

8.7 CDMA Uplink - simulation algorithm

The center cell site only is used to calculate the effects of interference. In spite of this fact, it is essential to consider the intra-system interference caused by other cells in the cluster for an accurate modelling of power control. The precise transmit power of all active mobile stations in the wrap-around cluster has to be calculated in the uplink power control loop.

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8.7.1 Power Control

In CDMA networks, closed-loop fast transmit power control (TPC) is supported in uplink. The base station estimates the signal-to-interference ratio (C/I), measured in bit energy-to-noise density ratio E_b/N_0 , and compares it to a target value (E_b/N_{0_target}). If the estimated C/I is below E_b/N_{0_target} , the base station commands the mobile station to increase the transmit power; if the measured C/I is above E_b/N_{0_target} , it commands the mobile station to lower its power. The fast transmit power control works at a frequency of f Hz (1500 Hz for WCDMA and 800 Hz in CDMA2000 1x), thus the TPC commands are transmitted at $1/f$ s time intervals (0.667 ms for WCDMA and 1.25 ms for CDMA2000 1x).

In reality, the fast TPC is not ideal because of issues such as

- inaccuracies in the C/I estimates;
- transmit power control signaling errors;
- delay in the transmit power control loop.

Links level simulations take these errors into account and reflect their impacts on the link quality figures in the look up tables to be input to the power control module of SEAMCAT. Therefore, we assume a simple C/I based fast closed-loop TPC of traffic channels for uplink in the following.

In the uplink, each mobile station perfectly achieves the target C/I, E_b/N_{0_target} , during the power control loop convergence, assuming that the maximum transmit (TX) power, $max_MS_Tx_Pw$, is not exceeded. Those mobile stations not able to achieve E_b/N_{0_target} after convergence of the power control loop are considered in outage.

The local-mean Signal-to-interference power ratio in the uplink, $(C/I)_{UL}$, is calculated by multiplying the received signal power S by the processing gain G , and dividing the result by the total interference power I_{total}

$$\left(\frac{C}{I}\right)_{UL} = \frac{G \cdot S}{I_{total}} \quad (\text{Eq. 43})$$

with

$$I_{total} = (1 - \beta) \cdot I_{int\ ra} + I_{int\ er} + I_{out} + N_0 \quad (\text{Eq. 44})$$

I_{intra} is the intra-cell interference power, i.e. the interference generated by those mobile stations served by the same base station as the considered mobile station. I_{inter} is the inter-cell interference power from other radio cells. I_{out} is the interference power coming from the interfering system. N_0 is thermal noise (as well as spurious interference) contained in the receiver bandwidth, W , and b is an interference reduction factor due to the use of interference mitigation signal processing techniques in the uplink, e.g. Multi User Detection. No such interference mitigation technique is assumed in these considerations, therefore $b = 0$.

Assuming a mobile station power control range in the order of MS_PC_Range dB; the minimum TX power is therefore $max_MS_Pw_Tx - MS_PC_Range$ dBm.

8.7.2 Soft and Softer Handover

The handover model proposed is a simplified soft handover. We assume that all base stations transmit with the same pilot power in downlink. Therefore, P_{L_fading} (path loss plus the shadow fading) is the only criterion for selecting the base stations belonging to the active set of a mobile station.

We assume that active set for a mobile station consists of two base stations; the base station with the strongest signal, i.e. the lowest P_{L_fading} , and the base station with the second strongest signal if its signal strength is within *Handover_Margin* dB of the strongest signal (in other words its P_{L_fading} is within *Handover_Margin* dB of the lowest P_{L_fading}).

In the case that base stations with omni-antenna are used at the cell sites, selection combining among the base stations in active set is performed and the base station with the strongest signal is selected as the serving base station of the mobile station. In the event of base stations with tri-sector antenna, similar procedure is applied, if the two sectors in the active set belong to different cell sites, else a maximal ratio combining is realized by summing the received signal powers. In the later case, the sum of received C/I values in two sectors should meet the C/I requirements specified by the link level simulation data. Because during softer handover, the mobile station is usually in the overlapping coverage area of two adjacent sectors of the base station, it is reasonable to assume that it has symmetric links to both sectors in the active set. As a consequence, each sector needs to fulfill one half of the C/I requirement.

