1. **A network protocol consultant (not a graduate of USC) has recommended to your company to use the following flag**

   01010101

   as frame delimiter in a bit-oriented link-layer protocol. The idea is that the alternating 0 and 1 allow for faster clock synchronization than the conventional 0111110 flag.

   Your boss has asked you to evaluate this proposal (you have taken EE450 already). You need to determine:

   (a) How should bit stuffing (if any) be performed? Explain. (5 pts)

   The idea is to avoid repeating the "01" sequence in the data portion, thus we stuff an extra 0 for each 0.

   (b) Does the proposed scheme make the stuffing and destuffing easier or more difficult? Why? (10 pts)

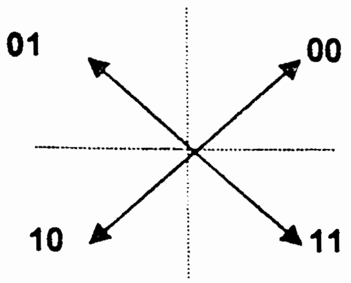
   The proposed scheme introduces a 50% overhead (one out of two bits).

   (c) Show the resulting bit stream after the following data bit sequence is stuffed using the stuffing algorithm you described in (a), if any. (5 pts)

   010101100001010000

   00100100100110000000100100000000

2. **In modulating computer data to be transmitted over a 3 MHz channel we use the following signal constellation diagram. (15 points total)**



signal constellation

   (i) Assuming a noise-free channel what is the maximum data rate that can be supported by this channel? What is the maximum baud rate? (10 pts)

   V=4 discrete signal levels. $\Rightarrow C = 2*H*\log_2 V = 2*3*\log_2 4 = 12$ Mbps
   Baud rate = 6 Mbaud/sec

(ii) What would be the minimal channel bandwidth required in order to support the same data rate (as in (i)) over a noisy channel with signal-to- noise ratio of 20 db? (5 pts)

$$C = H^{*}\log_2(1+S/N) \Rightarrow H = \frac{12Mbps}{\log_2(1+100)} \doteq 1.8 \text{ MHz.}$$

3. Consider a simple model of a *Token Bus* LAN with *N* stations attached to the cable (equally spaced) and numbered from *1* to *N* according to their physical order, i.e., numbered consecutively from the leftmost end (number *1*) to rightmost end (number *N*). Token is passed around in a cyclical order (*1* to *2*, *2* to *3*,..*N* to *1*). Let τ be the end-to-end cable propagation delay (secs), *C* the link capacity (in bps), *P* the data frame transmission time (secs) and assume the token's size is negligible (compared to the data frame size).

(i) Provide an expression of the bus's efficiency assuming the bus operates under heavy traffic. Show all your analytical work. (15 pts)

$$\text{Efficiency} = \frac{Useful\_time}{Cycle\_time} = \frac{N \times P}{N \times P + 2 \times \tau} = \frac{1}{1 + 2\tau(\frac{1}{N \times P})}$$

(ii) Would you recommend using Ethernet on this bus instead of Token Bus in order to maximize efficiency? Explain. (5 pts)

[Hint: use the expression in the notes for the Ethernet utilization]

$$\text{Ethernet efficiency} = \frac{1}{1 + 2\tau(\frac{e-1}{P})}$$

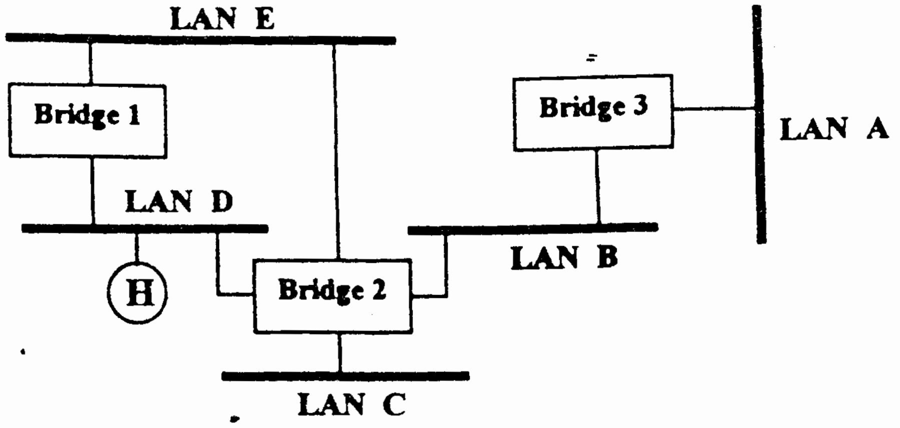
Use Ethernet if (e-1) <1/N.

4. Consider a 1 Mbps link where the probability that a frame is damaged or lost is 20% and the propagation delay is 1 msec. The frame's header is 5 bytes long. Find the number of the bytes that the data in the frame has to be in order for a stop-and-wait link-layer protocol to achieve an efficiency of at least 50%. Assume that ACKs are 7 bytes long and the processing delay is zero. (15 pts)

$$\text{Efficiency} = \frac{(1-P) \times D}{(D + H + A) + 2 \times C \times T_g} \geq 0.5$$

P=0.2, $T_g=10^{-3}$ sec, A=56 bits, H=40 bits. $\Rightarrow$
D>=3493.3 bits or
D>= 437 Bytes.

5. **Consider the following interconnected Ethernets. Station H sends a frame to a non-existing Ethernet address. How far will the frame travel? (10 pts)**



Answer: It will travel to all LANs.

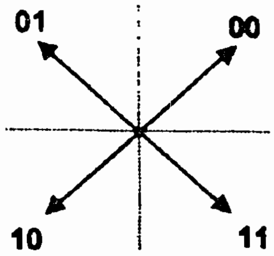
6. **An alternative MAC technique for ring LANs is the slotted ring. A number of fixed-length slots circulate continuously on the ring. Each slot contains a leading bit to designate the slot as empty or full (with a station's data). A station wishing to transmit waits until an empty slot arrives, marks the slot full, and inserts a frame of data as the slot goes by. The full slot makes a complete round trip, to be marked empty again by the station that marked it full. Discuss the advantages and disadvantages of this scheme (i.e., as compared to the token ring). (20 pts)**

Answer:
Similar to STDM

- Advantages
  - No token rotation latency.
  - Multiple stations can send data at the same time.
  - Less responsibilities for monitor station (all functions related to token maintenance are eliminated.)
  - Potentially smaller MAC frames.

- Disadvantages
  - No bounds on stations time to transmit data (can lead to starvation situations, i.e., assume heavy backlogged stations.)
  - Requires very good synchronization.
  - Limitation on frame size: frames can not be larger than time slot.
  - No priorities (unless implemented using a special flag in every slot).

2. In modulating computer data to be transmitted over a 3 MHz channel we use the following signal constellation diagram. (15 points total)



signal constellation

bps

(i) Assuming a noise-free channel what is the maximum data rate that can be supported by this channel? What is the maximum baud rate? (10 pts)

The maximum baud rate = $C = 2W = 2 \times 3$ MHz $= 6M$ (baud rate)

The maximum bit rate:

$C = 2W \log_2 V = \ldots 2W \times 2 = 4W = 12M$ bps

(ii) What would be the minimal channel bandwidth required in order to support the same data rate (as in (i)) over a noisy channel with signal-to-noise ratio of 20 db? (5 pts)

$12 = W \log_2 (1 + S/N)$ $\quad S/N = 20$ dB $\therefore S/N = 20 = 10 \log_{10} S/N$

$\therefore S/N = 100$ $\qquad W = 1.8$ $\qquad$ Ans: 1.8 MHz

$12 = W \log_2 (1+100)$ $\qquad 2^{12/W} = 101$

$\frac{12}{W} \log_2 2 = \log_2 101$

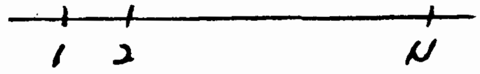
$= 2W$

$W = 1.8$

3. **Consider a simple model of a *Token Bus* LAN with *N* stations attached to the cable (equally spaced) and numbered from *1* to *N* according to their physical order, i.e., numbered consecutively from the leftmost end (number *1*) to rightmost end (number *N*). Token is passed around in a cyclical order (*1* to *2*, *2* to *3*,..*N* to *1*). Let τ be the end-to-end cable propagation delay (secs), *C* the link capacity (in bps), *P* the data frame transmission time (secs) and assume the token's size is negligible (compared to the data frame size).**

   (I) Provide an expression of the bus's efficiency assuming the bus operates under heavy traffic. Show all your analytical work. (15 pts)

In the Token bus model, only the station hold token can transmit data.



τ= propagation delay
C- capacity
p= dataframe transmission time

$\eta = \dfrac{\text{useful time}}{\text{cycle time}} =$ (assume no buffering in the node)

Assume on heavy traffic, everyone need to transmission.

$$\eta = \frac{N * p}{N \times p + 2\tau} \quad \#$$

3

$\eta = \dfrac{Np}{Np + 2\tau}$

   (II) Would you recommend using Ethernet on this bus instead of Token Bus in order to maximize efficiency? Explain. (5 pts)

   [Hint: use the expression in the notes for the Ethernet utilization]

I will not recommand to use this model.

$$\eta = \frac{p}{N \times p + 2\tau} \doteqdot \frac{1}{N} \quad (\text{when } \tau \text{ much smaller than } p)$$

In ethernet, we have a lot of stations.

So η is very low

√

University of Southern California
EE450: Introduction to Computer Networks
Midterm Exam
Spring 1999

Name: Fu-Jen Shiau **Location:** USC

Student ID: 889-79-4133

Part 1	20%	16
Part 2	20%	15
Part 3	20%	18
Part 4	20%	17
Part 5	20%	20
Total	100%	

86

V. good

Notes:

- All your answers should be on the exam paper.
- You can work the problems in any order you wish (the goal is to try to accumulate as many points as you can)
- Try your best to be clean, and to show all the steps of your work

Rules:

- This is a closed book, closed notes exam. You are only allowed two 8"x11" sheets of notes and a Calculator
- Adherence to the University's Code of Ethics will be strictly monitored and enforced. Academic Integrity violations, such as cheating, will result in a series of actions and penalties including the student failing the class.

-4

Part 1: True or False.

Note that if the statement is not fully true, your answer should be false.

F 1. In shared LANs, the activity of one station can not impact the other stations since all stations are peer stations

T 2. As the error rate increases, the effective data rate decreases

T 3. An odd parity can detect all odd number of errors but it cannot correct them

F T 4. A 1200 baud line can transmit at ~~most~~ least 1200 bits per second $R_s = n R_b$

F 5. Routing of data from node to node is the function of the data link layer Network
of the OSI model

T F 6. Digital data transmission can provide higher data rates than is possible with analog transmission

T 7. In Asynchronous transmission, there is no fixed time interval between characters

T F 8. In STDM, the aggregate data rates of the terminals can be more than the data rate of the line ∴ more terminals.

F 9. Full Duplex transmission require 4 wires, i.e. two pairs, since it implies that both sides can transmit simultaneously

F 10. In TDM, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

T 11. In STDM, Host ports can be shared

T 12 STDM can support more terminals than TDM for the same link speed

T 13. Data is transmitted more efficiently when compressed

T 14. Virtual circuits can be found in connection-oriented packet switched networks

F 15. One of the functions of the IP layer in the TCP/IP suite is to assure end-to-end packet delivery across the network

F 16. The OSI model is an international standard for designing networks.

F 17. TCP/IP protocol suite is used only over the Internet

T F 18. A message between peer layers is generically called PDU

F 19. You are logged into a computer. You want to log into a second computer to read your e-mail there. You need an SMTP (Simple Mail transfer Protocol) application.

F 20. The protocol used when a browser requests a webpage from a webserver is called HTML

Dic
wi

5

Part 2: Fill in the Plank

a) The ------Internet------ is a large collection of independent packet networks linked together via routers

b) A ---Trunks ~~Switching~~--- is a terminology given to the shared facilities connecting nodes in switched wide area networks trunk

c) The function of the ---session ~~Application~~--- layer in the OSI model is to establish A connection between application programs on different machines

d) ---Bit--- ---stuffing--- is a technique used by most data link protocols to insure that the Flag pattern does not appear anywhere in the frame

e) The elements of any protocol are ---Syntax---, ---Semantics--- and ---Timing---

f) Each layer in the OSI model provides ---Services--- to the layer above it

g) ---Flow--- ---Control--- is the mechanism by which the receiver can prevent the transmitter from overwhelming it with data

h) ARQ is the most widely used procedure in data links for error control. It stands for ---Automatic--- ---Repeat--- ---Request---

i) In ---Connectionless--- service , the service provider (i.e. the network) does not guarantee the delivery of packets in the same order in which they were transmitted.

j) The unit of data in the network layer is called a ---Packet---

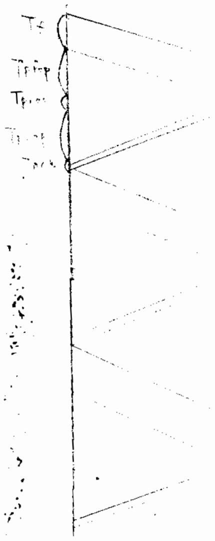
k) The ---Presentation--- layer is responsible for message encryption.

l) The most two important performance parameters of a packet data networks are the ---Throughput ~~Overhead~~--- and ---Delay---

m) In ---Baseband ~~LAN~~--- signaling, you insert the digital signal directly into the medium without the need of modems

Part 3 : 重做

Three frames are to be transmitted over a HDX link between two nodes A and B (i.e. all frames flow in one direction from node A to node B). Assume the following:



- Link Rate R is 64 Kbps   R=64kbps   1648
- There are 1600 data bits and 48 overhead bits in each information frame
- An ACK frame consists of 48 bits only
- Propagation delay is 10 msec 10×10^{-3}
- Processing delay and turn-around time at either node is 50 msec   ] 100ms
- No errors are detected 50×10^{-3}

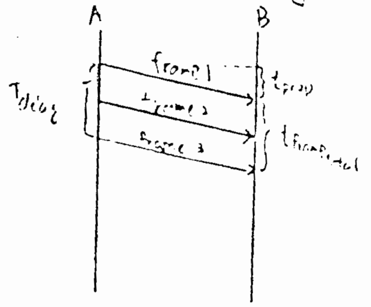
Calculate the total delay and the link utilization for each of the following two cases:

a) No Acknowledgements are transmitted
b) Stop and Wait ARQ procedure is used

Illustrate the timing diagram for each case.

Note : The turn-around time is defined as the time required to switch from a transmitting mode to a receiving mode and vice versa. Remember this is a HDX link

(a) No Acknowledgements:



$T_{prop} = 10$ msec

$T_{frame} = \dfrac{L}{R} = \dfrac{(1600+48)}{64K} = 0.02575$ sec

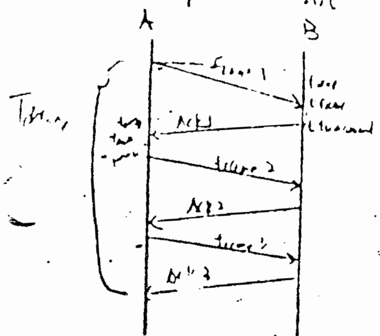
$T_{Delay} = T_{prop} + T_{frame\,total}$

$= 10 \times 10^{-3} + 3 \times 0.02575$

$= 0.08725$ sec

$Utilization = \dfrac{t_{data\,total}}{t_{delay}} = \dfrac{3\frac{1600}{64k}}{0.08725} = 85.96\%$

(b) Stop-and-wait



$T_{ACK} = \dfrac{48}{64k} = 7.5 \times 10^{-4}$

$T_{Delay} = T_{prop} + T_{frame_1} + T_{turn} + T_{prop} + T_{ACK_1} + T_{turn} + T_{prop} + T_{frame_2} + T_{turn} + T_{prop} + T_{ACK_2} + T_{turn} + T_{prop} + T_{frame_3} + T_{turn} + T_{prop} + T_{ACK_3}$

$= 6T_{prop} + 3T_{frame} + 6T_{turn} + 3T_{ACK}$

$= 6 \times 10 \times 10^{-3} + 3 \times 0.02575 + 5 \times 50 \times 10^{-3} + 3 \times 7.5 \times 10^{-4} = 0.3895$ sec

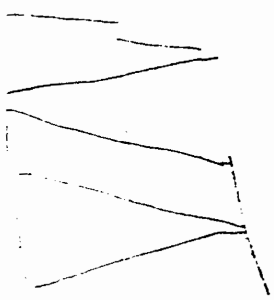
Part 4 :

Compute the total delay in transmitting an X-bit message (i.e. the message length is X bits) over a k-hop path using each of the following two technologies:

Case 1: Circuit Switching Technology

Assume the following:

Circuit set-up time = "S" seconds
Propagation delay per hop = "d" seconds



Case 2: Connection-less Packet Switching Technology

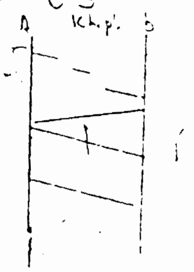
In this case assume that the X-bit message is broken into several packets, each with size "p" (how many of them?, ignore overhead). Assume that the packet switched network is lightly loaded (i.e. ignore Queuing delay, ignore processing delay. The propagation delay is "d" seconds per hop

For both cases assume that the data rate is "R" bits/sec

Under what conditions (find an expression) would the packet data network have a lower delay? $\Rightarrow T_2 < T_1$

Clearly illustrate the timing diagram for each of the above two cases

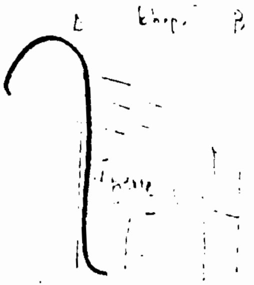
<1> CS



$$T_{delay} = T_{setup} + T_{trans} + T_{de}$$
$$= S + \frac{X}{R} + k \times d$$

-3

<ii> CNLS



$$T_{delay\,total} = T_{trans} + T_{delay}$$
$$= \frac{p}{R}\left\lceil\frac{X}{p}\right\rceil + (k-1)\frac{p}{R} + k \times d$$

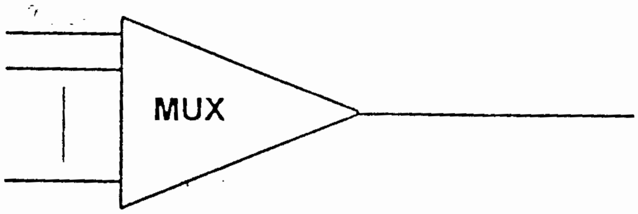
where $\lceil\frac{X}{p}\rceil$ is the upper ceiling of the integer

Condition: if p is good enough ... message can be divided into maximum small packet then $T_{delay\,total}$ can be lower, ... we need consider the Overhead.

condition: $(k-1)\frac{p}{R} < S$

Part 5 :

Consider the following multiplexer



Assume that you have ten input devices. Each input device, when active , generate traffic at a rate of 9600 bps. Input devices are active only 50% of the time.

