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Re:	Propose STC/MIMO Zone preamble sequences
Abstract	Proposing STC/MIMO preamble sequences for STC/MIMO for in IEEE P802.16e/D5-2004
Purpose	To improve the performance of STC/MIMO.
Notice	
Release	
Patent Policy and Procedures	

Preamble Structure for STC/MIMO Zone

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1. Problem Statement

STC/MIMO provides an effective way to improve the link-budget and system performance. To achieve the potential STC/MIMO gain, however, channel estimation must be performed accurately prior to data demodulation. Without reliable and accurate channel estimation the performance of STC/MIMO will be greatly compromised. In the current IEEE802.16-2004 standard, a STC preamble for STC/MIMO mode has been accepted for OFDM mode but is missing in the OFDMA mode. Although in general pilots may also be used for channel estimation, STC/MIMO Zone preamble based channel estimation has following benefits:

(1) Simpler and more robust channel estimation. To reduce transmission overhead the pilots generally are placed sparsely across the time and frequency domain but within the Nyquist sample rates in each domain. This could make channel estimation/interpolation computational intensive, e.g., 2-D or two 1-D processing. In comparison, preamble tones are more densely packed in frequency domain and this makes channel estimation/interpolation process much simpler and more robust.
(2) Better performance. In pilots based methods, the performance of the channel interpolation may suffer from model mismatch, resulting in inaccurate channel estimation. In preamble sequence-based methods, this estimation error can be greatly reduced due to small preamble tone spacing. In addition, preamble sequence may be boosted to that it will have higher SNR and therefore even better estimation performance.
(3) Reduced MSS memory requirement. In pilots based method, larger number of data (many OFDMA symbols) need to be buffered since pilots extraction involves many symbols and at the same time all the traffic data need to be saved for subsequent demodulating processing. Preamble based channel estimation does not need buffering the data since the preamble takes only one symbol and is located at the beginning of the STC/MIMO Zone and therefore large memory is no longer necessary in the MSS.

The apparent disadvantage of preamble structure over pilots is the overhead concern. However, a careful design of the preamble sequence can minimize this minor disadvantage and the acquired benefit of preamble design may well overweight the small overhead, esp. the higher cost MSS design in (3) can be avoided.

2. Proposed solutions

In this contribution, we propose two variations of low overhead preamble sequences for STC/MIMO. In solution 1, only one symbol time is allocated for the preamble sequence whereas in solution 2, one symbol period will be allocated for each of two transmitting antennas to improve and simplify channel estimation.

The location of the STC/MIMO preamble sequence is best placed at the beginning of the STC/MIMO Zone.

2.1. Solution Option 1

2.1.1. FUSC

Over a single symbol period, each antenna transmits one sub-carrier in turn over the entire *Nused* sub-carriers (excluding DC), as follows:

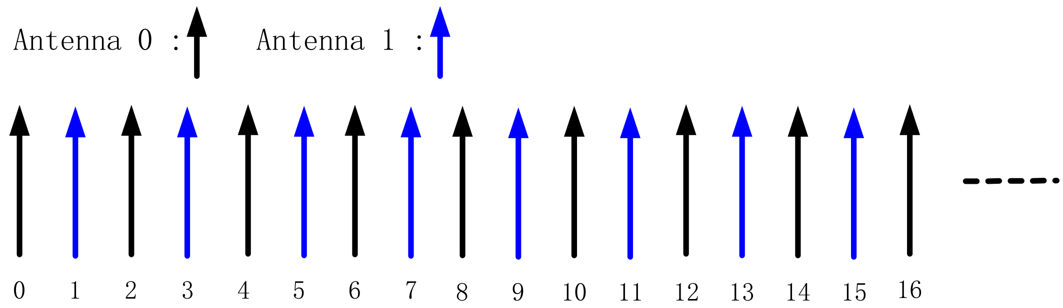

Figure 1. STC/MIMO Zone preamble allocation in FUSC for 2 antennas

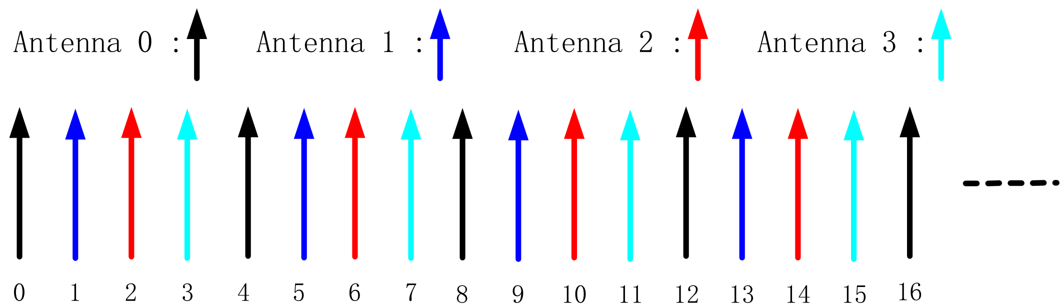

Figure 2. STC/MIMO Zone preamble allocation in FUSC for 4 antennas

2.1.2. PUSC

Since in PUSC each STC/MIMO user is allocated within the segment(s) consisting one or more groups of clusters, the Zone preamble sequence should be in line with the segmentation. However, we only to specify the Zone preamble sequence over a single cluster since a segment is a collection of clusters. The preamble sequence is shown as follows, for two and four antennas, respectively.

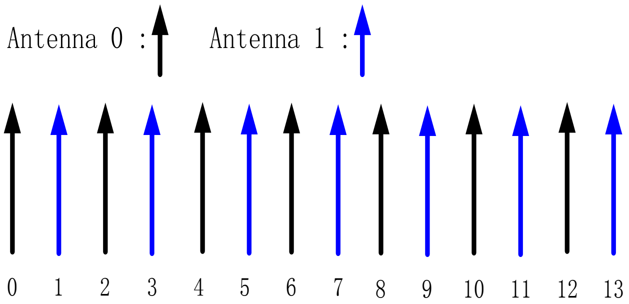

Figure 3. Preamble allocation of each physical cluster (2-antenna case)

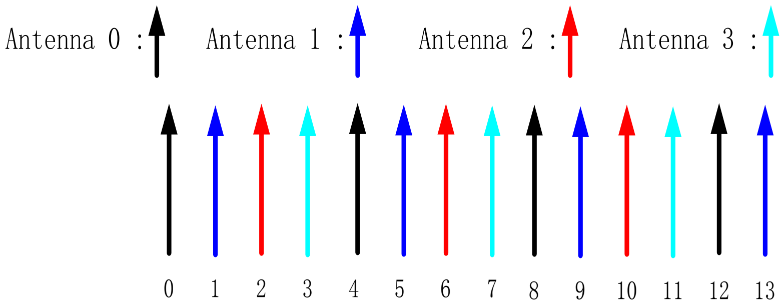

Figure 4. Preamble allocation of each physical cluster (4-antenna case)

The STC/MIMO Zone preamble sequence shall be applied to all the clusters within the groups of the same segment.

2.2. Solution Option 2

2.2.1. FUSC

To improve the performance and reduce complexity of the channel estimation for more than two antennas, we allocate a symbol period for each two additional antennas. Take four antennas for example. While the 1st and 2nd antenna transmit in the first preamble symbol, as in solution 1, and the 3rd and 4th antennas transmit in the preamble symbol, with preamble tons over the entire *Nused* FFT bins as follows:

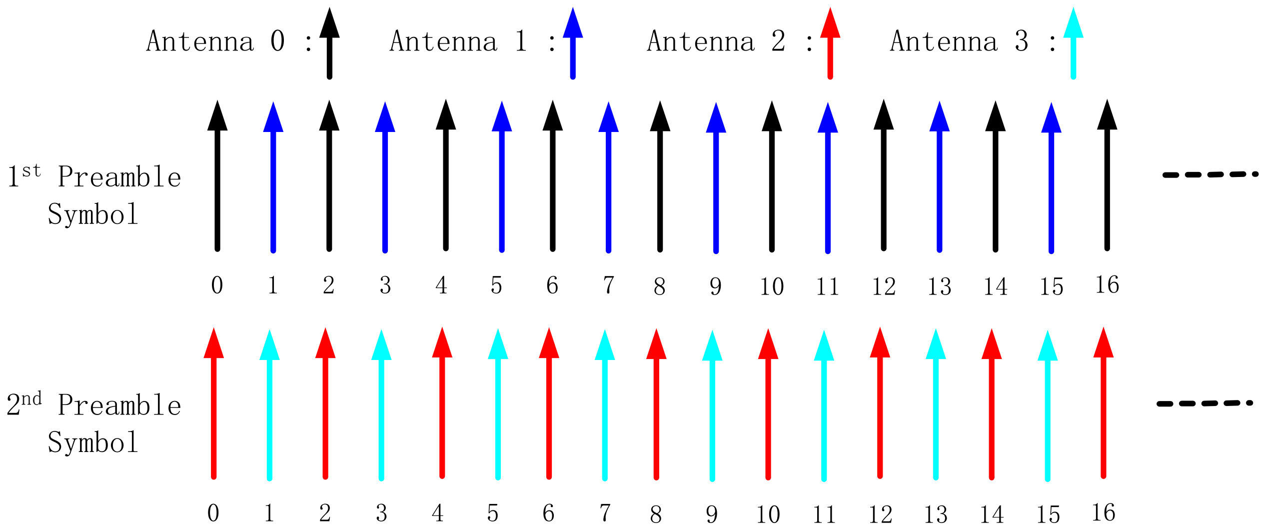

Figure 5. STC/MIMO Zone preamble allocation in FUSC (2-symbol, 4 antennas)

2.2.2. PUSC

Similar to Fig 3, for PUSC, we alternate 3rd and 4th antenna placement and extend it to full 14 sub-carriers, shown in Fig. 4.

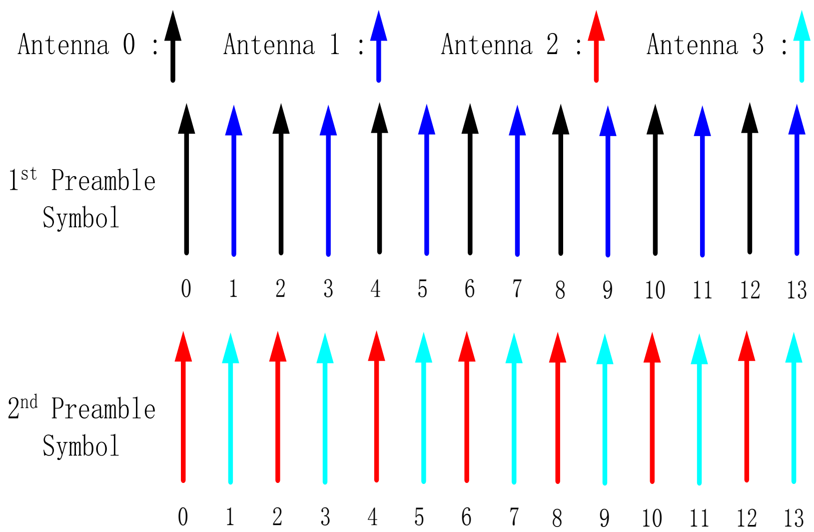

Figure 6. Preamble allocation of each physical cluster in PUSC (2-symbol, 4 antennas)

3. Specific text changes

[*Inserting a section* ***8.4.8.1. STC/MIMO Channel estimation*** *[1]*]

=== Start text changes ====

8.4.8.1. STC/MIMO channel estimation

Channel estimation required by STC/MIMO is provisioned by inserting an STC/MIMO Zone preamble sequence at the beginning of the STC/MIMO Zone. The preamble sequence will be different for different operation modes (e.g., PUSC or FUSC) and number of antennas. There are two options. In option 1, preamble consists of one symbol. In option 2, preamble consists of two symbols; each symbol is transmitted by a set of 2 or 3 antennas; two symbols are transmitted by 3 or 4 antennas.

8.4.8.1.1 STC/MIMO Zone preamble for FUSC

8.4.8.1.1.1 Single symbol STC/MIMO Zone preamble for FUSC

Over the entire N_{used} subcarriers (excluding DC), the subcarriers are evenly distributed into subsets of subcarriers with equal spacing; each subset is assigned for an antenna. For two, three, and four antennas, the patterns are shown in Figure 7, Figure 8, and Figure 9 respectively.

