Georgia Institute of Technology
School of Electrical and Computer Engineering

ECE6604 Personal & Mobile Communications

Term Test
Spring 2009

- Attempt all questions.
- All questions are of equal value.
- Open book, open notes, exam.

1) Consider the reverse link of a cellular system that uses a 7-cell reuse cluster with omnidirectional base station antennas. Ignore envelope fading and shadowing, and assume the simple path loss model

$$\mu_{\Omega_p\ (\mathrm{dBm})}(d) = \mu_{\Omega_p\ (\mathrm{dBm})}(d_o) - 10\beta \log_{10}(d/d_o) \ \ (\mathrm{dBm}) \ ,$$

where $\beta = 3.5$. Also assume that all mobile stations are transmitting at the same power level.

a) **5 marks:** Show graphically the worst case co-channel interference geometry for the reverse channel. *Use the hex grid on the next page.*

b) **5 marks:** Calculate the worst case carrier-to-interference ratio, Λ in terms of the co-channel reuse factor D/R.

The worst case interfering Mobile station locations are all at distance $\sqrt{13}R$ from the target Base station (located in the center cell). The serving mobile station is at distance R.

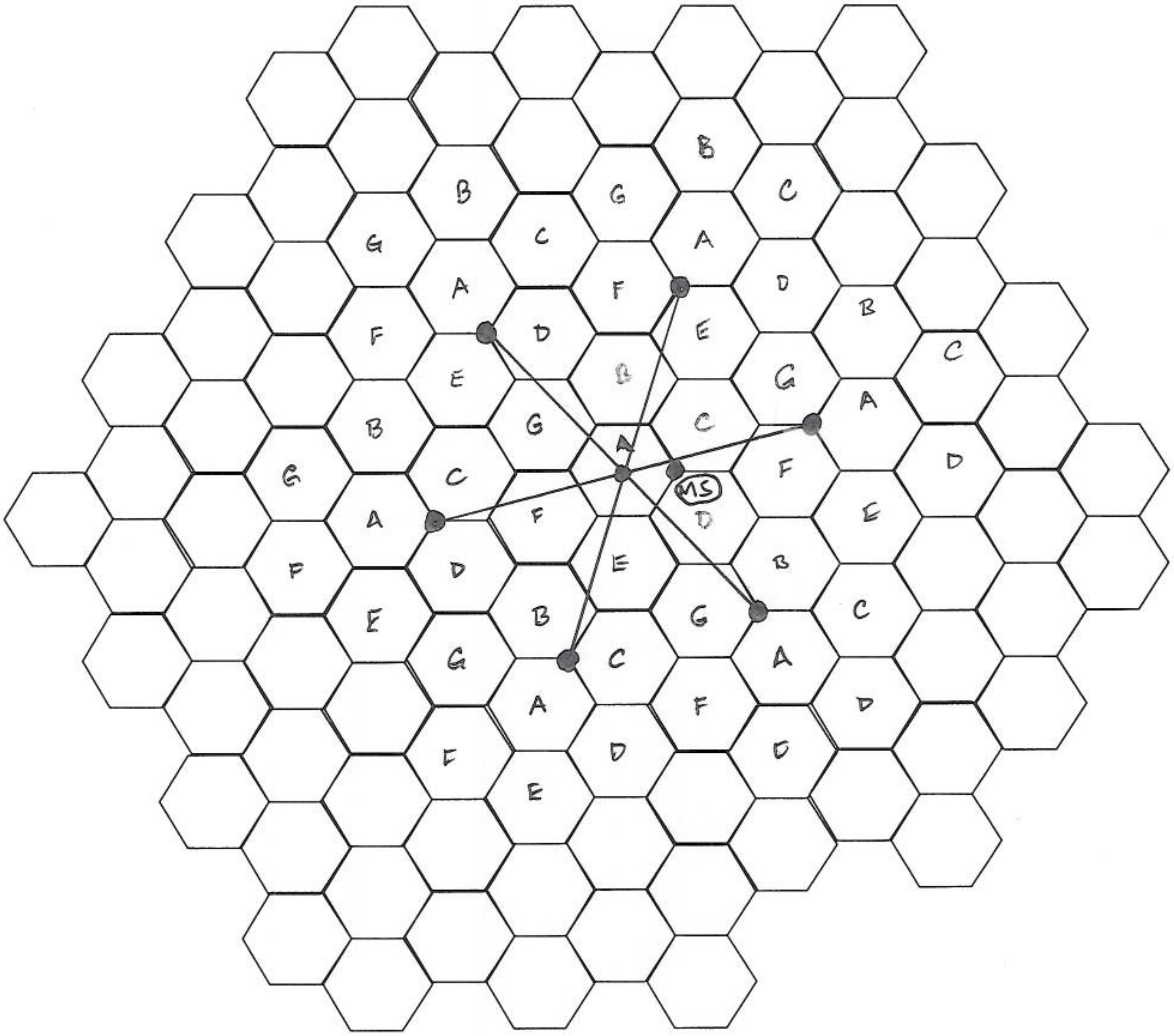
Hence,

$$\Lambda = \frac{C}{I} = \frac{R^{-\beta}}{6 \times (\sqrt{13}R)^{-\beta}}$$

$$= \frac{1}{6 \times (\sqrt{13})^{-\beta}} = 11.71 \text{ dB for } \beta = 3.5.$$

