Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Hybrid antenna transmit diversity and interference mitigation in PUSC**
Date Submitted	**2004-01-10**
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Re:	Contribution supporting TGe WG ballot
Abstract	Addition of a hybrid mode of PUSC and antenna transmit diversity in BS for the reduction of the number of required antenna subsystem while retaining PUSC interference reduction capability during cellular deployment.
Purpose	Adopting of proposed method into P802.16e D6
Notice	
Release	
Patent Policy and Procedures	

Hybrid antenna transmit diversity and interference mitigation in PUSC

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1. Problem Statement

IEEE802.16e OFDMA physical layer presented a cellular-like PUSC architecture that allows a high degree of interference reduction at cell edges and in overlap areas of same-cell antenna patterns. Unfortunately, it comes at a big price tag. With PUSC the number of antenna subsystems triples that of the equivalent FUSC architecture. To improve link quality using MIMO transmit diversity, the number of required antenna subsystems doubles for a 2Tx/segment configuration. The price to pay for interference reduction is great. For example, a basic PUSC requires three antenna subsystems to operate without any gain in spatial diversity (spatial multiplexing). At a 2x transmit diversity deployment, the basic PUSC architecture requires six antenna subsystems while the capacity is equivalent to a single 2TX FUSC. There is an addition of 4 antenna subsystems only for the purpose of interference reduction. For frequency reuse of one using three sector deployment (3 FUSC in 3 sectors or 9 PUSC segments at the same carrier frequency) with 2 Tx diversity, PUSC needs 18 antenna subsystems while FUSC needs 6 antenna subsystems. The cost differential for interference reduction is too great.

To improve antenna utilization, we propose a new scheme that combines PUSC and transmit diversity with compromised interference cancellation capability. It greatly reduces the required number of antenna subsystems that makes the cost of STC PUSC deployment manageable.

2. Proposed Solution

Figure 2 shows the proposed scheme of hybrid transmit diversity in PUSC. The scheme leverages the orthogonality of signals of different segments in PUSC mode as described in the IEEE802.16e standard. Overlaps of antenna patterns belonging to different segments do not introduce interference of current serving segment. To further improve link quality and coverage, MIMO/STC technology can be deployed in the BS. Although PUSC is an excellent vehicle in reducing cell interference, it is an expensive investment whereas no spatial multiplexing benefit is added. Figure 2 presents a compromise between transmit diversity and PUSC by allowing intentional overlaps of antenna patterns. At the overlap zones we introduce the transmit diversity as shown.

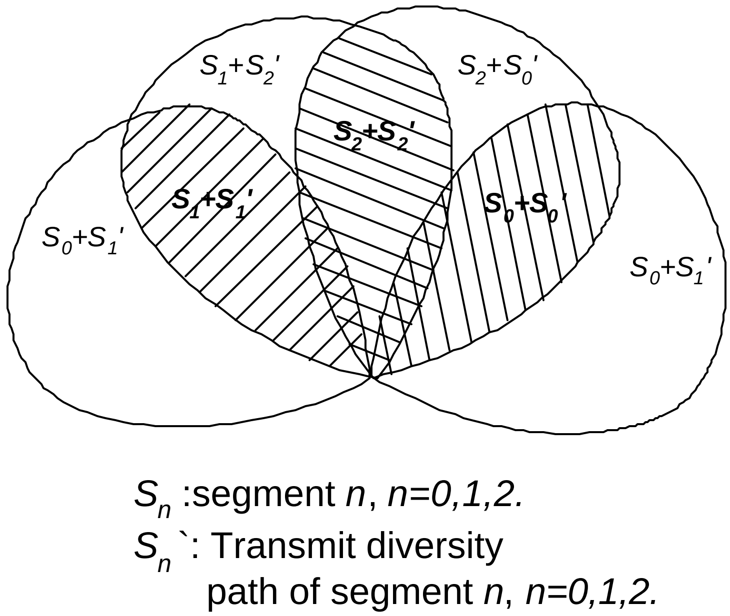


Figure 1. Illustration of antenna pattern overlaps in the hybrid TD-PUSC scheme

Figure 2 shows the system block diagram of TD-PUSC implementation in BS. It can be seen that the hybrid TD-PUSC scheme does not add complexity to the BS hardware implementation. In fact, it reduces the need for RF antenna subsystems by a wide margin. The saving in equipment cost can be substantial.

