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Title	**Power Control for Femtocell BS in IEEE 802.16m Amendment**
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Re:	802.16m Amendment Working Document Call for contributions on "Support for Femtocell BS"
Abstract	This contribution proposes the power control scheme for Femtocell BS**.**
Purpose	For discussion and approval by IEEE 802.16m TG
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Power Control for Femtocell BS in IEEE 802.16m Amendment

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NEC

1 Introduction

The transmit power of Femtocell BS shall be set appropriately so that quality of indoor communications or indoor coverage can be enough with mitigating the interference to outdoor macro/micro cell. In order to realized that, it is necessary for the Femtocell BS to have the knowledge of isolation between the Femtocell and macro/micro cell through building penetration loss. It is also necessary to keep the indoor quality regardless of relative position between the Femtocell BS and indoor MSs.

In this contribution, the adaptive control of the transmit power of Femtocell BS for DL and UL which takes into account building penetration loss and indoor coverage is provided.

2 Transmit Power Control

2.1 Downlink Power Control for Femtocell BS

2.1.1 Measurement for Power Control

Femtocell BS can measure the signal strength of carrier frequencies from surrounding cells for the interference mitigation via a DL or UL Receiver function. The DL Receiver function can periodically be switched from a DL transmitter function for the Femtocell BS within one antenna. Some measurements can also be collected through MSs attached to the Femtocell BS.

The measurement items shall be:

1) DL reception power of pilot subcarriers from macro/micro cells, measured by Femtocell BS
2) SIR which is the ratio of the DL reception power of pilot subcarriers from Femtocell BS attached by MSs vs interference power, measured and reported by MSs
3) UL reception power from MSs not attached to the Femtocell BS, measured by Femtocell BS
4) DL reception power of radio frequency from another radio system such as GPS, measured by Femtocell BS

2.1.2 Power Control Based Considering Penetration Loss and Indoor Coverage

Each building has the different properties such as penetration loss. When the transmit power of Femtocell BS

set large while the penetration loss is small, the interference from Femtocell BS to the macro/micro cell is increased. In opposite, the transmit power of Femtocell BS set small while the penetration loss is large, the quality or coverage of indoor communications becomes low.

Femtocell BS can detect and measure the radio frequency of surrounding macro/micro cells or another radio system such as GPS. The Femtocell BS shall set the transmit power of pilot subcarriers based on the measurements. The Femtocell BS can also set the DL maximum transmit power in proportion to the transmit power of pilot subcarriers.

The Femtocell BS shall set the transmit power of pilot subcarrier P_tx as follows:

$$P\_tx\ (dBm) = MEDIAN(\ P\_m + P\_offset,\ P\_tx\_max,\ P\_tx\_min\ ) \quad (1)$$

Where:
P_m (dBm) is the DL reception power of pilot subcarrier from the surrounding macro/micro cell.
P_offst (dB) is the power offset
P_tx_max/P_tx_min (dB) is the maximum/minimum value of the transmit power.

As the reception power decrease, which means the Femtocell BS will locate at close to the edge of the macro/micro cell, the DL maximum transmit power should be small in order to mitigate the DL interference to macro/micro cell.

Furthermore, P_offset is defined as follows:

$$P\_offset = MEDIAN(\ P\_offset\_o + K1*L_E,\ P\_offset\_max,\ P\_offset\_min\ ) \quad (2)$$

Where:
P_offset_o (dB) is the basis value for the power offset.
K1 is the positive factor such as 1 or 2.
L_E (dB) is estimated value of the penetration loss.
P_offset_max/P_offset_min (dB) is the maximum/minimum value of the power offset.

In (2), the penetration loss is estimated and shall be considered in the power offset. At the building which has the small penetration loss such as a house, the transmit power becomes small so that the interference can be mitigated. At the building which has the large penetration loss such as an office building, the transmit power becomes large so that the indoor communication quality can be high. Fig1 shows the indoor communication quality becomes high because the transmit power is compensated by the penetration loss.

