Upstream resource block structure

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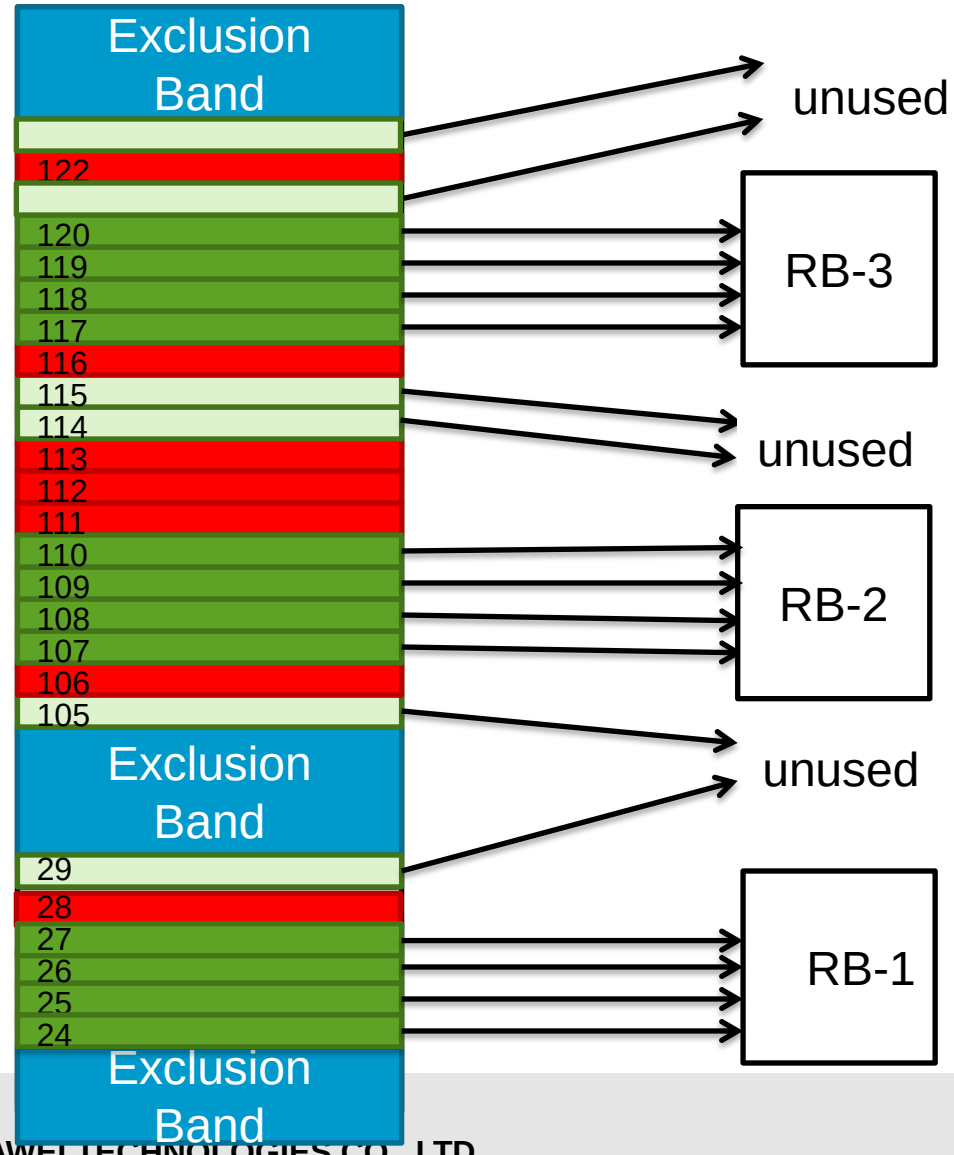
Definitions of terms used in this presentation

- “In active” sub-carriers are the null sub-carriers which are common to all profiles. Example sub-carriers effected by CTBs and CSBs.
- All other sub-carriers (with the exception of exclusion zones) are “Active” sub-carriers.