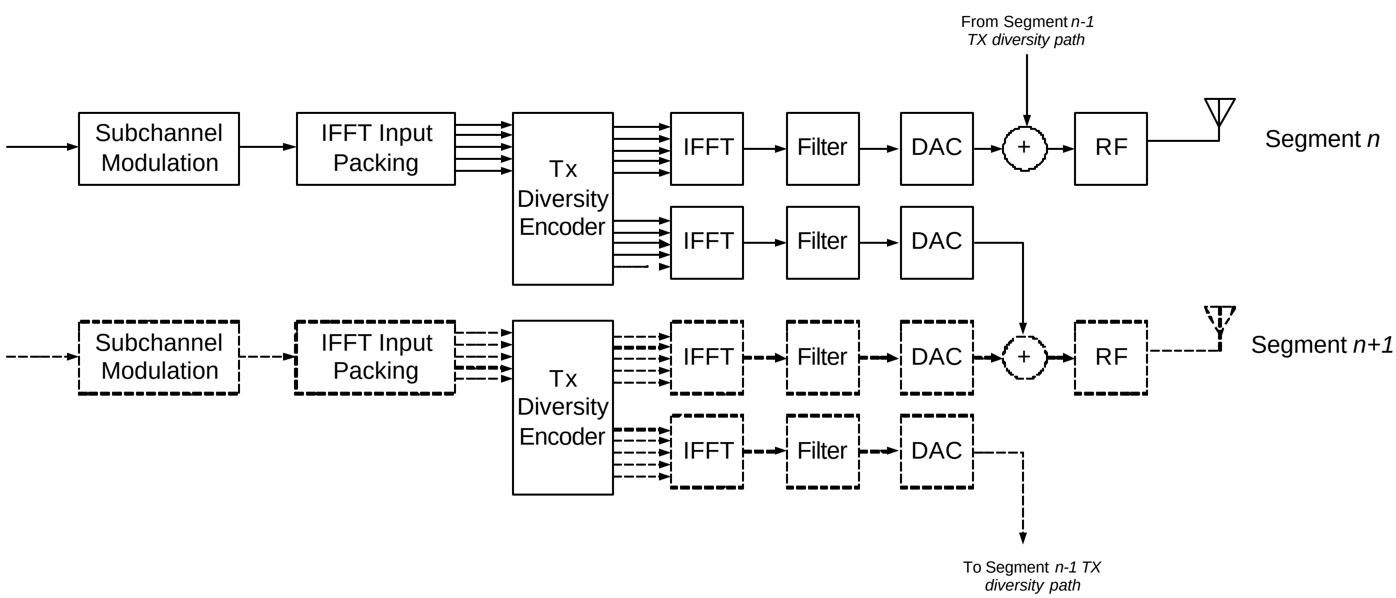


Figure 2. Block diagram of hybrid TD-PUSC scheme in BS.

Figure 3 shows an example of cellular deployment model utilizing the hybrid TD-PUSC scheme. In the figure 6-segment PUSC per cell configuration is used resulting in 2x spatial reuse. 2x transmit diversity is inherited from the overlaps of antenna patterns without adding more antenna subsystems. Without hybrid TD-PUSC scheme and to introduce 2x transmit diversity, the required antenna subsystems are 12 instead of 6 as proposed. There is a loss of 3dB antenna gain due to the widening of antenna angle.

The equivalent FUSC deployment is two FUSC zones per cell. At 2x transmit diversity the required number of antenna subsystems is 4. The penalty to pay for the reduced antenna count is high interference level at cell edges and antenna pattern overlap areas within the same cell. In it, the same cell interference poses a biggest problem because the interferers are strong. Reducing the antenna overlap lessens the problem but introduces another problem of coverage dead zones. With a simple investment of two antenna subsystems, the cellular deployment gains a lot in interference control using the hybrid TD-PUSC scheme.

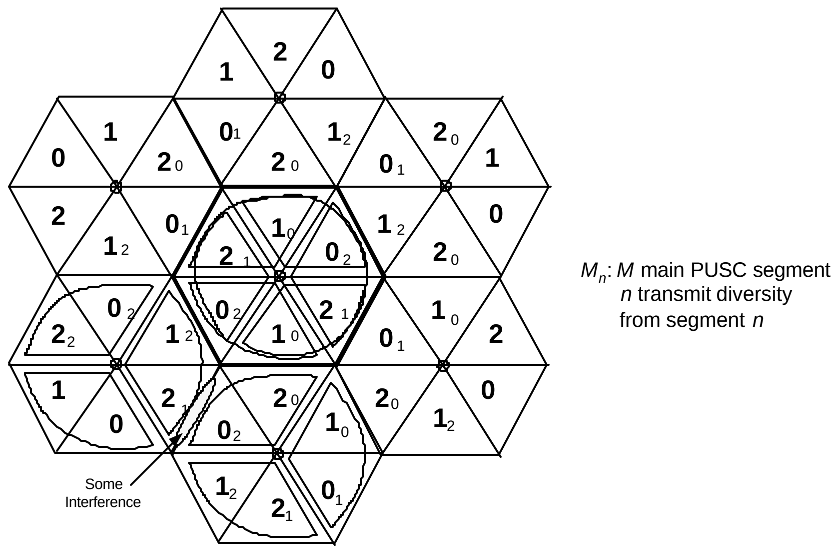


Figure 3. Example of cell planning using 6-segment PUSC cells and 2x transmit diversity with 2x spatial reuse.

