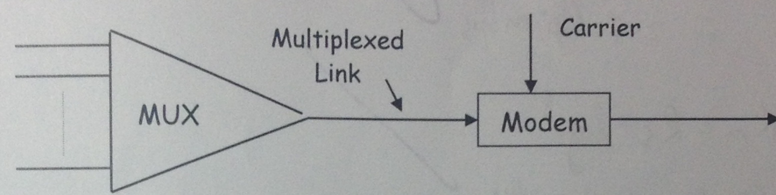
~~the remainder is 0, the receive pattern is 100X000, which would accept be the receiver.~~

receiver: 10011101100 ⊕ 10011000001 = 00000101101

```
          101
1001 ) 101101
       1001
       0100
       0000
        1001
        1001
         000
```

Part 4: Resource Sharing

Consider the following multiplexer



Assume that you have 10 input sources as follows:

Four sources generates 500 Kbps (each), 75% of the time
Three sources generates 250 Kbps (each), 50% of the time
Two sources generates 200 Kbps bits/sec (each), 100% of the time
One source generates 100 Kbps, 50% of the time

~~$4 \times 500k \times 75\% + 3 \times 250k \times 50\% + 2 \times 200k \times 100\% + 100k \times 50\% = 2325$ Kbps~~

$500 \times 4 + 3 \times 250 + 2 \times 200 + 100 = 3250$ Kbps $= 3.25$ Mbps

Case 1: Assume that the multiplexer is a synchronous TDM. What is the required data rate at the output of the MUX? Assume each time slot can support 50 Kbps and is 10 bits long. How many time slots are assigned to each of the above sources per frame? What is the frame duration? What is the frame rate? Assume that the modem is QPSK, what is the signaling rate at the output of the Modem?

2 4 5 10

0.2 ms

5000 frames/s

0.2 ms

$\frac{10 \text{ bits}}{50k}$ 50k 10 bits

$2.325M / 0.8 = 2.90625$ Mbps

Case 2: Now assume that the multiplexer is a Statistical TDM with a link utilization of 80%. What is the required data rate at the output of the MUX? If the modem is $\boxed{8\text{-Q}}$AM, what is the signaling rate at output of Modem? How many frequencies do we need?

$R_s = \frac{2.90625M}{3} = 968.75$ Kbps

one frequencies, in 8-QAM, we only change Amplitude and phase.

~~$R_s \times 2 = 1.375$ MHz~~

Case 1:

(1) $500\text{kbps} \times 4 + 250\text{kbps} \times 3 + 200\text{kbps} \times 2 + 100\text{kbps} \times 1 = 3250\text{kbps} = 3.25\text{mbps}$

(2) 2 time slots for each 100kbps source
4 time slots for each 200kbps source
5 time slots for each 250kbps source
10 time slots for each 500kbps source

(3) Since each time slot can support 50kbps, while it only has 10 bits, so the framing rate should be $\frac{50{,}000}{10} = 5000$ frams/s
so frame duration is $\frac{1}{5000} = 0.2$ ms

(4) frame rate = 5000 frames/s

(5) $3.25\text{mbps} = R_s \cdot \log_2 4$
so $R_s = 1.625$ mHz

continued behind ~~see~~

Case 2:

① $R_m = \dfrac{500k\times4\times0.75 + 250k\times3\times0.5 + 200k\times2\times1 + 100k\times1\times0.5}{0.8}$

$= 2906.25\,kbps$

$= 2.90625\,mbps$

② $R_m = R_s \cdot \log_2 8$

so $R_s = 968.75\,kHz$

③ $R_s = 2W$

$W = 484.375\,kHz$

-2

$1500 + 375 + 400 + 50$

$$\begin{array}{r} 2906.25 \\ 4\,\overline{)\,11625} \\ \underline{8} \\ 36 \\ \underline{36} \\ 25 \\ \underline{24} \\ 10 \end{array}$$

