Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Optional DL PUSC design**
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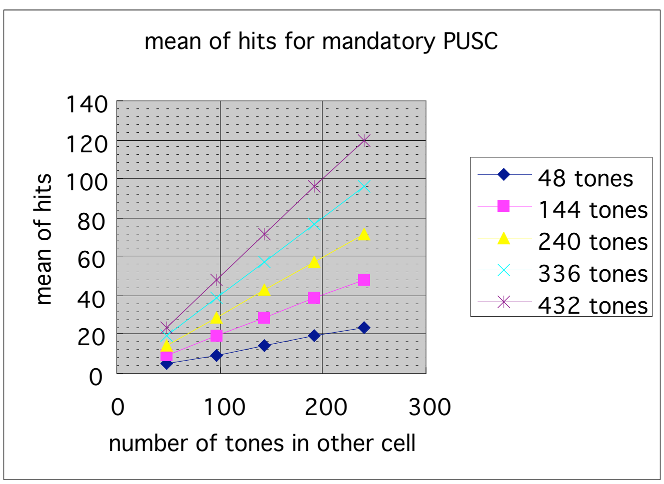
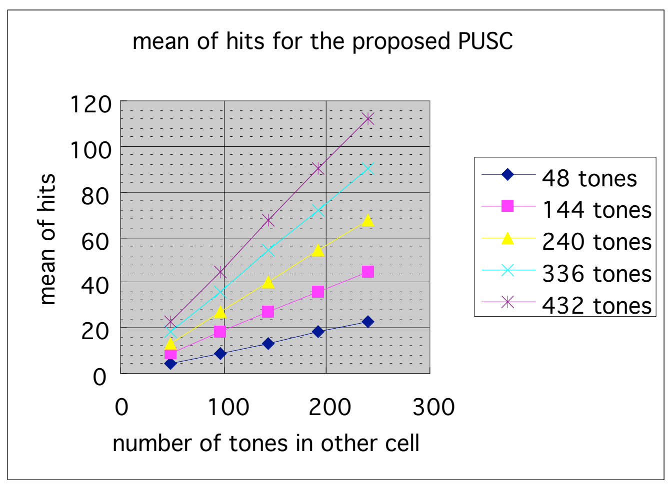
Re:	Contribution supporting Sponsor ballot
Abstract	In this contribution, optional DL PUSC which shows enhanced performance is proposed
Purpose	Adoption of suggested changes into P802.16e/D4
Notice	
Release	
Patent Policy and Procedures	

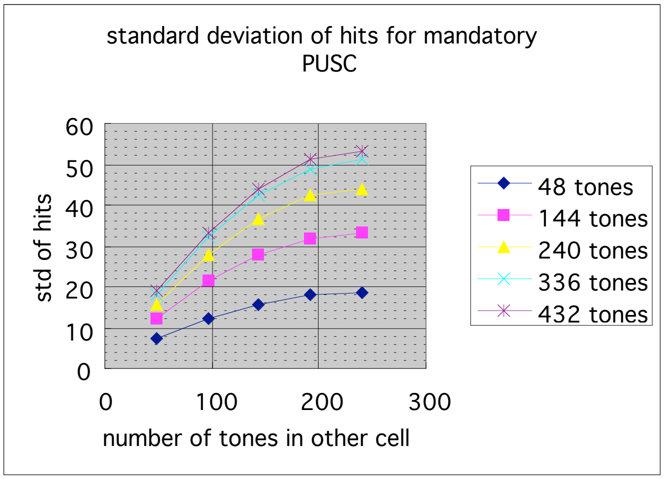
Problem definition

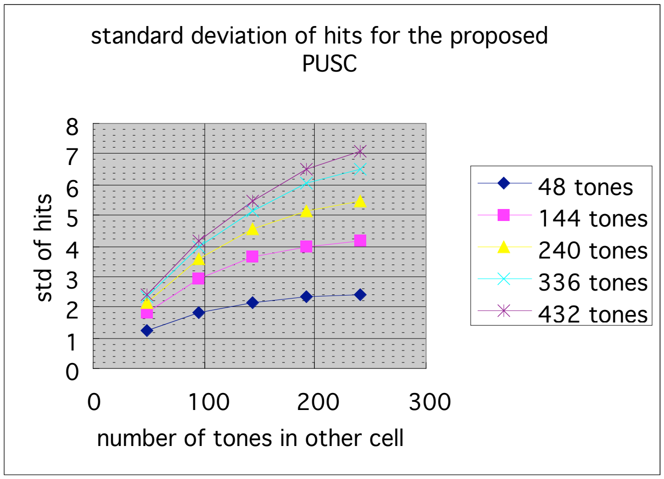
In the current downlink PUSC permutation specified in P802.16 REVe/D4, there are 6 major groups consisting of 12 or 8 clusters (1024-FFT case) that are scattered over whole frequency band. Since clusters in each segment are not located contiguously, channel estimation should be done within each cluster. That is, pilots in contiguous clusters cannot be used for channel estimation, which may degrade channel estimation performance. Also, pilots are spaced 4 subcarriers apart over 2 symbols, which may be insufficient for highly dispersive multi-path channels. In this contribution, new PUSC permutation method is proposed. The proposed PUSC permutation uses existing permutation formula used for optional downlink FUSC permutation in P802.16 REVe/D4. In the proposed PUSC permutation, effective pilot spacing is 3 subcarriers as is the case in optional downlink FUSC permutation. Also, in the proposed PUSC permutation the basic element constructing a segment is 36 contiguous subcarriers and hence all the pilots within these 36 subcarriers can be used for channel estimation, which may give better channel estimation performance.

