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Re:	Response to Recirculation Ballot #14c
Abstract	This document suggests changes in TGe Draft Document IEEE 802.16e-D4 to define downlink power control mechanism in order to reduce DL interference in multi-cell deployment.
Purpose	Adopt into the current TGe working draft
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Downlink Power Control for OFDMA PHY

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1. Motivation

Power control is employed in OFDMA uplink transmission to conserve mobile subscriber station (MSS) power and reduce co-channel interference. However, there is no description on downlink power control.

Transmission power capacity of a base station (BS) is shared among the MSS's within the same cell (or sector), and at the same time it is a source of interference to mobile stations (MS) at the other cell (or sector). Thus, it is desirable for the BS not to use excessive transmission power than what they need to. Several scenarios are described in the followings.

- In the downlink transmission, there are cases where downlink transmission power exceeds the CINR requirement that an SS needs to support its highest DIUC scheme. For example, an SS supporting up to 64QAM and rate 3/4 CC code may be located very close to the BS. It receives a strong DL signal from the BS and reports a CINR value of Y_1 dB which is greater than X_1 dB required for the 64QAM modulation and rate 3/4 CC code. In this case, the base station can reduce the transmitted power to that SS to a level that still meets the target CINR requirement.
- Some SSs may only support up to 16QAM and rate 3/4 CC code for DL. In this case, the actual SNR at these SSs is likely to exceed the required CINR. In this case, the base station can also reduce the transmitted power to these SSs to the levels that still meet the target CINR requirement.
- Total transmission power is shared among multiple MSS's in the same cell (or sector). Thus excessive power usage of one MSS may prevent another MSS into service.

There are four sub-channel permutation modes supported in IEEE802.16-2004 standard: FUSC, PUSC, additional optional FUSC (AO-FUSC), and AMC. For FUSC/PUSC/AO-FUSC, pilot tones and data tones are allocated independently. When reducing the power of a DL burst, only the power of data tones can be reduced while the pilot power shall remain the same. The base station should notify the SS of the power boosting factor in Boosting field of the DL_MAP_IE so that the SS can keep track of data scale. For the AMC permutation, the pilot tones and data tones are allocated within the same bin. The base can reduce the energy of both the data and pilots simultaneously. The SS may not need to be notified of the boosting factor.

For instance, on the DL FUSC, PUSC, or AO-FUSC mode, the power level of the data subcarriers of a burst can be reduced while the power of pilot tones shall remain the same. The power reduction factor (negative power boosting value) can be obtained as follows.

$Boosting_{new} = T_{MAX} - CINR_{new} + M$ **,**

if($Boosting_{new}$ **<0)**

Round up $Boosting_{new}$ **to the closest allowable values (-12, -9, -6, -3, 0).**

else

Trigger MCS update (may use lower MCS), or boost up power to the closest allowable values (3, 6, 9 dB).

$Boosting_{new} = 0$

end

where,

T_{MAX} denotes the target CINR (in dB) required by the highest MCS scheme supported by an SS;

$CINR_{new}$ is the CQI value (in dB) from the SS adjusted with boosting factor, i.e. $CINR_{new} = CINR_{measured}$ if measured using pilots/preambles, and $CINR_{new} = CINR_{measured} - Boosting_{last}$ if measured using data tones;

$CINR_{last}$ is the last CQI report;

$Boosting_{new}$ is the current boosting factor, $Boosting_{new} \le 0$;

$Boosting_{last}$ is the last boosting factor, $Boosting_{last} \le 0$;

M is a margin (in dB) which is vendor specific.

The base station can scale down the power of a DL burst to the SS by $Boosting_{new}$ dBs and set the Boosting field of DL_MAP_IE to $Boosting_{new}$.