Figure 3 presents the interference map of the 6-segment deployment in STC zones. As shown, along the edges within the same cell, STC transmission and reception is interference free. This type of interference is often the greatest and difficult to remove if PUSC-like bandwidth segmentation techniques are not used. At cell edges between cells, same-frequency interference is at least 3-dB lower in flat fading because of the addition of an additional transmit diversity path. Closer examination of Figure 4 further reveals that in TD-PUSC deployment in non-STC zones, two out of three segments can be interference free, thereby creating a deployment model where seamless coverage can be very well maintained and at the same time transmit diversity can be utilized at a modest increase of the number of antenna subsystems.

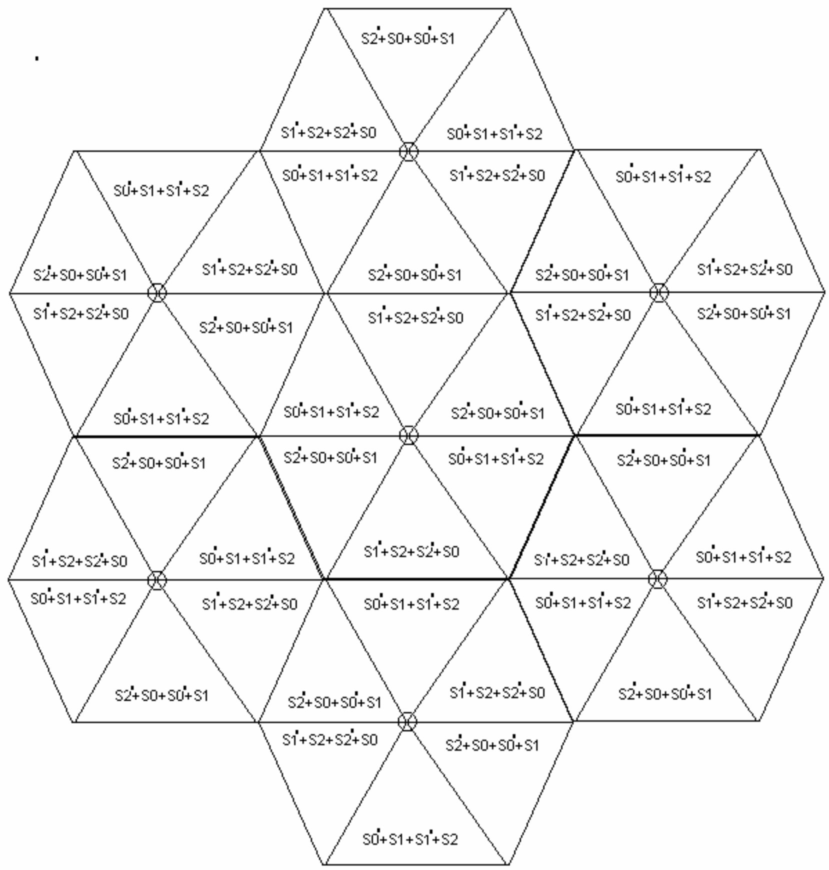


Figure 4. Interference map of the corresponding 6-segment TD-PUSC deployment in STC zones.

