ECE 686 (Wireless Communication Networks) – Assignment #3

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1. (8 points) Consider an FDMA-based hexagonal cellular system in which the one-way bandwidth of the system is 20 MHz, the channel spacing is 30 kHz, and the guard band at each boundary of the spectrum is 10 kHz. If i) the radius of a cell (the distance from the center of the cell to a vertex) is 1 km, ii) the frequency reuse factor (cluster size) is 7, and iii) 36 of the available channels in a cluster are used to handle control signaling, calculate the following.

    a. The total number of available channels per cluster;

    b. The number of available data channels per cluster;

    c. The number of available data channels per cell;

    d. The system spectral efficiency in unit of channel/MHz/km^2.

2. (4 points) Consider a synchronous N-TDMA/FDD system that uses a one-way bandwidth of 12.5 MHz for the forward (or reverse) channel. The system bandwidth is divided into radio channels of 30 kHz. Two guard bands each with B_g = 10 kHz are used. The frame duration is 50 ms, consisting of 5 time slots. Each time slot can support one user. Each time slot consists of 300 bits, among which 250 bits are for information data and the remaining 50 bits are overhead for access control. The system does not use channel coding. The modulation efficiency ϵ_{bw} is 1 bps/Hz. The frequency reuse factor is 7. Please find

    a. The cell capacity

    b. The overall spectral efficiency in unit bit/s/Hz/cell.

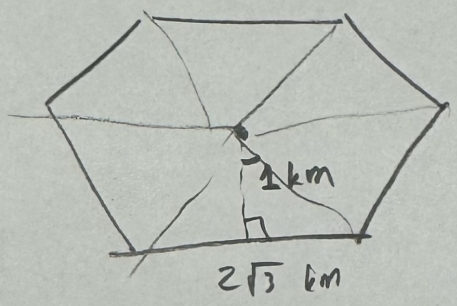
3. (4 points) For a CDMA system, if the following factors are specified, determine the cell capacity (that is, the maximal number of users that can be supported in a cell simultaneously) and the spectral efficiency (in terms of bit/s/Hz) at the cell capacity: 1) frequency reuse efficiency factor = 0.55, 2) capacity degradation factor due to imperfect power control = 0.9, 3) $E_b/I_0 \geq 10$ dB, 4) information bit rate = 16.2 kbps, 5) system bandwidth = 12.5 MHz, 6) neglecting background noise, 7) source activity factor $s_f = 1$.

Q1.

$B_s = 20\,MHz$

$B_c = 30\,kHz$

$B_g = 10\,kHz$



$N = 7$

$N_{ctrl} = 36$

a) $N_{ch/cluster} = \dfrac{B_s - 2B_g}{B_c} = 666$

b) $N_{data/cluster} = N_{ch/clus} - N_{ctrl/clus} = 630$

c) $N_{data/cell} = \dfrac{N_{data/clus}}{N} = 90$

d) $\eta = \dfrac{N_{data/cell}}{B_s \cdot A_{cell}} = \dfrac{90}{20 \times 6\sqrt{3}} = \dfrac{\sqrt{3}}{4} = 0.43 \ \dfrac{ch/MHz}{km^2}$

$A_{cell} = 6 \times \left(\dfrac{2\sqrt{3}}{2}\right) = 6\sqrt{3} \ (km^2)$

Q2.

$B_s = 12.5$ MHz

$B_c = 30$ kHz

$B_g = 10$ kHz

$T_f = 50$ ms

$N_{slot} = 5$

$L_d = 250$ bits

$L_s = 300$ bits

$\varepsilon_{bw} = 1$ bps/Hz

$N = 7$

a) $N_c = \dfrac{N_u N_{slot}}{S_f N} = \dfrac{416 \cdot 5}{1 \cdot 7} = 297.1 \ \dfrac{\text{user}}{\text{cell}}$

$N_u = \dfrac{B_s - 2B_g}{B_c} = 416$

b) $\eta = \varepsilon_{bw} \dfrac{T_f - T_p - T_t}{T_f} \dfrac{L_d}{L_s} \dfrac{B_s - 2B_g}{B_s} \times \dfrac{1}{N}$

$= 1 \cdot \dfrac{50 - 0 - 0}{50} \cdot \dfrac{250}{300} \cdot \dfrac{12.5 \times 10^3 - 20}{12.5 \times 10^3} \times \dfrac{1}{7}$

$= 0.1189 \ \text{bit/s/Hz/cell}$

Q3.

$\alpha = 0.55$

$Eb/I_0 = 10$ dB

$S_f = 1$

$R_b = 16.2$ kbps

$B_S = 12.5$

$$\rightarrow \eta = 0.55 \frac{1 \times 16.2}{12.5} = 0.7128 \text{ bit/s/Hz}$$