Case 1: Assume that the multiplexer is a TDM. What is the required capacity of the output line assuming that 4% of the output capacity is used for framing (i.e. overhead) purposes

Case 2: Now assume that the multiplexer is a STDM. Each device, when transmitting, must identify itself with an address (overhead). The ratio of overhead bits to the data bits is 50%. What is the required capacity of the output line in this case

1. TDM: The data capacity of ten input $= 10 \times 9600 = 96\text{k bps} \leftarrow$ 96% of output capacity

So the Output Capacity $= \dfrac{96k}{0.96} = \underline{100\text{k bps}}$ $\dfrac{96000}{1-0.04}$

2. STDM: The Rate of data with OH $= 9600(1+0.5) = 14400$ bps

but each input devices are active only 50% of the time

So

$C = 10 \times 0.5 \times 14400$
$= \underline{72\text{k bps}}$

$9600 \times 1.5 \times 10 \times 0.5$

the required capacity of the output line is 72k bps

Spring Mid

Solutions to EE450 MidTerm

① F, T, T, F, F, T, T, T, F, F, T, T, T, T, F, F, F, T, F, F

② Internet, Trunks, Session, Bit stuffing, Syntax-Semantics-Timing, Services, flow control, Automatic Repeat Request, Connection-less, Packet, Presentation, Throughput-Delay, Baseband.

③ Case 1. Total Delay $= 3\left[\frac{1600+48}{64,000}\right] + .01 = 87.25 \text{ msec}$

utilization $= \frac{(3)(1600/64000)}{0.08725} \simeq 86\%$

Data + Ack's process time.

Case 2: Total Delay $= 3\left[\frac{1600+48}{64,000} + 2(0.01) + 2(0.05) + \frac{48}{64000}\right] = 439.5 \text{ msec}$

utilization $= \frac{(3)(1600)/64000}{0.4395} \simeq 17\%$

④ Case a CS Delay $= S + \frac{X}{R} + Kd$

case b PS (connection less) Delay $= \frac{X}{R} + (K-1)\frac{P}{R} + Kd$

Part C Condition $(K-1)\frac{P}{R} < S$

⑤ Case 1 TDM $C = \frac{(10)(9600)}{1-0.04} = 100,000 \text{ bps}$

Case 2 STDM $C = (10)(9600)(0.5)(1+0.5) = 72,000 \text{ bps}$

Part 1: True or False. Fall 1999 Part 3 ~ 末?

Note that if the statement is not fully true, your answer should be false.

False 1. In shared LANs, the activity of one station can not impact the other stations since all stations are peer stations

True 2. As the error rate increases, the effective data rate decreases

False 3. An even parity can correct all even number of errors but it can't detect odd number of errors odd only

False 4. A 1200 baud line can transmit at most 1200 bits per second bps least

False 5. TCP/IP protocol suite is used only over the Internet (LANs also)
Transmission Control Protocol Internet protocol

True 6. Digital data transmission can provide higher data rates than is possible with analog transmission

True 7. Network topology is a term given to describe the physical arrangements of nodes in a network

False 8. A data link protocol that uses both positive and negative acknowledgements does not have to use time-outs

Medium Access control

True 9. MAC procedures are used in shared LANs to describe the way each station gains access to the transmission medium

Time Division Modulation

False 10. In TDM, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

statistic

True 11. In STDM, Host ports can be shared

True 12. STDM can support more terminals than TDM for the same link speed

壓縮

True 13. Data is transmitted more efficiently when compressed

True 14. Virtual circuits can be found in connection-oriented packet switched networks trans. ← Network related Layer

False 15. One of the functions of the IP layer in the TCP/IP suite is to assure end-to-end packet delivery across the network trans. network should be node-to-node

False 16. The OSI model is an international standard for designing networks
The OSI model doesn't tell you how to design your network.

True 17. Routing of data from node to node is the function of the network layer of the OSI model

False 18. The DLC layer is responsible for generating frames for transmission across a switched-WAN wide-Area Network

packet

False 19. You are logged into a computer. You want to log into a second computer to read your e-mail there. You need an SMTP (Simple Mail transfer Protocol) application.

Telnet

False 20. The protocol used when a browser requests a webpage from a webserver is called HTML

(HTTP)

1, 2, 4.2, 4.3, 5.2, 6.1, 6.2, 6.3, 6.4,

7.1, 7.2, 7.3, 8.1, 9.1, 12.1, 12.2, 12.3, 12.4, 13.1

+ Appendix 6A

Part 2: Fill in the Blank

a) The Internet is a large collection of independent packet networks linked together via routers

b) Trunks are the shared facilities connecting nodes in WANs

c) The most widely used topology in LANs is the Hub topology

d) polling / selecting is a protocol used in a master/slave multi-point link configurations

不懂

e) The elements of any protocol are Syntax, Semantics and Timing

f) Each layer in the OSI model provides services to the layer above it

g) Flow control is the mechanism by which the receiver can prevent the transmitter from overwhelming it with data

h) ARQ is the most widely used procedure in data links for error control.

It stands for Automatic Repeat reQuest

不连才近?

data-gram

i) In Connection-less service, the service provider (i.e. the network) does not guarantee the delivery of packets in the same order in which they were transmitted.

j) The unit of data in the network layer is called a packet

k) The presentation layer is responsible for message encryption

l) The two most important performance measures in a packet data networks

产量

are the Throughput and Delay

m) In LANs, Baseband signaling is used where the digital signal is inserted directly into the medium without the need of modems

physics → raw stream of bits.

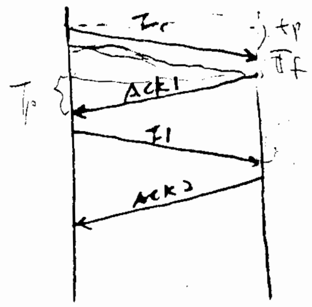
Part 3 :

Frames are to be transmitted over a 3000-km T1 link (1.544 Mbps). The propagation delay is 6µ second/km. Each frame is 560 bits long (48 bits of overhead and 512 bits of payload). Acknowledgement frames are 48 bits long.

a) Assume a Stop & Wait ARQ Protocol is used. What is the total delay required to transfer a frame and what is the link utilization in this case. Illustrate a timing diagram. the link utilization. Assume the channel is perfect (no errors)

b) Now assume a continuous ARQ protocol is used. What is the minimum number of bits required for identifying frame sequence numbers for maximum link utilization? Again assume error-free transmission

(a)



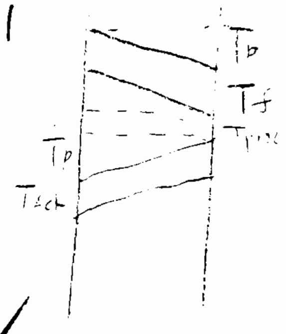
$T_p = 3\times10^3 \times 6\times10^{-6}$
$= 18\times10^{-3}$
$= 18\ ms$

$T_f = \frac{560}{1.544\times10^6} = 362.69\times10^{-6}$
$= 3.62\times10^{-4} = 0.36\ ms$

$T_{ack} = \frac{48}{1.544\times10^6} = 31\times10^{-6}$
$= 3.1\times10^{-5}$
$= 0.031\ ms$

⇒ Total delay

$= 2\times18 + 0.36 + 0.031$
$= 36.391\ (ms)$ ☆



$U = \frac{\frac{512}{1.544\times10^6}\times10^3}{36.391}$
$= \frac{512}{1.544\times10^3\times36.391}$
$= 9.11\times10^{-3}$
$= 0.911\ \%$ ☆

(b)

$a = \frac{T_p}{T_f} = \frac{18ms}{0.36ms} = 50$

$\Rightarrow N \ge 2a+1 = 101$

$\Rightarrow 2^7 \ge 101$

⇒ the minimum # of bits is 7 ☆

$Util. = \left(\frac{1}{1+2a}\right)N$

$N = 1+2a$

$N = (1+2a)$

Part 4 :

Compute the total delay to transfer a message 10,000 characters long (each character is 8 bits) across a 3-hop communications path illustrated below in each of the following two cases:

A —— B —— C —— D

Assume that each link operate at a rate of 4800 bps. The propagation delay over each link is 20 msec

$T_p = 20$ msec

Case 1: Circuit Switching

Assume the call set-up time and the call release time is a combined 200 msec

Case 2: Connection-less Packet Switching

In this case assume that the message is broken into 20 equal length packets. Ignore Queuing delay, ignore processing delay.

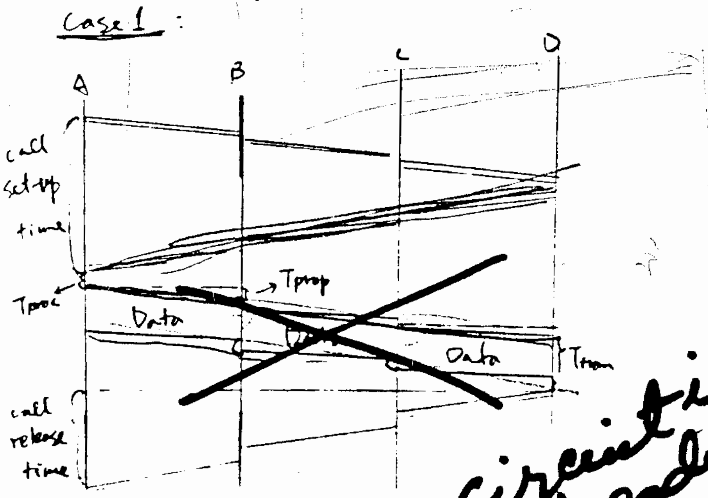
ch.9

Clearly illustrate the timing diagram for each of the above two cases. Label your diagrams with all delay components (even those you have neglected)

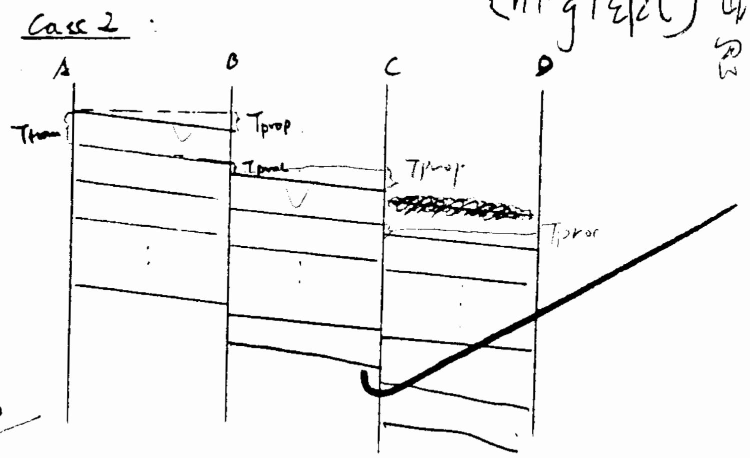
(neglect)

-3

Case 1 :



Case 2 :



circuit is already set!

total delay

$T_{setup} + T_{prop} + T_{tran}$

$= 200 + 3\times 20 + \frac{10\times10^3\times 8}{4.8\times10^3}\times10^3$

$= 260 + 16666$

$= 16926$ (ms)

For one packet $= \frac{10000}{20}$

$= 500$ chara/p

$\Rightarrow T_{tran} = \frac{500\times 8 \text{ bit}}{4800}$

$= 0.8333$ (sec)

$= 833.33$ ms

total delay

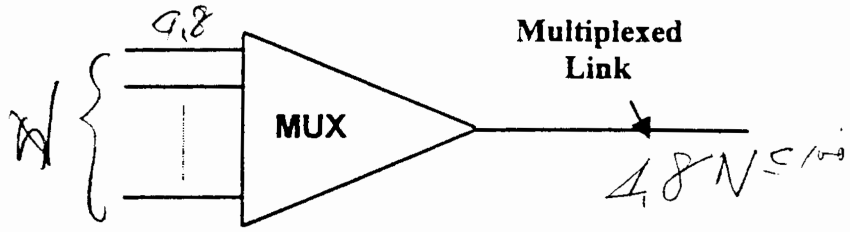
$= T_{prop} + T_{tran}$

$= 3\times 20 + (3-1)\times 833.33 + 20\times 833.33$

$= 18393.26$ (ms)

Part 5 :

Consider the following multiplexer



Assume that the capacity of the output link is 100 Kbps. Assume each terminal, when active, generates data at a rate of 4.8 Kbps.

a) Assume the multiplexer is a TDM. How many terminals can it support, assuming that the terminals are active 15% of the time? Repeat if the terminals are active 80% of the time. Neglect any framing overhead (i.e. assume that the multiplexed link utilization is 100%)

b) Now assume that the multiplexer is a STDM. Assume that the ratio of overhead bits (required to identify the address of each terminal) to the data bits is 75%. Assume that we want to limit the utilization of the multiplexed link utilization to 80%. How many terminals can the STDM support, assuming that the terminals are active 15% of the time? Repeat if the terminals are active 80% of the time

(a) ① $4.8\,N \le 100$

$N \le 20.8$

$\Rightarrow$ 20 terminals *

② ∵ in TDM

no change $\Rightarrow$ 20 terminals *

Active / don't care

OH Active Utilization

(b) ① $4.8\,N\,(1+75\%)\times 15\% \le 100\times 80\%$

$\Rightarrow 1.26\,N \le 80.$

$\Rightarrow N \le 63.49$

$\Rightarrow$ 63 terminals *

② $4.8\,N\,(1+75\%)\times 80\% \le 100\times 80\%.$

$\Rightarrow 6.72\,N \le 80$

$\Rightarrow N \le 11.9$

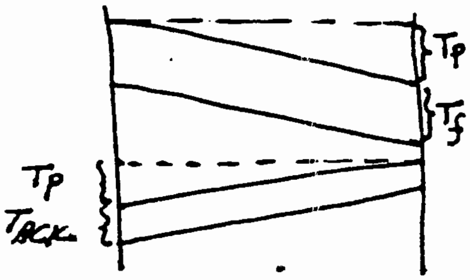
$\Rightarrow$ 11 terminals *

Solutions to Midterm EE450, Zahid

① F, T, F, F, F, T, T, F, T, F, T, T, T, T, F, F, T, F, F, F

② Internet, Trunks, Hub, Polling, Selecting, Syntax, Semantics, Timing
Service, Flow, Control, Automatic, Repeat, Request, CNLS,
Packet, Presentation, Throughput, Delay, Baseband

③



a) Total Delay $= T_f + 2T_p + T_{ACK}$

$$= \frac{560}{1.544M} + 2(6 \times 3000 \times 10^{-6}) + \frac{48}{1.544M}$$

$$= \boxed{36.39 \text{ msec}}$$

Link Utilization $= \frac{512/1.544M}{36.39 \text{ msec}} = \boxed{0.91\%}$

b) For Continuous ARQ

# of frames that can be transmitted before Ack

$$= \frac{2T_p}{T_f} \simeq 99.25 \Rightarrow \text{\# of Bits} = \boxed{7}$$

④ CS $D =$ Set up Delay $+ 3T_p + T_{Message}$

$$= .200 + 3(20 \times 10^{-3}) + \frac{(10{,}000)(8)}{4800} \simeq \boxed{16.93 \text{ sec}}$$

CNLS $D = (20+2)\left(\frac{4000}{4800}\right) + 3(20 \times 10^{-3}) \simeq \boxed{18.39 \text{ sec}}$

For Diagrams, See page 260 (a, c)

⑤ TDM # of Terminals supported $= \frac{100{,}000}{4.8} \simeq$ 20 Terminals (regardless of their activities)

STDM # of Terminals supported $= \frac{(0.8)(100K)}{(0.15)(4.8K)(1+0.75)} \simeq$ 63 Terminals (for 15% activity)

$\simeq$ 11 Terminals for 80% activity

2000 spring

EE450 – Introduction to Computer Networks

Midterm solution

Mar 7, 2000

Problem 1 (6 points) Define the following terms.

a. (2 points) Piggybacking.

b. (2 points) Encapsulation.

c. (2 points) Datagram.

