Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Improved BS training by TDD reciprocity
Date Submitted	**2004-09-01**
Source(s)	Ilan Sutskover, ilan.sutskover@intel.com Dudi Ben-Eli Intel Corporation, ICG-CHG-ART 94 Em Hamoshavot way. Petach Tikva, Israel.
Re:	IEEE P802.16e/D4-2004
Abstract	This contribution proposes a method of power assignment for uplink preambles described in contribution C80216e-04_263 to improve BS training of the downlink channel characteristics.
Purpose	Adopt the text proposed in this contribution into P802.16e/D4 draft document.
Notice	
Release	
Patent Policy and Procedures	

Improved BS training by TDD reciprocity

Ilan Sutskover and Dudi Ben-Eli
Intel, Israel

1. Introduction

In a separate contribution (C80216e-04_263) a capability called CSIT was proposed and a mechanism was created, so that a CSIT capable mobile may inform the BS with his downlink channel using TDD reciprocity by transmitting sounding symbols that contain pilot subcarriers. According to that contribution, any non-zeroed subcarrier is assigned equal power, such that the total transmit power agrees with previous power control instructions. This way, the phase rotation and the path loss may be reliably estimated by the BS. However, in general the achievable rate is determined not only by the path loss, but also by the interference level at the MSS side. Therefore, it is possible that even if a first mobile has smaller path loss than a second mobile, the achievable rate of the first MSS might be lower than the second MSS.

In this contribution, two additional power assignment methods are proposed with the aim of teaching the BS an equivalent channel so that the BS can make smarter decisions that take into account both channels and the interference of the different users in the cell. Identification of the power assignment method is done using the 3 bits added to the UL_sounding_command_IE().

The reasoning behind the two kinds of the additional schemes is that the first one is focused on exact characterization of the downlink channel, which allows for fair comparisons of quality among subscribers. The second scheme, on the other hand, distorts this comparison in favor of less attenuation of the pilots. The second scheme is favorable when a certain subscriber receives high priority (for example due to delay constraints) and the performance of the throughput optimization is sacrificed to support this priority. Another difference between the two methods is that the first controls the transmit power of the strongest pilot subcarrier while the second controls the total transmit power of the OFDMA symbol containing the pilots.

2. Text proposal

[After accepting the changes proposed in contribution C80216e-04_263, adopt the following changes]

[Insert a sub-section 8.4.6.2.7.1 after 8.4.6.2.7, and move the contents of 8.4.6.2.7 into it].

[Change the UL_Sounding_Command_IE() to include the new fields]

Table xx: UL_Sounding_Command_IE()

Syntax	Size	Notes
UL_Sounding_Command_IE(){		
Extended UIUC	4 bits	0x09

Length	4 bits	Variable
Sounding_Type	1 bit	0 – Type A 1 – Type B
Send Sounding Report Flag	1 bit	
If (Sounding_Type == 0) {		
Num_Sounding_symbols	3 bits	Total number of sounding symbols being allocated, from 1 (“000”) to 2^3=8 (“111”)
Separability Type	1 bit	0: occupy all subcarriers in the assigned bands; 1: occupy decimated subcarriers
if (Separability type==0) {		(using cyclic shift separability)
Max Cyclic Shift Index P	2 bits	“00”: P=4; “01”: P=8; “10”: P=16, “11”: P=32
}		
Else {		(using decimation separability)
Decimation Value D	3 bits	Sound every D^{th} subcarrier within the sounding allocation. Decimation value D is 2 to the power of (2 plus this value), hence 4,8,… up to maximum of 64.
Decimation offset randomization	1 bit	0= no randomization of decimation offset 1= decimation offset pseudo-randomly determined
}		
For (i=0;i<Num_Sounding_symbols;i++){		
Sounding symbol index	3 bits	Symbol index within the Sounding Zone, from 1 (bits “000”) to 2^3=8 (bits “111”)
Number of CIDs	4 bits	Number of CIDs sharing this sounding allocation
For (j = 0; j<Num. of CIDs; j++) {		
Shorted basic CID	12 bits	12 LS bits of the MSS basic CID value
Starting Frequency Band	7 bits	Out of 96 bands at most (FFT size dependent)
Number of frequency bands	7 bits	Contiguous bands used for sounding
Power Assignment Method	2 bit	0b00 = equal power. 0b01 = *reserved.* 0b10 = Interference dependent. Per subcarrier power limit. 0b11 = Interference dependent. Total power limit.
Power boost	1 bit	0b0 = no power boost. 0b1 = power boost.