Issues with a resource block of fixed number of 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.
- Carriers that do not fit into a RB are unused
- The last RB may have less than N active sub-carriers.
- N=4 in this example.

Active sub-carrier

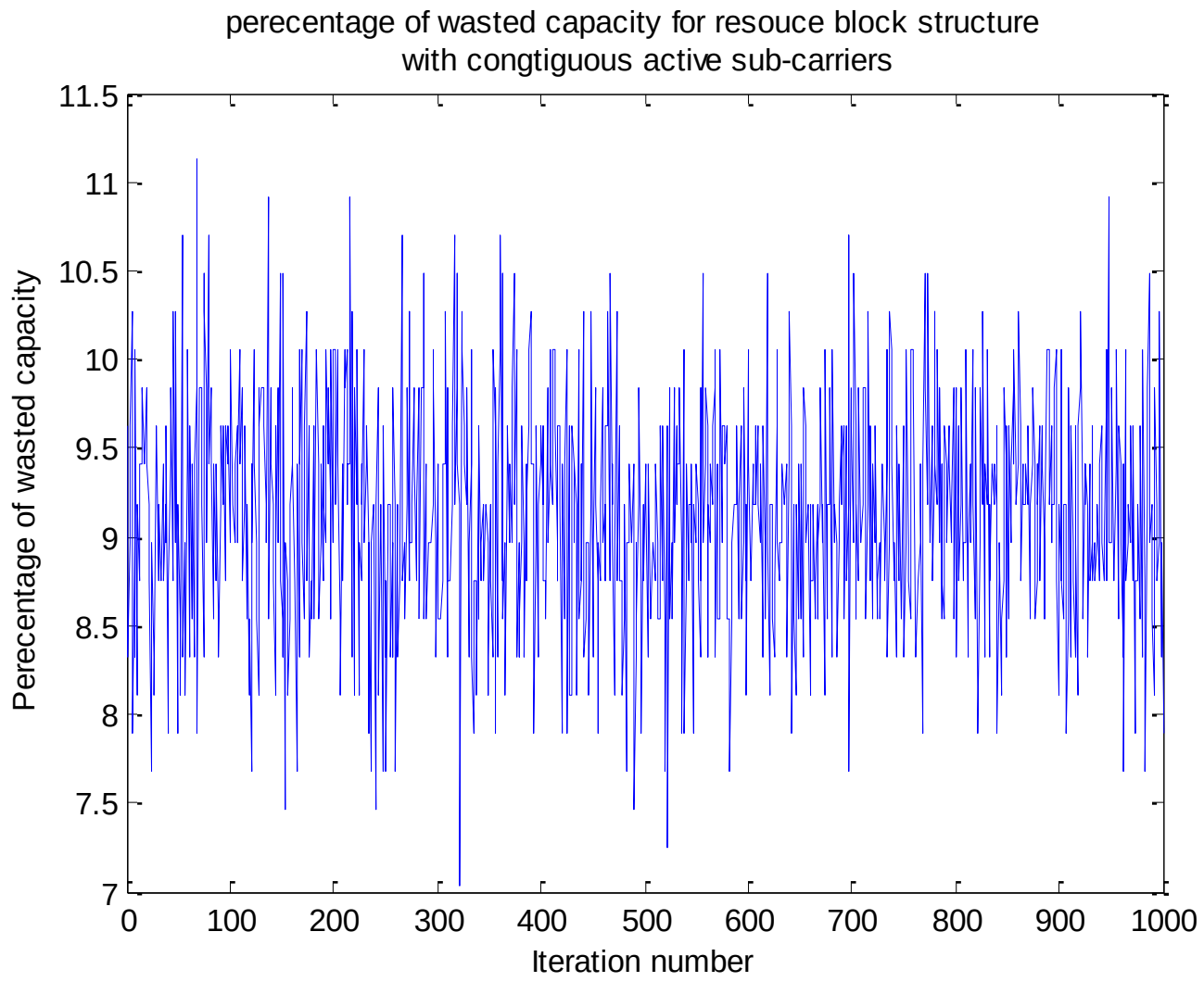
In active sub-carrier

Active but unusable sub-carrier

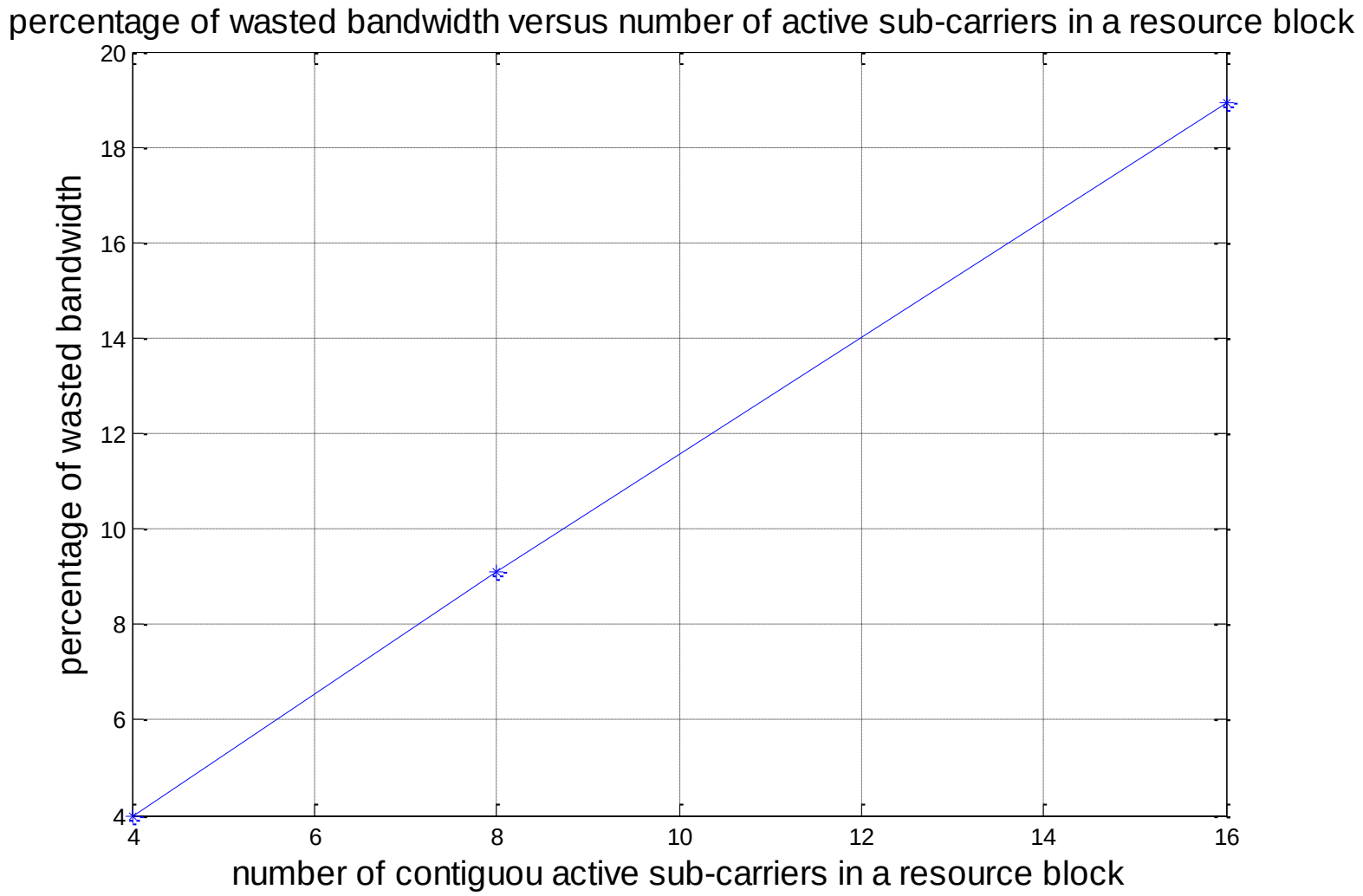
Simulation to show percentage of wasted capacity for the case of a resource block with fixed number of contiguous active sub-carriers

