CARLETON UNIVERSITY

Department of Systems and Computer Engineering

SYSC 4700 **Telecommunications Engineering** **Winter 2018**

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Assignment 3 [140 pts]

Posting date: **29 March 2018**
Due date: **2:00 pm, Monday, 09 April 2018**
Where to submit: **Assignment box, Mackenzie 4th floor, 4th wing**
Late submissions: **No late submissions (please)**

Q1 [30 pts] – Non-Terrestrial Networks

A terrestrial UE (user equipment) is in communication with a HAP (high-altitude platform) at an altitude of 20 kms at carrier frequency $f_{\text{UE-HAP}}$ = 30 GHz.

The UE is also in communication with a low earth orbit (LEO) satellite at an altitude of 2,000 kms at carrier frequency $f_{\text{UE-LEO}}$ = 3 GHz.

Both links have the same bandwidth. Antenna gains of HAP and the LEO satellite are G_{HAP} = 7 dB and G_{LEO} = 23 dB. UE uses the same transmit power for both links. The propagation exponent is given as 2.

Consider the uplink; if SNR_{HAP} = 11 dB, obtain SNR_{LEO}.

Q2 [30 pts] – Symmetric Key Cryptography vs Public Key Cryptography

Briefly describe the symmetric key cryptography and public key cryptography.

Q3 [30 pts] – Network Function Virtualization (NFV)

Briefly describe (NFV). State the main advantages of the NFV concept.

Q4 [50 pts] – Link Budget

Assume that Canada is auctioning spectrum for wireless 4G cellular services. Frequency bands can be leased at three different carrier frequencies (denoted by options A, B, and C) by the potential operators. The spectrum leasing cost (LC) for option B is given as $30 million per MHz; you are asked to determine the leasing costs for the other two options:

Carrier Frequency A: f_A = 800 MHz → Leasing Cost: LC_A = **?**
Carrier Frequency B: f_B = 1.8 GHz → Leasing Cost: LC_B = $30 M/MHz
Carrier Frequency C: f_C = 3.4 GHz → Leasing Cost: LC_C = **?**

Here are some figures from the operator specifications:

- BS transmit power: P_{TX} = 15 W
- Transmitter (BS) antenna gain: G_{TX} = 8 dB
- Receiver (terminal) antenna gain: G_{RX} = 10 dB
- Path loss: PL = $(4\pi f/c)^2 d^{3.4}$, where
    - Distance between BS and a terminal: d
    - Speed of light: $c = 3\text{x}10^8$ m/sec

The spectrum leasing costs should be related to how large an area one base station (BS) can provide radio coverage; note that a larger coverage area for a BS means more customers per BS, which in turn means more revenue per BS.

Let us consider the downlink (from BS to the terminals). The coverage region of a BS is the area in which the received power for a signal sent by that BS is greater than a threshold value (that threshold is the same for all the three options).

Here is the rule to determine the spectrum leasing costs: If option i allows a BS to serve an area u times larger in comparison to option j, then $LC_i = u\ LC_j$. Determine LC_A and LC_C.