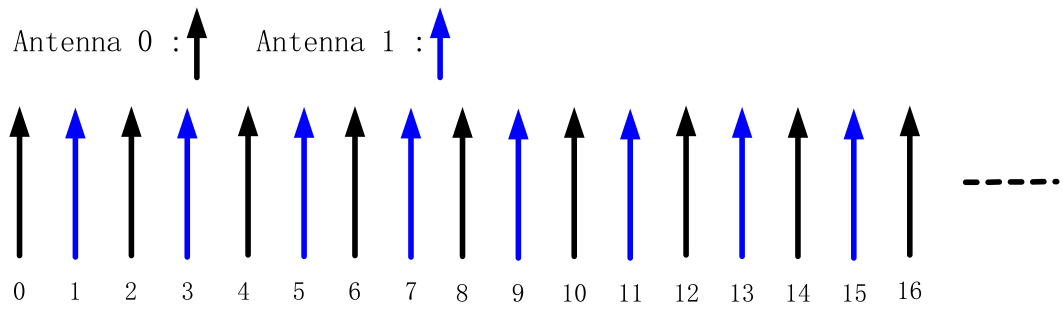

Figure 7. STC/MIMO Zone preamble allocation in FUSC for 2 antennas

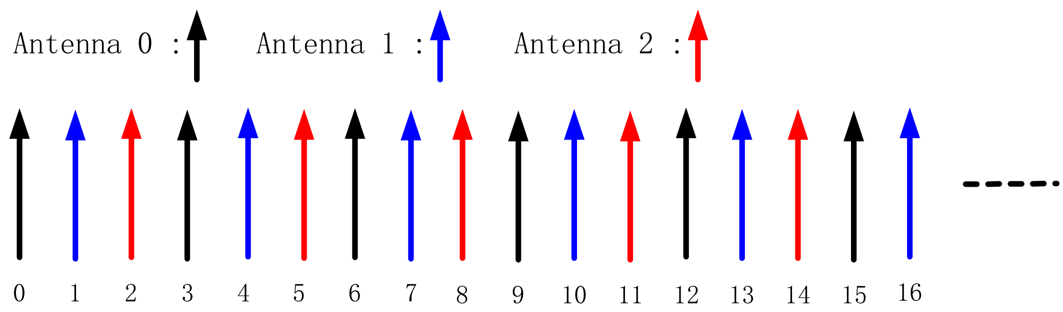

Figure 8. STC/MIMO Zone preamble allocation in FUSC for 3 antennas

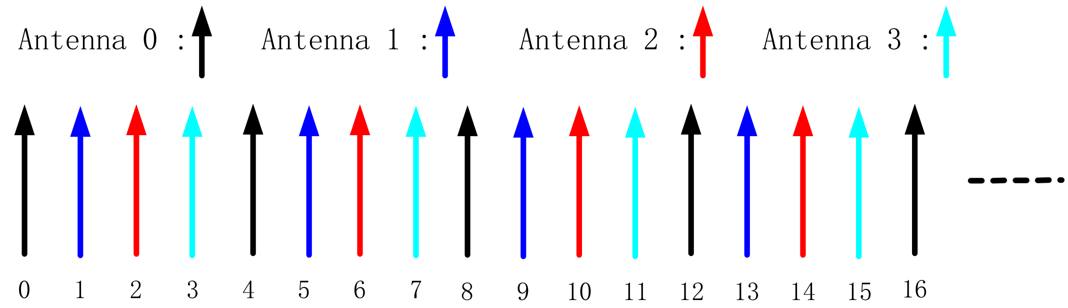

Figure 9. STC/MIMO Zone preamble allocation in FUSC for 4 antennas

8.4.8.1.1.2 Two-symbol STC/MIMO Zone preamble for FUSC

For more than two antennas, each symbol is transmitted by a set of 2 or 3 antennas. For example, the preamble allocation for 3 and 4 antennas is shown in Figure 10 and Figure 11 respectively.

