Details on Upstream Pilots and Resource Block Configuration for EPoC

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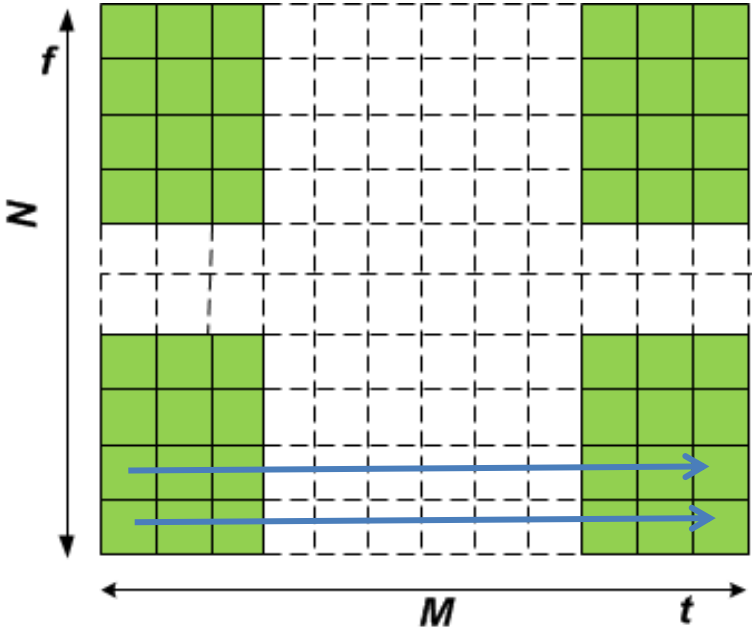
Scope

- This is a follow-up presentation on kliger_3bn_01_0313
- The intention is to
  - Reduce the number of options as was requested during the Orlando meeting
  - Provide more details on the parameterization
- For the sake of self-containedness of this presentation, also unchanged definitions and rules are repeated

Resource Block

- Resource block (RB)
  - Allocation unit comprised of N contiguous sub-carriers and M OFDMA symbols
  - N*M Resource Elements (RE)
- Each RB can only be allocated to a single CNU
- RBs are mapped to fix frequencies in the upstream channel
- One grant may include one or more RBs.



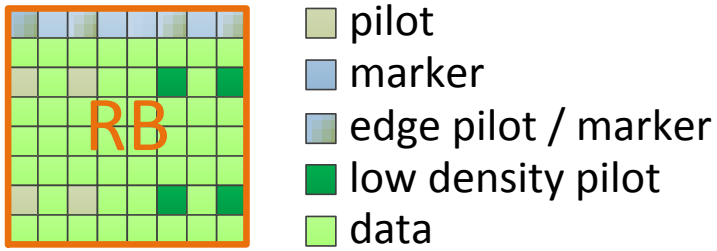
Data is written horizontally subcarrier by subcarrier to allow time interleaving of codewords

Resource Block Size Considerations

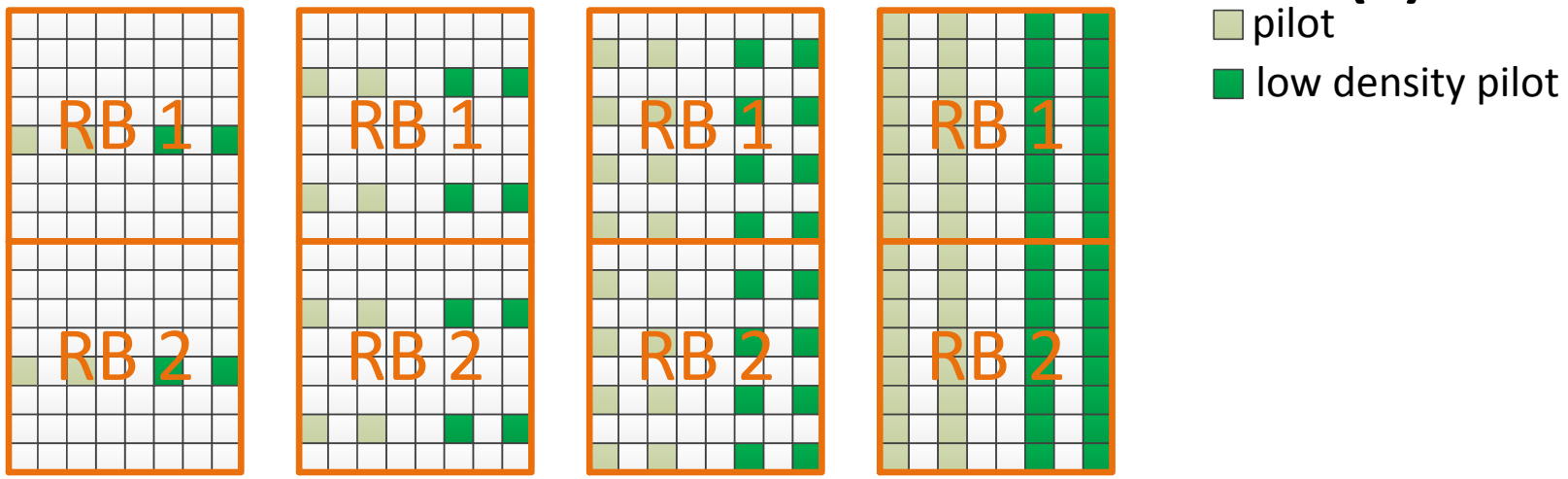
- Number of symbols (M)
  - Equals to the OFDMA Frame size which is determined by the Upstream Interleaver depth
  - Number of symbols should be configured by the CLT according to the usage of Interleaver and its size
- Number of subcarriers (N)
  - Is determined by the granularity
  - Large number of subcarriers provides better frequency tracking performance and lower pilots overhead
  - Smaller number of subcarrier has smaller granularity
- Number of pilots on pilot subcarriers
  - Large provides better tracking and channel estimation
  - Smaller provides lower overhead
  - Selection of pilots is very much dependent on the plant conditions

