CARLETON UNIVERSITY Department of Systems and Computer Engineering

SYSC4700 Telecommunications Engineering

Winter 2018

Term Exam – 15 February 2018

- 1. NO CELL PHONES. Closed-book exam (NO aid-sheet).
- 2. Write answers in the spaces provided on the question sheet.
- 3. 4 pages including this cover page.
- 4. **Duration: 75 minutes**

Name:

Student Number:

Question	Mark	Max possible mark
1		110
2		30
3		50
4		30
Total		220

USEFUL EXPRESSIONS:

Noise power: $P_N = k T B F$ Watts (linear scale) where $k = 1.38 \times 10^{-23}$ (Boltzmann's constant); $T = 273 + {}^{\circ}C$

Noise power: $P_N = -228.6 + 10log_{10}(273 + C^{\circ}) + 10log_{10}(B) + F dBW$ (dB scale) where °C: temp. in degrees centigrade; B: bandwidth in Hz; F: noise figure

 $SNR = P_{RX} - P_N$ (dB scale) SNR in linear: P_{RX}/P_N (linear scale)

Channel Capacity: $R_{max} = n B \log_2(1+SNR)$ bits/ sec, where B is the bandwidth in Hz and n is the MIMO gain

Q1. [110 pts] Short Questions

- a) [5 pts] What is the relation between <u>globalization</u> and <u>standardization</u>?
- b) [5 pts] What is the most important benefit of standardization? In other words, what do standards enable?:
- c) [5 pts] Which ministry in Canada represents the federal government in platforms such as ITU (International Telecommunications Union), and manages the Canadian private sector participation in such platforms?
- d) [5 pts] Why the <u>domain expert</u> is important?

- e) [10 pts] What is <u>modelling</u> in the context of machine learning?
- f) [5 pts] Give one example of a modelling platform, framework, or computer language for modelling:
- g) [10 pts] Consider a machine learning setting in which the prediction error at time instant *i* is defined as $\varepsilon_i = y_i \hat{y}_i$, where *y* is the true value and \hat{y} is the predicted value. Define mathematically the mean-squared error (MSE).
- h) [5 pts] What do <u>supervised</u> and <u>unsupervised</u> mean in the context of machine learning?
- i) [5 pts] Machine learning is used for two purposes; one of them is <u>prediction</u>. What is the other?
- j) [10 pts] What is the relation between <u>artificial intelligence</u> and <u>machine learning</u>?
- k) [5 pts] Write <u>SQL</u> in the open form.
- 1) [10 pts] What does SQL do?
- m) [5 pts] In the 7-layer OSI model, to which layer does IP (internet protocol) correspond to (write the layer name and the layer number)?
- n) [5 pts] What is the most important difference between $\underline{IPv4}$ and $\underline{IPv6}$?
- o) [10 pts] What is <u>Differential PCM</u>?
- p) [10 pts] What is <u>Delta Modulation</u> in the context of pulse-code modulation (PCM)?

Q2. [30 pts] Analog-to-Digital Conversion

8K UHD is the current highest ultra-high-definition television resolution in digital television and digital cinematography (expected to be used in 2020 Olympics) which formats an image in 7680×4320 pixels. Consider a video analog-to-digital conversion scheme using 8K UHD in which each pixel is composed of three colors (RBG) and that each color has 4096 levels; the video displays 60 images (frames) per second for motion effect.

- a) Find the bit rate to transmit this video in an uncompressed mode.
- b) If MP3 with a compression ratio of 11:1 is used, how much storage (in bytes) will be needed to store a 2-hr movie?

Q3. [50 pts] Rate, Power, and SNR Calculations

a) [15 pts] What is the maximum bit rate achievable when 64-QAM scheme is used in conjunction with sinc pulses in a bandwidth of 20 MHz, in the presence of a 4x2 MIMO?

b) [20 pts] Consider a wireless channel with a bandwidth of 3 MHz. SNR at the receiver is 7 dB, the AWGN power spectral density is $N_0 = -174$ dBm/Hz, and the receiver noise figure is 8 dB. Find the received signal power, P_{RX} , in Watts.

c) [15 pts] In a 5G wireless network, the target peak rate to be achieved is given as 40 Gbps. It is also given that there is a 16x8 MIMO system, and that the transmission bandwidth is 500 MHz. What is the minimum required SNR (in dB) to facilitate this peak rate?

Q4. [30 pts] xDSL

Consider an upcoming xDSL standard as an access technology over the copper telephone lines (i.e., lastmile access). Here are some relevant specifications:

- This standard uses a high number of 4 KHz channels. There is 1 KHz guard band between neighboring channels.
- The downstream portion uses the spectrum band between 2.000 MHz and 7.119 MHz with the following format: 4 KHz channel, 1 KHz guard band, 4 KHz channel, 1 KHz guard band, ..., 4 KHz channel.
- Spectral efficiency is 8 bits/sec/Hz.

(a) Find the downstream rate in bits/sec.

(b) Find the minimum required SNR (in dB) at the user modem to facilitate this system using the Shannon channel capacity formula.