- Example of 4K FFT
- Number of active sub-carriers = 3700
- Number of In active sub-carriers = 100
- 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-carriers 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



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



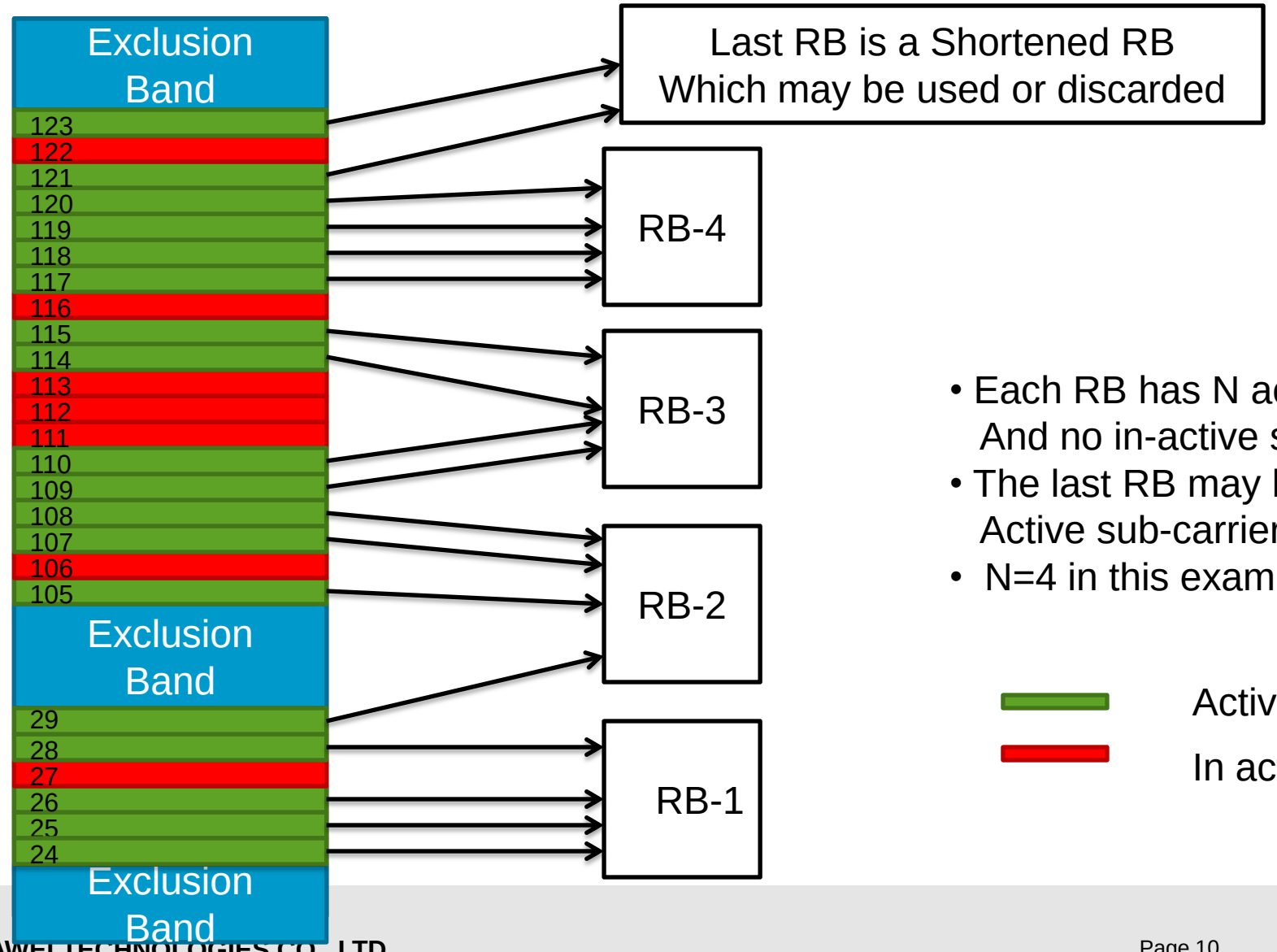
Proposed Upstream Resource block structure

