Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Power Control of Uplink AAS Preamble**
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Re:	Recirculation of P802.16 REVe/D5a
Abstract	Accurate spatial channel estimate is essential for AAS operation. For this end, framework for uplink AAS preamble power control is proposed.
Purpose	Adoption of suggested changes into P802.16e/D6
Notice	
Release	
Patent Policy and Procedures	

(The text change during the revision is in red for reader's convenience)

Problem Definition

The main purpose of uplink AAS preamble is for spatial signature estimation, which is necessary for deciding uplink demodulation beam-vector and downlink transmit beam-forming vector. In the current text, the normalized power level of AAS preamble is equal to that of the following data sub-carriers and 4 (PUSC), 3 (O-PUSC) and 9 (AMC, 1 × 6 type) consecutive tones in one AAS preamble is a minimal processing block for spatial signature estimation. Thus, the processing gains are 6.0, 4.7 and 9.5 dB, respectively. Although these gains are acceptable for SISO reception, more accurate estimation is required if we consider power control scenario in multiple antenna diversity reception in uplink since the SS's transmit power level decreases as the uplink antenna combining gain increases. In other words, the antenna combining gain is not applied for spatial signature estimation itself and therefore the boosting of uplink AAS preamble is required for better spatial channel estimate. The requirement for spatial signature estimation errors becomes more stringent when computationally efficient zero-forcing beam-forming algorithm is employed for SDMA operation.

