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Abstract	This submission is meant to clarify the use of layers in the MIMO_DL_basic_IE() and how they pertain to FEC block and burst allocation. Furthermore, the submission introduces a vertical encoding mode that ensures that the subcarriers from an FEC block are equally spread over all transmit antennas when using pure spatial multiplexing STCs
Purpose	Adoption of vertical encoding.
Notice	
Release	
Patent Policy and Procedures	

STC Layer Burst Mapping and Vertical Encoding

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Overview

This submission is meant to clarify the use of layers in the "MIMO DL basic IE" and how they pertain to FEC block and burst allocation. Furthermore, the submission introduces a vertical encoding mode that ensures that the subcarriers from an FEC block are equally spread over all transmit antennas when using pure spatial multiplexing STCs.

Clarifying MIMO DL Basic IE

There are several issues with the MIMO_DL_Basic_IE() that need to be modified. First, the field sizes for the allocation dimensions, (i.e., OFDMA symbol offset, subchannel offset, no. OFDMA symbols, and no. subchannels), should exactly match with the OFDMA DL-MAP-IE format. Furthermore, allocating only 2 bits for the number of different STC matrices is overly restrictive. The Matrix_Indicator field should be expanded to 3 bits to include up to eight STC options. Finally, the MIMO_DL_Basic_IE() needs to include an option to enable vertical encoding to help the diversity when using the spatial multiplexing STCs.

Layer Mapping

In the SISO case, the DL-MAP allocates a burst with a rectangular region in the DL subframe specifying a DIUC modulation and coding format. When extending to the STC case, the MIMO_DL_Basic_IE() also specifies the number of layers, which implies a number of virtual bursts allocated simultaneously in the physical burst rectangle. The DL_MAP allocates data to each of the layers as if they were independent bursts similar to the SISO case, each with their own DIUC format. Each layer is considered independently as an allocation region, and all FEC block concatenation rules from SISO case apply in forming the burst.

The STC_ZONE_IE() sets the number of transmit antennas in the system for the zone, and the selection of the STC matrix in the MIMO_DL_Basic_IE() identifies the spatial rate of the burst (the number of independent slots that are transmitted per OFDMA slot). In one case, the number of layers, L, can be set to the spatial rate of the channel. This allows independent allocations with different DIUC for best spectral efficiency. Alternatively, the number of layers can be set to 1, allowing a large virtual burst which where the length of the symbol region is multiplied by the spatial rate. This creates a burst allocation that maintains the same number of subchannels but also have room for the all the possible FEC blocks required.