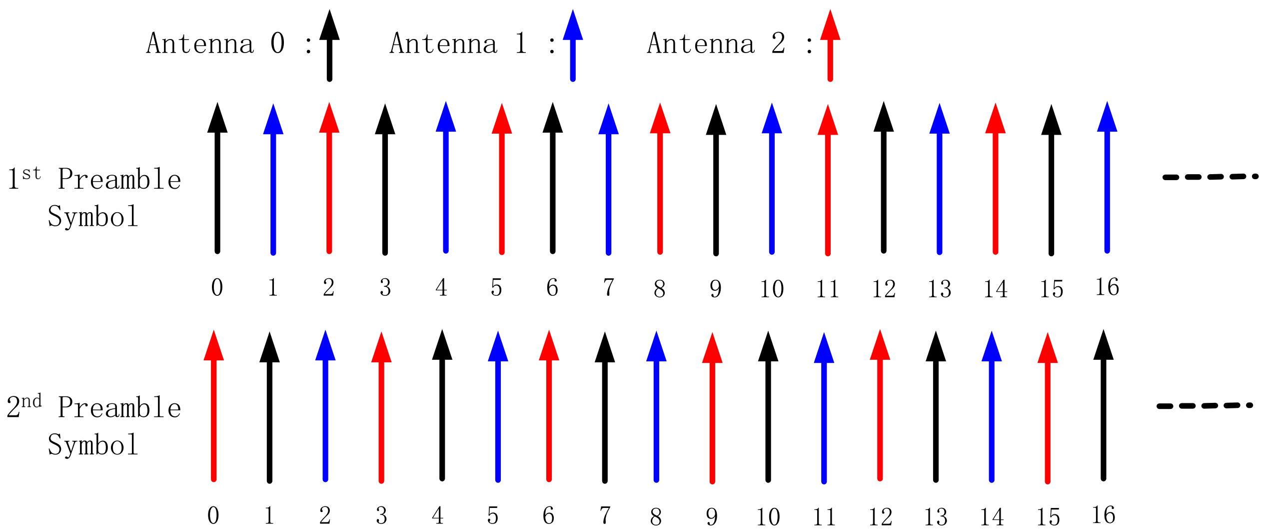

Figure 10. STC/MIMO Zone preamble allocation in FUSC (2-symbol, 3 antennas)

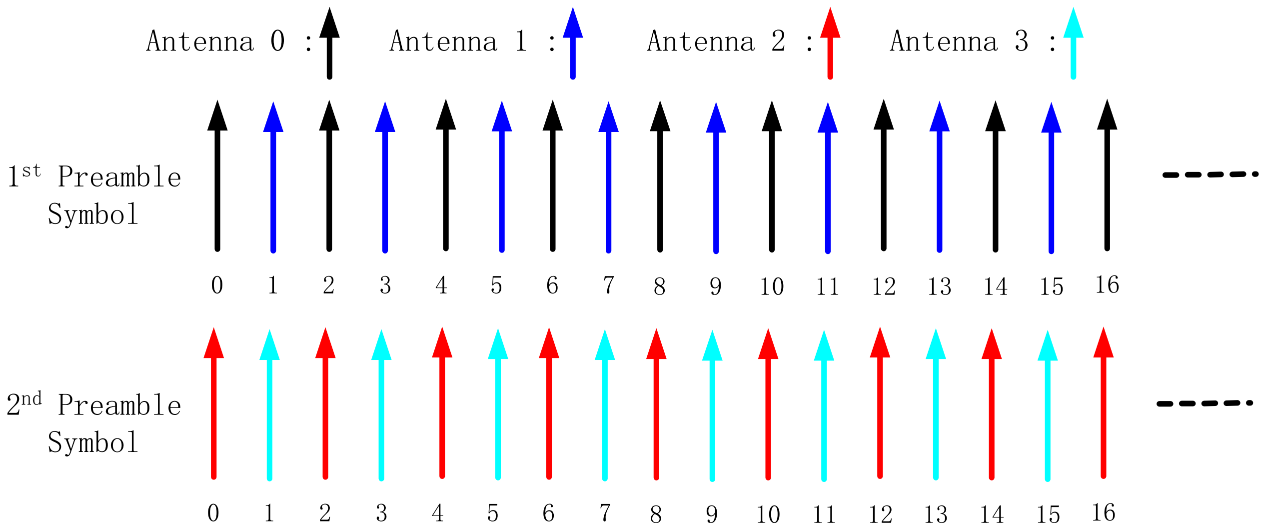

Figure 11. STC/MIMO Zone preamble allocation in FUSC (2-symbol, 4 antennas)

