CARLETON UNIVERSITY
Department of Systems and Computer Engineering

SYSC4700 Telecommunications Engineering Winter 2010

Term Exam – 11 February 2010

Duration: 80 minutes

Instructions:

1. **Closed-book exam (no aid-sheet). Use of non-programmable, non-communicating calculators is permitted.**
2. **Write answers in the spaces provided on the question sheet.**
3. **If necessary, use both sides of a page.**
4. **Write legibly, and state any assumptions that you make.**

Name:

Student Number:

E-mail:

Question	Mark	Max possible mark
1		21
2		36
3		30
4		20
Total		107

Question 1 [21 points] – Acronyms

What do the following acronyms stand for?

(a) ITU: **International Telecommunication Union**

(b) IETF: **Internet Engineering Task Force**

(c) TDM: **Time Division Multiplexing**

(d) CDMA: **Code Division Multiple Access**

(e) PON**: Passive Optical Network**

(f) FTTH: **Fiber- To-The-Home**

(g) WDM: **Wavelength Division Multiplexing**

Question 2 [36 marks] – Short Questions

(a) [6 pts] Briefly explain the concept of "High Performance Routing (HPR)", which is also referred to as "Dynamically Controlled Routing (DCR)", discussed in the Network Evolution lecture.

In dynamically controlled routing (DCR) with centralized intelligence, the network updates routing tables every few seconds based on current traffic patterns.
For example, if there is a peak of traffic between Montreal and Toronto at 10am every business day. Vancouver is not yet open for business, so why not provide a lesser quantity of direct trunks and use some of the idle ones to and from the west coast?

The enabler is digital transmission. If the trunks were analogue, the extra 8,000 km would introduce a severe impairment. The absolute quality would be low, and the relative quality, by comparison with a direct trunk, would be very low. Digital circuits on fibre are (almost) distance insensitive.

Even without the advantage of different time zones, a similar approach works in a metropolitan network, taking advantage of short term shifts in traffic load. DCR in metropolitan networks is called LDR - Local Dynamic Routing.

(b) [6 pts] A number of telephone related services (features) became possible with the Common Channel Signaling System Number 7 (often referred to as CCS7 or SS7). Give three examples.

- **Call Forwarding**
- **Calling Line ID**
- **Calling Line ID Blocking**
- **Auto Recall**
- **Auto Call Back**
- **Call Waiting**
- **Ident-a-call**

(c) [9 pts] Provide three differences between circuit (TDM) and packet switching.

- **Fixed speed vs speed conversion**
- **Fixed delay vs variable delay**
- **Dedicated vs shared bandwidth**
- **Switching + multiplexing vs integrated S+M**
- **Call set up vs IP routing**

(d) [9 pts] Identify three hot topics in packet switching.

- **Expanding role of Ethernet across the LAN/MAN/WAN up to 10Gbit/s**
- **Making the IP networks more saleable and improving economics**
- **Explosion in broadband wireless including 802.11n**
- **Beyond 10 Gbps Ethernet (40 or 100?)**
- **Terabit switch routers (hardware/hardware/hardware)**
- **Connection-oriented capabilities to make large IP networks more manageable (via MPLS)**
- **Evolution/transition to IPv6 for end-to-end addressing scalability**
- **Security everywhere and integrated with routing**
- **Expanding application fit of IP networking**
- **4G Internet-optimized public wireless (e.g. WiMax)**
- **IPTV**
- **Storage on IP**
- **More application-fluent intelligence in the network**

(e) [6 pts] Identify the two most important features of an "open standard".

- **Consensus derived (and interested parties are not excluded)**
- **Publicly available**

Note: "Open" does not necessarily mean available free or patent-free

Question 3 [30 marks] – Power Calculations in Wireless Communications

Consider a straight line with equidistant points A, B, C, D, and E on it such that |AB| = |BC| = |CD| = |DE|.

Assume that there is a Base Station located at point A with transmit power P_A. The power levels received at wireless terminal located at points B, C, D, and E are denoted by P_B, P_C, P_D, and P_E, respectively.