~~1.162~~

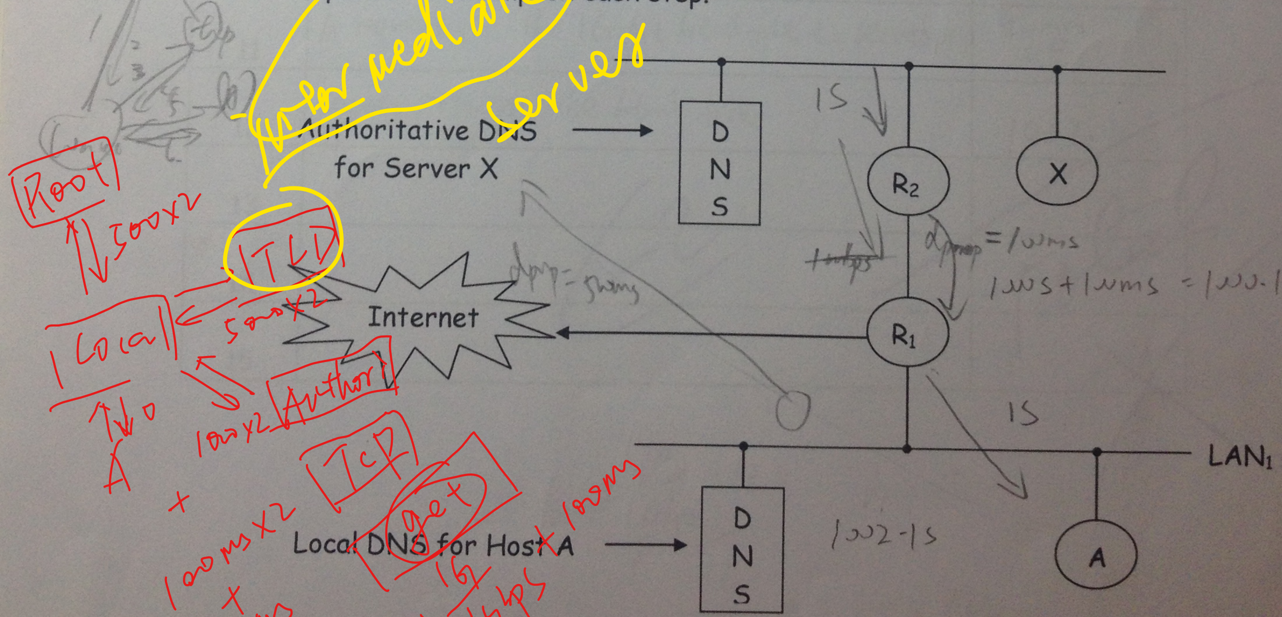
$$\begin{array}{r} 2906.25 \\ 4\,\overline{)\,11625} \\ \underline{8} \\ 36 \\ \underline{36} \\ 25 \\ \underline{24} \\ 10 \end{array}$$

Part 5: Name Resolution and Web Browsing

Consider the following configuration. Host A is located on LAN_1. A web Server X is located on LAN_2. Suppose that the user at host "A" types the URL of server X to download a given 1G-bit html file. Host A does NOT know the IP address of Server X. Host A is configured with the IP address of the local DNS server. Calculate the time elapsed from the moment user A enters the URL till the time the file is completely downloaded under the following assumptions:

a) DNS commands and http commands are so small compared to the file such that you can ignore their transmission times (ONLY)
b) The propagation delay within either LAN is negligible. The propagation delay from R_1 to R_2 is 100 msec. The propagation delay from anywhere in LAN_1 to any other site in the Internet (except LAN_2) is 500 msec.
c) Each LAN operates at 1 Gbps. The link between R_1 and R_2 is 1 Mbps (in each direction)
d) The DNS is iterative
e) The authoritative DNS server is located one level below the Top Level Domain (and hence two levels below the root name server). Only the authoritative DNS server knows the IP address of Server X.
f) DNS runs over UDP where as http runs over TCP.

Create a table that identifies the steps taken (in order) along with the time required to accomplish each step.



1+1+0.2+0.4+2s+1000s
= 1004.6 s

Work Sheet (Table maybe longer or shorter what you actually need)

Step	Action	Delay (msec)
1	Http protocol calls DNS client to get the IP Addr of the severname it resolved	0
2	DNS client requets ~~sever~~ IP to Local-DNS (UDP)	0
3	Local-DNS requests server IP to Root-DNS (UDP)	500
4	Root-DNS respones with no record and IP-add of top-level-DNS to Local-DNS (UDP)	500
5	Local-DNS requests server IP to top-level-DNS (UDP)	500
6	top-level-DNS respones with no record and the IP of Authoritative-DNS (UDP)	500
7	Local-DNS requests to Authoritative-DNS for server IP; (UDP)	100
8	Authoritative-DNS respones with the server IP to Local-DNS (UDP)	100
9	http calls TCP to connect the server using sever IP address and port number	100
10	server respones with a ACK to A to establish the connection	100
11	A requests for the 1G-bit html file to server	100
12	server returns the html file	1002.1
13		
14		
15		

-2

Total

$\frac{1G}{1Gbps} = 1s$ +

$\frac{1G}{1M} = 1000s$

+ 100 ms

$+ \frac{1G}{1Gbps} = 1s$

1002.1

EE450-Midterm-Spring-2014