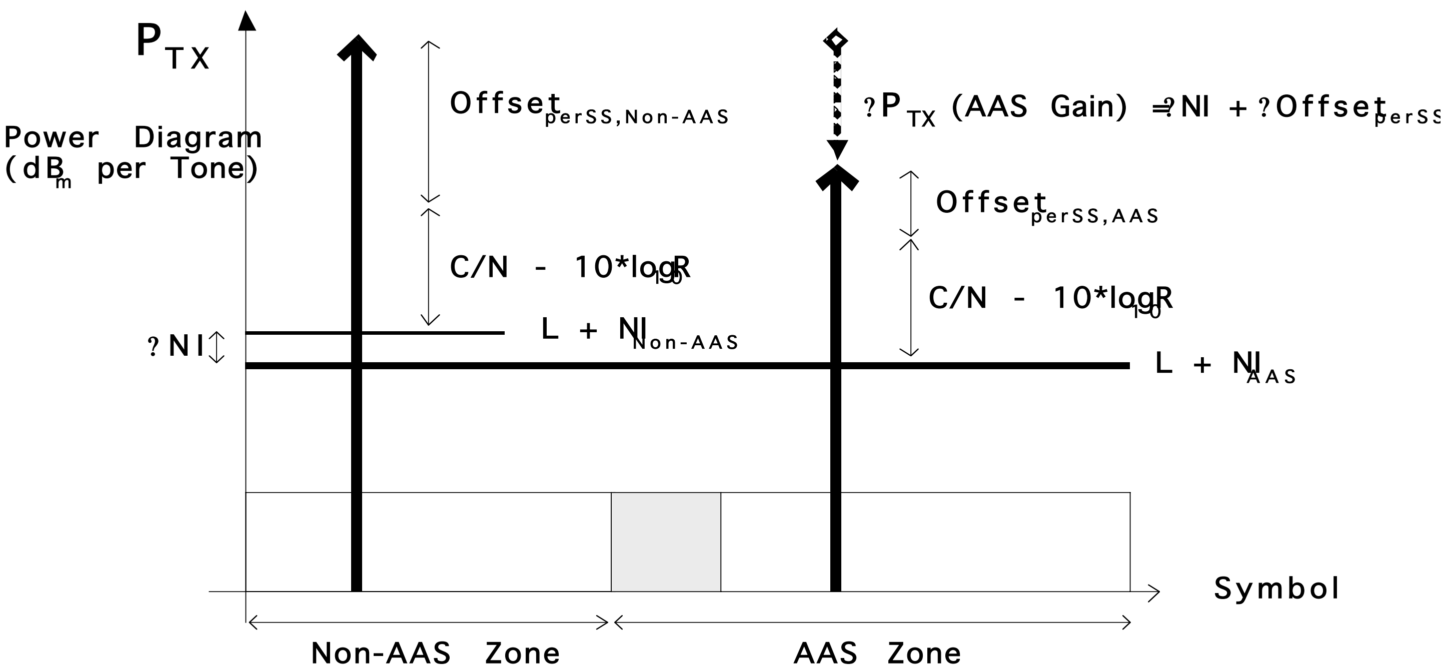

Fig. 1. Uplink Power Control Scenario

To investigate the channel estimation error, average transmit beam-forming gain under various channel estimation quality is illustrated in Fig. 2 when number of transmit antenna is 4. The channel estimation quality is the ratio of average power of each component in spatial channel vector **h** and estimation error vector **e.**

$$\text{Gain}_{BF} = |\mathbf{h}^*\mathbf{h}_{esti}|^2/(|\mathbf{h}||\,\mathbf{h}_{esti}|),\ \mathbf{h}_{esti} = \mathbf{h} + \mathbf{e} \text{ where } \mathbf{e} \text{ is a complex Gaussian vector with i.i.d components}$$

From the Fig. 2, we can find out that at least 15 dB channel estimation quality is required to achieve 0.1 dB loss. This means that SNR of AAS preamble should be greater than 9 dB for PUSC permutation since the maximum achievable filtering gain with one symbol preamble is $10*\log_{10}(4) \approx 6$ dB. The SNR of 9 dB may not be guaranteed since the transmit power for data symbol is decreased by AAS gain through the existing power control mechanism. Although the AAS gain can be used to increased modulation/FEC rate, there happens to be a case when this is prohibited for network level interference control. The object of the contribution is to provide a flexible mechanism to maintain the SNR of AAS preamble.

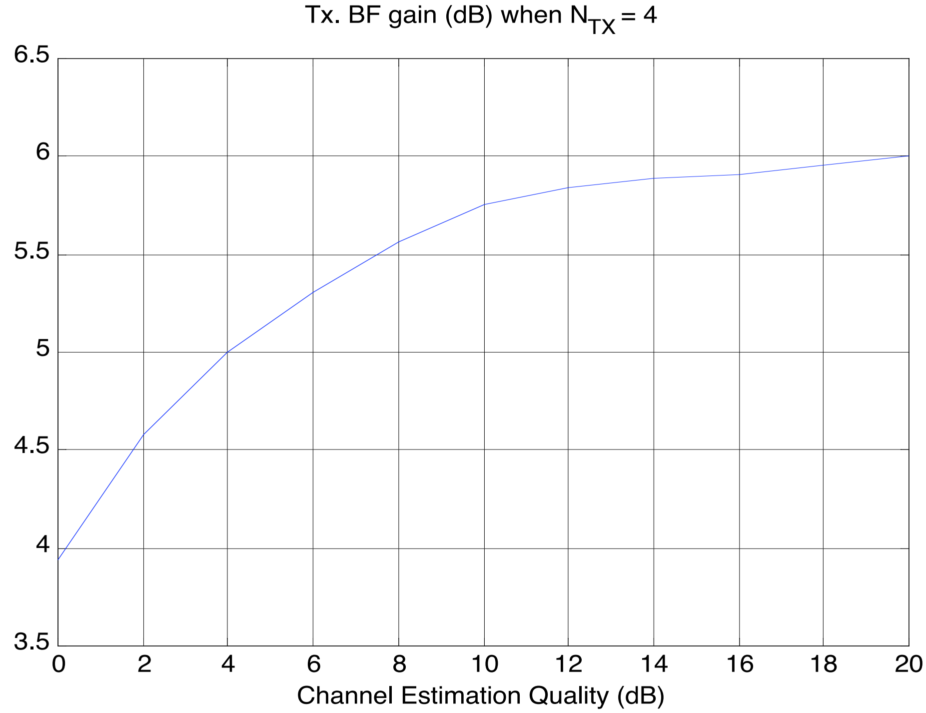

Fig. 2. Beam-forming Gain under Spatial Channel Estimation Error

Proposed Solution

The main purpose of this contribution is to provide a flexible power control mechanism for UL AAS preamble. In the current text, the power level of data sub-carrier in UL is determined by equation (135) in 8.4.10.3.