Solution a. Use data packet frame to send ack back.

b. Add headers as data goes down protocol stack.

c. Transmission unit in a datagram (connectionless) service.

Problem 2 (15 points) Enumerate

a. (2 points) Examples of unguided media.

b. (2 points) Differences between synchronous and asynchronous transmission.

c. (3 points) Differences between flow control and congestion control.

d. (4 points) Advantages and disadvantages of round-robin and contention MAC protocols.

e. (4 points) Two static routing metrics and two dynamic ones.

Solution a. Microwave, radio, infrared.

b. Asynchronous transmission requires start and stop bits for synchronization. Synchronous needs synchronous clocks between sender and receiver, or separate clock or embedded clock in signal.

c. Flow control avoids sender to overrun receiver while congestion control ensures total traffic can be handled by network.

d. Round-robin: (+) Fair, performs well under heavy load and stream traffic. (-) requires complex management (token maintenance etc), not efficient under light load or bursty traffic. Contention MAC protocols: (+) simple, no maintenance, etc. (Just the opposite of round-robin).

e. Static: hop count, propagation delay. Dynamic: queue length, available bandwidth.

Problem 3 (4 points) Suppose that data is generated in the form of an analog signal and will be transmitted over analog medium.

a. (3 points) Why would you encode such signal for transmission?

b. (1 points) How is this encoding process called?

Problem 6 (10 points) In stop-and-wait protocol, frame size is 1000 bits and the bit rate is 4Mbps. End-to-end delay is 50 μs. Suppose probability of frame error is 0.1. Assume the ACK and negative ACK has negligible length.

a. (3 points) What is the probability of k retransmissions of a frame?

b. (4 points) What is the expected number of transmissions of a frame?

c. (3 points) What is the average time delay before a frame is correctly received and acknowledged?

Solution a. For $k = 0, 1, 2 \ldots$, the probability of k retransmission of a frame is $(0.1)^k(0.9)$.

b. Expected number of transmissions of a frame is

$$\sum_{j=1}^{\infty} j(0.1)^{j-1}(0.9)$$

Two different methods of calculating the above sum was shown in discussion and HW solution, and yet there is a third one.

Suppose $|p| < 1$. The sum $\sum_{j=1}^{\infty} jp^{j-1}$ converges and let's denote the sum by S. Then

$$S = 1 + 2p + 3p^2 + 4p^3 + \ldots$$
$$pS = p + 2p^2 + 3p^3 + \ldots$$

Subtracting the two equations, we get

$$(1-p)S = 1 + p + p^2 + p^3 + \ldots = \frac{1}{1-p}.$$

Therefore

$$S = \frac{1}{(1-p)^2}.$$

The expected number of transmission is equal to

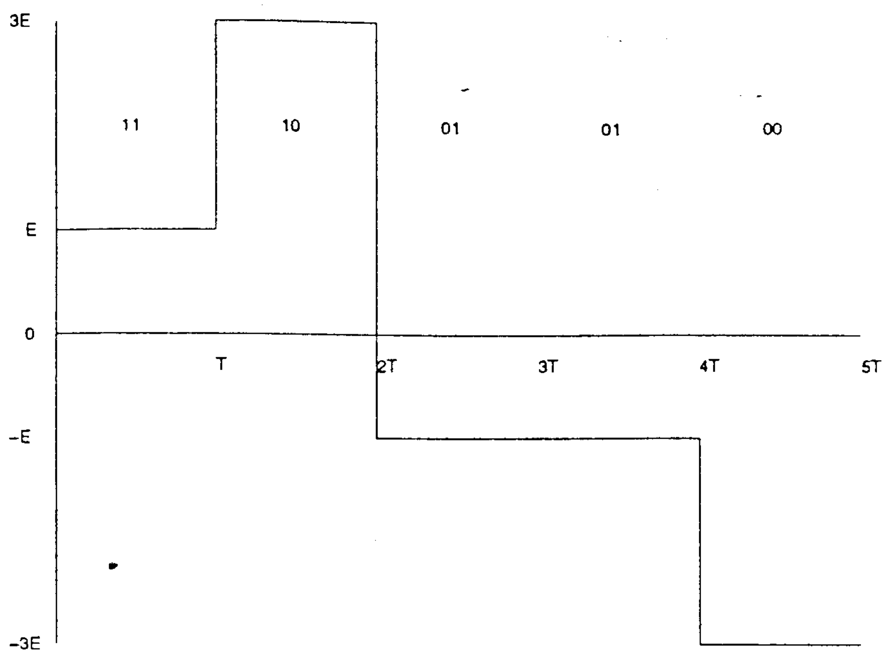
$$0.9\sum_{j=1}^{\infty} j(0.1)^{j-1} = 0.9\frac{1}{(1-0.1)^2} = \frac{1}{0.9}$$

c. Each transmission (including transmission time and waiting time for ACK) requires

$$\frac{1000\text{bits}}{4\text{Mbps}} + 2 \cdot 50\mu s = 0.35ms.$$

Hence the average time delay for a frame is

$$\frac{1}{0.9}0.35ms \approx 0.39ms.$$



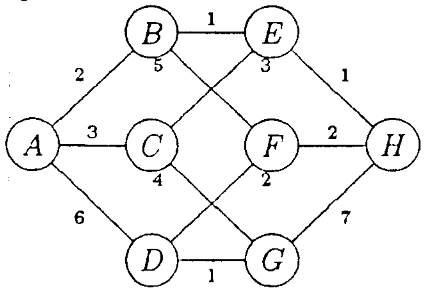
Problem 10 (10 points) In a channel of bandwidth 6kHz, what is the maximum achievable bit rate if the S/N ratio is equal to 13 dB.

Solution By Shannon's theorem,

$$\text{Capacity} = 6000 \log_2(1 + 10^{1.3}) = 26.3\text{kbps}$$

Problem 11 (18 points) Consider the following computer network where each node represents a router and the edge label is the corresponding link cost. The routing protocol used is link-state.

a. (9 points) Find the shortest path from router B to router G. Show all your work.



b. (9 points) Suppose the link between router D and router F is down. Describe how the link-state protocol handles it. What is the shortest path from B to G now (your solution can be derived by inspection)?

University of Southern California
EE450: Introduction to Computer Networks
Midterm Exam, Thursday July 6
Summer Semester 2000

Name: Tseng, Kuo-Ming **Location:** [illegible]

Student ID: 603-13-6896

Part 1	20%	14
Part 2	20%	12
Part 3	15%	15
Part 4	15%	8
Part 5	20%	20
Part 6	10%	0
Total	100%	

69

Notes:

- All your answers should be on the exam paper.
- There are 8 Pages, including cover sheet, in this exam
- You can work the problems in any order you wish (the goal is to try to accumulate as many points as you can).
- Try your best to be clean, and to show all the steps of your work

Rules:

- This is a closed book, closed notes exam. You are only allowed one 4"x6" post card of formulas only and a Calculator
- Adherence to the University's Code of Ethics will be strictly monitored and enforced. Academic Integrity violations, such as cheating, will result in a series of actions and penalties including the student failing the class.

Part 1: True or False.

-6

F 1. Data is transmitted more efficiently when encrypted

F 2. A T-1 line can support 32 voice calls each at 64 kbps

F 3. The transport layer is responsible for establishing end-to-end routing

T 4. A 1200 baud line can support at least 1200 bits per second

F 5. Some of the functions of the presentation layer are displaying, formatting and editing user inputs and outputs

F 6. The DLC layer is responsible for generating frames for transmission across a switched-WAN

T 7. A media access protocol describes the way in which a networked station gains access to the medium for transmitting data.

F 8. In TDM, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

F 9. Four-wire circuits are used for FDX transmission

T 10. A CRC (or FCS) is a technique used over data links to prevent errors

F 11. 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 12. An ARQ procedure that uses both positive and negative acknowledgements does not have to use time-outs

T 13. As the error rate increases, the effective data rate decreases

F 14. You are logged into a computer. You want to log into a second computer to read your e-mail there. You need an SMTP (Simple Mail transfer Protocol) application.

F 15. TCP is a end-to-end reliable protocol that requires acknowledgement for every packet transmitted

F 16. In shared LANs, the activity of one station can not impact the other stations since all stations are peer stations

✓ T 17. In Connectionless services, the switch has to make a switching decision for each and every packet.

X F 18. A message between adjacent layers in the OSI model is generically called a PDU

✓ T 19. In general, STDM can support more terminals than TDM for the same link speed.

X T 20. For the world wide web, the browser can be considered as a client or server program

✓

8

Part 2: Fill in the Plank

a) Adjacent layers in the OSI model communicate via ---interface---, where as peer layers communicate via ---route--- ---protocols---

b) ---Trunks--- are the shared facilities connecting nodes in WANs

c) The physical arrangement of nodes and links is referred to as network ---transport--- topology

d) The elements of any protocol are ---syntax---, ---semantics--- and ---Timing---

e) Each layer in the OSI model provides ---service--- to the layer above it

f) ---Flow--- ---control--- is the mechanism by which the receiver can prevent the transmitter from overwhelming it with data

g) The ---sess--- layer is responsible of providing reliable end-to-end communications where as the ---session--- ---Trans--- layer is responsible of providing reliable node-to-node communications.

h) In ---back-on--- ---ARQ--- services , the service provider (i.e. the network) guarantee the delivery of packets in the same order in which they were transmitted.

i) The unit of data in the network layer is called a ---packet---

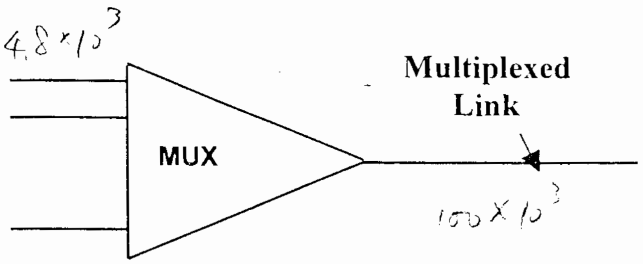
j) The ---session--- layer is responsible for determining the best path to route packets

k) The two most important performance measures in a packet data networks are the ---throughput--- and ---delay---

l) In LANs, ---baseband--- signaling is used where the digital signal is inserted directly into the medium without the need of modems

Part 3:

Consider the following multiplexer



Assume that the capacity of the output link is 100 Kbps. Assume each terminal, when active, generates data at a rate of 4.8 Kbps.

a) Assume the multiplexer is a TDM. How many terminals can it support, assuming that the terminals are active 15% of the time? Repeat if the terminals are active 80% of the time. Neglect any framing overhead (i.e. assume that the multiplexed link utilization is 100%)

b) Now assume that the multiplexer is a STDM. Assume that the ratio of overhead bits (required to identify the address of each terminal) to the data bits is 75%. Assume that we want to limit the utilization of the multiplexed link utilization to 80%. How many terminals can the STDM support, assuming that the terminals are active 15% of the time? Repeat if the terminals are active 80% of the time

(a) (1) $4.8 \times 10^3 \times N = 100 \times 10^3$

$N \doteq 20.83$

So, 20 terminals can it support

(2) active 15% or active 80% will not affect the number of terminals it can support. So the answer is still 20.

(b) (1) $\frac{\text{overhead bits}}{\text{data bits}} = 75\%$

$U = 80\%$

$15\% \times 4.8 \times 10^3 \times N(1+75\%)$

$= 100 \times 10^3 \times 80\%$

$1.26N = 80$

$N = 63.49$ 63 terminals

(2)

$80\% \times 4.8 \times 10^3 \times N \times (1+75\%)$

$= 100 \times 10^3 \times 80\%$

$6.72N = 80$

$N = 11.90$

11 terminals

Part 4 :

$T_{prop} = 20\times10^{-6}$ sec $\quad 10\times10^{6}$

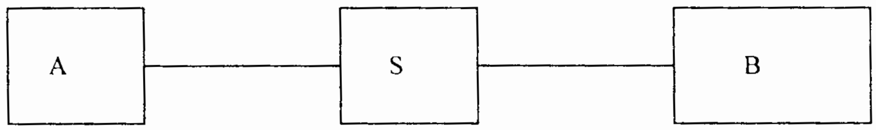
Hosts "A" and "B" are each connected, via 10 Mbps error-free links, to a packet switch "S". The propagation delay in each link is 20 μ seconds. The switch begins transmitting a packet 35 μ seconds after it has finished receiving it. Calculate the total time required to transmit 10,000 bits from "A" to "B" and the throughput in each of the following two cases:

a) As a single packet ?? T_{prop}

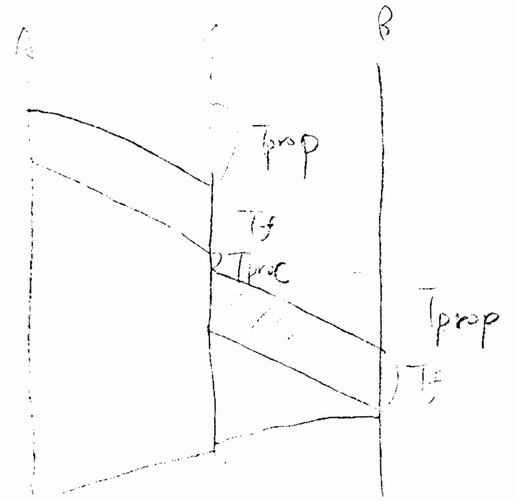
b) As two packets, each 5000 bits long, sent one right after the other.

Throughput

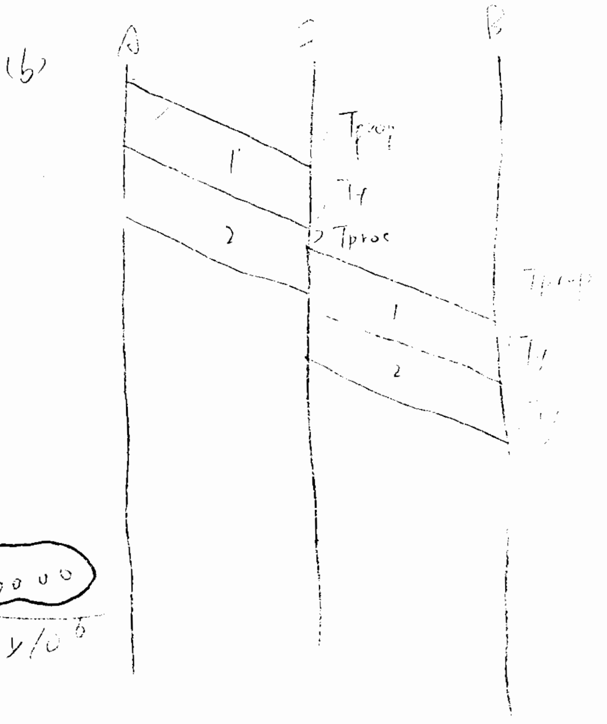
In each case, sketch and label clearly the timing diagrams



(a)



(b)



Time = $T_{prop} + T_{proc} + T_f$

$= 2\times20\times10^{-6} + 35\times10^{-6} + 2\times\frac{10000}{10\times10^{6}}$

$= 75\times10^{-6} + 2\times10^{-3}$ X

$= 20075\times10^{-6}$

$= 20075$ μ seconds

X

Total time $= 2\times20\times10^{-6} + 35\times10^{-6} + \cancel{3\times\frac{10000}{10\times10^{6}}}$

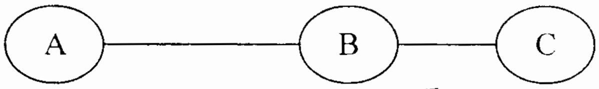
$= 30075\times10^{-6}$

$= 30075$ μ seconds

X

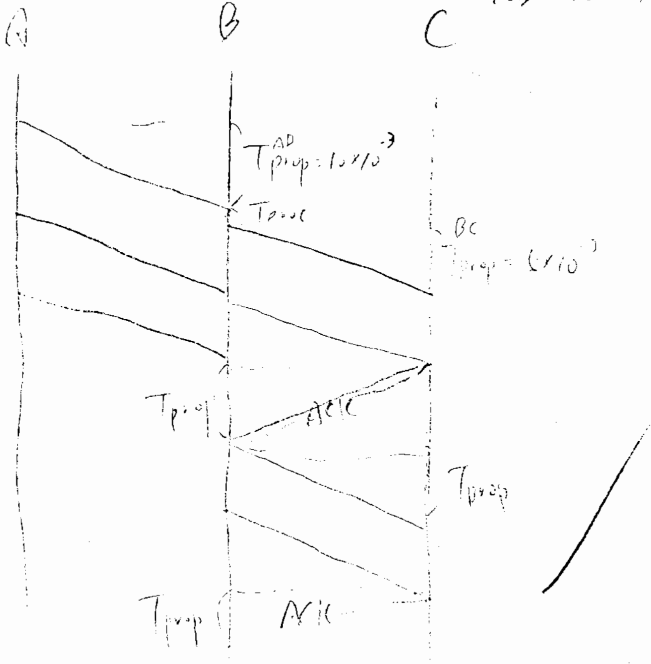
Part 5:

Suppose that node A sends information to node C over a two-hop path through node B as shown below. The propagation delay over the path A-B is 10 msec and the propagation delay over the path B-C is 5 msec. The data rate over the path A-B is 100 kbps. All data frames are 1000 bits long. Acknowledgement frames are of negligible length. Assume that both links are error-free. Between A and B a sliding window protocol of size 2 is used where as a Stop and Wait protocol is used between B and C. Both links are error-free. What is the minimum transmission rate required between nodes B and C to prevent the buffer at node B from flooding?



