Upstream Resource Block Structuring in EPoC

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Definitions of terms used in this presentation

- "In active" sub-carriers are the null sub-carriers which are common to all profiles.
- All other sub-carriers (with the exception of exclusion zones) are "Active" sub-carriers.

Issues with a resource block with fixed number of Contiguous sub-carriers.

- A resource block with fixed number of sub-carriers (which include both active and/or inactive sub-carriers), has following issue:

  - The capacity of resource blocks fluctuates between 0% (all in-active sub-carriers) to 100% (all active sub-carriers with highest order modulation).

- A resource block with fixed number of only active contiguous sub-carriers has the following issue:

  - A large number of active sub-carriers will not be part of any resource block, and will be left out, wasting bandwidth (see Figure-1).

# Figure:1 Resource block with fixed number of contiguous active sub-carriers
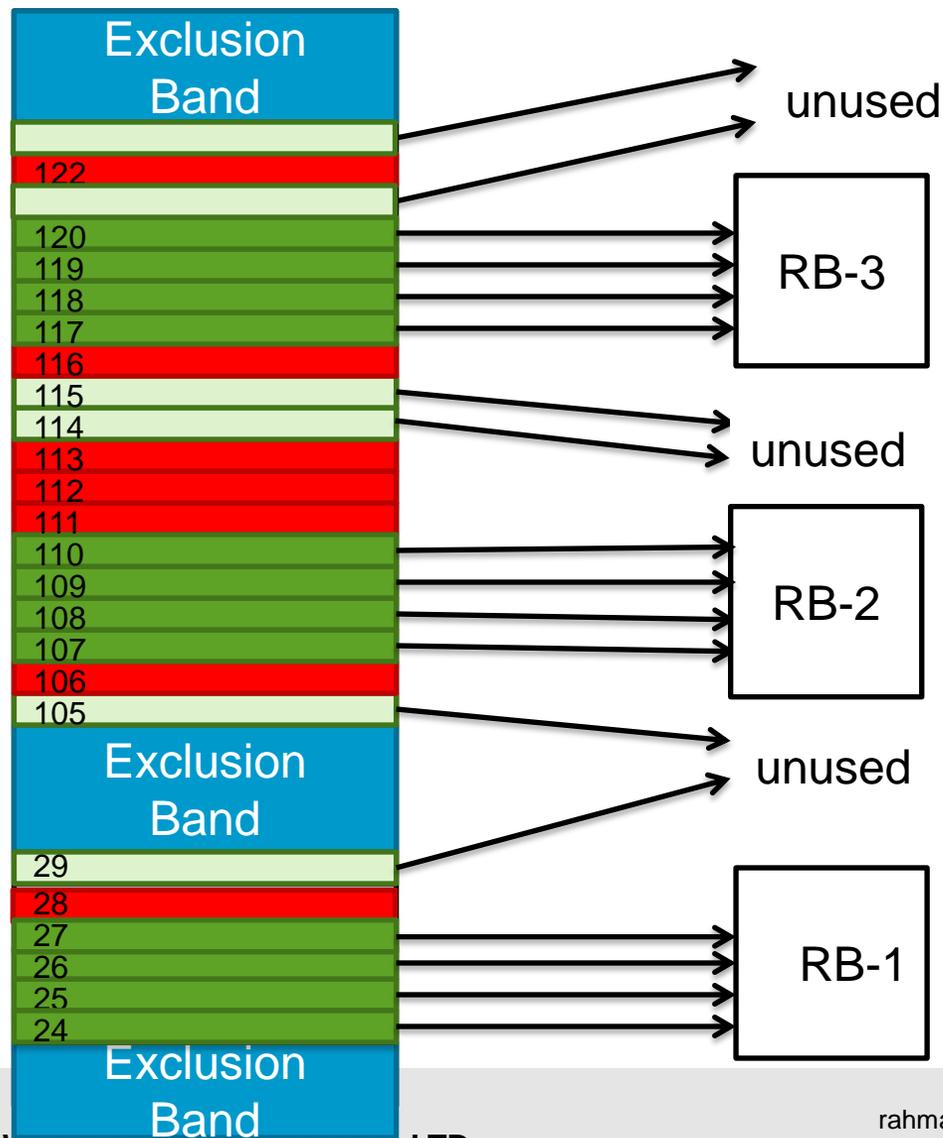
- Each RB has N active sub-carriers and no in-active sub-carrier.
- Sub-carriers that do not fit into a RB are unused
- N=4 in this example.