The following simple propagation model relates the received power P_r to the transmit power P_t in the given environment:

$$P_r = P_t \left(\frac{\lambda}{4\pi}\right)^2 \left(\frac{1}{d}\right)^n .$$

In the above, d is the distance between the transmitter and receiver, and n is the propagation exponent.

(a) Clearly, $P_E < P_D < P_C < P_B$. We'd like to determine the difference (in dB) between "P_C and P_B", "P_D and P_B", and "P_E and P_B". Towards that end, find x_1, x_2, and x_3, in terms of n:

P_C [dBm] = P_B [dBm] – x_1 [dB]

P_D [dBm] = P_B [dBm] – x_2 [dB]

P_E [dBm] = P_B [dBm] – x_3 [dB]

(b) If |DE| = 1.7 km and $n = 4$, find P_D [dBm] – P_E [dBm].

Suppose |AB| = |BC| = |CD| = |DE|=L, and

$$C = \log_{10}\left(P_t \left(\frac{\lambda}{4\pi}\right)^2\right)$$

x_1 [dB] = C – 10n $\log_{10}$ (L) + C + 10n $\log_{10}$ (2L) = 10n $\log_{10}$ (2) = 3n
x_2 [dB] = C – 10n $\log_{10}$ (L) + C + 10n $\log_{10}$ (3L) = 10n $\log_{10}$ (3) = 4.8n
x_3 [dB] = C – 10n $\log_{10}$ (L) + C + 10n $\log_{10}$ (4L) = 10n $\log_{10}$ (4) = 6n

P_D [dBm] - P_E [dBm]
= C – 10n $\log_{10}$ (3L) + C + 10n $\log_{10}$ (4L) = 10n $\log_{10}$ (4/3)
= 4.99 dB.

Question 4 [20 marks] – ADC and TDM

Consider a high-quality analog-to-digital converter (ADC) for voice signals with the following specifications:

- The ADC captures the detail in the voice signal up to 11 KHz.
- 512 levels are used for quantization.

Next, consider a time-division multiplexing scheme (TDM) which combines the digital output from 25 users whose analog data is digitized through the above described ADC scheme. A TDM frame consists of samples from 25 users plus four bits for synchronization purposes.

(a) [12 points] Find the line speed (in bits/sec) to carry this TDM traffic.

$$\textit{Sampling rate} = 2 \times 11 = 22\ \textit{Ksamples}/\mathrm{sec}\ (\textit{according to Nyquist Theorem})$$
$$512\ \textit{quantization levels} \rightarrow \log_2 512 = 9\ \textit{bits}/\textit{sample}$$
$$\textit{Frame length}: (25\ \textit{users} \times 1\ \textit{sample}/\textit{user} \times 9\ \textit{bits}/\textit{sample}) + 4\ \textit{synch bits} = 229\ \mathrm{bits}$$
$$\textit{Frame duration}: 1/22{,}000\ \mathrm{sec}.$$
$$\rightarrow \textit{Line speed}: 229\ \mathrm{bits\ in}\ 1/22{,}000\ \mathrm{sec} = 5.038\ \textit{Mbits}/\mathrm{sec}$$

(b) [8 points] Assuming that M-ary modulation is used, find M if the line has 1.5 MHz of bandwidth.

$$\textit{Highest spectral efficiency}: 1\ \textit{symbol}/\mathrm{sec}/\textit{Hz}.$$
$$\rightarrow \textit{Maximum symbol rate} = 1.5\ \textit{MHz} \times 1\ \textit{symbol}/\mathrm{sec}/\textit{Hz} = 1.5\ \textit{Msymbols}/\mathrm{sec}$$
$$\textit{ceiling}(5.038\ \textit{Mbits}/\mathrm{sec}/1.5\ \textit{Msymbols}/\mathrm{sec}) = 4\ \textit{bits}/\textit{symbol} \rightarrow 2^4 = 16\ \textit{levels}$$
$$\rightarrow 16 - \textit{QAM has to be used}.$$