AB $T_{prop} = 10\times10^{-3}$ sec   BC $T_{prop} = 5\times10^{-3}$ sec

$R_{AB} = 100\times10^{3}$ bps



$$10\times10^{-3} + \frac{2\times1000}{100\times10^{3}} = 4\times5\times10^{-3} + \frac{1000}{R}\times2$$

$$0.03 = 0.02 + \frac{2000}{R}$$

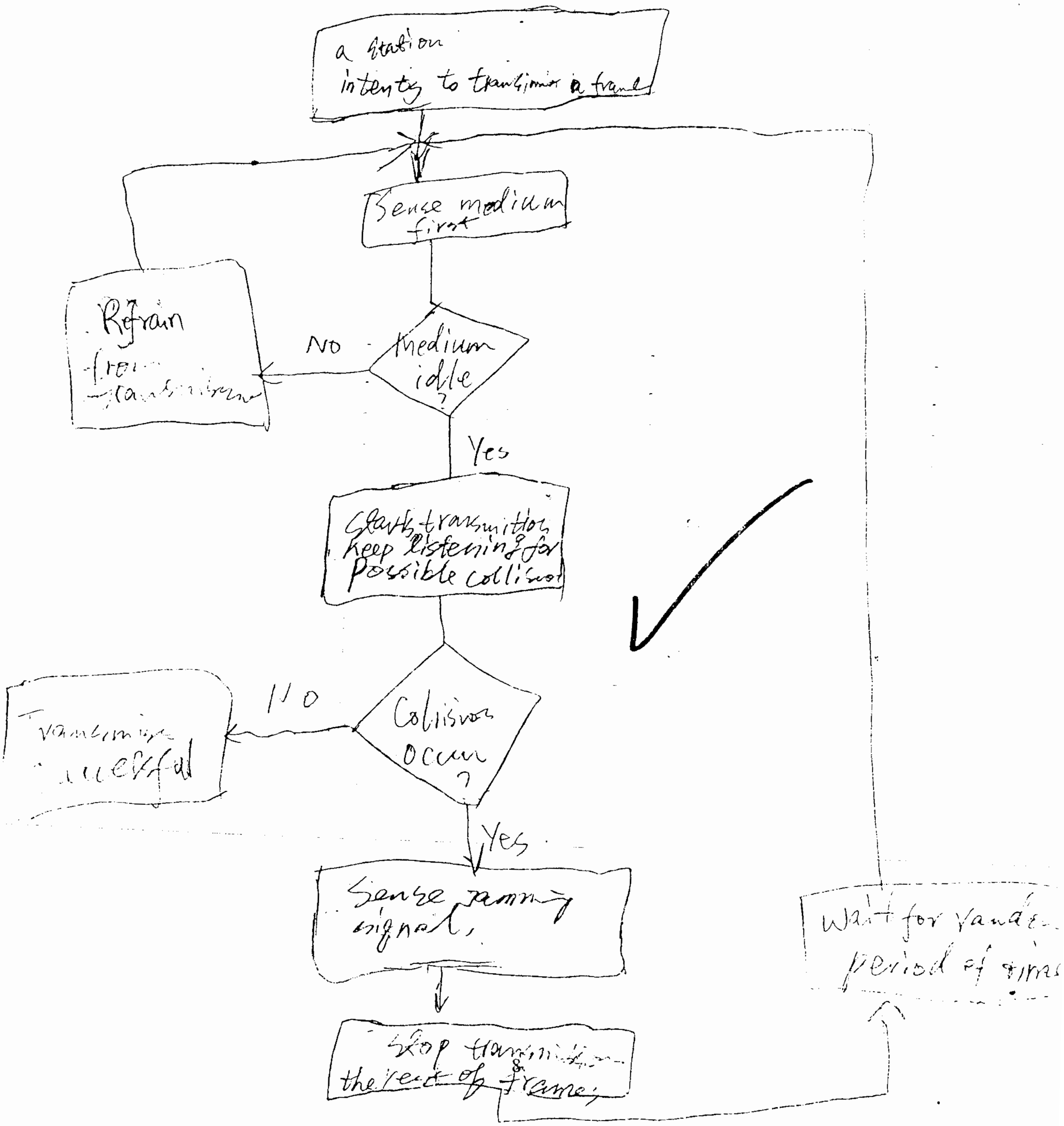
$R > 200000$ bps

Part 6:

Sketch and clearly label a flow chart describing the Carrier Sense Multiple Access/Collision Detection (CSMA/CD) used in IEEE802.3. Explain clearly why there are minimum and maximum limits on the size of the IEEE802.3 frame size. Theoretically, how many MAC addresses can we have? How many types could a destination MAC address be?

Part 6:

Sketch and clearly label a flow chart describing the Carrier Sense Multiple Access/Collision Detection (CSMA/CD) used in IEEE802.3. Explain clearly why there are minimum and maximum limits on the size of the IEEE802.3 frame size. Theoretically, how many MAC addresses can we have? How many types could a destination MAC address be?



Answers to Midterm

Part 1: F, F, F, T, T, F, T, F, F, F, T, F, T, F, T, F, T, T, T, F

Part 2: Interfaces, Protocols, Trunks, Topology, Syntax, Semantics, Timing, Services, Flow, Control, Transport, Data, Link, Virtual, Circuit, Packet, Network, Throughput, Delay, Baseband.

Part 3

a) TDM: $N = \frac{100K}{4.8K} \simeq 20$ Terminals (regardless of activity)

b) STDM: $N = \frac{(0.8)(100K)}{0.15\,(4.8K)(1+0.75)} \doteq 63$ Terminals

$N = \frac{(0.8)(100K)}{(0.8)(4.8K)(1+0.75)} \doteq 11$ Terminals

Part 4: a) End-to-End Delay $= 2T_f + 2T_p + T_{proc}$

$$= 2\left(\frac{10^4}{10^7}\right) + 2(20) + 35$$

$$= \boxed{2.075 \text{ msec}}$$

Throughput $= \frac{10^4}{2.075} = \boxed{4.82\ \cancel{\text{msec}}\ \text{Mbps}}$

b) End-to-End Delay $= 3T_f + 2T_p + T_{proc}$

$$= 3\left(\frac{5000}{10^7}\right) + 2(20) + 35 = \boxed{1.575 \text{ msec}}$$

Throughput $= 10{,}000/1.575 = \boxed{6.349 \text{ Mbps}}$

Part 5

For Buffer @ B not to overflow,

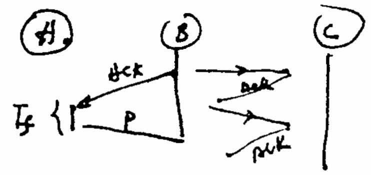
incoming rate = outgoing rate

$$\frac{2000 \text{ bits}}{(\underset{f_1}{10}+\underset{f_2}{10}+\underset{2P}{10})\,\text{msec}} = \frac{2000}{2\left(\frac{1000}{R_{BC}}\right) + 4(5\,\mu\text{sec})}$$

$$\Rightarrow R = 200\text{Kbps}$$

for B: 必须在一个时间内 (ACK + 2 Transfer + P) 把两frames传走。并删掉以腾出地方来！

B → C: 2Tr + 4P



Part 6

Flow Chart: Refer to notes

\# of MAC addresses $= 2^{48}$

Types of MAC addresses: Individual (unicast)
Multicast
Broadcast.

2000. 10. 19

2000 fall

-3

Part 1: True or False.

Note that if the statement is not fully true, your answer should be false.

T 1. The function of the network layer is to determine the best path to route packets.

F 2. FDX transmission requires 4 wires, i.e. 2 pairs since it implies that both sides can transmit simultaneously.

F 3. An even parity can detect all even number of errors where as an odd parity can detect all odd number of errors

F 4. In stop and wait ARQ, the receiver always send an acknowledgement frame each time it receives a frame with the wrong sequence number

F 5. TCP/IP protocol suite is used only over the Internet

T 6. Digital data transmission can provide higher data rates than is possible with analog transmission

F 7. If the generator polynomial is $g(x) = x^3 + x + 1$ and the information sequence is 1001, then the CRC is 101

F 8. A data link protocol that uses both positive and negative acknowledgements does not have to use time-outs

F 9. If the physical channel happens to be error-free, the data link layer is not needed.

F 10. In TDM, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

T 11. In TDM, for N signal sources, each frame contains at least N time slots where as in STDM, each frame contains M time slots where M is usually less than N.

T 12. STDM can usually support more terminals than TDM for the same link speed

F 13. Data is transmitted more efficiently when encrypted

T 14. In sliding window flow control, frames to the left of the receiver window are frames that are received and acknowledged.

F 15. For a sliding window of size n-1 (n is the sequence number), there can be a maximum of n frames sent but not acknowledged.

F 16. The OSI model is an international standard for designing networks

F 17. In sliding window flow control, if the window size is 63, then the range of the frames sequence numbers is 0~63

F 18. The DLC layer is responsible for generating frames for transmission across a switched-WAN

T 19. For stop and wait flow control, for N data frames sent , N acknowledgments are needed

F 20. The protocol used when a browser requests a webpage from a webserver is called HTML

Part 2: Fill in the Plank

a) The ------Internet------------ is a large collection of independent packet networks linked together via routers

b) ------Trunks------------ are the shared facilities connecting nodes in WANs.

c) Flow control is needed to prevent the overflow of the ---receiver--- buffer.

d) The retransmission of damaged or lost frames in the data link layer is known as ---------------- ----------------
Error (selective) control (repeat)

e) The elements of any protocol are ----syntax--------, ----semantics-------- and ------timing------

-4

f) Each layer in the OSI model provides -----service----------- to the layer above it

g) Regulation of the rate of transmission of data frames is known as ---------------- ---------------------------
control Flow

h) In connection-oriented packet switching, a ----Virtual-------------- -----Circuit----------- is set-up prior to transmission of packets

i) In ---connectionless---------- service , the service provider (i.e. the network) does not guarantee the delivery of packets in the same order in which they were transmitted.

j) The unit of data in the data link layer is called a -----frame-----------

k) The two most important performance measures in a packet data networks are the -----Throughput------- and -----delay-----------

l) In the OSI model, the -----transport------ layer is responsible for providing end-to-end reliable communications, where as the -------data--------- --------link--------- layer is responsible for providing node-to-node reliable communications

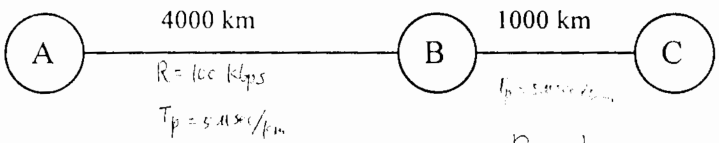
Part 3 :

In the figure shown below, frames are generated at node A and transmitted to node C through node B. Determine the minimum transmission rate required between nodes B and C so that the buffer at node B is not flooded, based on the following

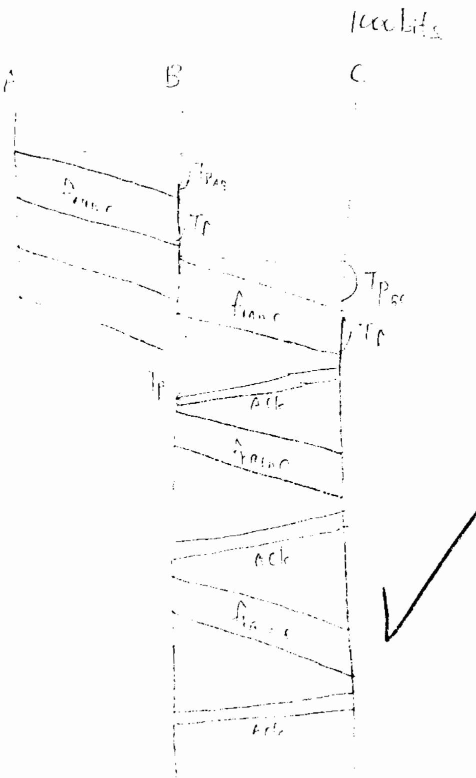
- The data rate between A and B is 100 kbps
- The propagation delay over each link is 5μsec/km
- Links are FDX and error-free
- All data frames are 1000 bits long. Acknowledgement frames are of negligible lengths
- Between A and B a sliding window protocol with window size 3 is used
- Between B and C, a stop and wait protocol is used

Show your solution in detail (I am not interested in answers only)

Hint: In order not to flood the buffer at B, the average number of frames entering and leaving B must be the same over a long interval



R = transmission rate of B-C



total delay of A-B

$= T_{p_{AB}} + 3T_f$

$= 5\times10^{-6}\times4\times10^3 + 3\cdot\frac{1000}{100\times10^3}$

$= 20\times10^{-3} + 30\times10^{-3}$

$= 50\times10^{-3}$

$= 50$ ms

total delay of B-C

$= (2T_{p_{BC}} + T_f)\times3$

$= 3\left(2\times5\times10^{-6}\times10^3 + \frac{1000}{R}\right)$

$= 3\left(10\times10^{-3} + \frac{1000}{R}\right)$

$= 30\times10^{-3} + \frac{3000}{R}$

$\therefore 50\times10^{-3} = 30\times10^{-3} + \frac{3000}{R}$

$\frac{3000}{R} = 20\times10^{-3}$

$\therefore R = 150000$ bps $= 150$ kbps

Part 4 :

Compute the total delay to transfer a message 10,000 characters long (each character is 8 bits) across a 3-hop communications path illustrated below in each of the following two cases:

$10000 \times 8 = 80000$ bits

Assume that each link operate at a rate of 4800 bps. The propagation delay over each link is 20 msec

Case 1: Circuit Switching

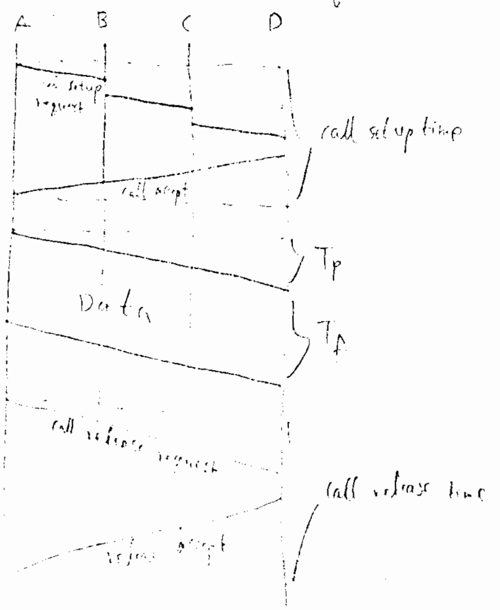
Assume the call set-up time and the call release time is a combined 200 msec

Case 2: Connection-less Packet Switching

In this case assume that the message is broken into 20 equal length packets. Ignore Queuing delay, ignore processing delay.