Active sub-carrier
In active sub-carrier
Active but unusable sub-carrier

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Simulation to show percentage of wasted capacity for the case of a resource block with fixed number of contiguous active sub-carriers

- Example of 4K FFT

- Number of active sub-carriers = 3700

- Number of In active sub-carriers = 100

- In active sub-carriers are contiguous in groups of size 1,2,4.

- Rest of the sub-carriers are inside the exclusion zones.

- Resource blocks are formed using 4/8 /16 contiguous active sub-carriers.

- 1000 iterations. For each iteration the locations of the Inactive sub-carrier groups are chosen randomly.

- Left out active sub-carriers are the active sub-carriers which could not become part of any of the resource blocks.

- Capacity loss % = 100* (Number of left out Active sub-carriers)/(Total number of active sub-carriers).

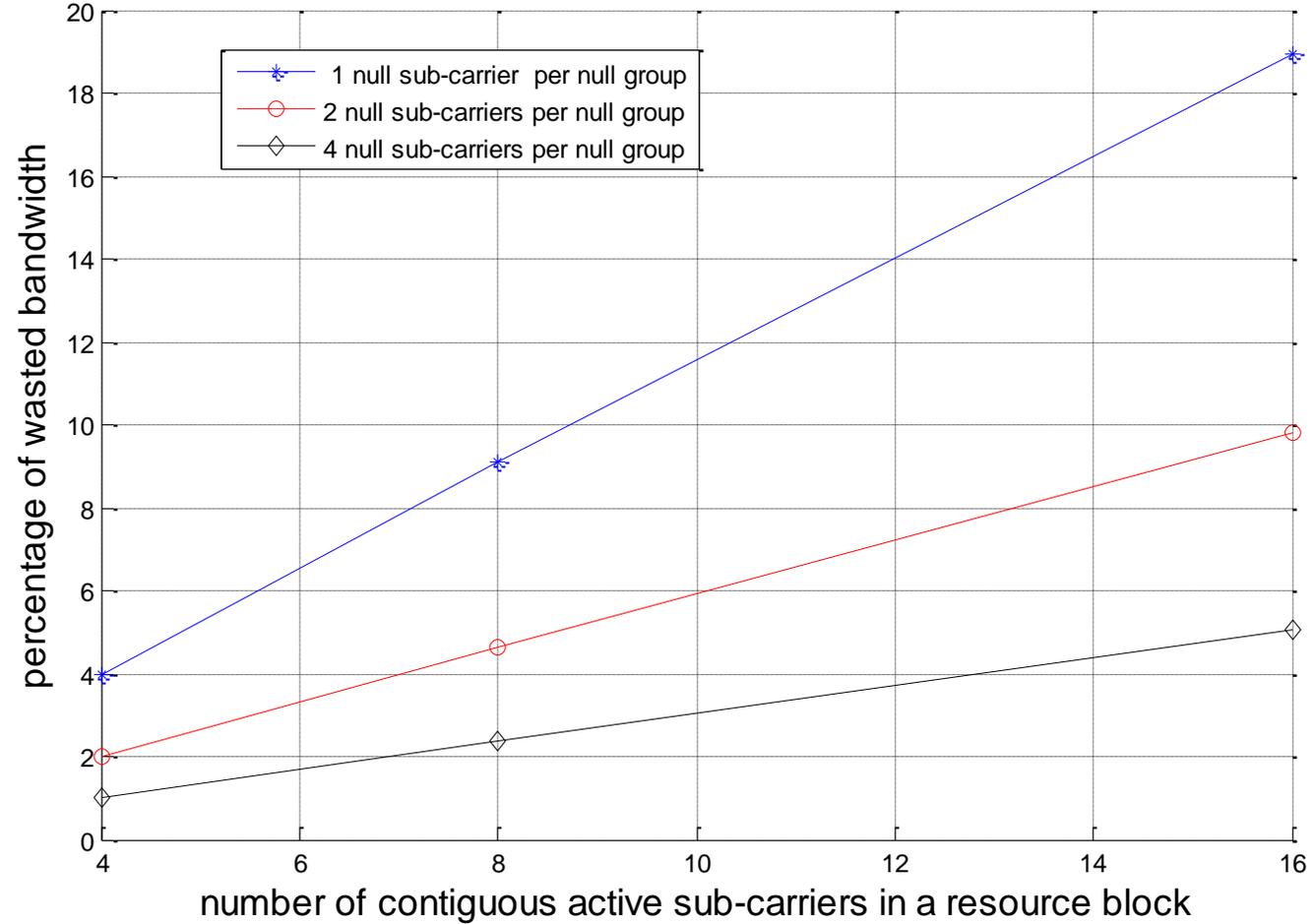# Plot:1 Resource block length of 8 contiguous active sub-carriers.