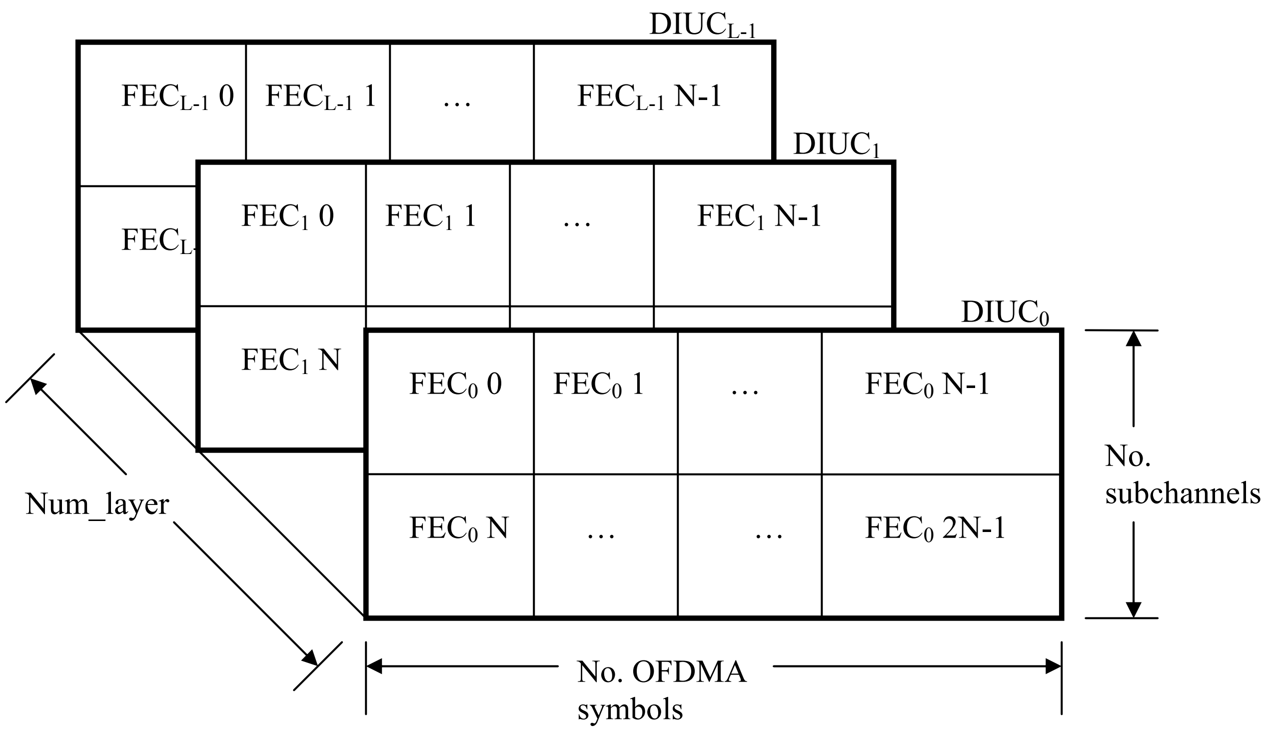

Figure 1: Virtual bursts with Num_layers = spatial rate

Figure 1 shows the FEC concatenation applied to the L layers allocated with the MIMO DL Basic IE.

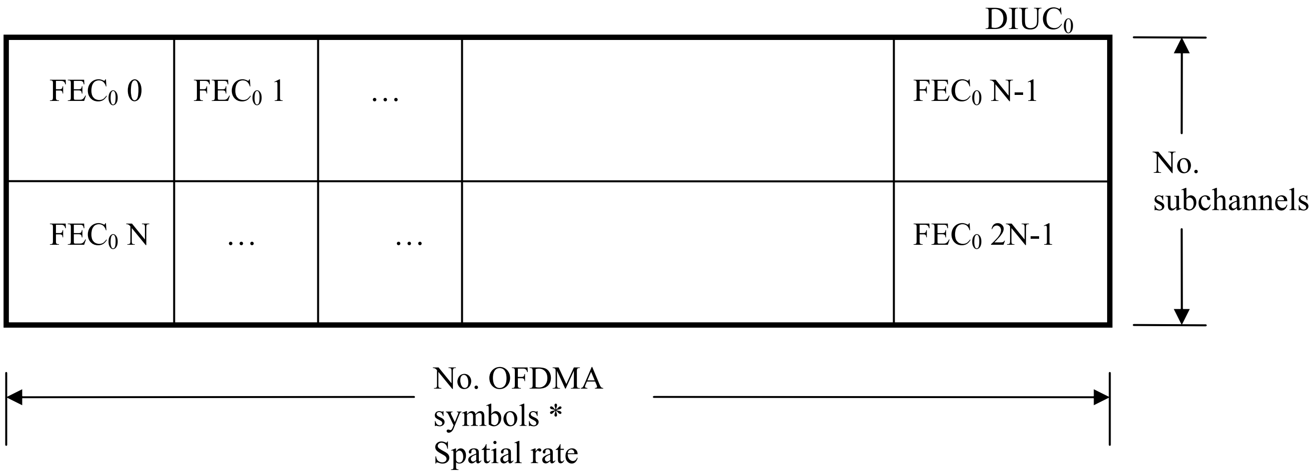

Figure 2: Layer with Num_layers = 1

Figure 2 shows the layer burst when the number of layers is set to 1. The time axis is expanded to apply standard FEC block concatenation rules and ordering, but the physical transmission still occurs only during the period specified by No. OFDMA symbols. Using one large virtual burst allows the most efficient packing of PDUs when the selected DIUC is the same on all spatial channels. Figure 3 demonstrates a hypothetical burst allocation, where two layers are used for the same DIUC. Each of the PDU from the MAC does not fit exactly in the allocated burst and are padded. Once the two PDU are combined into a single STC virtual burst, the MAC can fit an additional PDU in the remaining space.

