S-72.3275 Cellular Radio Network Planning and Optimization

Exercise Set 2

Solutions

Handover 1

1. What is meant by Hard Handover, Soft Handover and Softer Handover?

Hard: like in GSM, no multiple simultaneous links,
Soft: Multiple simultaneous links between mobile and several base stations
Softer: Multiple simultaneous links between mobile and several sectors of a single base station.]

2. What is the difference of selection combining and maximum ratio combining?

Selection: select the best block and discard the others;
MRC: exploit all the information from different blocks by weighted average of received bits]

3. Considering uplink, what kind of combining method is used in each different handover scheme of question 1?

Hard: none, Soft: selection, Softer: maximum ratio]

4. Why isn't maximum ratio combining utilized in uplink soft handover?

Iub capacity! The needed core NW capacity for transmitting soft bit values to RNC would be too high! The OPEXs of Iub links are very high to operators.]

5. What is meant by active set (AS)?

For a certain UE, the active set consists of the cells that are in SHO with the considered UE.]

6. What is meant by Neighbour Set (NS)/Monitored set (synonyms)?

Neighbour set consists of all the cells defined in the neighbour lists of AS cells, excluding the AS cells. Monitored set consists of the cells being strong enough for the UE to measure. See for example : http://www.epo.org/patents/patent-information/european-patent-documents/publication-server.html?iAction=3&cc=EP&pn=1449400&ki=B1]

7. What is meant by Detected Set (DS)?

The set includes the cells that UE has detected but belong neither to AS nor in NS]

8. Is it good to have a big DS?

No! Big DS => means either bad neighbor definitions or overshooting cells. -Excess interference.]

9. What is meant by soft handover window?

The SHO window unit is dB. The measured neighbor cells that are received within SHO window are allowed to be in active set]

10. Give some drawbacks if SHO window is too big?

AS size too big => Increased SHO overhead (data), Increased BS tx power, Increased MS tx power, Excess signaling]

11. Give some drawbacks if SHO window is too small?

AS size too small => Increased call drops due to shadowing especially in urban environment, Increased MS tx power, Increased BS tx power]

Handover 2

A short return to probability theory: Consider an arbitrary communication system using transmission blocks of B bits. Derive the equation for BER in function of BLER and B.

BLER= P("Block error occurs")
= P("One or more of the B bits are erroneous")
= 1 - P("None of the B bits are erroneous")
= 1 - P("B correct bits received consequently")
= 1 - $(1 - BER)^B$]

$$=> \left[BER = 1 - \sqrt[B]{1 - BLER} \right]$$

Now assume a wireless communication system with a single radio bearer (RAB) from BS to MS with following characteristics BLER = 10^{-4}, B = 100 bits, what is the required BER?

Apply to above formula, yields BER of ~10^{-6}]

Consider that the same requirements should be met by using two RABs in soft handover (SHO) manner with selection combining. What is the required block error ratio $BLER_{SHO}$ for both RABs now?

In this case the BLER of a single RAB can be increased:
P("Block error occurs")
= P("block error occurs simultaneously on both RABs")
= P("RAB1 block erroneous")* P("RAB2 block erroneous")

-RAB1 is similar to RAB2
=> $BLER_{SHO} = BLER$^0.5 = 10^{-2}]

How about the corresponding bit error ratio BER_{SHO}?

Apply $BLER_{SHO}$ to the formula of BER: 10^{-4}]

Now with the Q-value table provided below, calculate what is the gain achieved in reduced SNR requirement of one RAB. Remember:

$$P_e(BPSK) = Q\left(\sqrt{2SNR}\right)$$

The Q-values give the required signal amplitudes corresponding to BERs, hence 20log is needed for the powers:

$$\left[20\log\frac{4.75342}{3.71902} = 2.12 \text{ dB} \right]$$

Now, remember that in SHO we still use two RABs e.g. twice the power. So based on this analysis, compared with single RAB operation, what can you say about the efficiency of the SHO?

Seems inefficient, gain of 2.12 dB but loss of 3 dB in system efficiency due to doubling the power => a loss of 0.9 dB]

How to improve the efficiency?