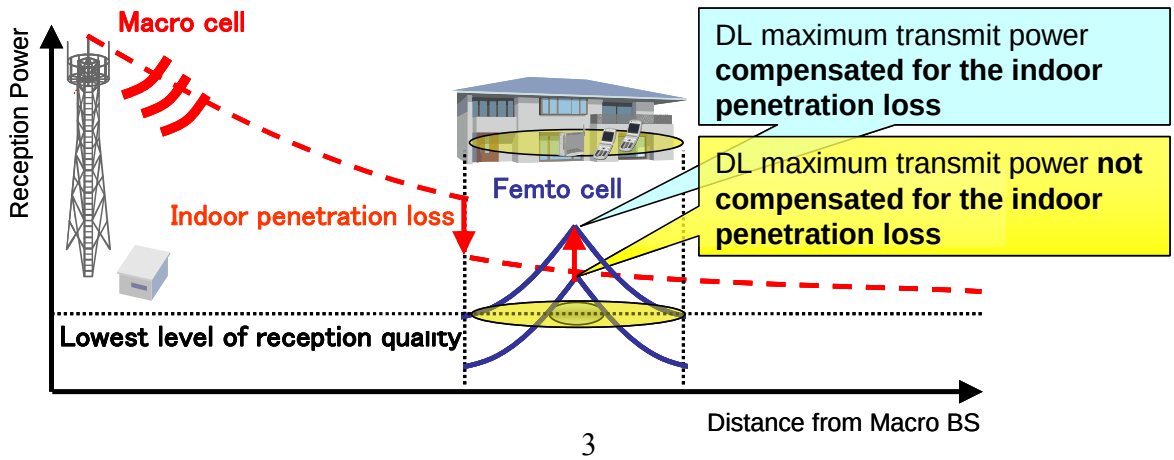

Fig1: DL Maximum transmit power setting compensated by penetration loss

The penetration loss can be estimated based on the reception of another radio system such as GPS or the estimated UL transmit power of a neighbor outdoor MS and the UL reception power from the MS.

P_offset can be optimized by adjusting the Femtocell BS's transmit power of pilot subcarriers or its maximum value based on one of the following measurements:

1. The indoor quality measurement such as SIR measured and reported by attached MSs so that the minimum value of the quality measurement results reported by each MS becomes close to a certain target value.
2. The comparison between the DL reception power of pilot subcarriers from macro/micro cells measured by the Femtocell BS and indoor MSs.

In Fig,2, When the DL reception power measured by the Femtocell BS is larger than that measured by one MS, the Femtocell BS shall adjust the transmit power to smaller value. When the DL reception power measured by the Femtocell BS is smaller than that measured by one MS, the Femtocell BS shall adjust the transmit power to larger value.

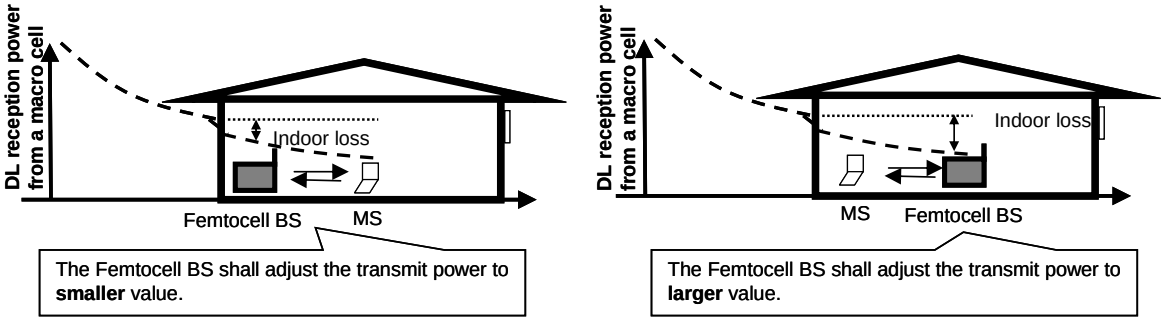

Fig2. Power Control Based on Indoor Coverage

2.2 Uplink Power Control for Femtocell BS

2.2.1 Power Control Considering Penetration Loss and Indoor Coverage

Femtocell BS shall control the uplink transmit power of camping MSs through the target uplink SINR or IoT control. In this contribution, the IoT control algorithm is introduced.

The Femtocell BS can detect and measure the radio frequency of surrounding macro/micro cells or another radio system such as GPS. The Femtocell BS shall set the UL maximum allowed transmit power for camping MSs based on the measurements.

The Femtocell BS shall set the UL maximum allowed IoT as follows:

$$IoT\ (dB) = MEDIAN(\ IoT\_o + K2*L_E,\ IoT\_max,\ IoT\_min\ ) \quad (3)$$

Where:

IoT_o (dB) is the basis value for IoT.

K2 is the positive factor such as 1 or 2.
L_E (dB) is estimated value of the penetration loss.
IoT_max/IoT_min (dB) is the maximum/minimum value of IoT.

In (3), the penetration loss is estimated and shall be considered in the IoT. At the building which has the small penetration loss such as a house, the IoT becomes small so that the interference can be mitigated. At the building which has the large penetration loss such as an office building, the IoT becomes large so that the indoor communication quality can be high.

The penetration loss can be estimated based on the reception of another radio system such as GPS or the estimated UL transmit power of a neighbor outdoor MS and the UL reception power from the MS.

The Femtocell BS can optimize the UL maximum allowed transmit power for camping MSs based on the comparison between the DL reception power of pilot subcarriers from macro/micro cells measured by the Femtocell BS and indoor MSs.

