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Abstract		
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Time first vs. Frequency first allocations in OFDMA mode

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1. Problem Statement

In the OFDMA mode, as specified in [1], the allocation of the OFDMA slots is performed time first. Currently the scheme works as follows ([1] 8.4.3.4):

Downlink:

The downlink is composed of several data regions. A Data Region is “a two dimensional allocation of a group of contiguous subchannels, in a group of contiguous OFDMA symbols”. ([1] , 8.4.3.1). In the DL a data region is equivalent to a burst.

Within each data region the mapping is performed time first. The first slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol. Subsequent slots are mapped such the OFDMA symbol index is increased. When the edge of the Data Region is reached, continue the mapping from the lowest numbered OFDMA symbol in the next subchannel. This is illustrated in Figure 1.

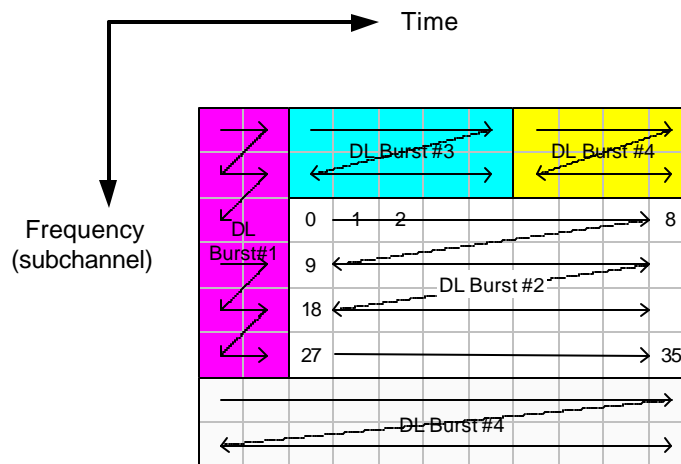


Figure 1 Mapping of DL bursts

Uplink:

The UL is composed of a single data region occupying the entire UL subframe (or the entire UL zone). Within the UL data region, slots are numbered beginning with the lowest subchannel of the first OFDMA symbols. Subsequent slots are mapped such the OFDMA symbol index is increased. When the edge of the Data Region is reached, continue the mapping from the lowest numbered OFDMA symbol in the next subchannel. A burst consists of contiguous slots. This is shown in Figure 2.

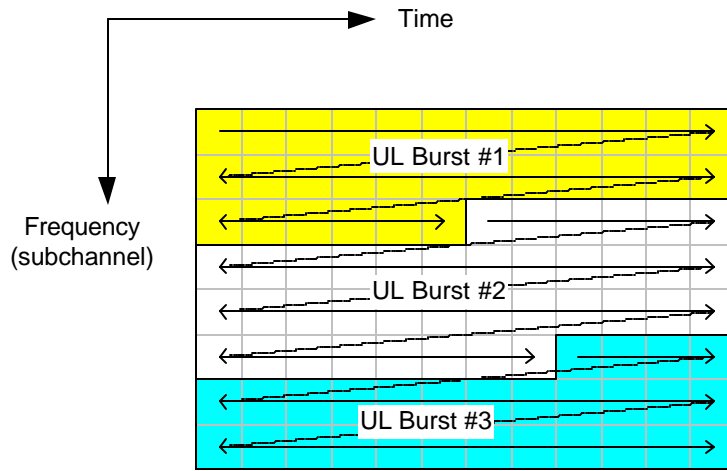


Figure 2 UL mapping

Note that a typical UL burst has the format shown in Figure 3

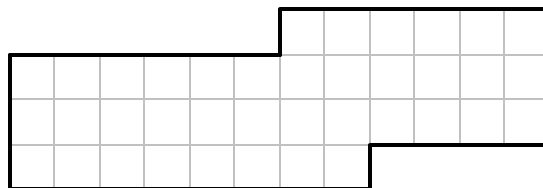


Figure 3 A typical UL burst

The motivation for such scheme is that the UL can be regarded as uni-dimensional allocation. A single parameter (burst duration) is required to describe the UL allocation. Thus, a significant reduction of the UL map size is achieved. Note that each DL allocation is still described by two parameters.

This scheme imposes significant buffering requirements. Bursts may span the entire duration of the sub-frame (In UL all bursts span the entire UL frame. In DL a burst may span the entire DL subframe). In both UL and DL a burst may span the entire bandwidth (i.e. the entire number of subchannels.)

In both cases the maximum buffer size needs to be equivalent to the entire subframe.

Let us consider the following scenario:

- 20MHz BW with maximum data rate of 71Mb/s
- 20msec frame duration
- FDD operation.

Burst buffering can be maintained in one of several stages within the encoding-decoding process. The most efficient buffering is performed by storing decoded data bits. In this case the buffer size is $20\text{msec} \times 71\text{Mb/s} = 1.42\text{Mbit}$. Memory requirements of this magnitude have a significant impact on the cost of the VLSI H/W.

One can argue that the above parameters present an extreme case. However a compliant SS must be designed to handle the above conditions.

2. Proposed solution

2.1. Downlink

In the DL it is proposed to change the mapping from time first to frequency first.