One more thing that has to be noted for the proposed PUSC permutation is hit distribution. Hit means the collision of subcarriers between subchannels in different cells. On the other hand, hit means the interference from other cell. Mean of hits can be regarded as average interference from other cell and the variance of hits is interference variation. Large variance of hits implies that there can be some SSs who experience severe interference compared to other SSs in the same cell, which is not desirable. It will be better that every SSs in a cell experience the same interference level as possible as one can. In the proposed permutation, the variance of hits is very small compared to that of the current PUSC permutation. The following figures show the standard deviation of hits for the current PUSC and the proposed PUSC. It is assumed that there are two cells, one cell is a serving cell and the other is just other cell. In order to obtain each point in each curve, cell ID for serving cell and other cell is randomly selected, subchannels in the serving cell and the other cell are randomly selected and the hits between selected subchannels are counted. This procedure repeats 100000 times. The label of each curve is the number of tones per symbol used in serving cell. As one can see in the figures, there is no significant difference in the mean of hits. But as for the standard deviation of hits two PUSC permutations give quite different results.









Suggested change to the standard

[Add the following section]

8.4.6.1.2.4 Additional optional symbol structure for PUSC

8.4.6.1.2.4.1 Subcarrier allocation in the downlink for PUSC

Subcarrier allocation for optional PUSC is depicted in Figure 1. A bunch of 9 contiguous subcarriers containing 1 pilot carrier and 8 data carriers is called a bin and 4 consecutive bins are called a band. Those bands are divided into three segments each of which is assigned to a PUSC zone.

Table 1 2048 FFT downlink subcarrier allocation for optional PUSC

Parameters	value	comments
Number of DC Subcarriers	1	
Number of Guard Subcarriers, Left	160	
Number of Guard Subcarriers, Right	159	
Number of Used Subcarriers(N_{used}) (including all possible allocated pilots and the DC carrier)	1729	
Number of Pilot Subcarriers	192	
Pilot subcarrier index	9k+3m+1, for k=0,…, 191 and m=[symbol index]mod3	Symbol of index 0 is the first symbol of a frame
Number of Data Subcarriers	1536	Data subcarriers are reordered and indexed as 0 ~ 1535
Number of Data Subcarriers for a PUSC zone	512	PUSC zone #0 : band index 3k PUSC zone #1 : band index 3k+1 PUSC zone #2 : band index 3k+2 k = 0,1,…15

Table 2 1024 FFT downlink subcarrier allocation for optional PUSC

parameters	value	comments
Number of DC Subcarriers	1	
Number of Guard Subcarriers, Left	80	
Number of Guard Subcarriers, Right	79	
Number of Used Subcarriers(Nused) (including all possible allocated pilots and the DC carrier)	865	
Number of Pilot Subcarriers	96	
Pilot subcarrier index	9k+3m+1, for k=0,…, 95 and m=[symbol index]mod3	Symbol of index 0 is the first symbol of a frame
Number of Data Subcarriers	768	Data subcarriers are reordered and indexed as 0 ~ 767
Number of Data Subcarriers for a PUSC zone	256	PUSC zone #0 : band index 3k PUSC zone #1 : band index 3k+1 PUSC zone #2 : band index 3k+2 k = 0,1,…7

Table 3 512 FFT downlink subcarrier allocation for optional PUSC

parameters	value	comments
Number of DC Subcarriers	1	
Number of Guard Subcarriers, Left	40	
Number of Guard Subcarriers, Right	39	
Number of Used Subcarriers(Nused) (including all possible allocated pilots and the DC carrier)	433	
Number of Pilot Subcarriers	48	
Pilot subcarrier index	9k+3m+1, for k=0,…, 47 and m=[symbol index]mod3	Symbol of index 0 is the first symbol of a frame
Number of Data Subcarriers	384	Data subcarriers are reordered and indexed as 0 ~ 383
Number of Data Subcarriers for a PUSC zone	128	PUSC zone #0 : band index 3k PUSC zone #1 : band index 3k+1 PUSC zone #2 : band index 3k+2 k = 0,1,…3

Table 4 128 FFT downlink subcarrier allocation for optional PUSC

parameters	value	comments
Number of DC Subcarriers	1	
Number of Guard Subcarriers, Left	10	
Number of Guard Subcarriers, Right	9	
Number of Used Subcarriers(Nused) (including all possible allocated pilots and the DC carrier)	109	
Number of Pilot Subcarriers	12	