$$P_{Data} = L + (C/N) + NI - 10 * \log_{10}(R) + Offset\_SS_{perSS} + Offset\_BS_{perSS} \quad (135)$$

where,

P_{Data}: Tx. Power level (dB_m) per a sub-carrier for current data transmission
L: Estimated current UL propagation loss including SS/BS antenna gain and path loss
(C/N): Required normalized C/N of the modulation/FEC rate for the current transmission in Table 332 ,which can be modified by UCD (Normalized C/N override)
R: Number of repetitions for the modulation/FEC rate
NI: Estimated average power level (dB_m) of the noise and interference per a sub-carrier at BS
$Offset\_SS_{per\ SS}$: Correction term for SS-specific power offset controlled by SS. Initially zero.
$Offset\_BS_{per\ SS}$: Correction term for SS-specific power offset controlled by BS with correction message. Initially zero.

For control of normalized transmit power of uplink AAS preamble, predefined upper bound and the predefined lower bound is introduced in normalized C/N Table 332. Then, if the required (C/N) value of the current transmission, excluding code repetition factor, is between the predefined upper bound and the predefined lower bound, then normalized transmit power of uplink AAS preamble is set to that of the current transmission. Otherwise, the transmit power level of uplink AAS preamble is increased or decreased by the difference between (C/N) excluding code repetition factor and lower bound and upper bound. The $LowerBound_{AAS\_PREAMBLE}$, $UpperBound_{AAS\_PREAMBLE}$ are broadcasted in UCD TLV.

$$\begin{cases} P_{AAS\_Preamble} = P_{Data} - (C/N) + 10 * \log_{10}(R) + LowerBound_{AAS\_PREAMBLE} & if\ (C/N) - 10 * \log_{10}(R) < LowerBound_{AAS\_PREAMBLE} \\ P_{AAS\_Preamble} = P_{Data} - (C/N) + 10 * \log_{10}(R) + UpperBound_{AAS\_PREAMBLE} & if\ (C/N) - 10 * \log_{10}(R) > UpperBound_{AAS\_PREAMBLE} \\ P_{AAS\_Preamble} = P_{Data} & else\ where \end{cases}$$

Note that power outage can occur for preamble power boosting. However, there is no amplitude ambiguity for uplink demodulation if we use only pilot tones after receiver beam-forming using the (relative) estimated spatial signature. When QPSK modulation is assigned, phase reference from AAS preamble can be also utilized for uplink demodulation.
The BS operation can be summarized as follows

1. Use UL AAS preamble only for spatial signature estimation.
2. For demodulation of 16 QAM or 64 QAM signals, channel estimation is carried out only with pilot sub-carriers in data symbols after receiver beam-forming.
3. For QPSK demodulation, both beam-formed UL AAS preamble and beam-formed pilot sub-carriers in data symbol can be used.

Also, notice that the proposed mechanism is disabled by setting the value of Upper_bound > (C/N) of highest data modulation/FEC level and Lower_bound < (C/N) of lowest data modulation/FEC level – $10*\log_{10}(R_{max})$ in Table 332.