percentage of wasted capacity
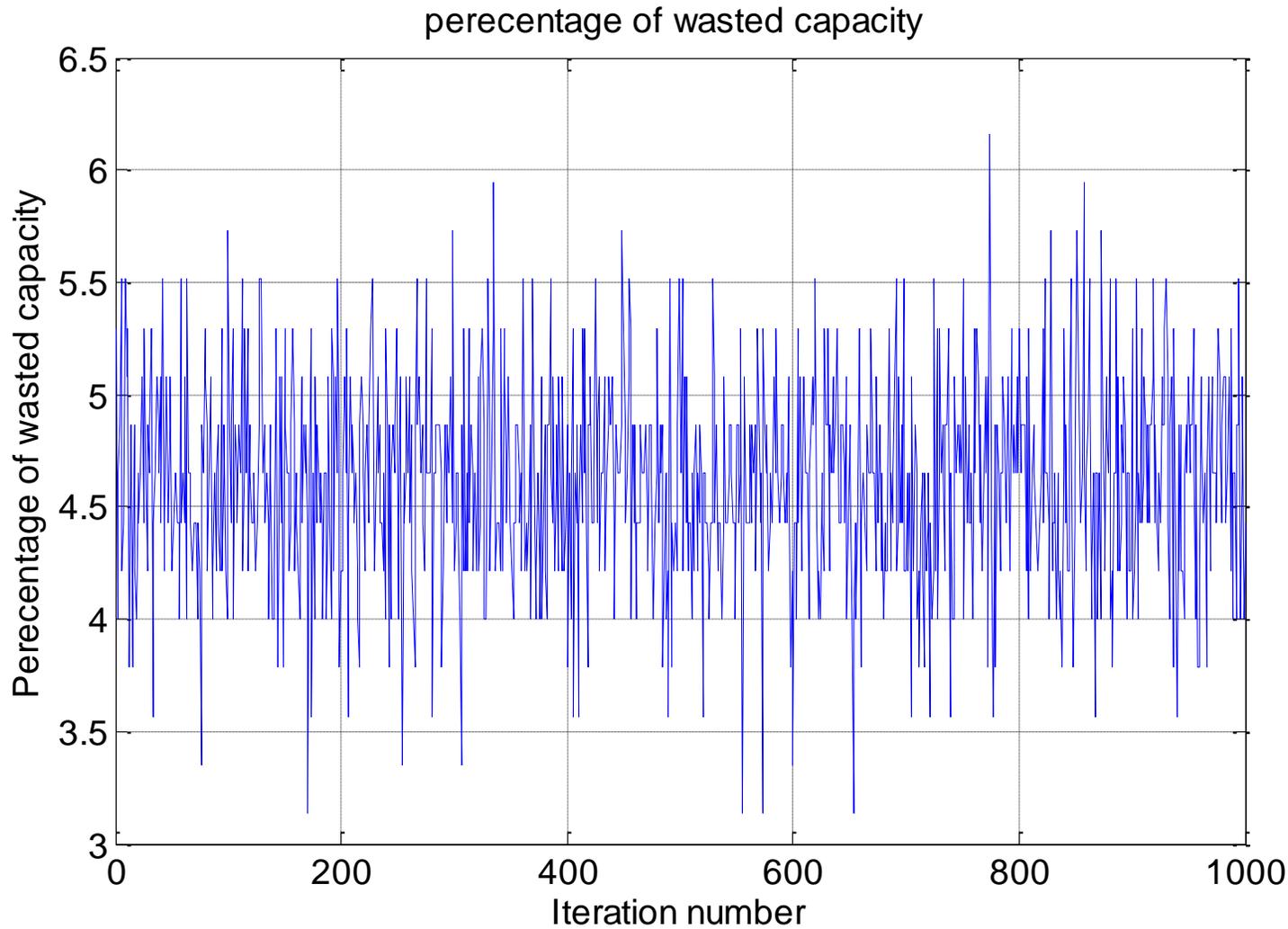
In active sub-carriers are contiguous
In groups of two sub-carriers each.

