CMSC 417 Midterm #1 (Spring 1997) - Solution

1.) (15 points) Define or explain the following terms:

a) count to infinity problem: *A problem with distance vector routing that causes it to react slowly of link failures since only a count of hops rather than the full path is exchanged between routers.*

b) packet: *a small unit of communication. It can be variable or fixed size, but there is a fixed maximum size.*

c) virtual circuit vs. packet switched: *Virtual circuits involve using a connection establishment message to store traffic connection state in a network. Virtual circuits tend to provide static routing for a single connection and thus ensure in-order delivery of packets.*

d) ISDN: *Integrated Services Digital Network. A way to provide 2 64kbps circuit switched channels over a single pair of copper wire.*

e) flooding: *a way to send information from a source to a destination by sending the traffic over* ***all*** *links. It its pure form is generally leads to infinite traffic, but it can be useful as a basis of comparison. Also, by adding ways to control the flood it becomes a practical algorithm.*

2.) (15 points) Consider using a 4khz channel and 16 discrete levels to send data.

a) What is the maximum possible transmission rate if the channel is noiseless?

$$2\ H \log_2 N = 2\ 4{,}000 \log_2 16 = \underline{32{,}000}$$

b) What if the signal to noise ratio is 30dB?

$$X\ dB = 10 \log_{10}(S/N) \Rightarrow 10 = 30 \log_{10}(S/N) \Rightarrow S/N = 1{,}000$$

$$H \log_2(1 + S/N) = 4{,}000 \log_2(1 + 1{,}000) \cong 4{,}000 \log_2(1024) = \underline{40{,}000}$$

3.) (15 Points) A cellular phone system needs to accommodate many users. Explain how the system uses space, frequency, and time division multiplexing.

Space Division*: many cells permit re-use of the same channels in any two non-adjacent cells.*
Frequency Division*: the cellular band is divided into 800 separate channels.*
Time Division*: frequencies are only allocated when they are in use. Since most cell phones in a single cell are not in use at any one time, this is a type of time division multiplexing.*

4.) (20 Points) List the seven layers of the ISO/OSI reference model and for each layer provide an example of a function commonly performed at that layer.

Application: mail header format

Presentation: encryption

Session: cursor movement

Transport: byte ordering

Network: routing, congestion control

Link: sending frames, link errors

Physical: representation of 0's,1's

5.) (20 points) Consider routing in a network with 200 routers, and on average every router is connected to 4 other routers. Routing information is exchanged every 100msec. How much network bandwidth is used under link-state and distance vector routing to exchange this information. Assume sequence numbers are used to damp flood packets for link-state. Please explain any assumptions you make about the size of routing table entries.

Link-state:

For each link, each router sends <neighbor id, link state> (2 bytes should be fine)
For each route update, each router sends a sequence number (4 bytes is safe)
Therefore each routing message contains: 4 links x 2 bytes/link + 4 bytes = 12 bytes.
Each routing message travels over every link (flooding with sequence numbers)
200 routers x 4 links/router / (2 end-points per link) = 400 links.
Routing messages are send 1/100msec = 10 messages/second
So 200 routers x 10 msgs/sec-router x 400 links x 12 bytes/msg = 9.6M bytes/sec

Distance Vector:

Each routing table entry contains <dest, hop count (metric), next hop> ≅ 3 bytes
Each host maintains a 200 entry routing table
At each update, each router sends all of its neighbors its entire table
So 200 routers x 10 updates/sec-router x 4 link/router x 3 x 200 bytes/link = 4.8 MB/sec

6.) (15 points) In a broadcast channel, link bandwidth is wasted due to multiple hosts trying to send at once and canceling each others communication. A simple model of this problem is that time is divided into discrete slots. If a network has n hosts, and the probability of any single host trying to use a slot is p, what fraction of slots are wasted due to collisions?

A collision is two or more stations sending a once. Let P(x) denote the probability of x stations sending at once.

$P(>=2) = 1 - P(0) - P(1)$

$P(0) = (1-P)^{n}$

$P(1) = n\ p\ (1-P)^{n-1}$

$(>=2) = \underline{1 - (1-P)^{n} - n\ p\ (1-P)^{n-1}}$