- Objective: To define resource block structure to:
  - Utilize almost all “active” sub-carriers with minimum loss of bandwidth.
  - Facilitate tone re-ordering in achieving near constant capacity per resource block.

Proposed Resource block structure

- A resource block shall consists of ‘N’ number of only “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.

Active sub-carrier

In active sub-carrier

Additional pilots for exclusion bands

- A large number of contiguous sub-carriers (that are part of an exclusion band) will be absent in some resource blocks.
- This creates issues in the interpolation.
- To assist interpolation, additional pilots can be added in these resource blocks as shown in figure-3
- For 10 exclusion bands the overhead of the additional pilots is 0.21% (see Appendix-1)
- An alternate option is to form resource block such that, the exclusion bands fall in between the resource blocks. (i.e outside the resource blocks). For this option the overhead is 0.4/0.9/1.8 % for resource block size of 4/8/16 sub-carriers

Figure:3

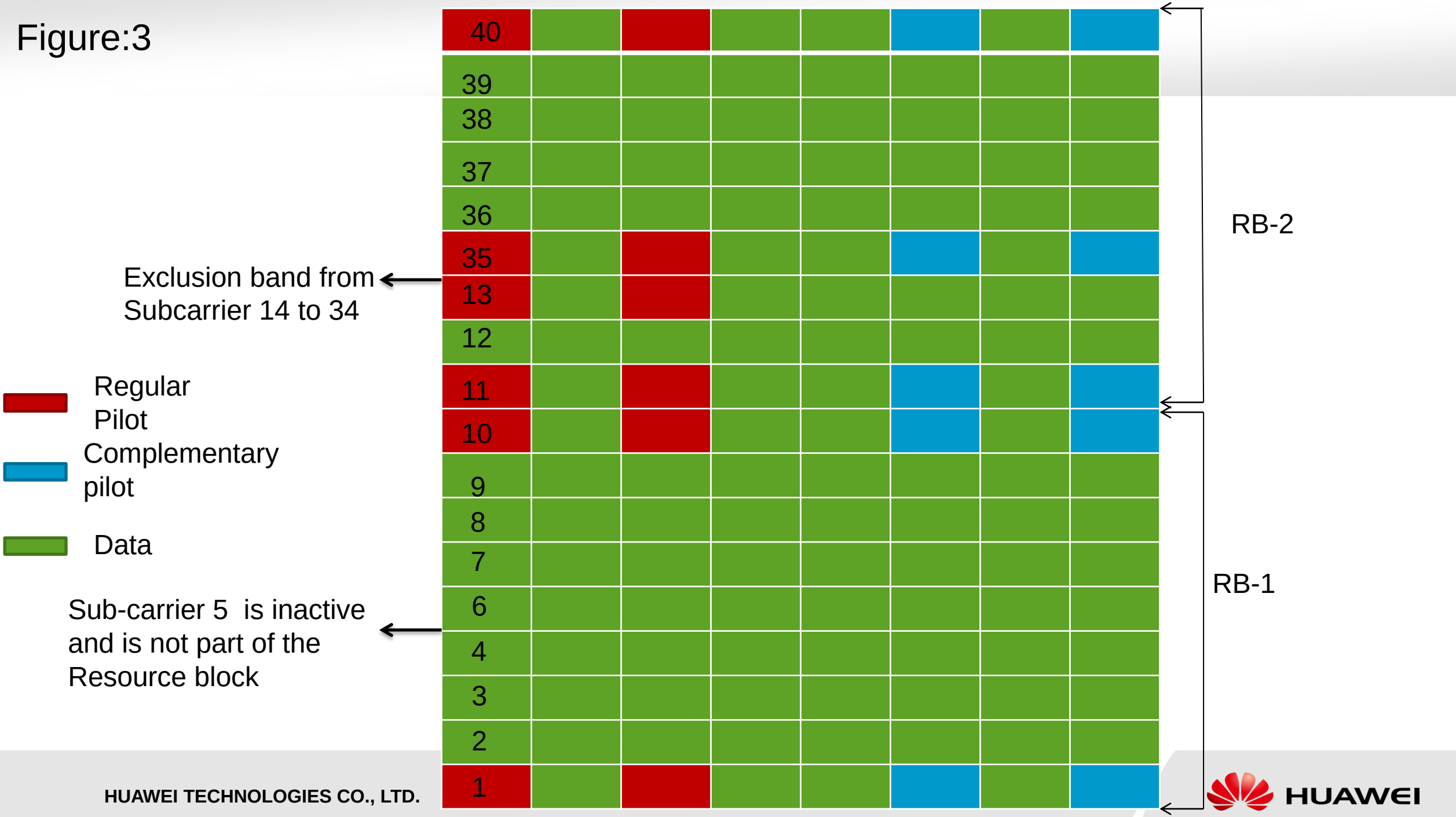
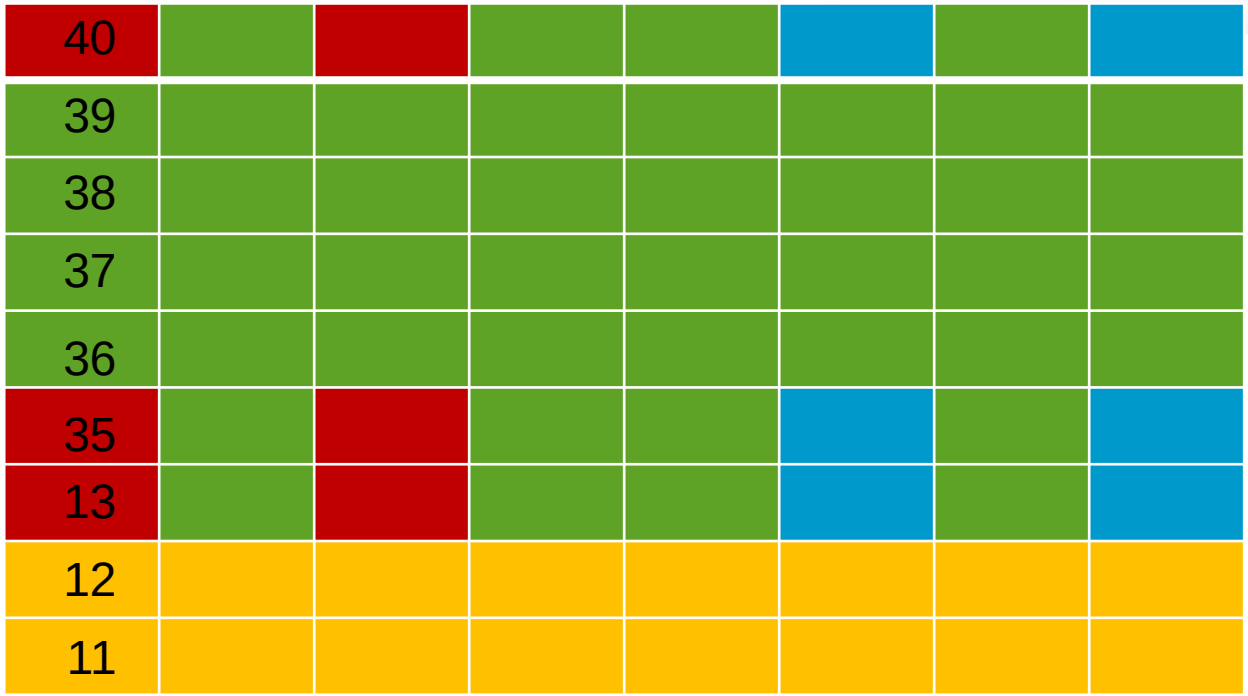