Clearly illustrate the timing diagram for each of the above two cases. Label your diagrams with all delay components (even those you have neglected)

Case 1 Circuit switching



total delay

$= 200\times10^{-3} + T_p + T_f$

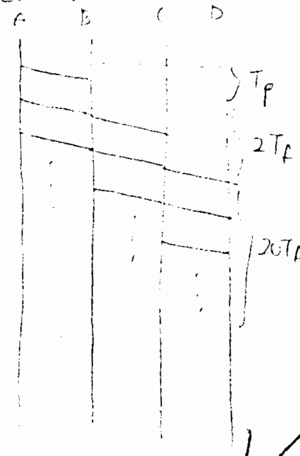
$= 200\times10^{-3} + 3\times20\times10^{-3} + \frac{8\times10^4}{4800}$

$= 260\times10^{-3} + 16.667$

$= 16.927$ sec

Case 2 CNLS

$\frac{80000}{20} = 4000$ bits per pa



total delay

$= T_p + (3-1)T_f + 20T_f$

$= T_p + 22T_f$

$= 3\times20\times10^{-3} + 22\times\frac{4000}{4800}$

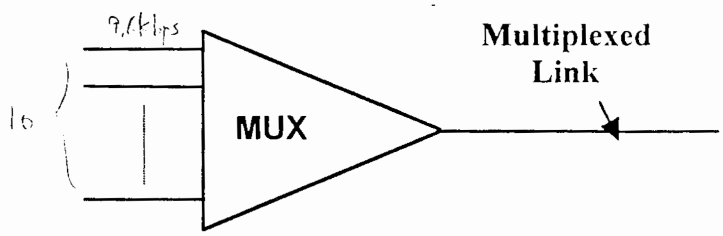
$= 60\times10^{-3} + 18.333$

$= 0.06 + 18.333$

$= 18.393$ sec

Part 5 :

Consider the following multiplexer



2

Ten 9.6 Kbps lines are to be multiplexed as shown above

a) Assume the multiplexer is a TDM. What is the capacity of the multiplexed link assuming that the terminals are active 15% of the time? Repeat if the terminals are active 80% of the time. Neglect any framing overhead (i.e. assume that the multiplexed link utilization is 100%)

b) Now assume that the multiplexer is a STDM. Assume that we want to limit the average link utilization to 80%. What is the capacity of the multiplexed link assuming that the terminals are active 15% of the time? Repeat if the terminals are active 80% of the time.

(a) In TDM,

active 15% or active 80% will not affect. why!

R: capacity of the multiplexed link

$10 \times 9.6 \times 10^3 = R$

$\therefore R = 96$ kbps

(b) STDM

i) active 15%

$0.15 \times 10 \times 9.6 \times 10^3 = R \times 0.8$

$14400 = 0.8R$

$\therefore R = 18000$ bps

= 18kbps

ii) active 80%

$0.8 \times 10 \times 9.6 \times 10^3 = R \times 0.8$

$76800 = 0.8R$

$\therefore R = 96000$ bps

= 96kbps

2001 spring

University of Southern California
"EE450: Introduction to Computer Networks"
Midterm Exam
February 27, 2001

Name: YI-TIEN TUAN **Location:**

Student ID: 857-71-2058

Part 1	20%	15
Part 2	20%	20
Part 3	20%	19
Part 4	20%	16
Part 5	20%	20
Total	100%	[redacted]

90

excellent Thanks

Notes:

- All your answers should be on the exam paper. If you need extra papers, please write your name on each one of them
- You can work the problems in any order you wish (the goal is to try to accumulate as many points as you can)

Rules:

- This is a closed book, closed notes exam. You are only allowed one post card 4"x6" of formulas and a Calculator

- Adherence to the University's Code of Ethics will be strictly monitored and enforced. Academic Integrity violations, such as cheating, will result in a series of actions and penalties including the student failing the class.

Part 1: True or False.

Note that if the statement is not fully true, your answer should be false.

X T 1. If the signaling rate on a line is 2.4 Kbaud line and QPSK is used then the bit rate supported is ~~9.6~~ 4.8 kbps Kbps

T 2. A T1 is a FDX (Full duplex) digital service that requires two pairs of wires to support transmission in both directions simultaneously

T 3. 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

T 4. In stop and wait ARQ, the receiver always send an acknowledgement frame each time it receives a frame with the wrong sequence number

F 5. The capacity of a channel is the maximum ~~signaling~~ Data rate possible over the channel

F 6. As the bit rate of a digital signal increases ~~so does~~ the bit duration and the error rate

$R_b = \frac{1}{T_b}$ bit duration

T 7. If the generator polynomial is $g(x) = x^3 + x^2 + 1$ and the received sequence is 100100001 , then no errors are detected

F 8. A data link protocol that uses both positive and negative acknowledgements does ~~not~~ have to use ~~time-outs~~

T 9. Serial transmission can be either synchronous or asynchronous

F 10. In ~~TDM~~, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

statistical TDM

T 11 In STDM, the time-slot order of a frame depends on which device have data to transmit at that time.

F 12. TDM can usually support ~~more~~ less terminals than STDM for the same link speed

T 13. In a multipoint line configuration, three or more devices share a link

X T 14. The method used to handle error control depends on the method used for flow control

-5

F 15. For a sliding window of size n-1 (n is the sequence number), there can be a maximum of ~~n~~ frames sent but not acknowledged.

/F n-1

T 16. The network layer is responsible for the source-to-destination delivery of the ~~entire message~~ packet

/T

T 17. In sliding window flow control, if the window size is 63, then the range of the frames sequence numbers is 0~63

/F

T 18. A message between adjacent layers in the OSI model is generically called a PDU ?

asymmettic

T 19. The 56kbps modems are ~~asynchronous~~ in the sense they download data at rates of ~ 56kbps and send data at rates of ~ 33.6kbps

T 20. In STDM, the transmission rate of the multiplexed link is usually less than the sum of the bit rates of the attached devices

Part 2: Fill in the Plank

a) The ---Transport--- layer is responsible for the end-to-end reliable delivery of messages

√ b) A T1 line can support ---24--- voice channels

c) In ---Selective reject--- ARQ, when a NAK is received, only the specific damaged or lost frame is retransmitted

d) The ---topology--- of a network is the physical arrangement of the nodes

√ e) Shared facilities connecting switching nodes in WANs are commonly known as ---trunks---

f) Peer layers communicate via ---protocol---, where as adjacent layers communicate via ---~~interface~~--- service interface

g) Each layer in the OSI model provides ---service--- to the layer above it

h) The ---bandwidth--- of a signal is the range of frequencies the signal occupies spectrum

i) The unit of data in the network layer is called a ---packet---

j) The two most important performance measures in a packet data networks are the ---throughput--- and ---delay---

√ k) In the OSI model, the ---presentation--- layer ensures interoperability between communicating devices through transformation of data into a mutually agreed-upon format

l) A carrier signal can be characterized by three parameters. They are ---phase---, ---Amplitude--- and ---frequency---

m) In A/D conversion, three processes are involved, namely ---sampling---, ---quantization--- and ---encoding---

n) For the world wide web, the browser is considered as a ---client-based--- program

-1

Part 3:

Frames are to be transmitted over a 3000-km T1 link. The propagation delay is 6 μ second/km. Each frame is 560 bits long (48 bits of overhead and 512 bits of payload). Acknowledgement frames are 48 bits long.

a) Assume a Stop & Wait ARQ Protocol is used. What is the total delay required to transfer a frame and what is the link utilization in this case. Illustrate a timing diagram. Assume the channel is perfect (no errors)

b) Now assume a continuous ARQ protocol is used. What is the minimum number of bits required for identifying frame sequence numbers for maximum link utilization? Again assume error-free transmission

Show your solution in detail (I am not interested in answers only)

(a) Stop and Wait ARQ

$R_b = 1.544$ Mbps

3000 km

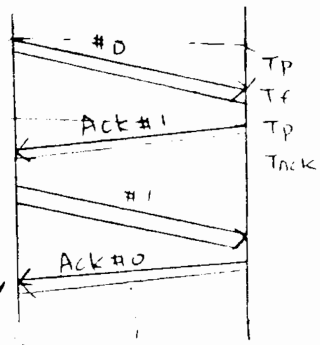
$T_p = 6 \times 10^{-6}$ sec/km

$T_p = 0.018$ sec

$T_{ACK} = \frac{48 \text{ bits}}{1.544 \times 10^6 \text{ bps}} = 31.08 \times 10^{-6}$ sec

$T_f = \frac{560 \text{ bits}}{1.544 \times 10^6 \text{ bps}} = 362.68 \times 10^{-6}$ sec

data $T = \frac{512 \text{ bits}}{1.544 \times 10^6 \text{ bps}} = 331.6 \times 10^{-6}$ sec



total delay time

$= T_p + T_f + T_p + T_{ACK}$

$= 2T_p + T_f + T_{ACK}$

$= 2 \times 0.018 + 0.00036 + 0.000031$

$= 0.0364$

Utilization (actual) $= \frac{t_f}{t_f + 2T_p + T_{ACK}}$

$= \frac{0.00033}{}$

$= 9\%$

(b) continuous ARQ

$\alpha = \frac{T_p}{T_f} = \frac{0.018}{0.000365} = 49.32$

$2\alpha = 98.448$

$2^7 > 98.448 > 2^6$

need 7 bits for identifying frame sequence numbers for max link utiliz

5

Part 4 :

Define the following parameters for a switching network:

-4

N: # of hops between two given end systems = 4
L: Message length in bits = 3200
B: Data rate in bps, on all links = 9600
P: Packet size in bits = 1024
H: # of Header bits/Packet = 16
S: Call set-up time (for CS and Virtual-CS cases only) in seconds = 0.2
D: Propagation delay per hop, in seconds = 0.001

one packet
: data : 1024 bits
header : 16 bits

Tp = 0.001 sec

without header:
$T_f = \frac{1024 \text{ bits}}{9600 \text{ bps}} = 0.107 \text{ sec}$

with header:
$T_f = \frac{1040 \text{ bits}}{9600 \text{ bps}} = 0.108 \text{ sec}$

a) Find the end-to-end delay in each of the following switching technologies. Ignore Processing delays and assume no acknowledgements, also ignore call-tear down in CS and VC cases.

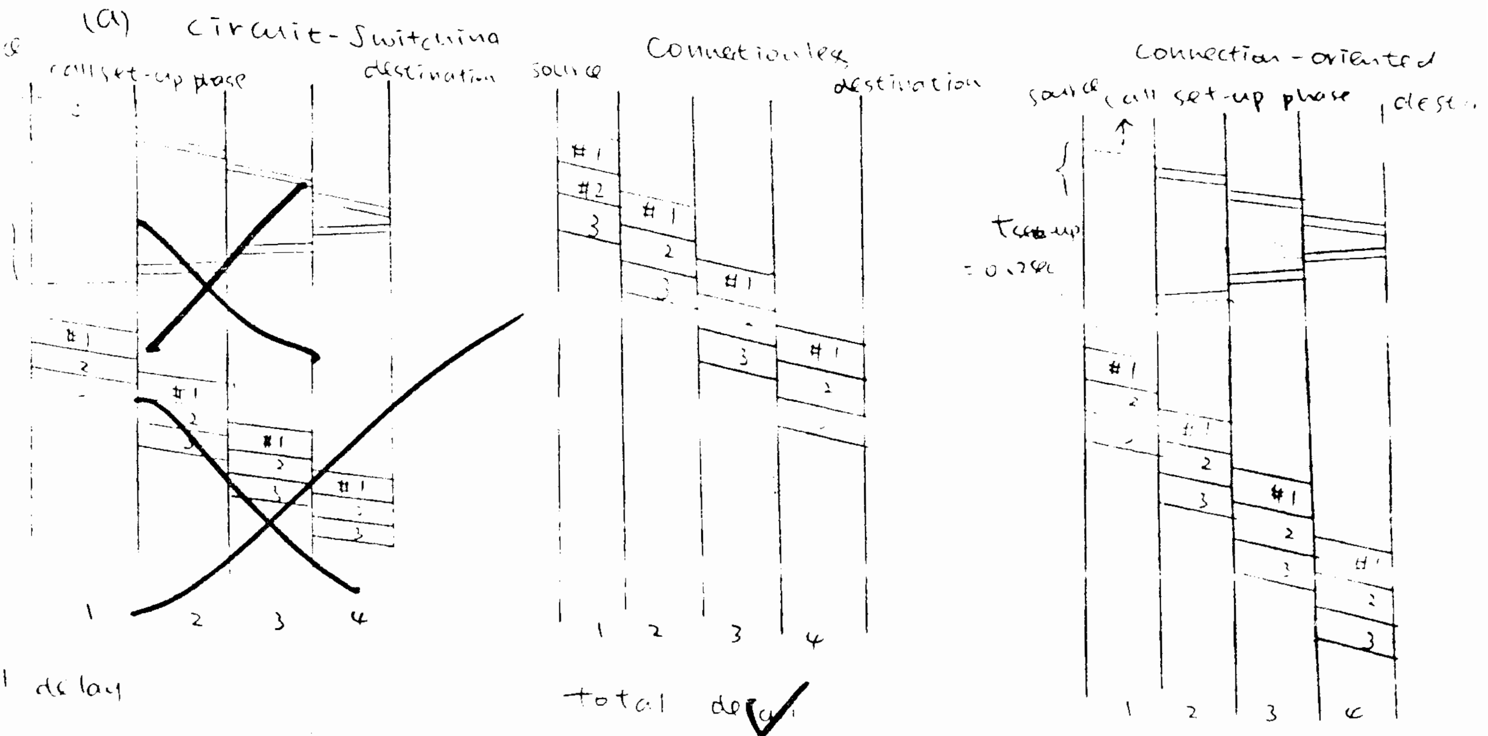
- Circuit-Switching
- Connection-less (Datagram) Packet Switching
- Connection-Oriented (Virtual Circuit) Packet Switching

Sketch and Label the Timing Diagram for each of the above cases.

b) List at least three differences between Connectionless Packet switching technology and connection-oriented Packet switching technology. For what type of applications is each suited for? → On the back side!

header

(a) Circuit-Switching



total delay

$= 4T_p + 3T_f + 3T_f + t_{setup}$

total delay

$= 4T_p + \cancel{3}T_f + 3T_f$

$= 0.652$ sec

delay

$= 4T_p + 3T_f + \dots$

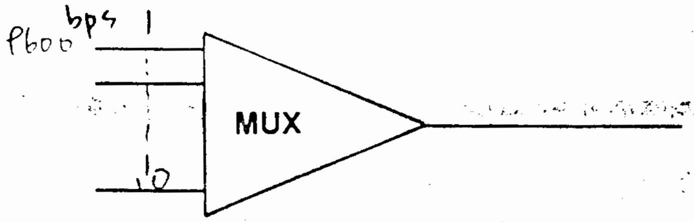
$= 0.004 + (6 \times 0.107) + 0.\dots$

for

connectionless	connection-oriented
1. no call set-up phase	need call setup phase and call tear phase
2. need add headers to packets to indicate (source + destination)	Once the phase is set, all the packets (from same message) follow by the same path. need a VCI (small bits) - Virtual circui identifier.
3. packets may recieved out of order (∵ every packet treats independently)	packets are all recieved in order
4. "Best Effort" no guarantee in delivery more flexible	Reliable delivery less flexible
Suites for: Small amount of data transmit mainly use in internet	large steady amount of data. Used in FR (frame Relay) ATM (Asynchronous transfer Model)

Part 5:

Consider the following multiplexer



Assume that you have ten input devices. Each input device, when active, generate traffic at a rate of 9600 bps. Input devices are active only 50% of the time.

Case 1: Assume that the multiplexer is a TDM. What is the required capacity of the output line assuming that 4% of the output capacity is used for framing (i.e. overhead) purpose.

Case 2: Now assume that the multiplexer is a STDM. Each device, when transmitting, must identify itself with an address (overhead). The ratio of overhead bits to the data bits is 50%. What is the required capacity of the output line in this case?

CASE 1. for TDM:

$$\frac{10 \times 9600}{(1-0{,}04)} = C \quad \Rightarrow C = 100000 \text{ bps} = 0{,}1 \text{ Mbps}$$

CASE 2. for STDM

$$9600 \times (1+0{,}50) \times 10 \times 0{,}5 = C$$

$$\Rightarrow C = 72000 \text{ bps} = 72 \text{ kbps}$$

2001 summer

√

University of Southern California
"EE450: Introduction to Computer Networks"
Midterm Exam, 8:$\underline{00}$ ~ 9:$\underline{40}$ AM
July 05, 2001

Name: XIANGRONG SHI Location: SAL 101 USC

Student ID: 887-30-7259

Part 1	20%	18
Part 2	20%	20
Part 3	20%	12
Part 4	20%	20
Part 5	20%	18
Total	100%	88

V. good!

Notes:

- All your answers should be on the exam paper. If you need extra papers, please write your name/ID on each one of them.
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Rules:

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Part 1: True or False.

Note that if the statement is not totally true, your answer should be false.

