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| Project | **IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>** |
| Title | **Open Loop Power Control Operation** |
| Date Submitted | **2004-07-15** |
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| Re: | Recirculation of P802.16 REVe/D3 |
| Abstract | Open loop power control operation is proposed to determine uplink transmit power |
| Purpose | Adoption of suggested changes into P802.16e/D4 |
| Notice |  |
| Release |  |
| Patent Policy and Procedures |  |

## Problem Definition

In the current IEEE P802.16REVd/D5, the SS should automatically update transmit power when the SS transmits in region of Fast-feedback, Ranging, and CDMA allocation. The current transmitting power is computed by adding a correction term power, based on the change in used bandwidth and CINR threshold, to the last transmission. The changes in network interference levels may be handled by changing the CINR threshold table with a dedicated UCD message TLV.

However, there are two factors which are not managed in the current scheme. The one is change in the propagation loss due to mobility and packet scheduling. The other is an SS specific link level non-ideality such as channel selectivity, propagation differences between uplink and downlink (especially for FDD systems), channel measurement error, and channel report delay under high mobility condition. To cope with these impairments, SS specific power margin is required to achieve desired packet error rate. In this contribution, enhanced open loop power control formula is introduced, which can compensate these two degradation factors.

## Proposed Solution

**Propagation loss estimation**

The change in propagation loss can be estimated by measuring the signal strength of preamble and/or pilot tones and then comparing it with transmitting power level. To get a better estimate, IIR filtering and linear interpolation can be applied. An example of implementation algorithm using DL preamble is shown as below (in dB scale)

$$L_{DL}(n) = \alpha(P_{TX,DL,Peamble} - P_{RX,DL,Preamble}(n)) + (1-\alpha)L_{DL}(n-1) \text{ (IIR filtering)}$$
$$L_{UL}(n) = L_{DL}(n) + \beta\{L_{DL}(n) - L_{DL}(n-1)\} \text{ (Linear interpolation)}$$

where $L_{DL}(n)$, and $P_{RX,DL,Preamble}(n)$ are an estimated downlink propagation loss, a received preamble strength at $n$-th frame and $L_{UL}(n)$ is an estimated uplink propagation loss. The parameter $\alpha$ is an IIR filter coefficient and $\beta$ is an offset considering time delay between uplink transmission slot and downlink preamble.

**SS specific power offset estimation**

The power offset for an SS-specific non-ideality can be estimated by observing the Ack/Nack of uplink burst. The specific algorithm can be described as follows (in dB scale).

$$\begin{cases} Offset_{perSS} = Offset_{perSS} + UP\_STEP & if\ NAK\ is\ received \\ Offset_{perSS} = Offset_{perSS} - \dfrac{1}{1/FER_{target} - 1} \cdot UP\_STEP & else\ if\ ACK\ is\ received \\ Offset_{perSS} = Offset_{perSS} & else\ where \end{cases}$$

$$\begin{cases} Offset_{perSS} = Offset\_Bound_{upper} & if\ Offset_{perSS} \geq Offset\_Bound_{upper} \\ Offset_{perSS} = Offset\_Bound_{lower} & else\ if\ Offset_{perSS} \leq Offset\_Bound_{lower} \end{cases}$$

The operating parameters $UP\_STEP$, $Offset\_Bound_{upper}$, $Offset\_Bound_{lower}$ are signaled by a UCD message TLV. The $FER_{TARGET}$ is also handled by a UCD message if not defined in service level negotiation process.

**Proposed power adjustment formula**

The proposed open loop power control algorithm can be summarized as follows,

$$P_{new} = P_{last} + (L_{UL\_new} - L_{UL\_last}) + 10\cdot\log_{10}(B_{new}/B_{last}) + C/N_{new} - C/N_{last} + Offset_{perSS}$$

where $B_{new}/B_{last}$ is the ratio of change in used bandwidth. Comparing the Eq. (134) in P802.16REVd/D5, correction terms for propagation loss difference and SS-specific power offset are added.