In Fig.3, when the DL reception power measured by the Femtocell BS is larger than that measured by one MS, the Femtocell BS shall adjust the UL maximum allowed transmit power for camping MSs to larger value. When the DL reception power measured by the Femtocell BS is smaller than that measured by one MS, the Femtocell BS shall adjust the UL maximum allowed transmit power for camping MSs to smaller value.

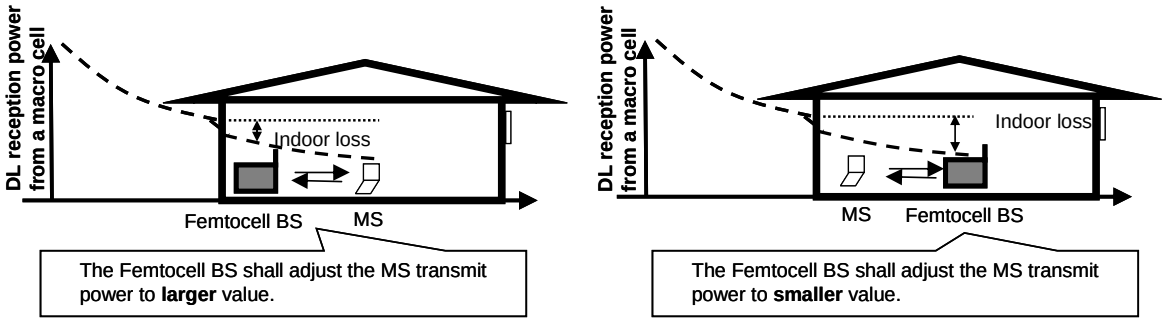

Fig3. Power Control Based on Indoor Coverage

Proposed Text Input to P802.16m Amendment Working Document

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15.3.6.4.2. Downlink Transmit Power Control for Femtocell BS (Related to Sec. 15.12 in SDD)

Femtocell BS can detect and measure the radio frequency of surrounding macro/micro cells or another radio system such as GPS. The Femtocell BS shall set the transmit power of pilot subcarriers based on the measurements. The Femtocell BS can also set the DL maximum transmit power in proportion to the transmit power of pilot subcarriers.

The Femtocell BS shall set the transmit power of pilot subcarrier P_tx as follows:

$$P\_tx\ (dBm) = MEDIAN(\ P\_m + P\_offset,\ P\_tx\_max,\ P\_tx\_min\ ) \quad (1)$$

Where:
P_m (dBm) is the DL reception power of pilot subcarrier from the surrounding macro/micro cell measured by the Femtocell BS
P_offst (dB) is the power offset and corresponds to the allowed indoor path loss between the Femtocell BS and cell edge of Femtocell
P_tx_max/P_tx_min (dB) is the maximum/minimum value of the transmit power.

Furthermore, P_offset is defined as follows:

$$P\_offset = MEDIAN(\ P\_offset\_o + K1*L_E,\ P\_offset\_max,\ P\_offset\_min\ ) \quad (2)$$

Where:
P_offset_o (dB) is the basis value for the power offset.
K1 is the positive factor such as 1 or 2.
L_E (dB) is estimated value of the penetration loss.
P_offset_max/P_offset_min (dB) is the maximum/minimum value of the power offset.

The penetration loss can be estimated based on the reception of another radio system such as GPS or the estimated UL transmit power of a neighbor outdoor MS and the UL reception power from the MS.

P_offset can be optimized by adjusting the Femtocell BS's transmit power of pilot subcarriers or its maximum value based on one of the following measurements:

1. The indoor quality measurement such as SIR measured and reported by attached MSs so that the minimum value of the quality measurement results reported by each MS becomes close to a certain target value.
2. The comparison between the DL reception power of pilot subcarriers from macro/micro cells measured by the Femtocell BS and indoor MSs.

15.3.9.4.5. Uplink Transmit Power Control for Femtocell BS (Related to Sec. 15.12 in SDD)

Femtocell BS shall control the uplink transmit power of camping MSs through the target uplink SINR or IoT. The Femtocell BS can detect and measure the radio frequency of surrounding macro/micro cells or another radio system such as GPS. The Femtocell BS shall set the UL maximum allowed transmit power for camping MSs based on the measurements.

The Femtocell BS shall set the UL maximum allowed IoT as follows:

$$IoT\ (dB) = MEDIAN(\ IoT\_o + K2*L_E,\ IoT\_max,\ IoT\_min\ ) \quad (3)$$

Where:
IoT_o (dB) is the basis value for IoT.
K2 is the positive factor such as 1 or 2.

L_E (dB) is estimated value of the penetration loss.
IoT_max/IoT_min (dB) is the maximum/minimum value of IoT.

The penetration loss can be estimated based on the reception of another radio system such as GPS or the estimated UL transmit power of a neighbor outdoor MS and the UL reception power from the MS.

The Femtocell BS can optimize the UL maximum allowed transmit power for camping MSs based on the comparison between the DL reception power of pilot subcarriers from macro/micro cells measured by the Femtocell BS and indoor MSs.

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