F 1. A 1200-baud line can support at most 1200 bits per second

F 2. When calculating the bit duration, it is necessary to ~~know~~ the number of bits to be sent

T 3. A modem controls the speed at which data bits can be transmitted but the bandwidth of the channel determines the maximum speed at which the data bits can be sent

-2

T 4. In stop and wait ARQ, the receiver always send an acknowledgement frame each time it receives a frame with the wrong sequence number

T 5. The capacity of a channel is the maximum data rate that we can transmit reliably over the channel. It is a function of the channel bandwidth and the SNR 公式 Shannon's Theorem $C = B \log_2(1+SNR)$

F 6. In a T-1 line, the number of overhead bits per second is 1

F 7. If the generator polynomial is $g(x) = x^3 + x + 1$ and the received sequence is 100100001 , then ~~no~~ errors are detected

F 8. If the physical channel happens to be error-free, the data link layer is ~~not needed.~~

F 9. Longer frames suffer from ~~longer~~ propagation delays than shorter frames

F 10. In ~~TDM~~, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

F 11 The DLC layer is responsible for generating frames for transmission across a ~~switched WAN~~ node to node

T 12. Statistical TDM can usually support more terminals than Synchronous TDM for the same link speed

F 13. Frame Relay is a connection-oriented packet switching technology that uses variable-size frames where as ATM is a connection-less packet switching technology that uses fixed size frames (cells)

F 14. In CRC error detection, the CRC generator pattern (polynomial) must be one bit less than the CRC

T 15. For a sliding window of size n-1 (n is the sequence number), there can be a maximum of n-1 frames sent but not acknowledged.

F /F 16. In baseband transmission, more than one signal can be transmitted on a single cable at any instant of time

T 17. In sliding window flow control, if the window size is 31, then the range of the frames sequence numbers is 0~31

T F 18. In Go-Back-N ARQ, when a NAK is received, all frames sent since the last frame acknowledged are retransmitted

T 19. In stop and wait ARQ, if frame #1 is received in error, the receiver will send NAK #1

T 20. In STDM, the transmission rate of the multiplexed link is usually less than the sum of the bit rates of the attached devices

Part 2: Fill in the Plank

a) The ---Transport------- layer in the reference OSI model is responsible for the end-to-end reliable delivery of messages

b) A synchronousT1 line can support ---24--- voice channels

c) In synchronous Data Link protocols, the procedure used to prevent the Flag pattern from occurring anywhere in the frame is called -~~Error~~ bit --- ~~Control~~ stuffing---

v (d) A 10BT ETHERNET LAN has a -hub-based--- topology

e) Peer layers communicate via -protocol---, where as adjacent layers communicate via ---interface-

v (f) Flow control is needed to prevent the -flooding--- of the receiver buffer

v g) The -Bandwidth- of a signal is the range of frequencies the signal occupies

h) The unit of data in the network layer is called a --packet-----

i) The two most important performance measures in a packet data networks are the -delay------ and --throughput-

v j) The retransmission of damaged or lost frames in the data link layer is one form of ----error---------- control mechanisms

k) A carrier signal can be characterized by three parameters. They are ~~Syntax~~ amplitude, ~~Semantics~~ frequency--- and ~~Timing~~------ phase

v l) In A/D conversion, three processes are involved, namely -sampling-, -Quantization and --Encoding------

v (n) The application layer protocol that allows you to browse the web is known as -Http------ (abbreviated)

-8

Part 3:

Computer A uses an ARQ protocol to send frames to Computer B. Frame length is 8000 bits and the transmission rate is 100 Mbps. The distance between A and B is 4000 Km and the speed of light is $3x10^5$ km/sec

a) Assume a Stop & Wait ARQ Protocol is used. How long will computer A be idle? Illustrate using a timing diagram. Ignore processing delay. Ignore ACK/NAK transmission delay. If the frame is successfully received the first time, what is the link utilization?

b) Now assume a continuous Go-Back N sliding window ARQ protocol is used. Assume the window size is 255. How long will computer A be idle in this case? Illustrate using a timing diagram What is the link utilization assuming error-free transmission? How many bits are required for frame sequencing?

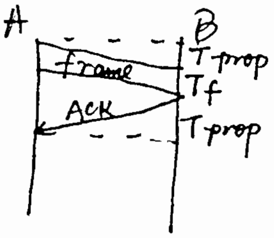
c) Now assume a window size of 15. Sketch the transmitting window after each of the following scenarios:

(正在傳送的 window. 不是 sender window 也不是 receiver window)

1. Computer A has sent frames numbered 0 through 11 and has received ACK # 8

2. Computer A has sent frames numbered 0 through 11 and has received NAK # 6

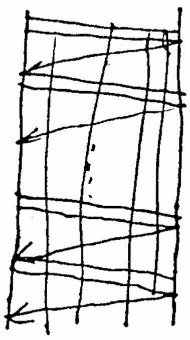
3. Computer A has sent frames numbered 0 through 14 and no ACK has been received and the time-outs have expired.



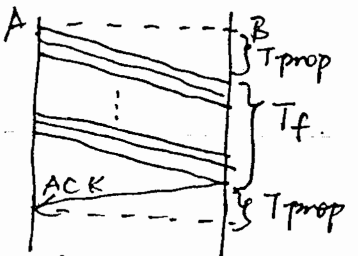
Total Time $= 2T_{prop} + T_f$

A idle time $=$ Total Time $- T_f = 2T_{prop} = 2 \times \frac{4000 km}{3 \times 10^5 km/sec} \approx 2\ldots$

Utilization $= \frac{\text{data transfer time}}{\text{total end-to-end time}} = \frac{8000/100Mbps}{2T_{prop} + T_f} = 0.3\%$.



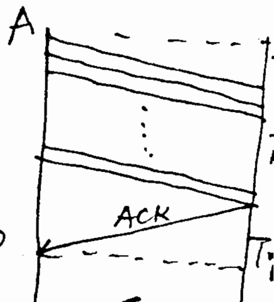
A idle time $= 2T_{prop} = \cancel{26.7 ms}$.



T_{total}

$\eta = \frac{T_f}{T_{total}} = \frac{T_f}{T_f + 2T_{prop}}$

$a = \frac{T_{prop}}{T_f}$ $\quad \eta = \frac{1}{1+a}$



$\cancel{\eta = \frac{255 \times 8000/100Mbps}{2T_{prop} + 255 \cdot 8000/100Mbps} = 33\%}$

~~W=255 (window size)~~ $2^8 = 256$, so 8 bits are needed for frame se…

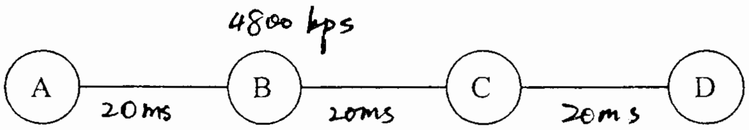
1. … 7 | 8 | 9 | 10 | 11 | 12 | 13 | … | 22 | 23 | 24 …
~~buffer position~~ ~~sliding window~~

2. … 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 … | 19 | 20 | 21
~~buffer position~~ ~~sliding window~~

(See back)

Part 4 :

Compute the total delay required to transfer a 80,000-bit long message across a 3-hop communications path illustrated below in each of the following two cases:



Assume that each link operate at a rate of 4800 bps. The propagation delay over each link is 20 msec

Case 1: Circuit Switching

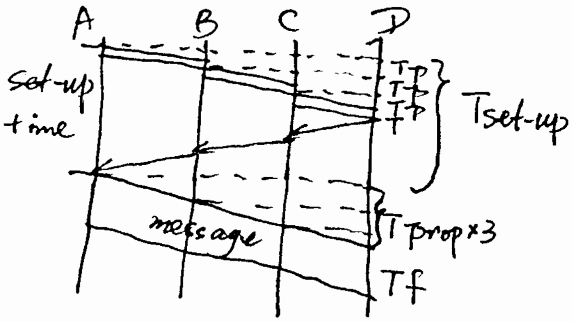
Assume the call set-up time and the call release time is a combined 200 msec

Case 2: Connection-less Packet Switching

In this case assume that the message is broken into 20 equal length packets. Ignore queuing delay, ignore processing delay.

For each of the above two cases, Clearly illustrate the timing diagram. Label your diagrams with all delay components you considered

Case 1 : CS.



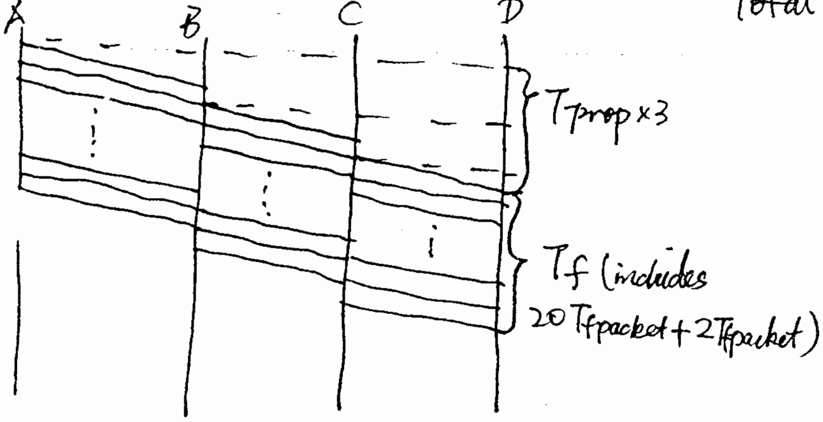
Total Delay = Tset-up + 3Tprop + Tf.

= 200msec + 3×20msec + 80,000/4800 bps

≈ 200 ms + 60ms + 16.667 s

≈ 16.927 s.

Case 2 : CNLS



Total Delay = 3 Tprop + 20 Tf(packet) + 2 Tf(packet)

= 3×20 msec + 20 × $\frac{80,000/20}{4800 \text{bps}}$ + 2 × $\frac{8000}{4800}$

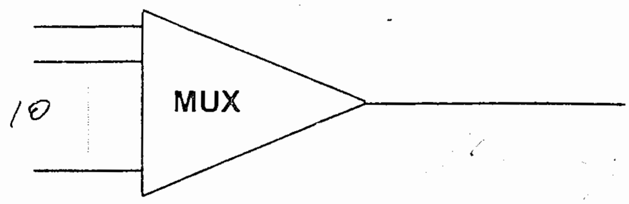
≈ 60 msec + 18.333 s

≈ ~~24.333 s~~ 18.393 s

-2

Part 5:

Consider the following multiplexer



Assume that you have 10 input sources as follows:

4 Four sources generates 1 Kbps, 75% of the time
3 Three sources generates 2 Kbps, 50% of the time
2 Two sources generates 8 Kbps ~~bits~~/sec, 100% of the time
1 One source generates 6 Kbps, 50% of the time

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 1 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?

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? Compare (and comment) with the data rate required for case 1.

Case 1: for synchronous TDM, time slots are pre-allocated, no matter the source is active or idle, so R_b will be the sum of all sources rates.

$R_b = 4 \times 1\text{Kbps} + 3 \times 2\text{Kbps} + 2 \times 8\text{Kbps} + 1 \times 6\text{Kbps} = 32\text{Kbps}$

When time slot = 1 Kbps, 10 bits long.

4 timeslots are assigned to Four sources 1Kbps. (1 time slot for each source)
6 time slots are assiged to Three Sources 2Kbps. (2 time slots for each)
16 time slots are assiged to Two Sources 8Kbps. (8 time slots for each)
6 time slots are assigned to One Sources 6Kbps.

Total time slots are $4+6+16+6=32$, total bits of time slots are $32 \times 10 = 320$ bits,

Time of frame = 320 bits / 32kbps = 10msec,

Frame Rate = 1/10msec = 10 Kbps.

Frame Rate is in frames/sec (case 2 see back)

?

Case 2: statistical TDM, time slots are assigned depends on source activity.

$$R_b = (4 \times 1\,\text{kbps} \times 75\% + 2 \times 3 \times 50\% + 2 \times 8 \times 100\% + 1 \times 6 \times 50\%)\ /\ 80\%$$

$$= (3\,\text{Kbps} + 3\,\text{Kbps} + 16\,\text{Kbps} + 3\,\text{Kbps})\ /\ 80\% = 25\,\text{Kbps}\ /\ 80\%$$

$$= 31.25\,\text{Kbps}$$

This rate is under 80% link utilization of STDM, when STDM utilization is 100%, the rate is only 25 Kbps. Compared with case 1 TDM, this need less rate to satisfy the source needs because its time slots are not pre-allocated, this avoid idle time slots.

Solutions to midterm #1, EE450, Summer 2001, Zahid

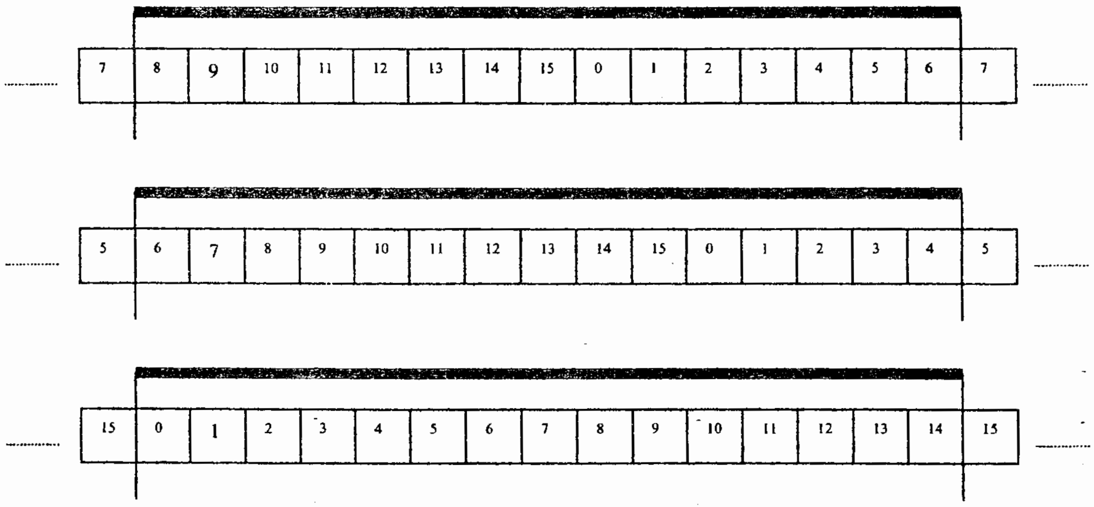
1. F, F, T, T, T, F, F, F, F, F, F, T, F, F, T, F, T, T, F, T

2. Transport, 24, Zero Stuffing, Hub, Protocols, Interfaces, Overflow, Bandwidth, Packet, Throughput, Delay, Error, Amplitude, Frequency, Phase, Sampling, Quantization, Encoding, http

3. A): Idle Time = $2*T_p$ = 26.6 msec, Utilization = $T_f/(T_f + 2T_p) = 0.3\%$

   B): Idle Time = $2*T_p - 255*T_f \approx 6$ msec, Utilization = $(255*T_f)/(255*T_f + 2*T_p) \approx 76.5\%$
   8-Bits are required for sequencing the frames

   C)



4. Circuit Switching: Total Dealy = 0.2 + 80000/4800 + 3*(0.02) = 16.93 s

   Connection-less Packet Switching: Total Dealy = 20*(4000/4800) + 2*(4000/4800) + 3*(0.02) = 18.4 s

   For timing diagrams refer to class notes.

5. Synchronous TDM case : R_m = 4*1K + 3*2K +2*8K +1*6K = 32 Kbps
   1 time slot for each device of 1 Kbps, 2 time slots for each device of 2 Kbps, 8 time slots for each device of 8 Kbps and 6 time slots for each device of 6 Kbps ⇒ 32 time slots / frame ⇒ 320 bits / frame ⇒ frame duration = 10 msec ⇒ frame rate is 100 frames/sec

   Statistical TDM case : R_m = {4*1K*0.75 + 3*2K*0.5 +2*8K*1 +1*6K*0.5}/0.8 = 31.25 Kbps

   Statistical TDM is more efficent than Synchronous TDM because it takes into account the bursty nature of the devices.

Ling

V 2001 Fall

University of Southern California
"EE450: Introduction to Computer Networks"
Midterm Exam, 1:^{20} hour
October 18, 2001

Name: LINGXIAN GU **Location:** ON-CAMPUS USC

Student ID:

Part 1	20%	18
Part 2	20%	18
Part 3	20%	17
Part 4	20%	18
Part 5	20%	20
Total	100%	

91

Excellent Effort! Thanks.

Notes:

- All your answers should be on the exam paper.
- You can work the problems in any order you wish (the goal is to try to accumulate as many points as you can)
- Try your best to be clean, and to show all the steps of your work

Rules:

- This is a closed book, closed notes exam. You are only allowed a 5"x7" postcard sheet of equations only and a Calculator
- Adherence to the University's Code of Ethics will be strictly monitored and enforced. Academic Integrity violations, such as cheating, will result in a series of actions and penalties including the student failing the class.

Part 1: True or False.

Note that if the statement is not fully true, your answer should be false.