8.7.3 Voice Activity Factor

The voice activity factor is the measure of how long the non-silence period is to the overall time for voice communication as it reflects the fact that speech users are silent or speaking. In SEAMCAT, It is assumed that all connected users are speaking constantly during a simulated event. It is therefore set to 1 (i.e. 100%).

8.7.4 System loading

The following procedures can be used for system loading during simulation and preparation of simulation outputs.

System loading

To determine the number of active mobile stations Act_MS in the network:

1. Set up:
 1. Average traffic load in terms of a predefined number of users per cluster: N_UL
 2. standard deviation of log-normal shadowing $\sigma_{shadowing}$
 3. voice activity factor Act_Factor (fixed to 100%)
 4. target maximum noise rise over the thermal noise in the network η_target
 5. target C/I (E_b/N_0_target) to fulfill service requirement depending on configuration and mobility (provided by link level simulations)
 6. maximum transmit power of mobile station $max_MS_Pw_Tx$
 7. power control range - MS_PC_Rang :
 8. In the case that the CDMA uplink is the victim link, add the received power from the interfering system to the thermal noise power
 2. For each event:
 1. put down uniformly mobile stations at pseudo-random locations across the network and distribute speed among them
 2. Add a new mobile station in the set of active users in the network
- - compute average path-loss from the mobile station to the base station of each cell
 - generate a log-normal pseudo-random value to add to each of the path losses to model shadow fading
 - perform a pseudo-random weighted coin-toss to determine voice activity, where 1 occurs with probability Act_Factor
 - compute required received power at the base station to meet $E_b \left(\frac{C}{I} \right)^{target}$, given interference from pre-existing mobiles and other sources (I_{total} and I_{total})
 - compute required transmit power of the mobile station
 - adjust the required transmit powers of the all existing mobile stations perturbed by addition of the new mobile station
 - continue the adjustment until the convergence of power control loop is achieved. A convergence criterion could be that the variation of two

consecutive transmit powers of each mobile station is within a predefined threshold.

- compare the number of active mobile stations, Act_MS , with N_UL
 - if $Act_MS \geq N_UL$ terminate the addition of a new mobile station in the network
 - else measure the average noise rise over the thermal noise η and compare it with the target noise rise limit η_target
 - if η_target is reached, terminate the addition of a new mobile station in the network
 - else add a new mobile station and go to step 2b

8.7.5 Outage calculation

Two conditions are counted as outage.

1. A mobile station, which is not able to transmit the required amount of power to meet the received E_b/N_{0_target} due to maximum power limitations. This mobile is counted as part of the specified traffic load N_{UL} . However, the mobile is assumed to be transmitting no power.
2. In the case of $Act_{MS} < N_{UL}$, no more mobile stations can be added to the set of active users because of noise rise limits. In this event, $N_{UL} - Act_{MS}$ outages are counted.

For each event, the number of optimised users is being re-calculated

8.7.6 CDMA UL cell selection

For the CDMA UL, there are two algorithms selectable in SEAMCAT:

Recommended algorithm when the interferer is a cellular network or affecting many cells in a network: the noise rise (which is measured per cell) is averaged over the whole network. This way, the UEs with highest power over the whole victim network are removed in order to compensate the noise rise due to external interference (Section 8.7.4).

Recommended algorithm when the interferer affects one or a few cells in a network (e.g. a strong interferer located close to a small part of the victim network): the noise rise is calculated per cell. This algorithm works as follows:

1. The cells with highest noise rise are selected.
2. Recursively, cell per cell, the UEs with highest power in the cell are removed in order to level out the network noise rise (see Annex A15.3 for further details on the algorithm)

This algorithm allows investigating per event how many cells are being affected (see Section 12.5.3).