بسم الله الرحمن الرحيم

King Fahd University of Petroleum and Minerals

**Department of Electrical Engineering**
**EE 400 Communication Networks,**

**Major Exam I**
**Sunday, 6 April 2008**
**6:30 pm – 8:00 pm**

**Name:**

**ID:**

**Sections: 1 , 2**

Solution

| Problem | Score | Out of |
|---|---|---|
| 1 | | 20 |
| 2 | | 10 |
| 3 | | 10 |
| 4 | | 10 |
| Total | | 50 |

**Good luck!**

**Problem 1)**

**1.1** Denote:

| | |
|---|---|
| Path setup required before session | A |
| Dedicated path during session | B |
| Contineous flow of data during session | C |
| Addressing Required | D |
| Routing Required | E |
| Data always arrive in sequence of transmission | F |

List ALL letters TRUE for:

1.5 (a) Circuit Switching: A B C D F

1.5 (b) Connection-Oriented Packet Switching: A C D F

1 (c) Connectionless-Oriented Packet Switching: D E

2 **1.2** Consider a multi-level M-ASK modulation scheme compared to the binary case. Answer the following (True/False)

- The multi-level scheme will consume more power at a given bit error rate, but will achieve higher data transmission rate for a fixed channel bandwidth — True
- The multi-level scheme will have better bandwidth efficiency, but higher power consumption — True

2 **1.3** Answer the following questions (True/False)

- The usable bandwidth for twisted-pair copper lines extends to ~ 1GHz — False
- The usable bandwidth for optical fiber (in the 1500 nm wavelength region) extends to several Tera Hertz — True

2 **1.4** Answer the following questions:

a) Give two disadvantages and two advantages of using fiber over copper.

Advantage
1. Extremly more Bandwidth
2. Very low Signal Attenuation

Disadvantage
1. More expensive
2. Needs very careful handling and installation

b) What is the difference between single mode and multi-mode fiber?

2 In Multimode, multiple rays follow different paths.
In Singlemode, only direct path propagates

2 c) For the same distance, arrange the following transmission media in terms of their need for repeaters: coaxial cable, twisted pair, single-mode fiber, multi-mode fiber.

Low to High ↓

Single-mode fiber
Multi-mode fiber
Coaxial cable
twisted pair

6 **1.5** Consider the OSI network model. Which layer is responsible for:

| **Functions, Services and Protocols** | Layer |
|---|---|
| Modulation | Physical |
| Medium access control | Data link |
| Flow Control | Data link |
| ARQ and Error detection | Data link |
| Application programs such as Web access and file transfer | Application |
| Message segmentation and reassembly | Transport |
| Pulse shaping of data bits for transmission through the channel | Physical |
| Node-to-Node delivery | Network |
| Routing | Network |
| Congestion control to deal with traffic surges | Network |
| End-to-End Delivery | Transport |
| Determining the best path to send packets | Network |

**Problem 2)**
Consider communication over a channel with bandwidth $W$ Hz and Signal-to-Noise Ratio SNR.

(a) If you have a choice between doubling the bandwidth and quadrupling (four times) the SNR, which one you think will increase the channel capacity more? Explain why?
(b) How should you increase the SNR in order to match the capacity increase that results from doubling the bandwidth?
(c) For a typical analog phone line used for data communication, compute the channel capacity for the following parameters: $W$=3400Hz and $SNR$ = 45dB.

Note: Channel capacity formula: $C = W\log_2(1+SNR)$ in bits/sec, where SNR is in linear scale (not dB). You can use the approximation: $C = W_c \log_2(SNR)$.

4

[a] $C_1 = 2W\log_2(SNR) \Rightarrow$ doubling BW

$C_2 = W\log_2(4SNR) \Rightarrow$ quadrupling SNR

$$\Delta C = C_1 - C_2 = 2W\log_2(SNR) - W\log_2(4SNR)$$
$$= W\log_2(SNR^2) - W\log_2(4SNR)$$
$$= W\log_2\left[\frac{SNR^2}{4SNR}\right]$$
$$= W\log_2\left[\frac{SNR}{4}\right]$$

∴ if $SNR > 4 \Rightarrow \Delta C > 0$
$\Rightarrow$ doubling the BW increases the capacity more.

if $SNR < 4 \Rightarrow \Delta C < 0$
$\Rightarrow$ quadrupling the SNR increases the capacity more.

Usually, we operate at high SNR $\gg 4$
So in general, doubling the BW will increase the capacity more than quadrupling the SNR.