F 1. If the signaling rate on a line is 2.4 Kbaud line and QPSK is used then the bit rate supported is ~~9.6~~ Kbps

Full duplex

T 2. To support T1 which is a FDX digital service over copper wires would require two pairs to support transmission in both directions simultaneously

-2

T 3. 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

T 4. In stop and wait ARQ, the receiver always send an acknowledgement frame each time it receives a frame with the wrong sequence number

T 5. The capacity of a channel is the maximum rate at which data can be transmitted reliably over the channel

F 6. As the bit rate of a digital signal increases ~~so~~ does the bit duration and the error rate

T 7. If the generator polynomial is $g(x) = x^3 + x^2 + 1$ and the received sequence is 100100001 , then no errors are detected

F 8. A data link protocol that uses both positive and negative acknowledgements ~~does not have to~~ use time-outs

F 9. In ~~synchronous TDM~~, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

T 10. In statistical TDM, the time-slot order of a frame depends on which device have data to transmit at that time.

T 11. Statistical TDM can usually support more terminals than synchronous TDM for the same link speed

T

F 12. As the signal to noise ratio increases, the bit error rate decreases

F

F 13. The network layer is responsible for the source-to-destination delivery of the ~~entire message~~

packet

T 14. As the error rate increases, the effective data rate decreases

F 15. An odd parity can detect all even number of errors but it can't detect odd number of errors

T 16. Network topology is a term given to describe the physical arrangements of nodes in a network

F 17. It takes longer to send a large frame than a short frame because the larger frame experiences ~~greater~~ propagation delay

T 18. For a sliding window of size n-1 (n is the sequence number), there can be a maximum of n-1 frames sent but not acknowledged

T 19. In stop and wait ARQ, if frame #1 is received in error, the receiver will send NAK #1

F 20. In baseband transmission, more than one signal can be transmitted on a single cable at any instant of time

12

Part 2: Fill in the Blanks

a) The ----Transfer---- layer is responsible for the end-to-end reliable delivery of messages

b) A synchronous T1 line can support ---24--- voice channels

c) In LANs, ----baseband---- signaling is used where the digital signal is inserted directly into the medium without the need of modems

d) Peer layers communicate via ---protocol---, where as adjacent layers communicate via ---SAP ?---

e) The retransmission of damaged or lost frames in the data link layer is one form of ----error---- control mechanisms

f) The ---bandwidth--- of a signal is the range of frequencies the signal occupies

g) The unit of data in the network layer is called a ---packet---

h) The two most important performance measures in a packet data networks are the ---delay--- and ---throughput---

i) In the OSI model, the ---Presentation--- layer ensures interoperability between communicating devices through transformation of data into a mutually agreed-upon format

j) A carrier signal can be characterized by three parameters. They are ---Amplitude---, ---frequency--- and ---phase---

k) In A/D conversion, three processes are involved, namely ---~~sample~~ sampling---, ---quantization--- and ---~~encode~~ encoding---

l) ---Bit--- ---~~Buffering~~ Stuffing--- is a procedure used to insure that the flag pattern does not occur anywhere in the data frame

m) ---Multiplexing--- is the process of aggregating traffic from several sources onto a single high rate link

Part 3: (Part "a" is 7 points, part "b" is 7 points and part "c" is 6 points)

Frames are to be transmitted over a 3000-km, 1.5 Mbps link. The propagation delay is 6μ second/km. Each frame is 500 bits long (including header/trailer)

-3

a) Assume a Stop & Wait ARQ Protocol is used. What is the total delay required in transferring a frame? What are the link utilization and the throughput in this case. Illustrate with a timing diagram. Assume the channel is perfect (no errors). Ignore the transmission time of acknowledgements and processing delays

b) Now assume a continuous ARQ protocol is used. What is the minimum number of bits required for identifying frame sequence numbers for maximum link utilization? Repeat for a link utilization of 80%. Again assume error-free transmission

c) This part has nothing to do with parts "a" and "b".

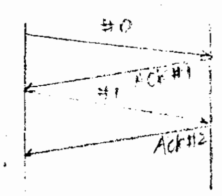
A host "A" is sending a file to host "B" . A sliding window flow control mechanism is employed. The sender maximum window size is 4 frames. Three bits are used to sequence frames. Draw the frame-exchange-timing diagram for the following sequence of events. Be sure to label each frame with a sequence number. At each point in time draw the sliding window diagrams at both the sender "A" and the receiver "B"

t_1 : "A" sends 3 frames to "B"
t_2 : "B" receives all frames and sends an ACK (for all frames received)
t_3 : "A" receives the acknowledgement and sends 2 more frames to "B"
t_4 : "B" receives both of these frames and sends an ACK back to "A"

If the last ACK from "B" gets lost in transmission, what happens? Explain graphically the actions taken by "A" and "B" assuming GO-Back-N ARQ.

suppose GO-BACK-N

a)



$T_D = 2T_{prop} + T_f$

$= 2 \times (6\times10^{-6} \times 3000) + \frac{500}{1.5\times10^6}$ s

$= 0.036$ s

$\eta = \frac{T_f}{T_D} = \frac{500/(1.5\times10^6)}{0.036} = 9.26\times10^{-3}$

Throughput $= \frac{\text{Transferred}}{\text{transfer time}} = \frac{500 \text{ bits}}{0.036 \text{ s}} = 1.39\times10^4$ bits/s

b) ① for $\eta = 100\%$

we need Window Size

$W > 1+2\alpha$

$\alpha = \frac{T_{prop}}{T_f} = \frac{18000\times10^{-6}}{333.3\times10^{-6}} = 54$

$W > 1+2\times54 = 109$

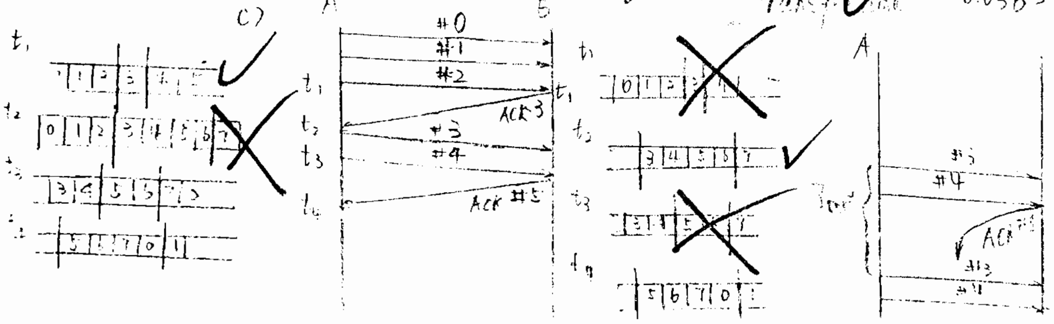
$W < 2^n-1$ $n = 7$

② for $\eta = 80\%$

$\frac{W}{1+2\alpha} = 80\% \Rightarrow W \approx 87$

$W < 2^n-1$ $n = 7$

c)

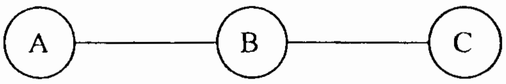


If Ack is lost A will resend #3 #4 after timeout!

-2

Part 4:

Compute the total delay to transfer a message 10,000 characters long (each character is 8 bits) across a 2-hop communications path illustrated below in each of the following two cases:



Assume that each link operate at a rate of 4800 bps. The propagation delay over each link is 20 msec

Case 1: Circuit Switching

Assume the call set-up time is 200 msec. Ignore the call release time.

Case 2: Connection-less Packet Switching

In this case assume that the message is broken into 20 equal length packets. Ignore queuing delay, ignore processing delay.

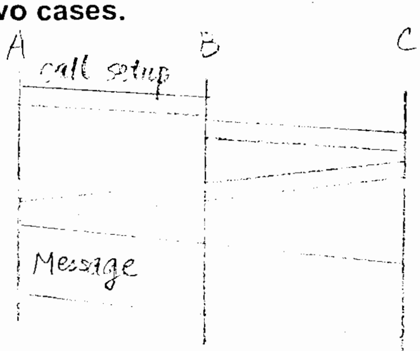
Clearly illustrate the timing diagram for each of the above two cases.

Case 1:

$T_D \simeq S + \cancel{t_{prop}} + t_f$ 2tprop.

$= 200 \times 10^{-3} + 20 \times 10^{-3} + \frac{10000 \times 8 \text{ bits}}{4800 \text{ bps}}$

$= 16.88s$



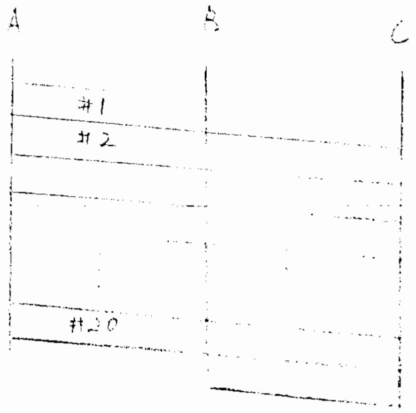
Case 2:

$T_D = (\# \text{ of packets}) \cdot T_t + (\# \text{ of hops} - 1) T_t + 2 T_{prop}$

$T_t = \frac{10000 \times 8}{20} / 4800 \text{bps} = 0.833 s$

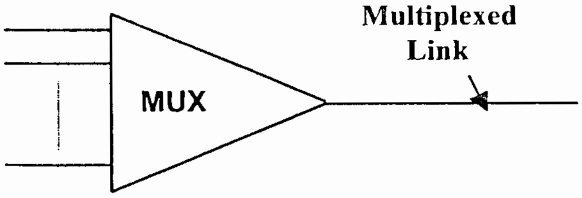
$T_D = 20 \times 0.833 s + 0.833 s + 2 \times 20 \times 10^{-3}$

$= 17.54 s$



Part 5 :

Consider the following multiplexer



Assume that the capacity of the output link is 100 Kbps. Assume each terminal, <u>when active</u>, generates data at a rate of 5 Kbps.

a) Assume the multiplexer is a synchronous TDM. How many terminals can it support, assuming that the terminals are active 20% of the time? Neglect any framing overhead (i.e. assume that the multiplexed link utilization is 100%)

b) Now assume that the multiplexer is a statistical TDM. Assume that the ratio of overhead bits (required to identify the address of each terminal) to the data bits (payload) is 75%. Assume that we want to limit the utilization of the multiplexed link utilization to 80%. How many terminals can the ~~synchronous~~ statistical TDM support, assuming that the terminals are active 20% of the time?

a) For synchronous TDM

$(5\,kbps) \cdot N = 100\,kbps$

$N = 20$

b) For statistical TDM

$5kbps \times 20\% \times (1+0.75) \times N = 100kbps \times 80\%$

$N \doteq 45.7$

so $N = 45$

Solutions to midterm #1, EE450, Fall 2001, Zahid

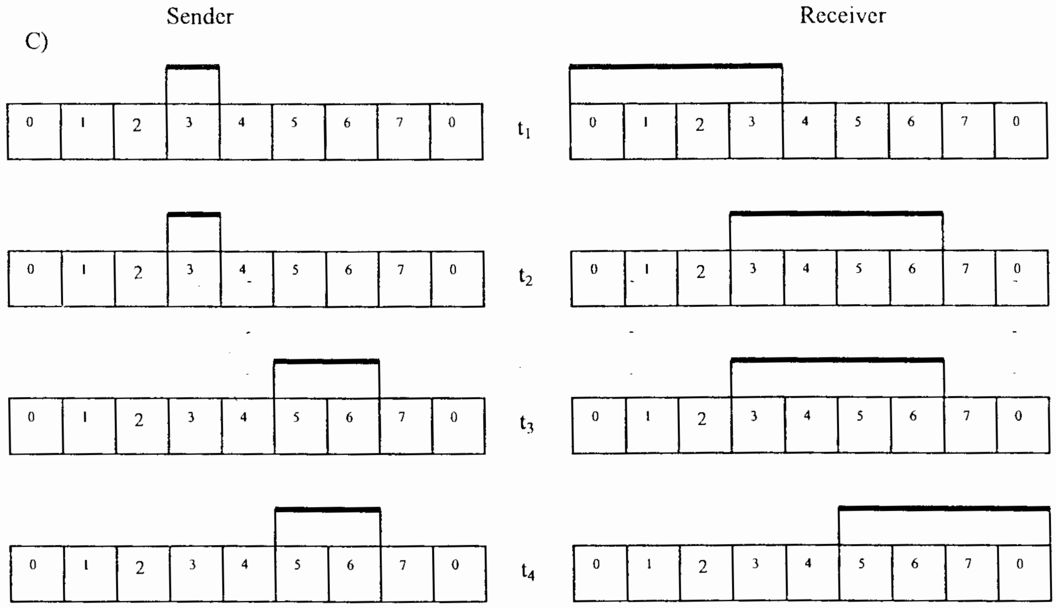
1. F, T, T, T, T, F, T, F, F, T, T, T, F, T, F, T, F, T, F, F

2. Transport, 24, Baseband, Protocols, Interfaces, Error, Bandwidth, Packet, Throughput, Delay, Presentation, Amplitude, Frequency, Phase, Sampling, Quantization, Encoding, Zero, Stuffing, Multiplexing

3. A): Total Delay = $2*T_p + T_f = 2(18\text{msec}) + 500/1.5M = 36.33$ msec, Utilization = $T_f / (T_f + 2\,T_p)$ = 0.91% (very bad!), Throughput = 500/36.33m = 13.75 Kbps (very bad!)

   B): For maximum utilization, let N= # of frames that can be transmitted continuously before having to stop for an ACK. The $N*T_f = 2*T_p \Rightarrow N \approx 109$ frames $\Rightarrow$ k = minimum # of bits required for frame sequencing is 7 bits. For 80% utilization, the number of frames that can be transmitted continuously before having to stop for an ACK is $N \approx 86$ frames $\Rightarrow$ k = minimum # of bits required for frame sequencing is still 7 bits.

   C)



After the expiration of the time-out, sender will retransmits frames #3 and #4 if the ACK #5 is lost.

4. Circuit Switching: Total Dealy = 0.2 + 80000/4800 + 2*(0.02) = 16.91 s

   Connection-less Packet Switching: Total Dealy = 20*(4000/4800) + 1*(4000/4800) + 2*(0.02) = 17.5 s

   For timing diagrams refer to class notes.

5. For the synchronous TDM case : # of Terminals = 100K/5K = 20 regardless of the activity factor of the terrminal since the time slots are pre-allocated

   For the Statistical TDM case : # of terminals = $(100K)(0.8)/(5K)(1+0.75)(0.2) \approx 45$. Statistical TDM is more efficent than Synchronous TDM because it takes into account the bursty nature of the devices.

Mid

Part 1: True or False.

Note that if the statement is not fully true, your answer should be false.

False 1. In shared LANs, the activity of one station can not impact the other stations since all stations are peer stations

True 2. As the error rate increases, the effective data rate decreases

True 3. An odd parity can detect all odd number of errors but it cannot correct them
even

bps
least
False 4. A 1200 baud line can transmit at most 1200 bits per second

F 5. Routing of data from node to node is the function of the ~~data link~~ layer of the OSI model
internet.

T 6. Digital data transmission can provide higher data rates than is possible with analog transmission

F T 7. In Asynchronous transmission, there is no fixed time interval between characters

T 8. In STDM, the aggregate data rates of the terminals can be more than the data rate of the line
P219
wireless、optical fiber.

FD
F T 9. Full Duplex transmission require 4 wires, i.e. two pairs, since it implies that both sides can transmit simultaneously optical fiber P80 P145

F 10. In TDM, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal

T 11. In STDM, Host ports can be shared

T 12. STDM can support more terminals than TDM for the same link speed

T 13. Data is transmitted more efficiently when compressed

T 14. Virtual circuits can be found in connection-oriented packet switched networks

TCP
F 15. One of the functions of the IP layer in the TCP/IP suite is to assure end-to-end packet delivery across the network

F 16. The OSI model is an international standard for designing networks
TCP/IP

F 17. TCP/IP protocol suite is used only over the internet

T 18. A message between peer layers is generically called PDU — Protocol ~~Smart~~ Data Unit

同僚

False F 19. You are logged into a computer. You want to log into a second computer to read your e-mail there. You need an ~~SMTP~~ (Simple Mail transfer Protocol) application. Telnet

Telnet

False F 20. The protocol used when a browser requests a webpage from a webserver is called HTML HTTP

HTTP

internet

Part 2: Fill in the Plank

Internet

a) The ~~Network~~ is a large collection of independent packet networks linked together via routers

b) A trunk is a terminology given to the shared facilities connecting nodes in switched wide area networks WAN

['seʃən]

c) The function of the session layer in the OSI model is to establish A connection between application programs on different machines

Bit stuffing

d) ~~Bits shift~~ is a technique used by most data link protocols to insure that the Flag pattern does not appear anywhere in the frame

e) The elements of any protocol are syntax, semantics and timing

f) Each layer in the OSI model provides services to the layer above it

g) Flow control is the mechanism by which the receiver can prevent the transmitter from overwhelming it with data

-5

Automatic Repeat reQuest

h) ARQ is the most widely used procedure in data links for error control. It stands for ~~stop-and-wait Go-back-N Selective-reject~~

i) In connectionless (datagram packet switching) service, the service provider (i.e. the network) does not guarantee the delivery of packets in the same order in which they were transmitte

j) The unit of data in the network layer is called a packet

k) The presentation layer is responsible for message encryption 加密

l) The most two important performance parameters of a packet data networks are the ~~packet~~ and ~~data rate~~

Throughput 流量 Delay

Baseband baseband

m) In ~~digital~~ signaling, you insert the digital signal directly into the medium without the need of modems

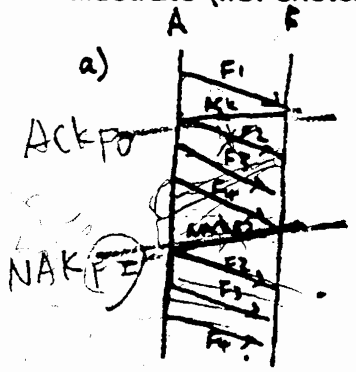
baseband

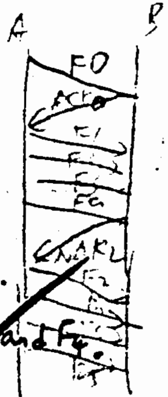
3) In a sequence of frame transmissions between two nodes, Data frame F_0 has just been positively acknowledged. Four more frame F_1, F_2, F_3 and F_4 is next transmitted from node A. After all frames are transmitted, Node A receives a message from node B. This message is " NAK F_2 ". What should node A do if it is using :

a) Go-Back-N protocol

b) Selective repeat protocol

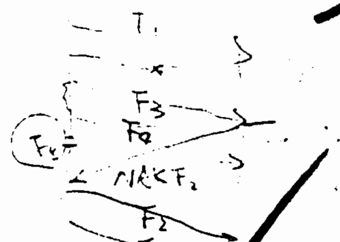
Illustrate (i.e. sketch) your answer to both parts





For Go-Back-N protocol.