8.4.8.1.2 STC/MIMO channel estimation for PUSC

In PUSC mode, antennas shall transmit preamble symbol(s) within the segment(s) dedicated for the STC/MIMO Zone. Since each segment consists of one or more groups of clusters, the preamble sequence is reused on a cluster base. The STC/MIMO Zone preamble symbol shall be transmitted over all the clusters within the segment(s) before the STC/MIMO Zone.

8.4.8.1.2.1 Single symbol STC/MIMO Zone preamble for PUSC

The 14 subcarriers in each cluster are evenly distributed into subsets of subcarriers with equal spacing; each subset is assigned for an antenna. Figure 12, Figure 13, and Figure 14 show the preamble allocation for 2, 3 and 4 antennas.

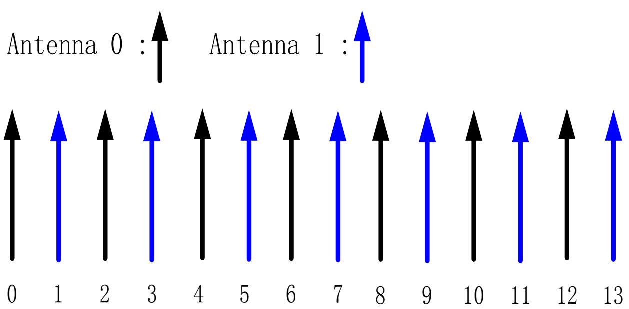

Figure 12. Preamble allocation of each physical cluster (2-antenna case)

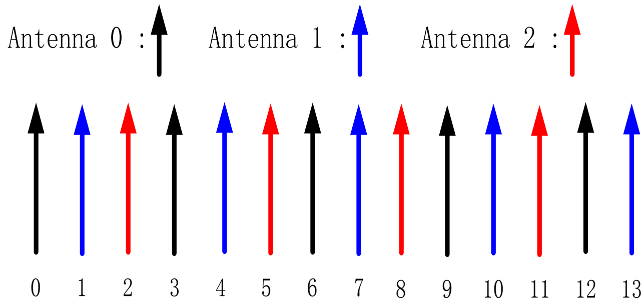

Figure 13. Preamble allocation of each physical cluster (3-antenna case)

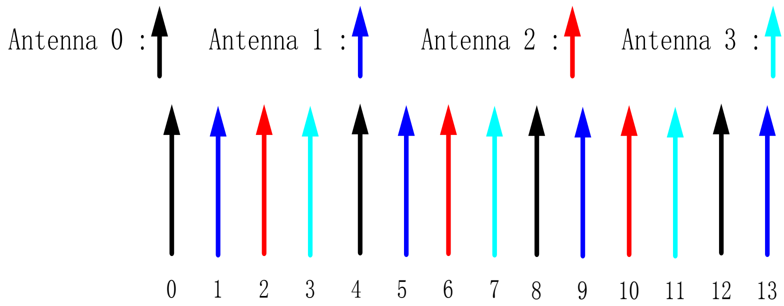

Figure 14. Preamble allocation of each physical cluster (4-antenna case)

8.4.8.1.2.2 Two-symbol STC/MIMO Zone preamble for PUSC

Two symbols are transmitted before the STC/MIMO Zone within each cluster. For more than two antennas, each symbol is transmitted by a set of 2 or 3 antennas. For example, the preamble allocation of each cluster for 3 and 4 antennas is shown in Figure 15 and Figure 16 respectively.