3

[b] If we double the BW, we should square the SNR to get the same capacity. $C_1 = 2W\log_2(SNR)$
$= W\log_2(SNR^2)$

3

[c] $C = W\log_2(1+SNR)$ ; $45dB = 10^{45/10} = 10^{4.5} =$
$= 3400\log_2(1+10^{4.5}) = 50.83$ kbps

**Problem 3)**

An organization is assigned the network address 200.11.8.0. The organization has 5 departments. It is required that each department has its own subnet.

3 (a) What mask should be used, expressed in decimal notation, in order to serve this purpose, while allowing the maximum number of hosts in each department?

Use these bits from the HostID $\Rightarrow 2^3 = 8-2 = 6$ Subnets

NetID. NetID. NetID. HostID (use these 3 bits)

Two are Reserved for Net address and Broadcast address

$\therefore$ Mask = 11111111.11111111.11111111.11100000

= 255.255.255.224

4 (b) What is the subnet address for each of the 5 departments?

1- $200.11.8.(0010\ 0000)_2 = 200.11.8.32$

2- $200.11.8.(0100\ 0000)_2 = 200.11.8.64$

3- $200.11.8.(0110\ 0000)_2 = 200.11.8.96$

4- $200.11.8.(1000\ 0000)_2 = 200.11.8.128$

5- $200.11.8.(1010\ 0000)_2 = 200.11.8.160$

6- $200.11.8.(1100\ 0000)_2 = 200.11.8.192$

3 (c) How many hosts can be assigned to each department?

Number of Hosts per department $= 2^5 - 2 = 32 - 2 = 30$

**Problem 4)**

Problem 4)

5

a). Suppose a header consists of four 16-bit words: (11111111 11111111, 11111111 00000000, 11110000 11110000, 11000000 11000000). Find the internet checksum for this code.

**Solution:**

$b_0$ = 11111111 11111111 = $2^{16} - 1$ = 65535

$b_1$ = 11111111 00000000 = 65280

$b_2$ = 11110000 11110000 = 61680

$b_3$ = 11000000 11000000 = 49344

$x = b_0 + b_1 + b_2 + b_3$ modulo 65535 = 241839 modulo 65535 = 45234

$b_4 = -x$ modulo 65535 = 20301

So the internet checksum = 01001111 01001101

---

5

b) Let $g_1(x) = x + 1$ and let $g_2(x) = x^3 + x^2 + 1$.
Consider the information bits sequence m = (1,1,0,1,1,0), Find the codeword corresponding to this sequence if $g(x) = g_1(x)g_2(x)$ is used as the generator polynomial.

$m = (1,1,0,1,1,0) \Rightarrow m(x) = x^5 + x^4 + x^2 + x \Rightarrow k = 6$

$g(x) = g_1(x)g_2(x) = (x+1)(x^3+x^2+1) = x^4 + x^2 + x + 1$ } $\deg(g(x)) = 4$, $r = n - k \Rightarrow n = 10$

Method1 : Non Systematic

The codeword $c(x) = g(x)m(x)$

$= (x^4 + x^2 + x + 1)(x^5 + x^4 + x^2 + x)$

$= x^9 + x^8 + x^7 + x^6 + x^5 + x$

$\Rightarrow$ c = 1111100010

Method2 : Systematic

$c(x) = x^{n-k} m(x) + r(x)$

where $r(x)$ = reminder $[x^{n-k} m(x) / g(x)]$

$x^{n-k} m(x) = x^4 (x^5 + x^4 + x^2 + x) = x^9 + x^8 + x^6 + x^5$

to find $r(x)$:

$x^4 + x^2 + x + 1 \;\overline{)\; x^9 + x^8 + x^6 + x^5}$

$x^5 + x^4 + x^3 + x^2 + 1$

$x^9 + x^8 + x^6 + x^5$

$x^9 + x^7 + x^6 + x^5$

$x^8 + x^7$

$x^8 + x^6 + x^5 + x^4$

$x^7 + x^6 + x^5 + x^4$

$x^7 + x^5 + x^4 + x^3$

$x^6 + x^3$

$x^6 + x^4 + x^3 + x^2$

$x^4 + x^2$

$x^4 + x^2 + x + 1$

$r(x) \Rightarrow x + 1$

$c(x) = x^9 + x^8 + x^6 + x^5 + x + 1$

$\Rightarrow$ c = 1101100011