CARLETON UNIVERSITY
Department of Systems and Computer Engineering

SYSC5608 – Wireless Communications Systems Engineering – Winter 2016

Term Exam II

17 March 2016 – Prof. H. Yanikomeroglu

Closed-book. Two-page aid-sheet is permitted. No smart phones.
Duration = **90** min. Total mark = **265** points.

Q1 [90 pts] – Qualitative Questions

a) [10 pts] Why ICIC (intercell interference coordination) results in a better overall reuse of the resources in comparison to the fixed resource assignment used in 1G and 2G networks?

b) [10 pts] Why "paired spectrum" (rather than "contiguous") is necessary for the FDD operation?

c) [10 pts] Why the existence of 3GPP is important in the cellular industry? In other words, what would be the problem if 3GPP did not exist?

d) [10 pts] What is the primary advantage of "multihop relaying"? That is, what does this framework enable which would have otherwise been difficult to achieve?

e) [10 pts] What does "HetNets" refer to?

f) [15 pts] The downlink aggregate peak rate that a BS should support is specified as follows in the IMT circular letters:

- IMT-2000 (~2000) → 3G: 2 Mbps
- IMT-Advanced (2008) → 4G: 1 Gbps
- IMT-2020 (2016-2017) → 5G: 20 Gbps (anticipated)

From IMT-2000 to IMT-Advanced, the aggregate peak rate requirement is increased almost three orders of magnitude, while that increase is slightly more than only one order of magnitude from IMT-Advanced to IMT-2020. Why?

g) [20 pts] Standards play an important role in the wireless industry.

- g.1) Write one benefit of the standards to the vendors.
- g.2) Write one benefit of the standards to the operators.
- g.3) Write one benefit of the standards to the customer.
- g.4) Write one disadvantage of the standards.

Q2 [35 pts] – Reuse Factor and Capacity

Consider a cellular network with a fixed number of BSs. The operator upgrades the network from 2.5G EDGE with a reuse factor of 1/4, to 3.5G HSPA+ with a reuse factor of 11/20. If everything else remains the same in the network, what percentage of capacity increase is achieved by this upgrade? (Note: reuse factor can be thought as the inverse of the cluster size.)

Q3 [60 pts] – SIR Calculations

Consider a large cellular network in which BSs are located in the centers of a regular square grid. The path-loss expression is given as (in dB) PL = 48 + 34 log *d*, where *d* is the distance between the transmitter and the receiver; for simplicity, shadowing is not considered. Assume that all the BSs transmit at the same transmit power and have omni-directional antennas.

Consider a worst-case (cell-edge) user which is located at the vertex of the square cell from which it is being served. In an interference-limited scenario, compute the downlink SIR (i.e., ignore the noise power) for this worst-case user for two different cluster size (*N*) values:

a) $N = 1$,
b) $N = 4$.

Although the user will receive co-channel interference from a very large number of BSs, include only the first three most dominant (strongest) interferers in your SIR calculations:

Q4 [50 pts] – Reuse Factor Calculation in Fractional Frequency Reuse

Consider a cellular network with hexagonal cells (i.e., hexagonal layout). In this network a "fractional frequency reuse (FFR)" scheme is used as described next.

The 20 MHz of spectrum is divided into 5 non-overlapping segments, denoted by $\mathcal{A}$, $\mathcal{B}$, $\mathcal{C}$, $\mathcal{D}$, and $\mathcal{E}$, and with bandwidths as follows: $\mathcal{A}$ = 3 MHz, $\mathcal{B}$ = 3 MHz, $\mathcal{C}$ = 8 MHz, $\mathcal{D}$ = 3 MHz, $\mathcal{E}$ = 3 MHz. The segment $\mathcal{C}$ is used in the core of each and every cell. The remaining four segments are used outside the mentioned cores with a reuse factor of 1/4.

Compute the overall reuse factor.

Q5 [35 pts] – FDD FD/TDMA

Consider a FDD FD/TDMA cellular network with a paired spectrum of 10 MHz for each of the uplink and downlink portions (therefore, symmetric rates).

The uplink portion is divided into four 2.5-MHz channels (FD). In each of these channels 32 users are accommodated through equal-duration time-slots in a TDMA fashion. Assume that the average spectral efficiency for each user is the same, SE = 1.6 b/s/Hz, and that all the users run the same application.

a) What is the total number of users that can be accommodated in an orthogonal manner?
b) Find the rate of the application.
c) If SE is calculated through the Shannon's formula, what should be the SNR in dB?