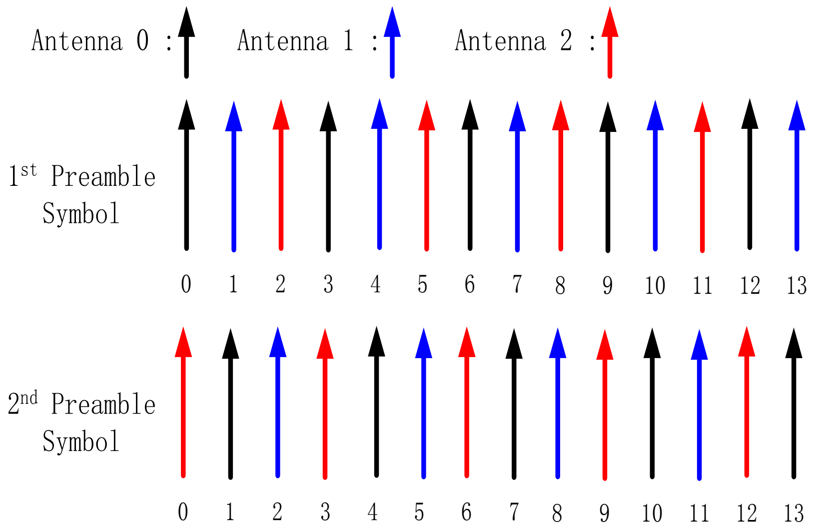

Figure 15. Preamble allocation of each physical cluster in PUSC (2-symbol, 3 antennas)

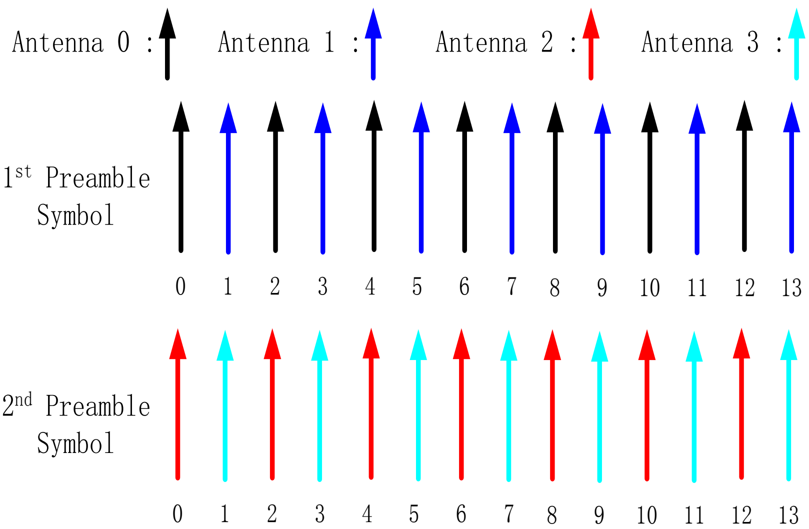

Figure 16. Preamble allocation of each physical cluster in PUSC (2-symbol, 4 antennas)

STC/MIMO Zone sequence modulation and boost level

TBD

=== End text changes ====

[*Inserting a section* ***8.4.5.3.4. Space-Time Coding (STC) Zone switch IE format for DL*** *[1]*]

=== Start text changes ====

Table 277a -OFDMA downlink STC_ZONE IE format

Syntax	Size (bits)	Notes
STC_ZONE_IE() {		
Extended DIUC	4	STC/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	00 = STC using 2 antennas 01 = STC using 3 antennas 10 = STC using 4 antennas 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~~	~~3~~	~~Shall be set to zero~~
If (STC=00){		
STC/MIMO Zone preamble power boost	3	000 = STC/MIMO Zone preamble off 001 = Preamble power boost level 1 (0 dB) 010 = Preamble power boost level 2 (2 dB) 011 = Preamble power boost level 3 (3 dB) 100 = Preamble power boost level 4 (4 dB) 101 = Preamble power boost level 5 (5 dB) 110 = Preamble power boost level 6 (6 dB) 111 = Preamble power boost level 7 (7 dB)
} Else if (STC=10 or STC=01){		
STC/MIMO Zone preamble Options	1	0 = Single-symbol preamble 1 = Two-symbol preamble
STC/MIMO Zone preamble power 3dB boost	2	00 = STC/MIMO Zone preamble off 01 = Preamble power boost level 1 (0 dB) 10 = Preamble power boost level 2 (2 dB) 11 = Preamble power boost level 3 (3 dB)
}		
}		

=== End text changes ====

4. References

[1] IEEE P802.16-REVd/D5-2004
[2] IEEE P802.16d/D3-2004