Suggested text changes to 16.e standard

[Add the text as follows somewhere in 8.4.4.6.4 "AAS Uplink Preamble"]

8.4.4.6.4 AAS Uplink Preamble

The transmit power level of uplink AAS preamble is equal to that of data sub-carrier determined by Eq. (135) in 8.4.10.3 when the required (C/N) value of the current transmission, excluding code repetition factor, is between the predefined lower bound and the predetermined upper bound. Otherwise, the transmit power level of uplink AAS preamble is boosted or reduced. The predefined $LowerBound_{AAS\_PREAMBLE}$ and $UpperBound_{AAS\_PREAMBLE}$ are broadcasted in UCD TLV. Thus, transmit power level of AAS preamble can be determined as follows

$$\begin{cases} P_{AAS\_Preamble} = P_{Data} - (C/N) + 10*\log_{10}(R) + LowerBound_{AAS\_PREAMBLE} & if\ (C/N) - 10*\log_{10}(R) < LowerBound_{AAS\_PREAMBLE} \\ P_{AAS\_Preamble} = P_{Data} - (C/N) + 10*\log_{10}(R) + UpperBound_{AAS\_PREAMBLE} & if\ (C/N) - 10*\log_{10}(R) > UpperBound_{AAS\_PREAMBLE} \\ P_{AAS\_Preamble} = P_{Data} & else\ where \end{cases}$$

(aaa)

where,

P_{Data}: Tx. Power level (dB_m) per a sub-carrier for current data transmission determined by Eq. (135) in 8.4.10.3
(C/N): Required normalized C/N of the modulation/FEC rate for the current transmission in Table 332.
R: Number of repetitions for the modulation/FEC rate

When SS does not have enough power to boost up AAS preamble, the power of AAS preamble is set equal to data symbol power. The power control of the uplink AAS preamble is normally disabled by setting the initial values of $LowerBound_{AAS\_PREAMBLE}$ and $UpperBound_{AAS\_PREAMBLE}$ equal to –32 dB, 31.75 dB, respectively. The SS that doesn't support preamble power control set the AAS preamble power equal to that of data symbols.

[Modified Table 332 Normalized C/N table in 8.4.10.3 as follows]

Add "$LowerBound_{AAS\_PREAMBLE}$","$UpperBound_{AAS\_PREAMBLE}$" in Table 332.

Table 332 – Normalized C/N per Modulation

Modulation/FEC rate	Normalized C/N
…	
….	
…	
$LowerBound_{AAS\_PREAMBLE}$	6 dB
…	
…	
$UpperBound_{AAS\_PREAMBLE}$	23 dB

[Modified Table 355 UCD burst profile encodings – WirelessMAN-OFMDA in 11.3.1.1 as follows]

Add "LowerBound$_{AAS_PREAMBLE}$","UpperBound$_{AAS_PREAMBLE}$" in Table 355.

Table 355 – **UCD burst profile encodings – WirelessMAN-OFMDA**

Name	Type (1 byte)	Length	Value (variable length)
FEC Code type and Modulation type	150	1	0 = QPSK (CC) 1/2 … 25 = 64 QAM (ZT-CC) 3/4 26 ~ 255 = Reserved 26 = LowerBound$_{AAS_PREAMBLE}$ 27 = UpperBound$_{AAS_PREAMBLE}$ 28 ~ 255 = Reserved
….			

[Add LowerBound$_{AAS_PREAMBLE}$ and UpperBound$_{AAS_PREAMBLE}$ in Table 351]

Table 351 – **UCD PHY-specific channel encodings – WirelessMAN-OFMDA**

Name	Type (1 byte)	Length	Value (variable length)
LowerBound$_{AAS_PREAMBLE}$	xxx	1	Signed in units of 0.25 dB
UpperBound$_{AAS_PREAMBLE}$	yyy	1	Signed in units of 0.25 dB

[Add Capability bit in 11.8.3.7.7 OFDMA SS uplink power control support]

Table xxx – **OFDMA SS uplink power control support – WirelessMAN-OFMDA**

Type	Length	Value (variable length)	Scope
157	1	Bit #0: Uplink open loop power control support Bit #1: Uplink AAS preamble power control support Bit #1-7: reserved, shall be set to zero Bit #2-7: reserved, shall be set to zero	SBC-REQ (See 6.3.2.3.23) SBC-RSP (See 6.3.2.3.24)