# Plot:2 Wasted bandwidth as a function of RB length.

percentage of wasted bandwidth versus number of active sub-carriers in a resource block

Proposed Resource block structure

- A resource block shall consist of 'N' "active" sub-carriers.

- The 'N' sub-carriers may be contiguous and or non-contiguous.

- There are no "in-active" sub-carriers within a resource block.

Figure:2   Proposed Resource block structure

Each RB has N active sub-carriers And no in-active sub-carrier.
The last RB may have less than N Active sub-carriers.
N=4 in this example.
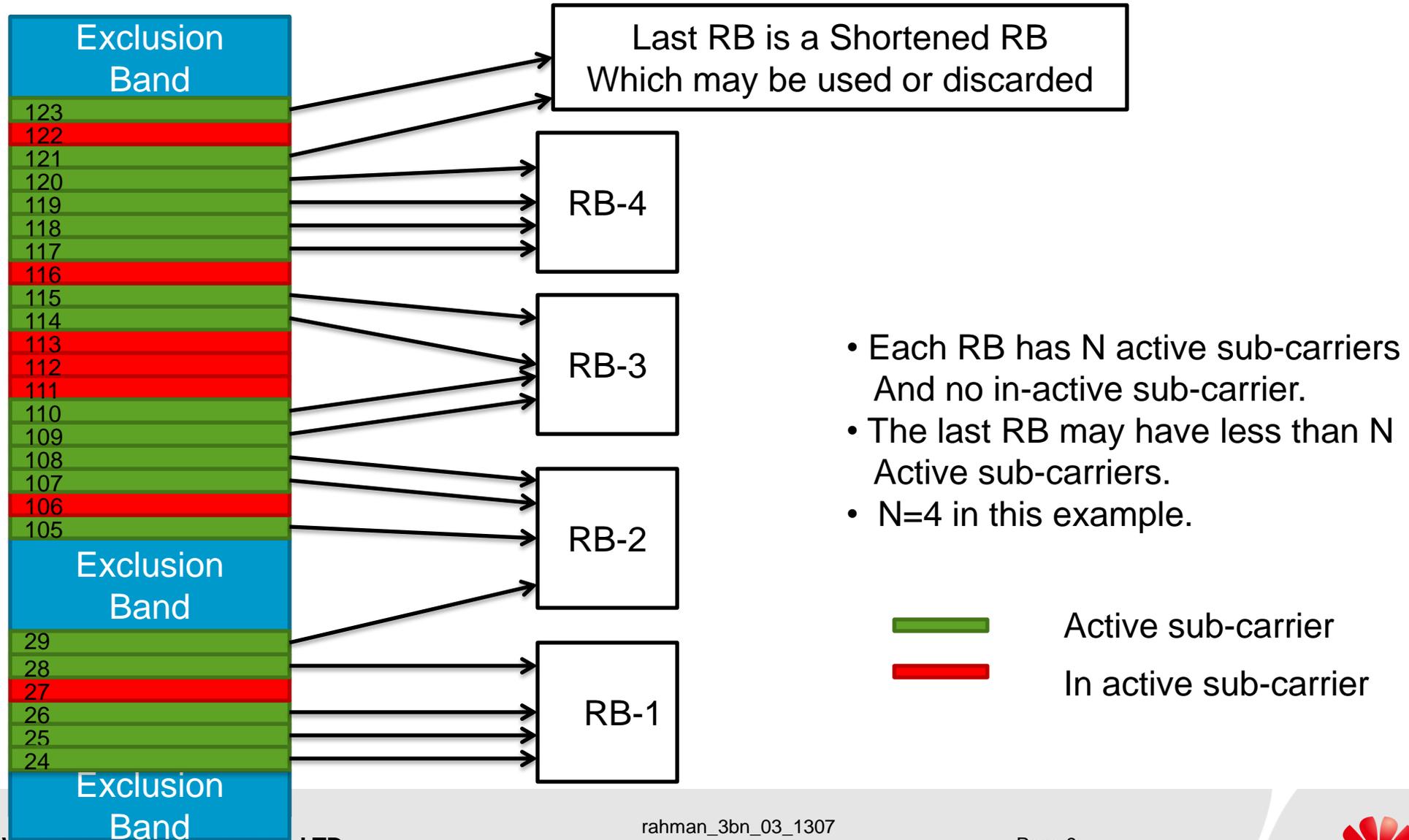
Additional pilots for Null bands

- Both exclusion bands and the contiguous inactive sub-carriers, create Null bands (frequency jumps) inside a resource block.

- The presence of Null bands   creates issues in the interpolation due to increased pilot spacing.

- To assist interpolation, additional pilots can be added in these resource blocks as shown in figure-3