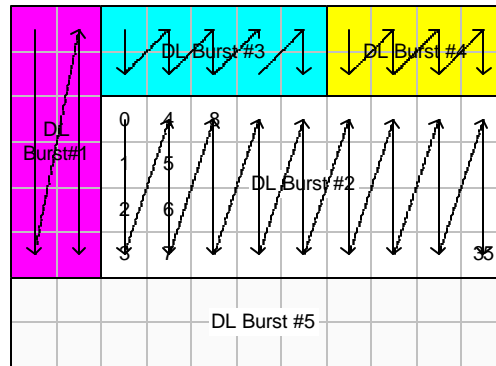


Figure 4 Proposed Mapping of DL bursts

2.2. Uplink

It is proposed to maintain the same uni-dimensional mapping structure as in figure Figure 2. However, within each allocated burst, the mapping order shall be frequency first. This is illustrated in Figure 5.

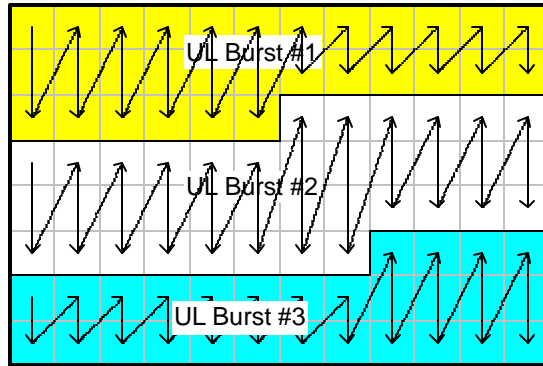


Figure 5 Proposed Mapping of UL bursts

2.3. The span of the FEC block

2.3.1. Uplink

In the UL, a FEC block shall span s slots, where s is the number of subchannels per FEC block, as defined in 8.4.9.2.

Note that a FEC block may span more than one OFDMA slot epoch (a slot epoch is time duration of slot e.g. 3 OFDMA symbols in PUSC). A FEC block boundary may not coincide with a OFDMA slot epoch. This is illustrated in Figure 6, where a QPSK rate $\frac{1}{2}$ ($j=6$) allocation of 45 subchannel \times symbols is encoded using 6 FEC block with $s=6$; one FEC block with $s=5$; and one FEC block with $s=4$. This is according to the rules of 8.4.9.2.

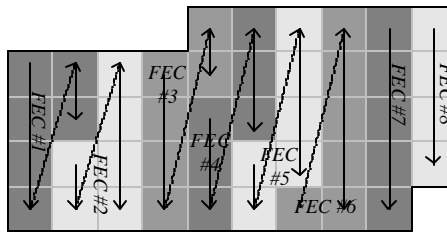


Figure 6 Example of FEC blocks in an UL burst

2.3.2. Downlink

In the DL, it is desired to prevent cases such as described above. In the DL the FEC size is constructed such that a FEC block shall always occupy a single OFDMA slot epoch.

3. Specific text changes

[1] 8.4.3.4 Page 499 Line 40

Downlink:

- 1) Segment the data into blocks sized to fit into one OFDMA slot.
- 2) Each slot shall span one or more subchannels in the subchannel axis and two OFDMA symbols in the time axis (see Figure 216). Map the slots such that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol.
- 3) Continue the mapping such that the ~~OFDMA symbol index is increased~~ Subchannel index is increased. When ~~the last subchannel is reached~~ ~~edge of the Data Region is reached~~, continue the mapping from the lowest numbered ~~subchannel~~ ~~OFDMA symbol~~ in the next OFDMA symbol ~~subchannel~~.

Uplink:

<<Replace the text with the following>>

The UL mapping consists of two steps. In the first the OFDMA slots allocated to each burst are selected. In the second steps the allocated slots are mapped.

A. Step 1 –allocate OFDMA slots to bursts

- 1) Segment the data into blocks sized to fit into one OFDMA slot.
- 2) Each slot shall span one or more subchannels in the subchannel axis and three OFDMA symbols in the time axis (see Figure 217). Order the slots such that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol.
- 3) Continue the ordering such that the OFDMA symbol index is increased. When the edge of the UL zone (which is marked with Zone_switch_IE) is reached, continue the ordering from the lowest numbered OFDMA symbol in the next available subchannel. Thus an ordered list of slots is thus created.
- 4) An UL allocation is created by selecting an integer number of contiguous slots, according to the ordering of steps 1-3. This results in the general Burst structure shown in figure XXX

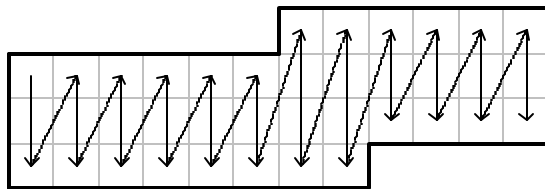


Figure 7 General structure of an UL burst

B. Step 2 – Map OFDMA slots within the allocation.

- 1) Map the slots such that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol.
- 2) Continue the mapping such that the Subchannel index is increased. When the last subchannel is reached, continue the mapping from the lowest numbered subchannel in the next OFDMA symbol. The resulting order is shown in figure XXXX.

[1] 8.4.9.2 Page 592 Line 45

Change:

n : number of allocated subchannels

To

n : For the DL, number of allocated subchannels. For the uplink, the number of slots in the allocation.

4. Reference

[1] IEEE P802.16REVd-D5.