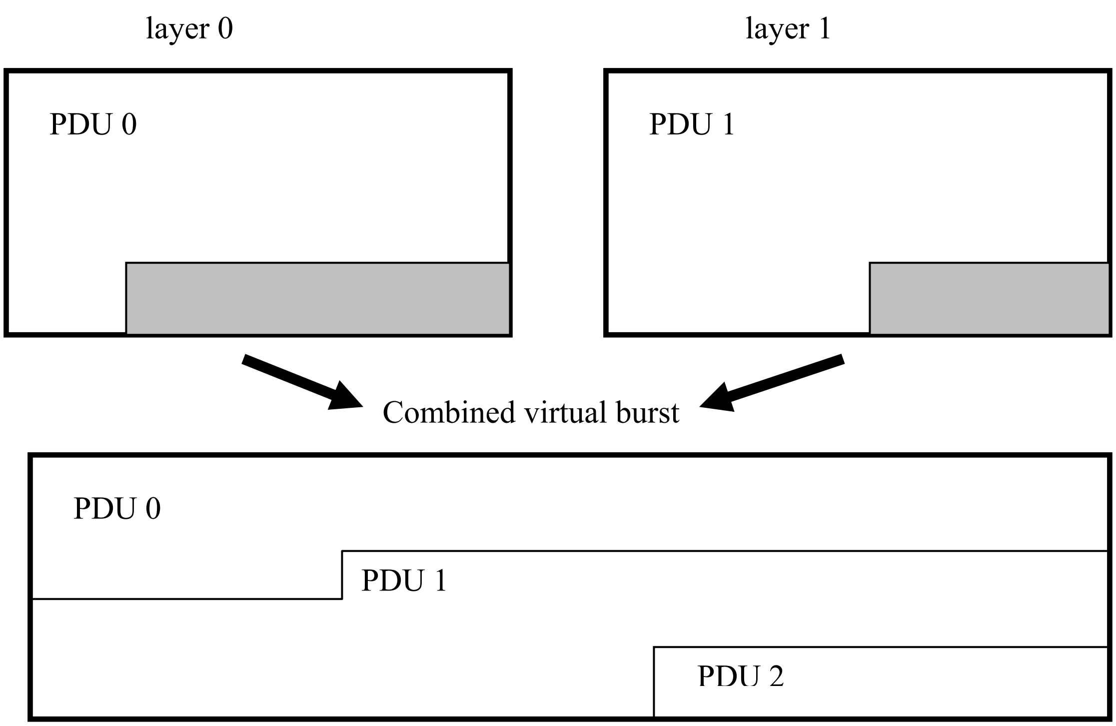

Figure 3: Packing efficiency with a single virtual burst

Mapping to STC Matrices

The various STC matrices are defined to be applied on slots, where a slot is the minimum unit of allocation that is one subchannel over the specified number of symbols (one symbol in DL-FUSC, two symbols in DL PUSC, and three symbols in the uplink PUSC), always allocating 48 data subcarriers. A particular STC matrix requires multiple slots in parallel, sometimes even more than the spatial rate of the code. The order of the of the slots fed to the STC code is first with the lowest numbered subchannel and symbol offset in the first layer, and sequentially through the corresponding slots in each higher layer. The STC matrix operates on slots, although the slots are retrieved as a column vectors from the bursts in order to send all the subchannels over the air simultaneously. In the case of one layer, multiple columns are retrieved starting with the lowest symbol offset. Figure 4 illustrates a 4 transmit STC using two layers.