Pilot subcarrier index	9k+3m+1, for k=0,…, 11 and m=[symbol index]mod3	Symbol of index 0 is the first symbol of a frame
Number of Data Subcarriers	96	Data subcarriers are reordered and indexed as 0 ~ 95
Number of Data Subcarriers for a PUSC zone	32	PUSC zone #0 : band index 0 PUSC zone #1 : band index 1 PUSC zone #2 : band index 2

8.4.6.1.2.4.2 Downlink subchannels subcarrier allocation

For optional PUSC operation, total bands are partitioned into 3 segments and subchannel subcarrier allocation is done in each segment. The partition into 3 segments is shown in Figure 1. To allocate the diversity subchannels, data tones in 3 consecutive symbols in a segment are partitioned into 48 groups of contiguous data subcarriers. Each subchannel consists of one subcarrier from each of these groups. The exact partitioning into subchannels is according to the permutation formula in section 8.4.6.1.2.3.1. As shown in Table 309a, Ns is determined by FFT size. Also, the basic permutation sequences P_1 and P_2 are shown in Table 309a. The enumeration of the subcarriers in a segment within three symbols starts from the lowest numbered data subcarrier of the first symbol in a segment and goes to the next carriers. If it reaches the last carrier in the symbol in the segment, it goes to the lowest data carrier of the next symbol and so on.

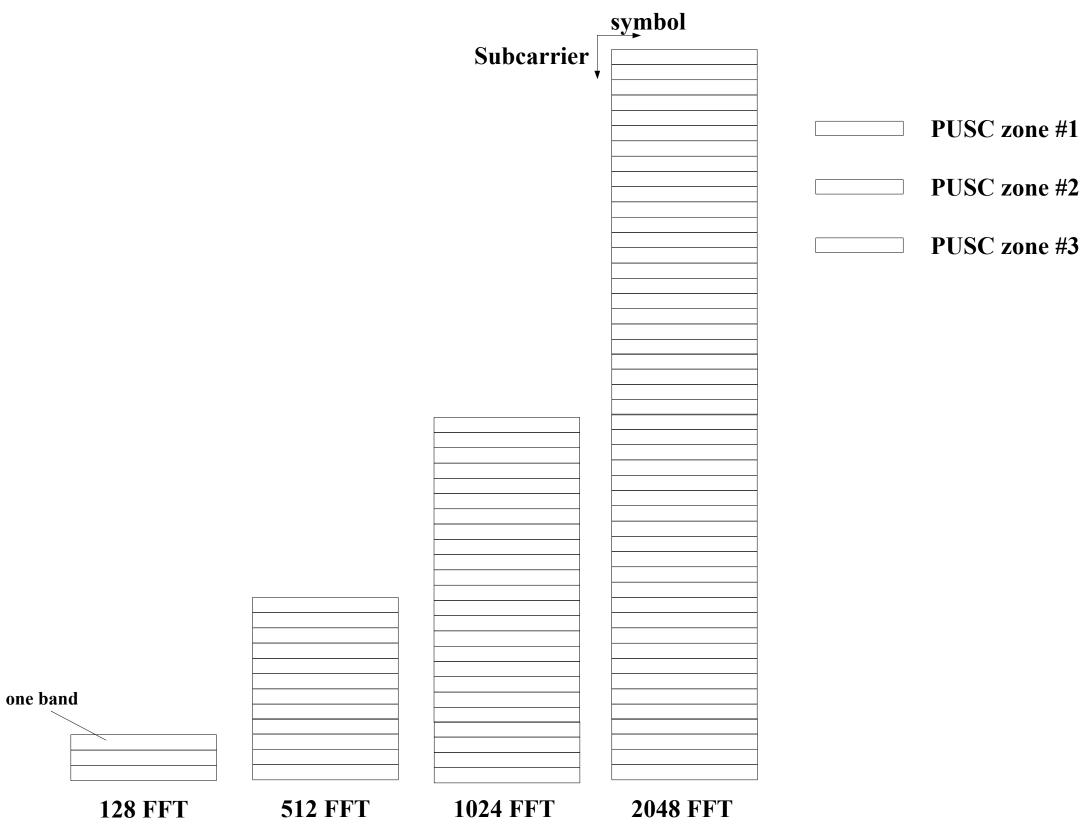


Figure 1 - Subcarrier allocation for optional downlink PUSC

[Adopt the following changes in section 8.4.5.3.4, in page 114, line 26]

Table 272a – OFDMA downlink TD_ZONE IE format

Syntax	Size (bits)	Notes
STC_ZONE_IE() {		
Extended DIUC	4	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	2	~~0b~~00 = 2 antennas ~~0b~~01 = 3 antennas ~~0b~~10 = STC using 4 antennas ~~0b~~11 = FHDC using 2 antennas
Matrix indicator	2	Antenna STC/FHDC matrix (see 8.4.8) 00 = Matrix A 01 = Matrix B 10 = Matrix C 11 = reserved
IDcell	6	
~~Reserved~~ Extended Permutation indicator	~~3~~ 1	0 = use the permutation as indicated above 1 = use the optional PUSC instead of the permutation as indicated above
Reserved	2	Shall be set to zero
}		