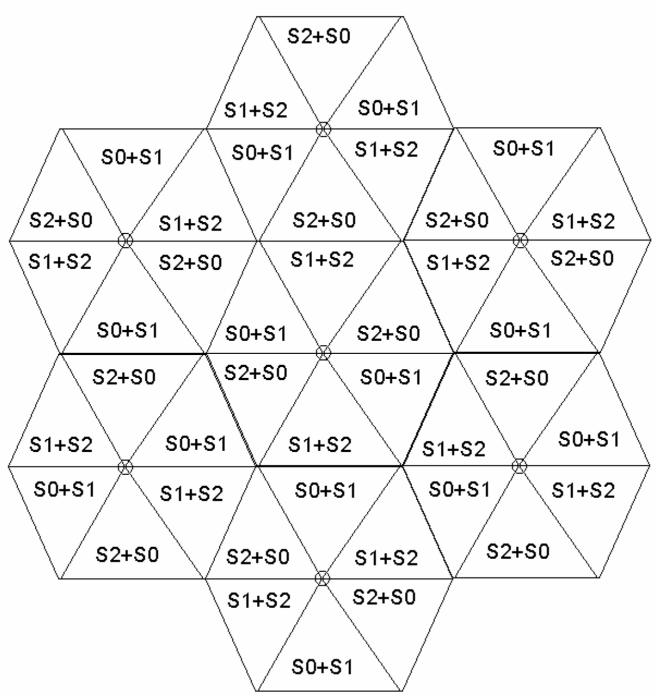


Figure 5. Interference map of the corresponding 6-segment TD-PUSC deployment in non-STC zones.

One other important advantage of the proposed hybrid TD-PUSC is that it provides a mechanizm for deriving channel estimation from segment preambles. In the current IEEE802.16e, channel estimation of the MIMO/STC path is derived solely from pilot symbols unless MIMO/STC midamble is added to the down link. Adding MIMO/STC midamble has an undesirable effect of costing DL capacity while using pilot for channel estimation requires that mobile adds a good amount of symbol memory buffers and computation complexity in interpolating estimation results. Additionally, the current STC pilot structure can only cope with maximum RF delay spread of 4 us.

3. Proposed Text Change

[Change Table 272a as follows]

Table 272a-OFDMA downlink TD_ZONE IE format

Syntax	Size (bits)	Notes
STC~~TD~~_ZONE_IE() {		
Extended DIUC	4	STC~~TD~~/ZONE = 0x01
Length	4	~~Length = 0x02~~
Permutation	2	00 = PUSC permutation 01 = FUSC permutation 10 = Optional FUSC permutation 11 = Optional adjacent subcarrier permutation
Use All SC indicator	1	0 = Do not use all subchannels 1 = Use all subchannels
STC~~Transmit Diversity~~	2	0b00 = No transmit diversity 0b01 = STC using 2/3 antennas 0b10 = STC using 4 antennas 0b11 = FHDC using 2 antennas
Matrix indicator	2	Antenna STC/FHDC matrix (see 8.4.8) 00 = Matrix A 01 = Matrix B 10 = Matrix C (applicable to 3 or 4 antennas only) 11 = *reserved*
IDcell	6	
~~*reserved*~~	~~2 bits~~	~~Shall be set to zero~~
~~Midamble presence~~	~~1~~	~~0 = not present~~ ~~1 = present at the first symbol in STC zone~~
~~Midamble boosting~~	~~1~~	~~0 = no boost~~

		~~1 = Boosting (3dB)~~
STC Channel Estimation	2	0b00 = Midamble not present 0b01 = Midamble present at the first symbol in STC zone without boosting 0b11 = Midamble present at the first symbol in STC zone with 3dB boosting 0b10 = TD-PUSC mode enabled with diversity paths from segments with preamble IDcell indexes listed below.
2/3 antennas select	1	0 = STC using 2 antennas 1 = STC using 3 antennas Selects 2/3 antennas when STC = 01
if length = 0x03 and STC Channel Estimation != 0b10{		
Dedicated_Pilots	1	0 = Pilot symbols are broadcast 1 = Pilot symbols are dedicated. An MSS should use only pilots specific to its burst for channel estimation
Reserved	7	Shall be set to zero
}elsif STC Channel Estimation = 0b10{		
For (n=0;n<No_Diversity_Path){		
Preamble_IDcell_index	7	Preamble IDcell index of the transmit diversity path in TD-PUSC overlaps
reserved	1	
}		
}		
}		

[Add the following text to 16.5a 8.4.5.3.4 at line 45 after Dedicated Pilots]

STC Channel Estimation

Indicates whether channel estimation of the STC diversity paths can be derived from the added STC midamble or whether hybrid TD-PUSC mode is enabled for use in STC transmission (see 8.4.8.10).