If you express in terms of D/R, we have $\frac{D}{R} = \sqrt{21}$ and $\sqrt{13}R = \left(\frac{D}{R}\right)\sqrt{\frac{13}{21}}\,R$

$$\therefore \quad \Lambda = \frac{C}{I} = \frac{1}{6 \times \left(\frac{D}{R}\sqrt{\frac{13}{21}}\right)^{-\beta}}$$



Note: For the UPLINK, mobile stations in co-channel cells generate co-channel interference. The worst case location for the interfering mobile stations is at the corner of their respective cells that is closest to the target base station (all at distance sqrt(13)R). The desired mobile station is also located in a corner of its cell (at distance R).

2) The scattering function for a WSSUS scattering channel is given by the following

$$\psi_S(\tau,\nu) = \Omega_p \cdot \frac{2a}{a^2 + (2\pi\nu)^2} \cdot be^{-b\tau}u(\tau)$$

a) **5 marks:** What is the spaced-time spaced-frequency correlation function?

b) **2 marks:** What is the average delay?

b) **3 marks:** What is the rms delay spread?

a) we have

$$\psi_g(\Delta t, \tau) = \mathcal{F}^{-1}\{\psi_s(\tau,\nu)\}$$

$$= \Omega_p e^{-a|\Delta t|} \cdot be^{-b\tau} u(\tau)$$

Also,

$$\phi_T(\Delta t : \Delta f) = \mathcal{F}\{\psi_g(\Delta t, \tau)\}$$

$$= \Omega_p e^{-a|\Delta t|} \cdot \frac{b}{b + j2\pi f}$$

b) $\psi_g(\tau) = \Omega_p be^{-b\tau} u(\tau)$

$$\mu_\tau = \frac{\int_0^\infty \tau \psi_g(\tau)d\tau}{\int_0^\infty \psi_g(\tau)d\tau} = b\int_0^\infty \tau e^{-b\tau} d\tau$$

$$= b \cdot \frac{1}{b^2} = \frac{1}{b}$$

c)

$$\sigma_\tau^2 = \frac{\int_0^\infty (\tau - \mu_\tau)^2 \psi_g(\tau)d\tau}{\int_0^\infty \psi_g(\tau)d\tau}$$

cont'd

$$= \int_0^\infty \tau^2 b e^{-b\tau} d\tau - \int_0^\infty \frac{2\tau}{b} \cdot b e^{-b\tau} d\tau + \frac{1}{b^2} \int_0^\infty b e^{-b\tau} d\tau$$

$$= \frac{2}{b^2} - \frac{2}{b^2} + \frac{1}{b^2}$$

$$= \frac{1}{b^2}$$

$$\therefore \quad \sigma_\tau = \frac{1}{b}$$

3) A vehicle experiences 2-D isotropic scattering and receives a Rayleigh faded 900 MHz signal while traveling at a constant velocity for 10 s. Assume that the local mean remains constant during travel, and the average duration of fades 10 dB below the rms envelope level is 1 ms.

a) **5 marks:** How far does the vehicle travel during the 10 s interval?

b) **5 marks:** How many fades is the envelope expected to undergo that are 10 dB below the rms envelope level during the 10 s interval?

a) $$\bar{t} = \frac{e^{\rho^2} - 1}{\rho f_m \sqrt{2\pi}} \Rightarrow f_m = \frac{v}{\lambda_c} = \frac{e^{\rho^2} - 1}{\bar{t} \rho \sqrt{2\pi}}$$

For 900 MHz, $\lambda_c = \frac{c}{f_c} = \frac{3 \times 10^8}{9 \times 10^8} = .33\text{ m}$

Then for $\rho = -10\text{dB}$

$(\rho = 10^{-1/2} = .31623)$

and $\bar{t} = 1\text{ms}$, the vehicle speed is 43.78 m/s. Hence, the vehicle travels $\boxed{437.8\text{ m}}$ in 10 seconds.

b) $L_R = \sqrt{2\pi} f_m \rho e^{-\rho^2}$ $\quad \rho = .31623$, $f_m = 132.68$

$= 95.16$ crossings/second

Expected number of envelope crossings in 10 s is $95.16 \times 10 = 951.6$ crossings.