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Title: Power control in DCH/DSCH mode

Document for: Discussion & decision

Background

Power control of the PDSCH is described in section 5.2.2 of TS 25.214. The specification currently assumes that the power control commands which are used to control the DPCH power should also be used to control the DPSCH power. Although this assumption is valid in a single cell case (i.e. no soft hand-off), it is not appropriate when considering soft hand-off scenarios. Indeed, the specification currently does not allow the operation of DPSCH in soft-handoff. The DPSCH and its associated DPCH may be therefore be in different hand-off mode. Consequently, when the DPCH is in soft-handoff, the power control commands derived based on the total received DPCH power (from all soft-handoff legs) are not relevant for the DPSCH. Should those commands still be used to control the DPSCH power this would result in random DPSCH power allocation (relative to the appropriate power allocation). This is not desirable as it would clearly be detrimental to the link quality and overall system capacity.

Additional Consideration

The DPSCH channel is expected to be used for high rate packet transmissions and the average transmit fraction required to provide the desired quality of service may represent a non negligible fraction of the total base station maximum transmit power. Channels for which fast power control is used are transmitted with time-varying power correlated with the inverse of the channel. The dynamic range of single path Rayleigh fading is in the order of 10 to 20 dB. When considering high rate channels with for example average power fraction requirement equal to or higher than 13 dB (5% of total base station transmit power) one can easily realize that the system can not inverse the channel for such links since the base station would run out of power or would have to drop other users to transmit at appropriate power. When considering high rate channels such as the DPSCH, it is therefore not essential to send power control commands at 1600 Hz since in most cases the base station will not have the power resource available to follow those commands. Consequently, using lower power control rates might not be as detrimental as what could be suggested by simple link level simulations with unlimited power dynamic range.

Proposed Solutions

Obviously, when the DPSCH and PDCH can not be controlled together the addition of independent power control stream for the DPSCH is necessary. There are two possible types of solution to accommodate a second parallel power control channel in the uplink direction:

- Share the existing power control stream (using existing slot formats).
- Define additional slot formats with two power control streams.

We will expand on each solution but we already note that the first option has some impact on the downlink performance while the second option has some impact on the uplink performance.

Solution 1: Subchannel multiplexing

A first solution consists in multiplexing two power control streams onto the existing UL DPCCH 1500 Hz power control subchannel. The respective power control streams could have the same or different rates. Rate combinations which have regular repetition patterns are as follows:

1. 750 / 750 Hz (repeats over 2 frames)
2. 1000 / 500 Hz
3. 1200 / 300 Hz
4. 1400 / 100 Hz

Based on the reasoning described in the previous section, it is suggested that the lower power control rate be used to control the DPSCH transmit power while the highest rate is used to control the DPCH transmit power. One more argument in favor of this approach is that the DPCH contains all the critical control (e.g. TFCI) and signaling messages used to control both the DPCH and DPSCH.

The impact of this solution on the overall system performance has not been studied from a quantitative point of view. However we can make some qualitative observations. Multiplexing 1 essentially reduces the power control rate to 750 Hz for both the DPCH and DPSCH. The rate reduction has very limited or no impact when the terminal is moving at lower or higher speeds where the channel variation is respectively slow and easy to track at 750 Hz or too rapid and impossible to correct. The rate reduction therefore affects terminals with mid-range (30 to 60 km/h) speeds. At those speeds, the impact is expected to be in the order of 0.5 dB or less in most cases.

Considering that fast power control of the DPSCH won't be possible in cases such as high rate transmission, multiplexing 2, 3 or 4 could represent the best compromise. With those options, the DPCH power is still controlled at relatively high rate (>1000 Hz) therefore limiting the performance degradation to a few tens of a dB in mid-range speeds while the DPSCH power is controlled at a lower rate which does not necessarily affect the performance since the base station might not be able to apply those commands in the first place.

Solution 2: New uplink slot formats

A second solution consists in defining an additional set of uplink slot formats which include two independent power control subchannels. Considering all possible combinations, including compressed mode, the additional set of slot formats is shown in Table 1.

Table 1. UL DPCCH slot formats with two power control subchannels

Format	Pilot	PC1	**PC2**	TFCI	FBI
6	6	2	**2**	0	0
7	4	2	**2**	2	0
7A	4	1	**1**	4	0
7B	2	2	**2**	4	0
8	4	2	**2**	0	2
9	2	2	**2**	2	2
9A	2	1	**1**	4	2

Because the addition of a second power control subchannel is at the expense of the pilot subchannel, using those slot formats would obviously require the terminal to increase the DPCCH transmit power in order to allow for proper tracking and demodulation at the base station. Taking the rough assumption that equivalent pilot energy would be required at the base station to get similar performance the DPCCH power would have to be increased from 1 dB with format #6 to

3 dB with format #9A as compared to the equivalent format without the second power control stream. Note that this performance degradation is almost independent of the environment.

Summary

We have described a problem with the power control of the DPSCH when associated with a DPCH and operated in soft handoff. We have introduced two possible solutions to overcome this problem. Both solutions have some impact on either the uplink or downlink performance. In case of multiplexing we only expect some degradation at medium speeds. In case of new uplink slot formats the degradation would be independent of the radio environment.

Based on feedback received from other members we will prepare appropriate change requests to integrate either or both solutions in the specification.