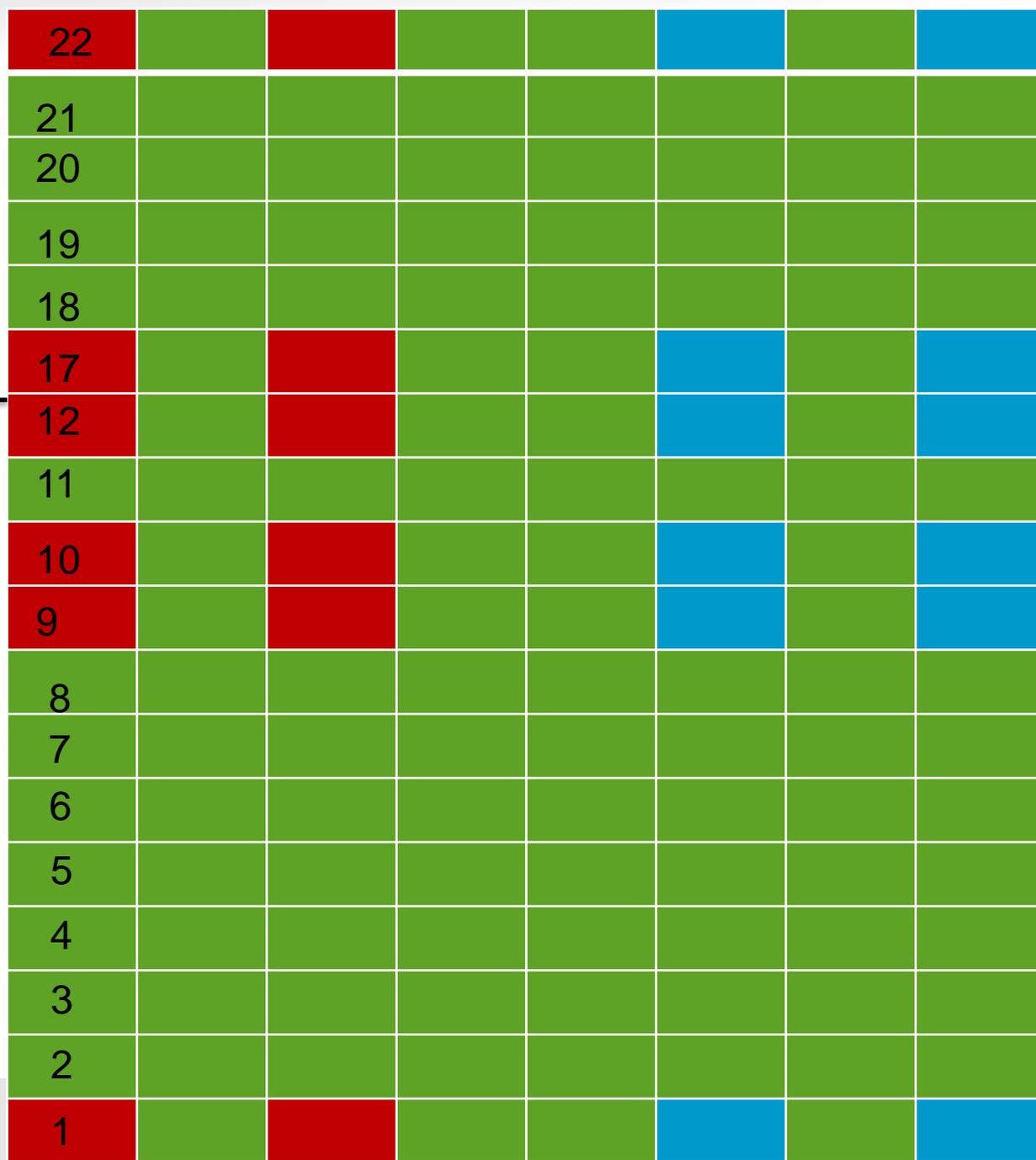- For 25 Null bands the overhead of the additional pilots is 0.4% (see Appendix-1).

Figure:3

Null band size In number of sub-carriers	Resource block size In number of sub-carriers	% of Capacity Loss for RBs with contiguous number of sub-carriers	% of capacity loss for proposed method
1	4	4 %	0.002 %
1	8	9.18 %	0.002 %
1	16	18.87 %	0.002 %
2	4	2 %	0.4 %
2	8	4.65 %	0.4 %
2	16	9.82 %	0.4 %
4	4	1 %	0.4 %
4	8	2.36 %	0.4 %
4	16	5.04 %	0.4 %

Advantages of Proposed Resource Block structure

- Very low (0.4%) loss of capacity (due to additional pilots)
- But the additional pilots make the system more robust. Better channel estimation accuracy, more immunity to impairments.

Thank you

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Appendix-1 Overhead of additional pilots for Null bands

- Assume Number of Null bands =25. (Each band has multiple sub-carriers).

- For each null band, there are 4 additional regular pilots and 4 additional complementary pilots.

- For simplicity of analysis, assume the 4 additional complementary pilots amount to loss of 2 resource elements in terms of capacity.

- Thus the additional pilots for each null band results in loss of 6 resource elements.

- For 25 Null bands, 150 resource elements are lost (in terms of capacity).

- Total number of resource elements in a frame = (Number of active sub carriers)* (Number of symbols in frame) = 3700*10 = 3700.

- Capacity loss due to additional pilots = 150/3700 = 0.4%