Resource Elements

- Resource Elements (RE)
  - A RE is the smallest time/frequency resource (one subcarrier in one OFDM symbol)
  - A RE contains a constellation symbol
  - A block of N*M REs composes a RB
- Types of REs:
  - Data REs
  - Pilot REs:
    - Known constellation symbols used for frequency acquisition and channel estimation
    - Interpolation of estimates can be used to avoid pilots on every subcarrier
  - Marker REs:
    - Used as delimiters of transmission bursts
    - Start Marker – identify the start of a burst and corresponding profile
    - End Marker – identify the end of the burst
  - Edge Pilot REs:
    - REs on edge subcarriers in a transmission burst used as pilots to avoid extrapolation
    - Typically shared with the marker REs; marker REs are know REs after marker detection.
  - Low density pilot:
    - Data symbol with modulation order that carries 4 bits less than other data REs in the RB.

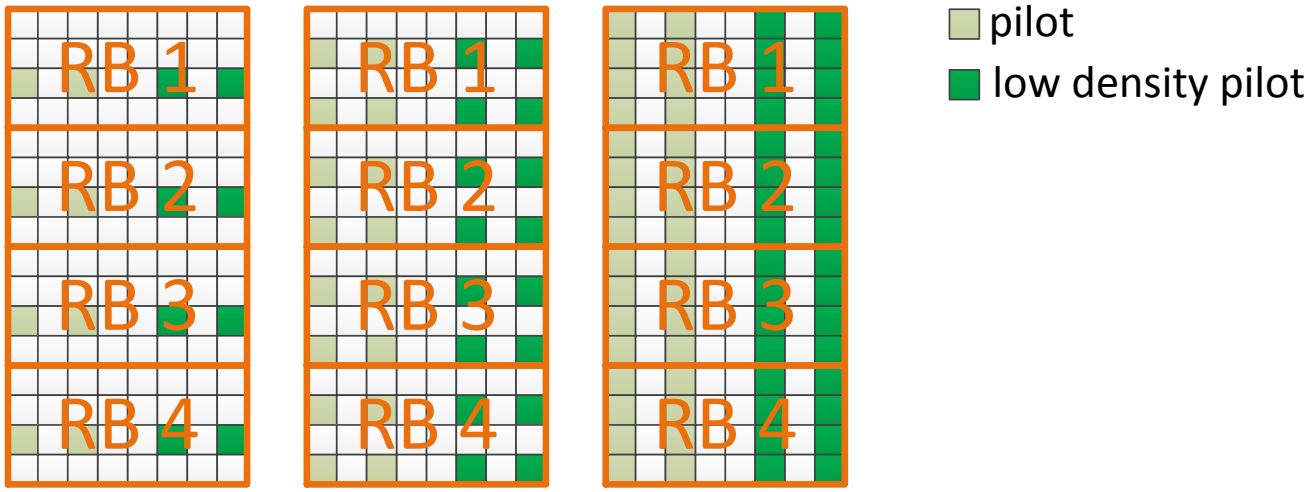


RB Size and Pilots Structure (I)



- A default RB configuration (CONF1) contains 8 subcarriers:
  - The pilot spacing can be 8, 4, 2, or 1 subcarriers
- The pilot spacing in frequency could be profile specific:
  - The choice of pilot spacing depends on pre-equalization quality and channel conditions
  - E.g. some CNUs use a pilot spacing of 8 while others use a pilot spacing of 4
- OFDM symbols in a RB where pilots and low density pilots are:
  - Symbol 1 always contains pilots
  - For M ≥ 2, symbol M contains low density pilots
  - For M ≥ 5, symbol 3 has additional pilots and symbol M-2 has additional low density pilots
- The values for M are 1 to 17 depending on interleaver depth