# Suggested text changes to 16.e standard

**8.4.10.3 Power Control**

***[Modify the text describing the Eq. (134):]***

To maintain at the BS a power density consistent with the modulation and FEC rate used by each SS, the BS may change the SS TX power as well as the SS assigned modulation and FEC rate. There are, however, situations where the SS should automatically update its TX power, without being explicitly instructed by the BS. This happens when the SS transmits in region marked by UIUC=0, UIUC=12 or UIUC=14. In all these situations the SS shall use a temporary a TX power value set according to the formula (in dB),

~~$P_{new} = P_{last} + (C/N_{new} - C/N_{last}) - (\log10(R_{new}) - \log10(R_{last}))$ (134)~~

$P_{new} = P_{last} + (L_{new} - L_{last}) + (C/N_{new} - C/N_{last}) - (10\log10(R_{new}) - 10\log10(R_{last})) + Offset_{perSS}$ (134)

Where,

$P_{new}$ is the temporary TX Power

$P_{last}$ is the last used TX Power. When any power control message is arrived and the TX Power is updated based on the message before new transmission, $P_{last}$ is the updated TX Power.

$L_{new}$ is the estimated current UL propagation loss

$L_{last}$ is the estimated last UL propagation loss. When any power control message is arrived and the TX Power is updated based on the message before new transmission, $L_{last}$ is the value of the estimated UL propagation loss when the TX Power is updated.

$C/N_{new}$ is the normalized C/N of new modulation/FEC rate instructed by the UIUC

$C/N_{last}$ is the normalized C/N of the last used modulation/FEC rate

$R_{new}$ is the number of repetitions for the new modulation/FEC rate instructed by the UIUC

$R_{last}$ is the number of repetitions on the last used modulation/FEC rate

$Offset_{perSS}$ is the correction term for SS-specific power offset.

The power offset for an SS-specific non-ideality shall be estimated by observing the Ack/Nack of uplink burst. The specific algorithm is described as follows (in dB). The initial value of $Offset_{perSS}$ is '0'.

$$\begin{cases} Offset_{perSS} = Offset_{perSS} + UP\_STEP & \text{if } NAK \text{ is received} \\ Offset_{perSS} = Offset_{perSS} - \dfrac{1}{1/FER_{target} - 1} \cdot UP\_STEP & \text{else if } ACK \text{ is received} \\ Offset_{perSS} = Offset_{perSS} & \text{elsewhere} \end{cases} \quad \text{(aaa)}$$

$$\begin{cases} Offset_{perSS} = Offset\_Bound_{upper} & \text{if } Offset_{perSS} \geq Offset\_Bound_{upper} \\ Offset_{perSS} = Offset\_Bound_{lower} & \text{else if } Offset_{perSS} \leq Offset\_Bound_{lower} \end{cases} \quad \text{(bbb)}$$

Where,

$UP\_STEP$ is the adjustment step

$FER_{TARGET}$ is the target frame error rate

$Offset\_Bound_{upper}$ is the upper bound of power offset adjustment

$Offset\_Bound_{lower}$ is the lower bound of power offset adjustment

The operating parameters $UP\_STEP$, $FER_{TARGET}$, $Offset\_Bound_{upper}$, $Offset\_Bound_{lower}$ are signaled by a dedicated UCD message TLV. The default normalized C/N values per modulation are given by Table 332. These values may be overridden by the BS by using a dedicated UCD message TLV. The minimum step size and accuracy of the RF transmit power level shall satisfy the transmitter requirements in Section 8.4.12.1.

### 11.3.1 UCD channel encodings

*[Add the following rows to Table 351 – UCD PHY-specific channel encodings – WirelessMAN-OFDMA:]*

| Name | Type (1 byte) | Length | Value |
|---|---|---|---|
| SS-specific power offset adjustment step | www | 1 | Unsigned in units of 0.01 dB |
| Target frame error rate of UL burst transmission | xxx | 1 | Unsigned integer of -10*log10($FER_{target}$) |
| Minimum level of power offset adjustment | yyy | 1 | Signed in units of 0.1 dB |
| Maximum level of power offset adjustment | zzz | 1 | Signed in units of 0.1 dB |