In another example, on the AMC zone, the transmission power of both data tones and pilot tones within a DL burst can be reduced. The power reduction factor can be obtained as follows,

$\Delta B = T_{MAX} - CINR_{new} + M$,

if(ΔB **<0)**

$Boosting_{new} = Boosting_{last} + \Delta B$

else

$Boosting_{new} = Boosting_{last} + \Delta B$

if($Boosting_{new}$ **>0)**

$CINR_{new} = CINR_{new} + Boosting_{new}$ **, trigger MCS update (may use lower MCS)**

$Boosting_{new} = 0$

end

end

The base station can scale down the power level of the entire burst (including data and pilots) by $Boosting_{new}$ dBs and set the Boosting field of DL_MAP_IE to 0.

The boosting field with 3 bits in DL_MAP_IE supports boosting factor of -12, -9, -6, -3, 0, 3, 6, and 9 dBs. The granularity of 3dB step is too coarse for power control. If we detect that there is 2 dB excessive power assigned for a MSS, we need to change modulation and coding scheme or waste 2 dB of transmission power (that 2dB of power can be assigned to other MSS within the cell or reduced to lower the interference level to other cells). We suggest use 4 bits and 1dB step from -8 to +7.
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2. Specific Changes Suggested to TGe Draft Document IEEE P802.16e-D4

Add the following text in 8.4.10.3 right before 8.4.10.11

A base station shall reduce the transmit power of a DL burst to an SS when the transmit power is excessive, i.e. when the received CINR at an SS is greater than the level the SS requires to support its highest modulation and coding scheme (MCS). For FUSC/PUSC/AO-FUSC, the power of data tones will be reduced while the pilot power shall remain the same. The base station shall notify the SS of the power boosting factor in Boosting field of the DL_MAP_IE so that the SS can keep track of data scale. For the AMC permutation, the base can reduce the power of both the data and pilots simultaneously. The SS may not need to be notified of the boosting factor.

In the DL FUSC, PUSC, or AO-FUSC mode, the power level of the data subcarriers of a burst can be reduced while the power of pilot tones shall remain the same. The power reduction factor (negative power boosting value) can be obtained as follows.

$Boosting_{new} = T_{MAX} - CINR_{new} + M$,

if($Boosting_{new}$ **<0)**

Round up $Boosting_{new}$ **to the closest allowable values (-12, -9, -6, -3, 0).**

else

Trigger MCS update (may use lower MCS), or boost up power to the closest allowable values (3, 6, 9 dB).

$Boosting_{new} = 0$

end

where,

T_{MAX} denotes the target CINR (in dB) required by the highest MCS scheme supported by an SS;

$CINR_{new}$ is the CQI value (in dB) from the SS adjusted with boosting factor, i.e. $CINR_{new} = CINR_{measured}$ if measured using pilots/preambles, and $CINR_{new} = CINR_{measured} - Boosting_{last}$ if measured using data tones;

$CINR_{last}$ is the last CQI report;

$Boosting_{new}$ is the current boosting factor, $Boosting_{new} \leq 0$;

$Boosting_{last}$ is the last boosting factor, $Boosting_{last} \leq 0$;

M is a margin (in dB) which is vendor specific.

The base station can scale down the power of a DL burst to the SS by $Boosting_{new}$ dBs and set the Boosting field of DL_MAP_IE to $Boosting_{new}$.

In the AMC zone, the transmission power of both data tones and pilot tones within a DL burst can be reduced. The power reduction factor can be obtained as follows,

$\Delta B = T_{MAX} - CINR_{new} + M$,

if(ΔB **<0)**

$Boosting_{new} = Boosting_{last} + \Delta B$

else

$Boosting_{new} = Boosting_{last} + \Delta B$

if($Boosting_{new}$ **>0)**

$CINR_{new} = CINR_{new} + Boosting_{new}$, **trigger MCS update (may use lower MCS)**

$Boosting_{new} = 0$

end

end

The base station can scale down the power level of the entire burst (including data and pilots) by $Boosting_{new}$ dBs and set the Boosting field of DL_MAP_IE to 0.