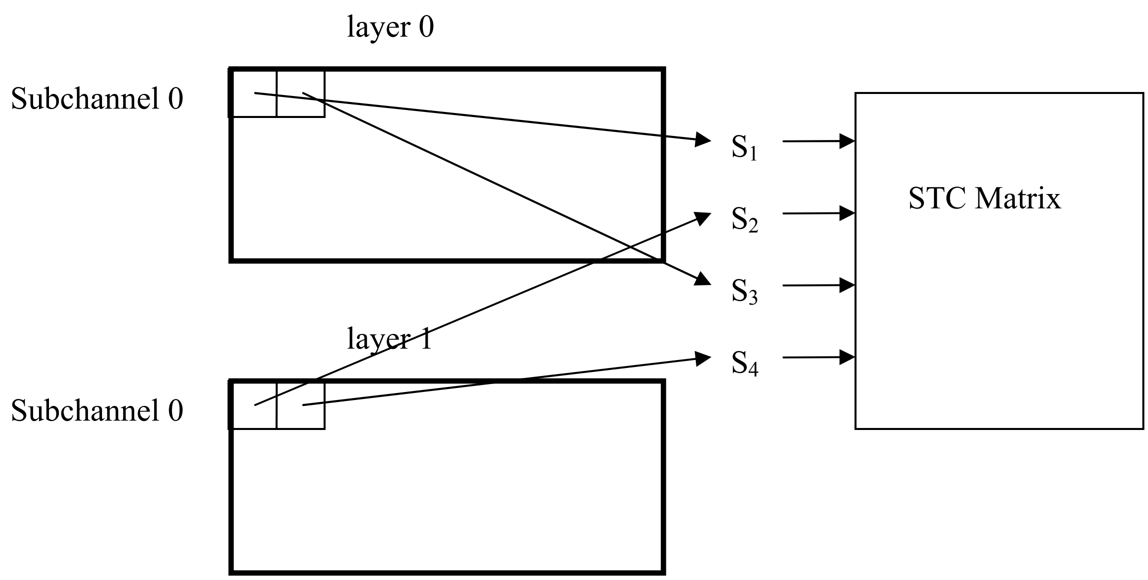

Figure 4: Order of slots in STC Matrix

Vertical Encoding

Horizontal encoding for STC specifies that separate FEC blocks are encoded for each of the parallel spatial channels separately. Vertical encoding specifies that one FEC block is encoded and multiplexed onto all the spatial channels for spatial diversity. Horizontal encoding allows the users to control the modulation and coding rate based on the individual SNR of the spatial transmit mode. The problem with horizontal encoding with pure spatial multiplexing is that the FEC blocks are not interleaved over the various transmit antennas (foregoing any spatial diversity). The MIMO_DL_Basic_IE() as specified implies horizontal encoding, but the STC zone burst allocation needs to consider vertical encoding.

Vertical encoding can be applied for spatial multiplexing by independently applying a cyclic shift on the individual 48 subcarriers that constitute a slot over antennas. With horizontal encoding all of the data subcarriers for first slot are applied to STC matrix input S_1, all of the data subcarriers of the second slot are applied to S_2, etc. When vertical encoding is enabled the individual data subcarriers are allocated to the matrix input S1, S2, etc based on the following equation:

$S_m(n,k) = ((n-1 + k) \text{ MOD } M) + 1$

Where S_m specifies the m^{th} input the STC matrix given an original location of n, and a data subcarrier location k.

M = number of inputs to the STC matric

n = original slot STC matrix input (1..M)

k = data subcarrier index (0..47)

The rotation works for all STCs, but the most benefit will be achieved with the pure spatial multiplexing STCs which do not have inherent spatial diversity. Figure 5 shows an example of the subcarrier re-ordering process. At the receiver, the cyclic rotation is undone after the STC demodulation process.