40
39
38
37
36
35
13
12
11
10
9
8
7
6
4
3
2
1
RB-2
RB-1
Exclusion band from
Subcarrier 14 to 34
Regular
Pilot
Complementary
pilot
Data
Sub-carrier 5 is inactive
and is not part of the
Resource block

Figure:4



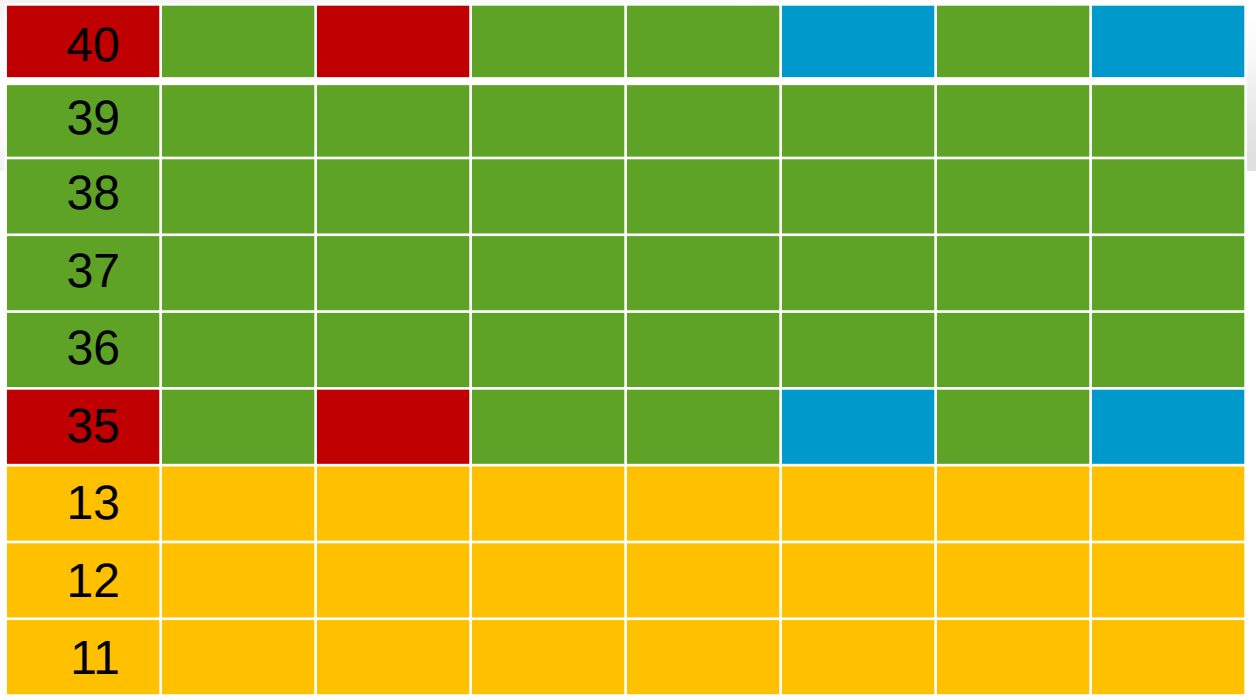
Regular Pilot

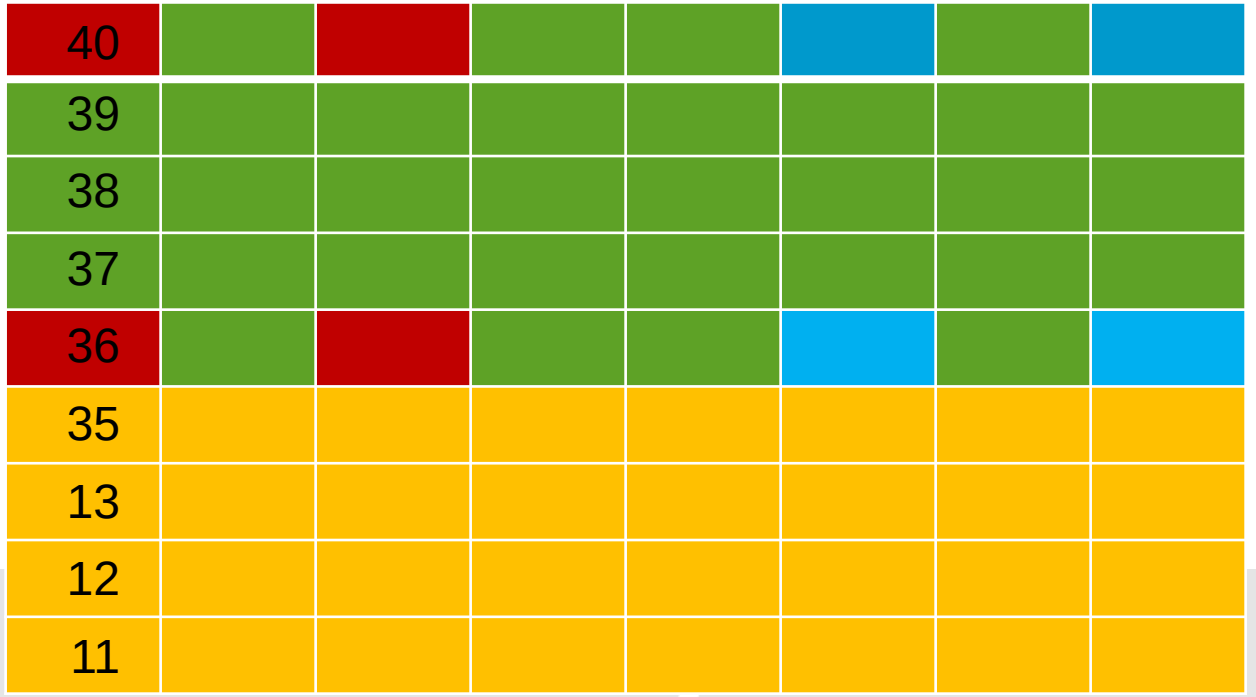
Complementary Pilot

Data

Burst Marker

Exclusion band from
Subcarrier 14 to 34





Conclusion

- Using a resource block structure with fixed number of contiguous active sub-carriers will result in a huge loss of bandwidth. Approximately 4/9/19 % bandwidth loss for the resource block lengths of 4/8/16 contiguous active sub-carriers.
- The proposed resource block structure utilizes almost all of the active sub-carriers, with essentially no loss of bandwidth (approximately 0.02% loss).
- The proposed definition facilitates tone re-ordering in achieving near constant capacity per resource block.
- The same resource block structure can be applied to scattered sub-carriers for tone re-ordering.

Thank you

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Appendex-1 Overhead of additional pilots for exclusion bands

- Assume Number of exclusion bands =10
- For each exclusion band, there are 4 additional regular pilots and 4 additional complementary pilots.
- For simplicity of analysis, assume complete loss of capacity, even for complementary pilots. (In reality complementary pilots has only a partial loss of capacity).
- Thus the additional pilots for each exclusion band results in loss of 8 resource elements.
- For 10 exclusion bands, 80 resource elements are lost.
- Total number of resource elements in a frame = (Number of active sub carriers)* (Number of symbols in frame) = 3800*10 = 38000.
- Capacity loss due to additional pilots = 80/38000 = 0.21%