Remember, in WCDMA Maximum Ratio Combining instead of selection combining! And moreover, we didn't consider diversity gains against fast and slow fading at all]

Q(x)	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
x	1.28155	2.32635	3.09023	3.71902	4.26489	4.75342

Handover 3

(Hint: Read first the whole paper to get the big picture of the task -an approach typically yielding the best results!)

In the following analysis, we consider the downlink direction only. A WCDMA UE is operating in soft handover (SHO) with two radio bearers (RABs 1 and 2) from different base stations BS1 and BS2. The corresponding received signal to interference ratios are denoted SIR_1 and SIR_2.

Keeping the SIR_1 as a reference level, let the SIR_2 be 0 dB, 2 dB, 3 dB, 6 dB, and 10 dB weaker. Assuming maximum ratio combining (MRC) and perfect channel estimation, what is the corresponding SIR gain in decibels, achieved by adding the weaker RAB2 to the active set?

$$\left[MRCgain = 10\log\left(1+10^{(SIR_2-SIR_1)/10}\right)\right]$$

Next assume that all the RABs are sent with equal power from the BSs. What is the rise in interference in the soft handover zone due to addition of RAB2 compared to operating only with RAB1?

[3 decibels]

Finally, you may determine the net gain of DL SHO assuming diversity gain G_D = 4 dB (reduced fast fading + reduced shadowing margin) and a reduction in MRC gain due to imperfect channel estimation of L_{ChEst} = 1.5 dB.

When carrying out the task, following table might be useful:

SIR_1	SIR_2 - SIR_1	MRC gain	Rise in I	G_D	L_{ChEst}	Net gain
Ref	0					
Ref	-2					
Ref	-3					
Ref	-6					
Ref	-10					

Table filled:

SIR_1	SIR_2 - SIR_1	MRC gain	Rise in I	G_D	L_{ChEst}	Net gain
Ref	0	3	3	4	-1.5	2.5
Ref	-2	2.12	3	4	-1.5	1.62
Ref	-3	1.76	3	4	-1.5	1.26
Ref	-6	0.97	3	4	-1.5	0.47
Ref	-10	0.41	3	4	-1.5	-0.09

MRC gain is determined with the presented equation for *MRCgain.* In side the log operation we have the "1" representing the reference, $10^{(SIR_2 - SIR_1)}$ represents the relative SIR of RAB2 compared to RAB1.

The *Rise in I* is 3 dB in every case due to the fact that compared to single RAB case, in 2 cell SHO we double the power in the SHO area.

Based on your analysis, what would be an appropriate SHO window size?

With the assumptions made, we see that the net gain from SHO starts to go very small when the relative SIR of RAB2 goes below -6 dB, hence we could consider that as a good value for SHO window.

The exact value for relative SIR yielding 0dB net gain:
Required MRC gain: G_D - Rise in I - L_{ChEst} = 0.5 dB
Realtive SIR giving MRC gain of 0.5 dB:
$10\log(1 + 10^{(SIR_2 - SIR_1)/10}) = 0.5$
$\Rightarrow 10^{0.05} - 1 = 10^{(SIR_2 - SIR_1)/10}$
$\Rightarrow SIR_2 - SIR_1 = 10\log(10^{0.05} - 1) = -9.1$ dB

Any justified value between 6 dB and -9.1 dB can be considered reasonable, different operators have different strategies!

Handover 4 (Bonus)

You have just carried out a drive test from a 3G network. The measurement software indicates that a handover failure was occurred in a certain location. Due to the the failure a call drop was experienced. How would you begin your trouble shooting? (This one is probably the most typical engineering task related to 3G-optimization!)

The idea of the exercise was to make you think of probable causes of errors. Giving a full detailed check list is not required, but for example following issues could be considered:

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Radio related problem or core problem?

The handover type:

- inter system or intra system
- inter frequency or intra frequency

Blocking of target cell

Received signal strength

CINR

- Low Ec/N0?, reason: Overshooting antennas?

Neighbor list problem?

- detected set big and high Ec/N0 and RSCP

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