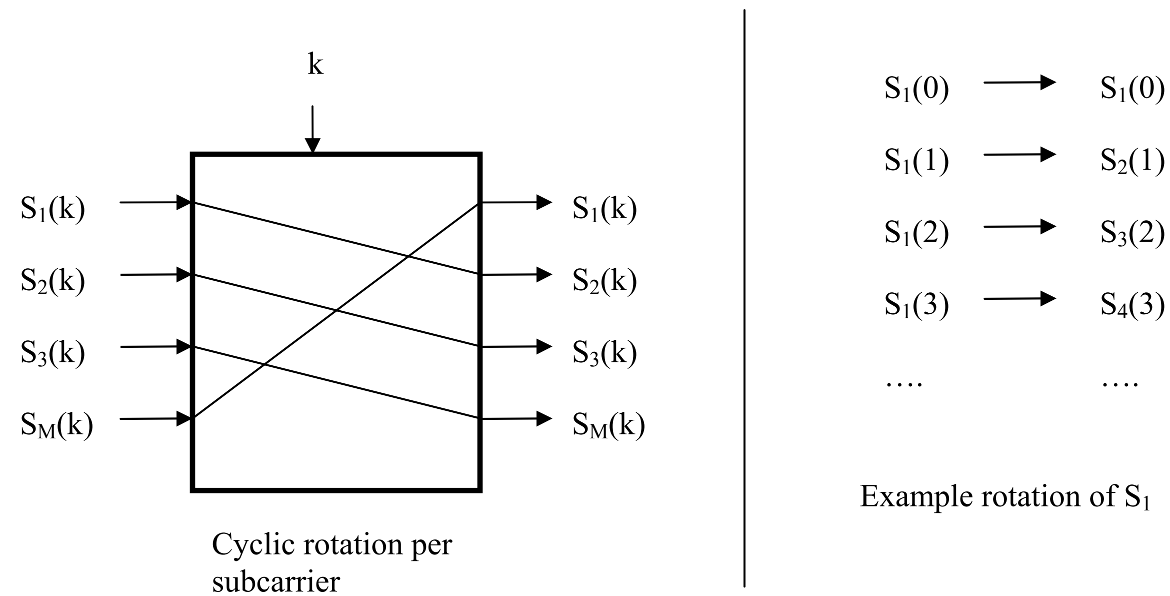

Figure 5: Per subcarrier reordering for vertical encoding

Specific Modifications to the text

Modifications will be inserted here related to section 8.4.5.3 on the DL_MAP_Basic_IE(), and including a version of the text above to fully specify the modes. The MIMO_DL_basic_IE() includes a switch to define vertical encoding mode.

Table 281 – MIMO DL basic IE format

Syntax	Size	Notes

MIMO_DL_Basic_IE() {		
Extended DIUC	4 bits	MIMO = 0x05
Length	4 bits	Length of the message in bytes (variable)
Num_Region	4 bits	
For (i=0; i < Num_Region; i++) {		
OFDMA Symbol Offset	8 bits	
Subchannel offset	6 bits	
Boosting	3 bits	
No. OFDMA Symbols	7 bits	
No. subchannels	6 bits	

Matrix_indicator	3 bits	STC matrix (see 8.4.8.1.4)
		Transmit_diversity = transmit diversity mode indicated in the latest STC_Zone_IE().
		If (Transmit_Diversity == 0b01)
		{
		000 = Matrix A
		001 = Matrix B
		010 = Matrix C
		011-111 = reserved
		}
		Elseif (Transmit_Diversity = 0b10)
		{
		000 = Matrix A
		001 = Matrix B
		010 = Matrix C
		011 = Matrix D
		101 = Matrix E
		110-111 = reserved
		}

Vertical Encoding Enabled	1 bit	1 – enable, 0 – disabled
Num_layer	2 bits	Either 1 layer, or set to the spatial rate of STC matric (00 = 1 layer, 01 = 2 layers, etc..)
For (j=0; j<=Num_layer;j++) {		

If (INC_CID == 1) {		
CID	16 bits	
}		
Layer_index	2 bits	
DIUC	4 bits	
}		
}		
}		