RB Size and Pilots Structure (II)



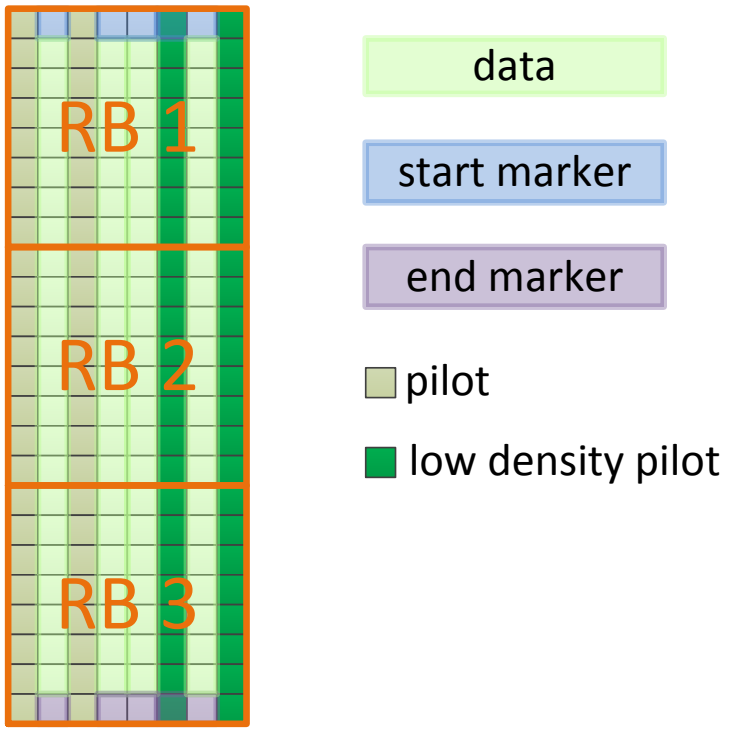
- An alternative RB configuration (CONF2) contains 4 subcarriers:
  - The pilot spacing can be 4, 2, or 1 subcarriers, but not 8 subcarriers
  - This configuration enhances granularity by making the RBs smaller
  - Suitable for plants where a pilot spacing of 8 subcarriers is not possible
- The MSO decides which RB configuration is suited for their plant
  - Tradeoff between RB granularity, pilot spacing, and pilot overhead
  - Example 1: If M = 4 (interleaving across 4 OFDM symbols), an RB with N = 8 is favorable
  - Example 2: If M = 17 (need for long time interleaver), an RB with N = 4 is favorable

RB size and Pilot Spacing (III)

- Configurable number of OFDM symbols
  - {1 to 17} with 20 uSec symbols
    - 17 corresponds to 400 uSec interleaver depth
  - {1 to 9} with 40 uSec symbols
    - 9 corresponds to 400 uSec interleaver depth
- Configurable number of subcarriers per RB: {4, 8}
- Configurable pilots spacing in frequency (Ps): {1,2,4,8}
- Still open for discussion:
  - Is the RB size configured for the entire plant, or could it be profile specific? Probably, it is favorable to have one RB size per plant.
  - Do we need the special case M = 1? Could probably be removed.

