S-72.2211 Mobile Communication Systems and Services

Exercise session 5 29.2.2008
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1. Power Control

Power control (PC) is introduced in the down-link direction to reduce the average transmit power level in the cell. With single-slope channel model and perfect compensation of path loss by PC, the transmit power $P_{tx}(r)$ when MS is at distance r from the BS with a cell radius R and path loss exponent n is expressed by

$$P_{tx}(r) = P_{max}(\frac{r}{R})^n \quad (1)$$

Where P_{max} is the maximum transmit power used for the cell-edge users. Assume for users very close to the BS, we have a minimum transmit power $P_{min} \approx 0$. The mean transmit power averaged over the spatial distribution of MSs is expressed by

$$P_{txm} = \int_0^R \int_0^{2\pi} p(r,\phi) P_{tx}(r) d\phi dr \quad (2)$$

Where $p(r,\phi)$ is the MS distribution function. When MSs are more concentrated around the BS, a spherically symmetric probability density function used to describe the MSs' distribution is

$$p(r,\phi) = \frac{(k+1)r^k}{R^{k+1}} \frac{1}{2\pi}, \; r \in [0,R], \; \phi \in [0,2\pi], \; k < 1. \quad (3)$$

The spatially uniform distribution of MSs is obtained from (3) when $k = 1$.

a) How large is the fractional area of the cell where 50% of the MSs nearest to the BS are located, when $k = 0$ and $k = 1$?

b) How much average power reduction is achieved if we have uniform user distribution when $n = 2, 3, 4, 5$?

c) Repeat the calculation for a non-uniform, spherically symmetrical distribution with $k = 0$

2. Power Control

Assume the similar PC scheme as the previous task, with a uniform user distribution. However, the minimum transmit power P_{min} is no longer 0 and the minimum transmit power P_{min} is used whenever the PC result requires a power level less than P_{min}.

a) At which distance, P_{min} is exactly achieved according to PC result?

b) Calculate the average transmit power over all possible user positions in the cell.

c) How much power reduction is reached by PC compared to the maximum transmit power P_{max}?

Give the results assuming that the power control range is 10, 20, 30, 40 dB and the path loss exponent is 2, 2.5, 3, 3.5, 4, 4.5, 5.

3. WCDMA Capacity

In a DS-CDMA system the up-link fractional load is defined as

$$\eta = (1 + f) \sum_{i=1}^{N} \frac{\rho_i \gamma_i}{G_i} \tag{4}$$

and the interference margin is

$$IM = 10 \cdot \log_{10}\left(\frac{1}{1 - \eta}\right) \tag{5}$$

Where ρ is the channel activity factor, γ is the target SINR after despreading, G is the spreading factor and f is the ratio of other cell interference to own cell interference.

a) How many speech users ($\rho_i = 0.4,\ \gamma_i = 8\ dB,\ G_i = 256$) can be served when $f = 0.75$, and the fractional load target is 0.7?

b) If a new user ($\rho_{N+1} = 1,\ \gamma_{N+1} = 4\ dB,\ G_{N+1} = 32$) is admitted in the cell, how many dB must the interference margin be increased from the value in subtask a) to maintain all the connections?

4. WCDMA Capacity

In the WCDMA system the chip rate is 3.84 Mchips/s.

a) Assume a single cell system with the user bit rate after channel coding 15 kbits/s and the E_b/I_0 requirement for proper reception 5 dB, where E_b is the bit energy and I_0 is the experienced interference. With user activity factor 0.4 and AWGN noise not considered, how many users in a cell, theoretically, can be simultaneously served in the up-link direction?

b) How many users with 10 times higher received power can exist in a cell before the total number of users is halved in a single cell system?

c) Repeat the calculation for a multicell system when the other to own cell interference ratio is 0.6.