CARLETON UNIVERSITY

Department of Systems and Computer Engineering

SYSC4700 Telecommunications Engineering Winter 2014

Term Exam – 13 February 2014

Duration: 75 minutes

Instructions:

1. **Closed-book exam (no aid-sheet). No cell phones.**
2. **Write answers in the spaces provided on the question sheet.**
3. **If necessary, use both sides of a page.**

Name:

Student Number:

Question	Mark	Max possible mark
1		155
2		85
Total		240

Question 1 – Short Questions [155 points]

a) **[5 pts]** What is the data rate for digital voice commonly used in the current wireless cellular networks?

10Kbps.

b) **[15 pts]** What is the data rate when voice is digitized through PCM in wired telephone networks? How is that number obtained?

64Kbps.
Given that the voice signal bandwidth is 4KHz.
By Nyquist sampling theorem: Number of samples is 8000 sample/sec.
Using 8 bits per sample:

Rate= 8000*8=64Kbps.

c) [**10 pts**] The PSD (power spectral density) of a signal X(t) is given as

$$S_X(f) = \begin{cases} N_0/2, & -400MHz \le f \le -390MHz \\ N_0/2, & 390MHz \le f \le 400MHz \\ 0, & elsewhere \end{cases}$$

Find the bandwidth of X(t).

BW=400-390= 10 MHz.

d) [**10 pts**] Which one of the following numbers is a typical path-loss value in a cellular network, if a user is about 1 km away from BS: -1000 dB, -100 dB, -10 dB, 0 dB , 10 dB , 100 dB, 1000 dB?

100dB

e) **[10 pts]** What are the per cell shared peak rates that the upcoming 4G LTE-Advanced wireless networks will provide in the downlink for stationary (no or limited movement) applications?

1Gbps

f) **[15 pts]** Suppose that you are involved in the design of a next-generation cellular network which targets to deliver a shared peak rate of 20 Gbps per base station in the downlink. Choose some appropriate values for the following:

- bandwidth
- spectral efficiency, and
- number of antennas (for MIMO gain)

BW= 315 MHz.
Spectral efficiency= 8 b/s/Hz.
Number of antennas=8.
Rate= 20.16 Gbps.

g) **[10 pts]** Consider a wireless system operating in the 1133–1138 MHz band. The synch pulses are used; the highest modulation level is 128-QAM. The system supports 4x4 MIMO. Find the highest data rate (in bits/sec) that this wireless system can support.

BW= 5MHz.
Spectral efficiency= Log_2 128=7 b/s/Hz.
N= 4 antennas.

R=5*10^6*7*4=140 Mbps.

h) **[10 pts]** State one reason why the telecom standards are beneficial for the vendors (such as Ericsson, Samsung, Apple)?

-Enable the vendors to sell globally.
-Lower the cost of R&D

State one reason why the telecom standards are beneficial for the operators (Verizon, Bell Mobility, AT&T)?

-Enable operators to buy from different vendors.
-Interoperability.

i) **[5 pts]** The International Telecommunications Union (ITU) was founded in 1865. What application/service was being standardized at the time?

-Telegraph.

j) **[10 pts]** Give an example of a successful IEEE standard.

-802 family.

k) **[5 pts]** Give the acronym for the primary standards body for the Internet.

-Internet Engineering Task Force (IETF).

l) **[10 pts]** ADSL stands for "Asymmetric Digital Subscribers Line". What does asymmetric mean in this context?

-Transmission rates are different in uplink and downlink.

m) **[20 pts]** State two advantages of packet switching over circuit switching:

- BW consumed when needed.
- Speed conversion.

State two disadvantages of packet switching over circuit switching:

- Complexity.
- Variable delay.

n) **[10 pts]** Briefly explain the major contribution of Claude Shannon? (Do not use any equations)

-Provided the channel capacity theorem, which gives the maximum number of bits each symbol can carry at a given SNR.

o) **[10 pts]** Who developed the noise model in digital communication systems?

-Nyquist and Hartley.

Question 2 – Link Budget and Path-Loss [85 pts]

a) [35 pts] In a WLAN (wireless local area network), the path-loss is given as PL [dB] = 43 + $38\log_{10}(d)$ where d is the distance between the access point (AP) and a user. The AP transmits at the same power level to all users. If the distance between the AP and a user i is 8 times the distance

between the AP and a user *j*, how many dB less power does user *i* receive in comparison to user *j*?

PL_j= 43 +38 log x

PL_i=43+38 log 8x

$PL_i - PL_j$=38 log8x-38logx=38log8=34.32 dB.

b) [25 pts] The free-space path-loss is given as FSPL = $(4\pi/\lambda)^2 d^2$. If the carrier frequency is 2.5 GHz, for what distance between the transmitter and receiver a FSPL of 120 dB correspond? (Speed of light: $3x10^8$ m/sec.)

$\lambda = \frac{c}{f} = \frac{3*10^8}{2.5*10^9}$= 0.12 meter.

FSPL=$(4\pi/\lambda)^2 d^2$=$(4\pi/0.12)^2 d^2$ =10^{12}.

D=9.55 Km

c) [25 pts] The free-space path-loss is given as FSPL = $(4\pi/\lambda)^2 d^2$. Propagation measurements in a city suggest a terrestrial path-loss of TPL = $(4\pi/\lambda)^2 d^{3.6}$. If a transmitter and a receiver are 1.5 km apart, how many dBs less power will be received in the city in comparison to space? Assume a carrier frequency of 700 MHz. (Speed of light: $3x10^8$ m/sec.)

$$Loss\ in\ power\ in\ the\ city = \frac{TPL}{FSPL} = \frac{d^{3.6}}{d^2} = d^{1.6}$$

At (d=1500m):

Loss= $10log_{10}(1500^{1.6})$= 10.8 dB.