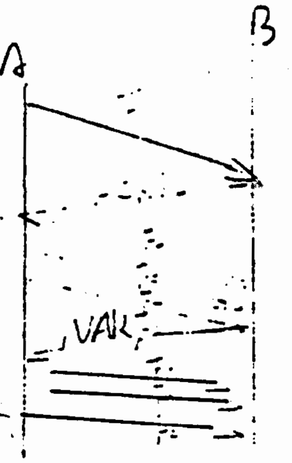
A will retransmit F_2, F_3 and F_4.

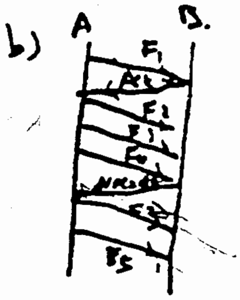


NAK 2

↓

#2, 3, 4, 5





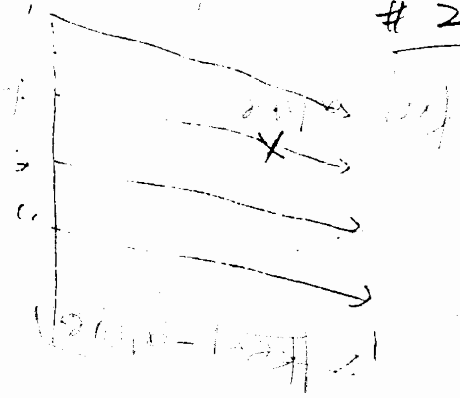
For Selective repeat protocol.

A will just retransmit F_2, then transmit F_5, if A doesn't get any other NACK.

NAK 2

↓

#2 → #5



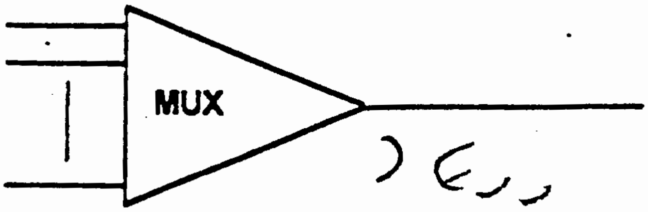
4) List three major differences between connection-oriented and connection-less packet switch networks. Give an example for an application that is best suited for each technology

-2

Connection-oriented	connectionless
① need call set up phase	① don't need call-set up phase
② Routing decision is done only when call set up. Then assgned the connection a VCI.	② Treat each packet as individual one. Make routing decision for each packet.
③ Packet arrive in the same order.	③ Packet may arrive out of order.
- It suitable for transmitting large numbers of packets. It provides more reliability than connectionless. So it also suitable for applications which needs reliability.	It suitable for few numbers of packets. It may drop the packet when there is an error occured. So also named Best eff
Such as!	application?
file transfer, & remote terminal	P.262 real time applications

Extra Credit Problem

Consider the following multiplexer



Each input device, when active, generate traffic at a rate of 150 bps. Input devices are active only 15% of the time. Assume that the output link has a capacity of 2400 bps.

Case 1: Assume that the multiplexer is a TDM. What is the maximum number of input devices can this multiplexer support? Ignore framing overhead.

Case 2: Now assume that the multiplexer is a STDM. Each device, when transmitting, must identify itself with an address (overhead). The ratio of overhead bits to the data bits is 50%. What is the maximum number of input devices can this STDM support?

Case 1: $2400 = N \times 150$ $N = 16.$

Maximum number of input devices is 16.

Case 2: $\frac{\text{overhead}}{\text{Data bit}} = 0.5$

$0.15 \cdot [150 \times (1+0.5)] \cdot N = 2400$ $N = 71.11$

$\Rightarrow N = 71$

Maximum number of input devices is 71.

+10

V

Part 1: True or False. Note that if the statement is not fully true, your answer should be false. No reason is required.

-7

1. If two terminals share the same line (multi-point line), then the activity of one cannot impact the other, since they are going to be polled independently T ✗ (no two terminals can transmit at the same time)
2. The bit error rate may be reduced by transmitting at lower speed
   T ✓
3. An even parity can detect all even number of errors but it cannot correct them
   F ✓
4. A physical interface is necessary only when you want to interface one vendor's equipment with another vendor's equipment
   F ✓ (equipments from the same vendor requires physical interface as well)
5. Routing of data from node to node is the function of the data link layer of the OSI model F ✓ (should be network layer)
6. The transmission time of a packet depends only on the speed of the link
   F ✓ (speed of the link ~~involves the propagation delay~~)
7. Multiplexers, like modems, are used in pairs STDM
   F ✗ (STDM have a MUX at the terminal end, Host port is shared)
8. Multiplexing is "conceptually" similar to polling in that both allow multiple terminal to share a single line (polling will dedicate connection between host & terminal for the duration of transmission, Multiplexing uses time slots to communicate all devices)
   F ✗
9. A protocol is concerned only with the reliable transmission of data
   F ✓
10. In TDM, the terminal identification must be transmitted along with the terminal data but only during the time slot that is allocated to that terminal
    F ✓
11. In STDM, Host ports can be shared
    T ✓
12. STDM can support more terminals than TDM for the same link speed
    F ✓ (STDM support more terminal only when Bursty Data are present)
13. Data is transmitted more efficiently when encrypted
    F ✓ (encryption is for security)
14. Layers of the OSI model are independent with each layer providing services to the layer below it. F ✓
15. The OSI model is an international standard for designing networks
    T ✗

Part 2: Fill in the Plank

a) A Multiplexer ---------- is a device that aggregates traffic from several Information sources onto a single high rate link

b) A modem ---------- is a device that is used to connect a Personal computer to the telephone line

c) The function of the Transport ---------- layer in the OSI model is to provide end-to-end error control

d) Polling ---------- / Selecting ---------- are two commands used by a master station to inquire whether a slave station has any data to transmit / or if it is ready to receive data

e) The elements of any protocol are Syntax ----------, Semantic ---------- and Synchronization ----------

f) Each layer in the OSI model provides Service ---------- to the layer above it

g) Flow Control ---------- is the mechanism by which the receiver can prevent the transmitter from overwhelming it with data

h) ARQ is the most widely used procedure in data links for error control. It stands for Automatic ---------- Repeat ---------- Request ----------

i) In CNLS ---------- service , the service provider (i.e. the network) does not guarantee the delivery of packets in the same order in which they were transmitted.

j) The unit of data in the data link control layer is called a Frame ----------

k) The presentation ---------- layer is responsible for code conversion, data compression, etc...

l) A overhead (Header) ---------- is the control information added to the beginning of a packet for the purpose of synchronization, addressing, sequencing, etc... It is not part of the data.

Part 3 : **Performance Analysis**

1) Consider a link connecting two nodes. Assume the following:

- All frames flow in one direction (i.e. HDX), from node A to node B.
- acknowledgments (ACK or NAK) are used after every frame (i.e. Stop & Wait ARQ protocol is used)
- Link Rate R_d is 64 Kbps
- There are 200 data characters and 6 overhead characters in each information frame $\boxed{6 \mid 200}$
- An ACK or a NAK frame consists of 6 characters
- All characters are 8 bits long (don't worry about parity !)
- Propagation delay is 10 msec $t_p = 10_{ms}$
- Processing delays are negligible $t_{proc} = 0_{ms}$
- ACK/NAK frames are always received correctly

Calculate the **effective** data rate (i.e. the Throughput, in bps) for the following two cases: $\frac{bits}{t_{total}}$ t

a) The frame is received correctly in the first try
b) The frame is received correctly in the second try

A B

a) $\frac{200 \times 8}{t_t + t_p + t_p + t_{ACK}}$

$t_{NACK} = t_{ACK} = \frac{(6 \times 8)}{Rd} = 0.75ms$

t_t = transmission time

$Rd = \frac{\text{Data bits} + \text{OH bits}}{t_t}$

$64Kbps = \frac{(200 \times 8) + (6 \times 8)}{t_t}$

$t_t = 25.75\ ms$

$Throuput = \frac{200 \times 8\ bit}{25.75_{ms} + 10_{ms} + 10_{ms} + 0.75_{ms}}$

$\simeq 34.41\ Kbps$

b)

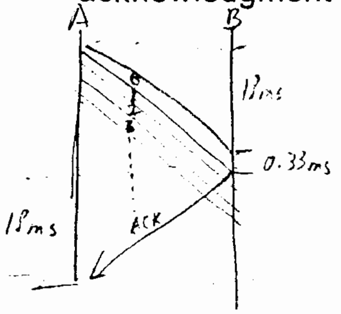
$Throuput = \frac{200 \times 8}{t_t + t_p + t_{NACK} + t_p + t_t + t_p + t_{ACK} + t_p}$

$= \frac{200 \times 8\ bits}{25.75_{ms} + 10_{ms} + 0.75_{ms} + 10_{ms} + 25.75_{ms} + 10_{ms} + 0.75_{ms} + 10_{ms}}$

$\simeq 17.20\ Kbps.$

3

2) A 3000-km long T1 trunk (Rate=1.544Mbps) is used to transmit 64-octets frames (an octet is an 8-bit word), using a continuous ARQ protocol. What is the **maximum** number of frames that could be transmitted without waiting for any acknowledgments ? How many bits would you need to represent the sequence numbers of these frames? Assume that the propagation delay is 6 µsec/km. Ignore the processing delay and the time required to transmit an acknowledgment



$R_d = 1.544$ Mbps

$t_p = 6 \times 10^{-6} \times 3000 = 0.018\,sec = 18ms$

Frame Length $= 64 \times 8$ bits

$= 512$ bits

$t_{tran} = 512/R_d = 0.33ms/frame$

$18ms + 0.33ms + 18ms/0.33ms = 110$ frame before the ACK 0 is recieved by A

$2^K - 1 = N$

$2^K - 1 \approx 110$

$2^K < 111$

$K = 6$

6 bits sequence frame

$2^6 = 64$

?

$2^n - 1 \geq 109$

$\Rightarrow n \simeq 8$?

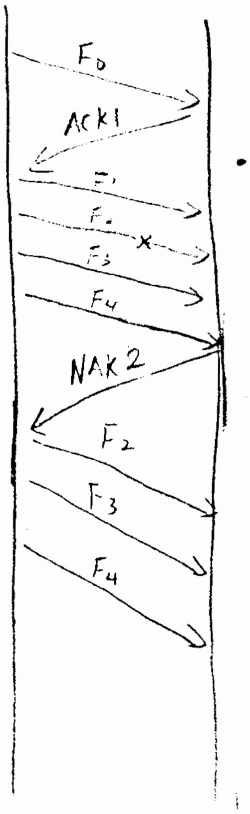
$2^8 = 128$

3) In a sequence of frame transmissions between two nodes, Data frame F_0 has just been positively acknowledged. Four more frame F_1, F_2, F_3 and F_4 is next transmitted from node A. After all frames are transmitted, Node A receives a message from node B. This message is " NAK F_2 ". What should node A do if it is using :

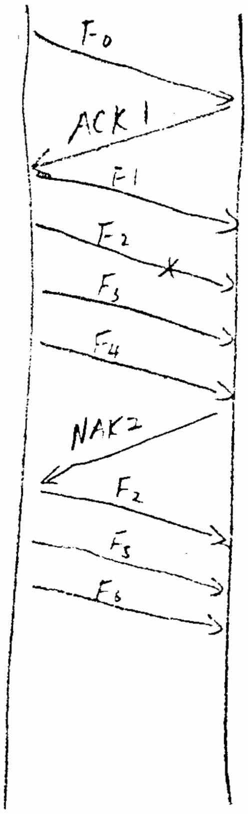
a) Go-Back-N protocol
b) Selective repeat protocol

Illustrate (i.e. sketch) your answer to both parts

a)



b)



all frame subsequent F_2 and before NAK_2 are resent.

only F_2 is resent. subsequent frames before NAK_2 are buffered for insertion of F_2.

5

4) List three major differences between connection-oriented and connection-less packet switch networks. Give an example for an application that is best suited for each technology

V.C	CNLS
- call setup	No call setup
- Routing path is virtually defined after the call setup	- Routing is done by each individual node.
- use ARQ for error control	- drop packet when it is erroneous

?

Technology

Teleconferencing: Video + voice has longer data	Internet Browsing: when Bursty data are presented
However, some IP based software are available to support teleconferencing w/ some delay.	

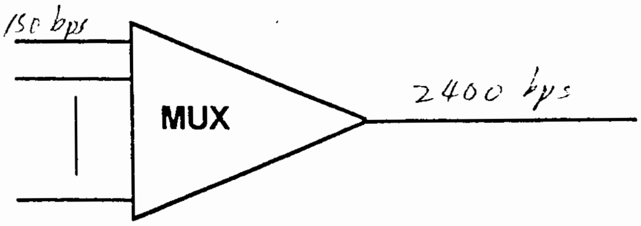
?

what does voice have longer data means!!!

?

Extra Credit Problem

Consider the following multiplexer



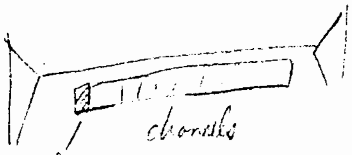
Each input device, **when active** , generate traffic at a rate of 150 bps. Input devices are active only 15% of the time. Assume that the output link has a capacity of 2400 bps. $\alpha = 15\%$

Case 1: Assume that the multiplexer is a TDM. What is the maximum number of input devices can this multiplexer support ? Ignore framing overhead.

Case 2: Now assume that the multiplexer is a STDM. Each device, when transmitting, must identify itself with an address (overhead). The ratio of overhead bits to the data bits is 50%. What is the maximum number of input devices can this STDM support?

Case 1

time slots are dedicated for each channel (device)



use "<" because framing bit is not included

$150\alpha < 2400$

$\alpha < 16$

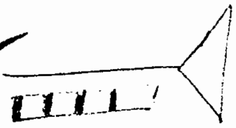
approx 16 max. devices

+6

Case 2.

utilization

$f = \frac{\alpha N R}{M}$



max

$1 = \frac{.15 N 150}{2400}$

$N = 106$ devices

$\frac{2400}{150 \times 0.15}$

Solution to Midterm EE450

1) F, T, F, F, F, F, T, T, F, F, T, T, F, F, F

2) Multiplexor, Modem, Transport, Polling, Selecting, Syntax, Semantics, Timing, Services, Flow, Control, Automatic, Repeat, Request, connection-less, Frame, Presentation, Header

3) a)
$$\frac{1600}{\frac{1600+48+48}{64K}+2(.01)} = 34.4 \text{ Kbps}$$

b) Effective data rate $= \frac{34.4}{2} = 17.2$ Kbps

4) Max # of Frames $= \frac{2T_P}{T_F}$

$$= \frac{(2)(3000)(6\times10^{-6})}{(64)(8)/1.544\times10^{6}} \simeq 109 \text{ Frames}$$

we need at least 7 bits to represent the sequence numbers.

5) In Go-back-N, the T/x will resend Frames 2 and all subsequent Frames. In Selective ARQ, the T/x resend the erroneous frame only.

6) See Page 261, Table 9.1

Extra Credit:

a) # of devices supported in TDM $= \frac{2400}{150} = 16$

b) # of devices supported in STDM $= \frac{2400}{(0.15)(150)(1+\epsilon)}$

$\cong 71$