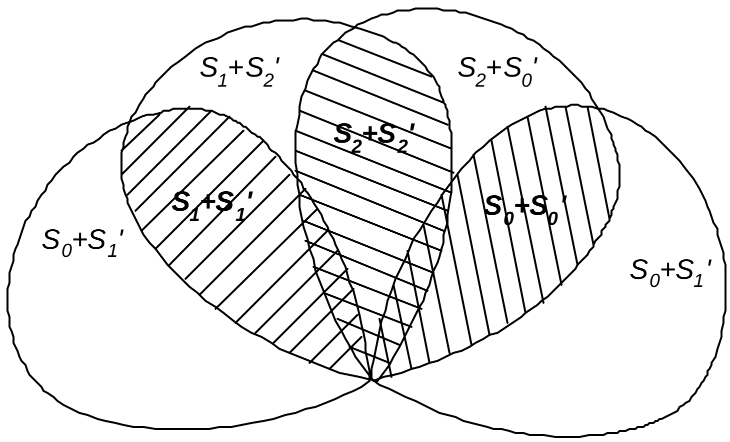
Preamble IDcell Index

When hybrid TD-PUSC mode is enabled (STC Channel Estimation = 0b10), the transmit antenna diversity paths are transmit via the segments with preamble IDcell index listed. STC channel estimation may be derived from segment preamble. The number of diversity paths No_Diversity_Path is embedded in the number if IDcell parameters attached to the end of this IE.

[Insert the following section]

8.4.8.10 Hybrid transmit diversity in PUSC segmentation (TD-PUSC)

In the downlink PUSC configuration, antenna patterns may be heavily overlapped between different segments without introducing interference due to the orthogonality of permutation patterns of different segments when the IDcell parameter is the same. In hybrid transmit diversity in PUSC segmentation (TD-PUSC) mode, the transmit diversity paths come from the transmit antenna of overlapped segments. Figure xxx illustrates a scenario of the overlapping and sources of diversity paths.



S_n :segment *n*, *n=0,1,2.*
S_n`: Transmit diversity path of segment *n*, *n=0,1,2.*

Figure xxx- Illustration of antenna pattern overlaps in the hybrid TD-PUSC scheme

Figure yyy shows the block diagram of the hybrid TD-PUSC scheme in BS implementation. Instead of a dedicated antenna subsystem for the diversity path in a specific segment, the signal can be added to the adjacent segment signal where the antenna pattern overlaps with the current serving segment. Because data symbols are orthogonal to each other from the same PUSC permutation with an identical IDcell parameter, adding signals from different segments do no introduce interference.

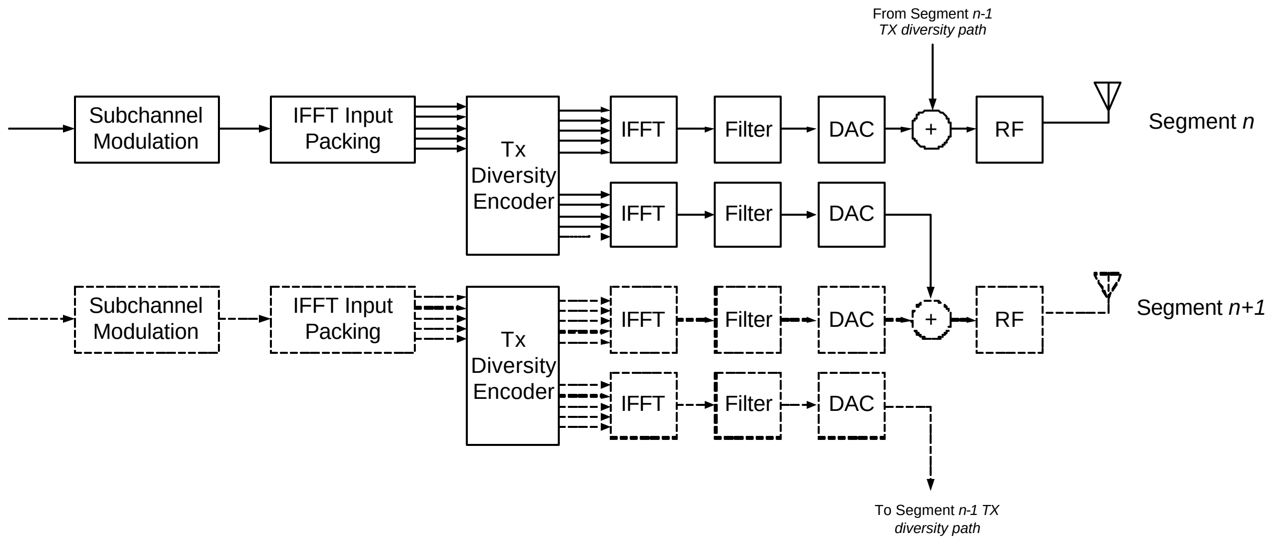


Figure yyy. Block diagram of hybrid TD-PUSC scheme in BS

At MSS, the channel estimation of the diversity path may be obtained from the preamble symbol of the diversity segment as indicated in the TD_ZONE IE (see 8.4.5.3.4) and tracked with the pilots specific to the segments.

References

[1] IEEE P802.16-REVd/D5-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems.

[2] IEEE P802.16-REVe/D5a-2004 Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands.