

S-72.3275 Cellular Radio Network Planning and Optimization

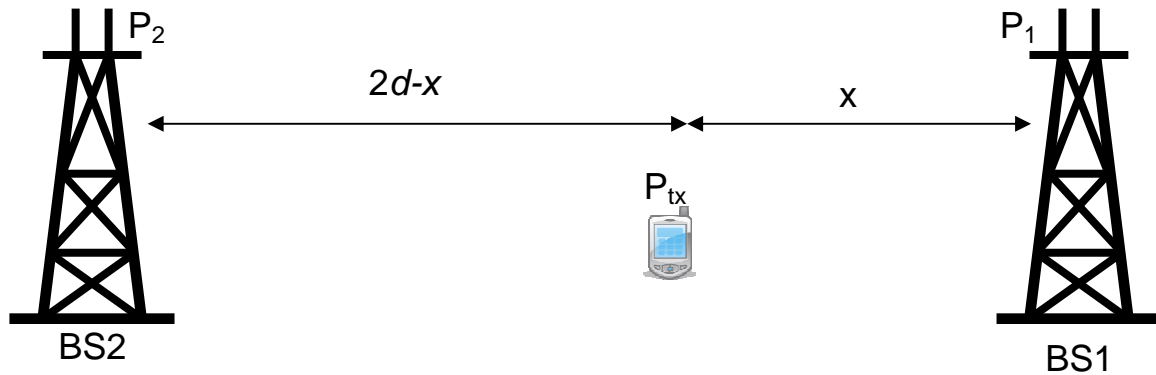
Exercise Set 3

Solutions

Handover4

In following task you investigate the handover operation in uplink only. Two base stations (BS1 and BS2) are 2d apart from each other. Furthermore, between the two BSs there is a UE located at distance x (0 < x < 2d) from BS1. The UE transmits with output power P_{tx} so that the signal is received at BS1 with power P₁ and with power P₂ at BS2 correspondingly.

ation in uplink only. Two base stations (BS1 and BS2) are 2d apart from each other. Furthermore, between the two BSs there is a UE located at distance x (0 < x < 2d) from BS1. The UE transmits with output power P_{tx} so that the signal is received at BS1 with power P₁ and with power P₂ at BS2 correspondingly.



1. Assume path-loss exponent $\alpha = 4$, and find the relation P_2/P_1 with respect to x and d . Hint: $\alpha = 4$ means that instead of calculating the powers in free space (loss (PLE=2), we assume a stronger distance dependent fading.

Start in linear domain (d_0 is an arbitrary referenced distance):

$$P_2 = [(2d-x)/d_0]^{-4} P_{tx}, \quad P_1 = [(x)/d_0]^{-4} P_{tx}$$

$$\Rightarrow P_{tx} = [(x)/d_0]^{-4} P_1$$

$$\Rightarrow P_2 = [(2d-x)/d_0]^{-4} [(x)/d_0]^{-4} P_1$$

$$\Rightarrow \left[\frac{P_2}{P_1} = \left(\frac{2d-x}{x} \right)^{-4} \right]$$

2. Now assume that the considered UE is the only terminal in the system. Furthermore, the UE belongs to EUL category 3 and is transmitting a large email attachment to BS1, which is the serving cell. To achieve upload speed of 1 Mbps, the E_c/N_0 of the P_1/P_n needs to be 0 dB. What is the corresponding noise rise R_oT (in dB) at BS1? (Hint: Here, as well as for your future work, it might be useful to find out what is meant by R_oT !)

With R_oT (Rise over Thermal) we consider the loaded situation compared to an empty network with only thermal noise:

$R_oT = 10 \log(RSSI/P_n)$, where $RSSI$ denotes the whole wideband power in the measured point, including the noise power, hence for E_c/N_0 (P_1/P_n) of 0 dB we have:

$$\left[R_oT = 10 \log \left(\frac{P_n + P_I}{P_n} \right) = 10 \log \left(1 + \frac{P_I}{P_n} \right) = 10 \log (1 + 10^{0dB/10}) = 3dB \right]$$

3. As you already know, due to the cell breathing property of WCDMA, the coverage area of a BS decreases as R_oT (e.g. network load) increases. In microcells, at typical value of R_oT limit, before admission control starts to operate, is set to be 6 dB. Define the distance x leading to situation where the

RoT₂ of BS2 exceeds that threshold value. P_{tx} is determined so that the E_c/N₀ target for 1 Mbps upload is satisfied. (Hint: Start from the power P₂ yielding RoT₂ of 6dB...)

This task is more complicated. Due to some misunderstandings we decided to have this one as a bonus task. However the idea is to investigate how far we can go from the serving cell BS1 so that we produce 6dB RoT to BS2, fulfilling the requirement that E_c/N₀ in the BS1 should be 0dB.

As given in the hint, we start from P₂ yielding RoT₂ of 6dB:

$$RoT_2 = 6\text{dB} \Leftrightarrow 10 \log \left(1 + \frac{P_2}{P_n} \right) = 6\text{dB}$$

$$\Rightarrow \frac{P_2}{P_n} = 10^{0.6} - 1,$$

$$\text{remember: } 10 \log \left(\frac{P_1}{P_n} \right) = 0\text{dB} \Leftrightarrow P_1 = P_n$$

$$\Rightarrow \frac{P_2}{P_1} = 10^{0.6} - 1$$

$$\text{remember: } \frac{P_2}{P_1} = \left(\frac{2d-x}{x} \right)^{-4}$$

$$\Rightarrow \left(\frac{2d-x}{x} \right)^{-4} = 10^{0.6} - 1 \Rightarrow x = 1.136d$$

The point is that with high uplink bit rates near where we completely fill up the neighbouring cell why we have to have accurate power control and fine WCDMA.

lledge, we easily run into a situation of limits. That's one of the reasons tuned handover parameters in

Handover5

1. Describe the differences between soft and softer handover on the uplink of WCDMA. Which are the predominant gain mechanisms in both cases?

[Soft handover: **no MRC**, selection in RNC based on reliability indicator; gain due to better diversity against fast fading and slow fading
Softer handover: **MRC at NodeB**; gain due to antenna gain and diversity gain against fast fading (slow fading in different sectors is typically correlated)]

2. Is there a difference between soft and softer handover on the downlink? Consider UE and NodeB sides separately.

[From the mobile station perspective there is no difference between soft and softer handover on the downlink!
From the base station perspective there is the following difference: in softer handover there is one unique power control command sent to the mobile station; in soft handover the two base stations can potentially send two different power control commands]

3. On the uplink the two base stations independently measure the received SIR of the mobile station. Consequently they derive two power control commands and send them to the mobile station. Explain how the mobile station should react in case it receives two different commands, i.e., one "power up" and one "power down" command?

[The mobile station should react with "power down" because link quality will be sufficient and interference to other links will be kept low. A more advanced algorithm could take the reliability (soft values) of the power control commands into account]

4. A hard one: Is it reasonable to modify the power control step size in a handover situation?

This task really demands some thinking and "computing power". There might also be other opinions but at least following applies:

[Step size in general:
high: fast reaction to link quality changes
low: high accuracy]

Accuracy is more important in a handover situation since there is lower fading fluctuation due to enhanced diversity! Thus, it is reasonable to reduce the power control step size.]

Coverage1

Define the increase in coverage area if a gain of 1, 3, or 6 dB is obtained on the link. Calculate for path loss exponents $PLE=3.52$ and $PLE=4.52$

Denote: G =link gain, d_0 =original cell radius, d_{new} =new cell radius

$$10 \log(d_{new}/d_0)^{PLE} = G \Rightarrow d_{new}/d_0 = 10^{G/(10PLE)}$$

Cell area grows WRT. Square of radius:

$$A_{new}/A_0 = [10^{G/(10PLE)}]^2$$

For $PLE=3.52$, $G=[1\text{dB}, 3\text{dB}, 6\text{dB}]$: $A_{new}/A_0=[1.14, 1.48, 2.19]$

For $PLE=4.52$, $G=[1\text{dB}, 3\text{dB}, 6\text{dB}]$: $A_{new}/A_0=[1.11, 1.36, 1.84]$

Now, assume that you are an experienced WCDMA engineer working in product development and make an invention that increases the performance by 1 dB. What is the CAPEX value of your invention, if network operator would build a network needing 500 base stations without your invention? Assume $PLE=3.52$. Comment the result, and keep it in your mind in salary negotiations!

$PLE=3.52, G=1\text{dB}$

\Rightarrow site density decreases by a factor of 1.14

\Rightarrow number of BSs with invention = $500/1.14 = 438.6 \sim 439$

\Rightarrow CAPEX savings are $(500-439) * 43000 = 2623000$

In your analysis, assume following cost structure for CAPEX of one BS:

Sites survey and design	4000
Permits	1000
Civil and electricity work	10000
Mast	1000
Housing/Cabinet	5000
Antenna system & cables	2000
Base station equipment	15000
Radiotx	5000