Multi-Antenna Flag	1 bit	0=MSS sounds first antenna only 1=MSS sounds all antennas
if (Separability type==0) {		
Cyclic time shift index m	5 bits	Cyclically shifts the time domain symbol by multiples (from 0 to P –1) of N/P where N=FFT size, and P=Max Cyclic Shift Index.
Else {		
Decimation Offset d	6 bits	Relative starting offset position for the first sounding occupied subcarrier in the sounding allocation
}		
Periodicity	2 bits	00=single command, not periodic, or terminate periodicity 01=repeat sounding once per frame until terminated 10= repeat instructions once per 2 frames 11= repeat instructions once per 4 frames
}		
}		
}		
else {		
Permutation	2 bits	0b00 = PUSC perm. 0b01 = FUSC perm. 0b10 = Optional FUSC perm. 0b11 = Adjacent subcarrier perm.
IDcell	6 bits	
Num_Sounding_symbols	3 bits	
for (i=0;i<Num_Sounding_symbols;i++){		
Number of CIDs	7 bits	
For (j=0; j<Number of CIDs; j++) {		
Shortend basic CID	12 bits	12 LS bits of the MSS basic CID value
Subchannel offset	7 bits	The lowest index subchannel used for carrying the burst, starting from subchannel 0
Number of subchannels	3 bits	The number subchannels with subsequent indexes, used to carry the burst.

Periodicity	2 bits	00=single command, not periodic, or terminate periodicity 01=repeat sounding once per frame until terminated 10= repeat instructions once per 2 frames 11= repeat instructions once per 4 frames
Power Assignment Method	2 bit	0b00 = equal power. 0b01 = *reserved.* 0b10 = Interference dependent. Per subcarrier power limit. 0b11 = Interference dependent. Total power limit.
Power boost	1 bit	0b0 = no power boost. 0b1 = power boost.
}		
}		
}		
Padding	Variable	Pad IE to octet boundary. Bits shall be set to 0
}		

[Add section 8.4.6.2.7.2]

8.4.6.2.7.2 Power assignment

If inside UL_Sounding_Command_IE() the power assignment method field is set to 0b00 then the mobile shall transmit all pilots with equal power. In general, the transmission power is according to previous commands of the power control mechanism (see 8.4.10.3).

If the power assignment method is 0b10, then the power allocated to each pilot shall be proportional to $Q = \frac{1}{\sigma_k^2}$ where σ_k^2 is the estimated absolute interference level at the vicinity of the k-th pilot subcarrier (without normalization to received signal strength at each OFDMA tone). The transmit power shall be normalized so that the maximal power over all tones is the same as the power density of regular data transmission.

If the power assignment method is set to 0b11, then the power allocated to each pilot is set proportional to $Q = \max\left\{10, \min\left\{0.1, \frac{\hat{\sigma}^2}{\sigma_k^2}\right\}\right\}$ where $\hat{\sigma}^2$ is the average interference level over the entire spectrum associated with the channel sounding command. The transmit power shall be normalized so that the average power per tone is the same as the power density of regular data.

In both cases, an additional power boost of 3dB will be applied if the field power boost is set on.

[Replace in section 8.4.12.2]

The average energy of the constellations in each of the n spectral lines shall deviate no more than indicated in Table 333. The absolute difference between adjacent subcarriers shall not exceed 0.1 dB excluding intentional boosting or suppression of subcarriers, CSIT sounding symbols and PAPR reduction subchannels are not allocated.

[Change the text in 8.4.10.3 as follows:
Replace "UIUC=0, UIUC=12 or UIUC=14" with "UIUC=0, UIUC=12, UIUC=13 (Sounding) or UIUC=14"]

[Add the following line in table 332, section 8.4.10.3]

Modulation / FEC rate	Normalized C/N
Sounding transmission	9