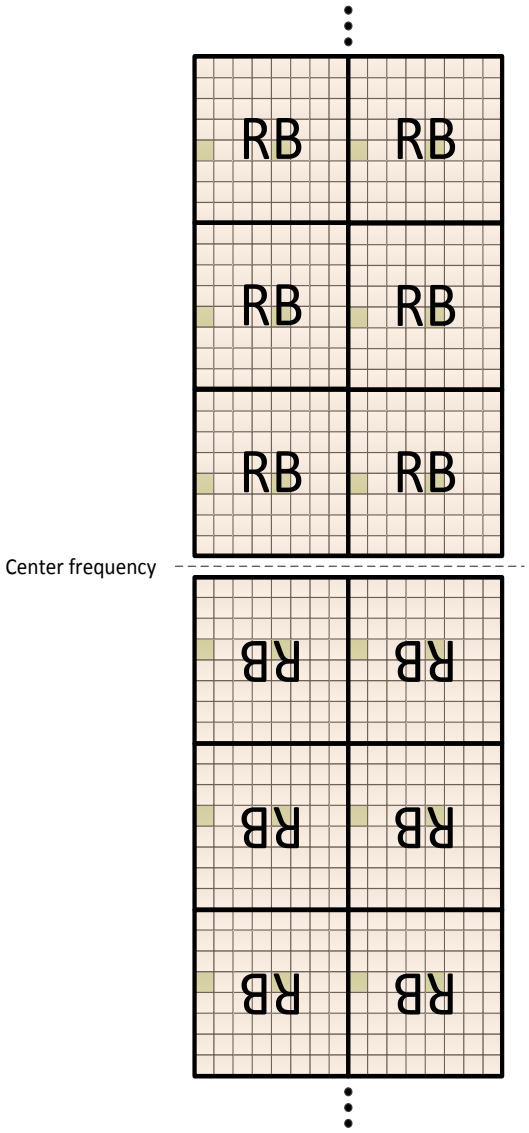
Burst Markers

- Start and End Markers indicate the boundaries and profile of a transmission burst
- The markers are detected incoherently, without prior knowledge of the transmission profile
- Number of profile is TBD
- Markers are contained in the first and last RB and do not overwrite pilots
- Marker structure and number of marker REs is TBD



RB Placement For TDD Top split

- RBs are placed symmetrically around the center frequency:
  One RB covers subcarriers ±Nn+1 to ±N(n+1) where n is the RB index counted from the center frequency



EPoC Upstream Pilots

THANK YOU

Update on EPoC Upstream Pilots

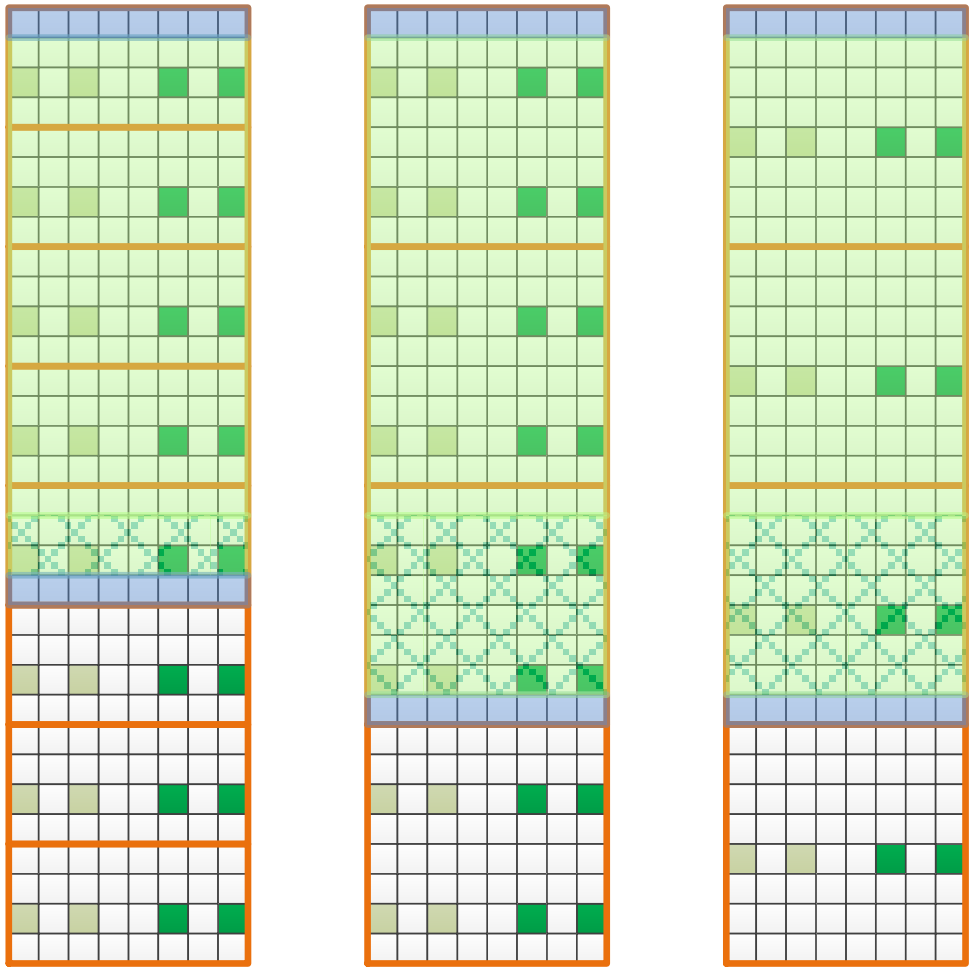
BACKUP

Granularity and RB Size

SC per RB: 4
Ps: 4

SC per RB: 8
Ps: 4

SC per RB: 8
Ps: 8



data

overhead

marker

pilot

low density pilot

- For a pilot spacing of 8 SCs the finest granularity is 8 SCs per RB.
- A pilot spacing of 4 SCs allows for RBs of 4 and 8 SCs.
- A lower pilot spacing is favorable over smaller RB size.
- The figure here shows the required resources for an example set of data that requires 112 REs for the data