3GPP TSG-RAN WG4 RAN#84

Berlin, Germany, August 21st-25th, 2017

R4-1708841

Channel Raster and Sync Raster for NR

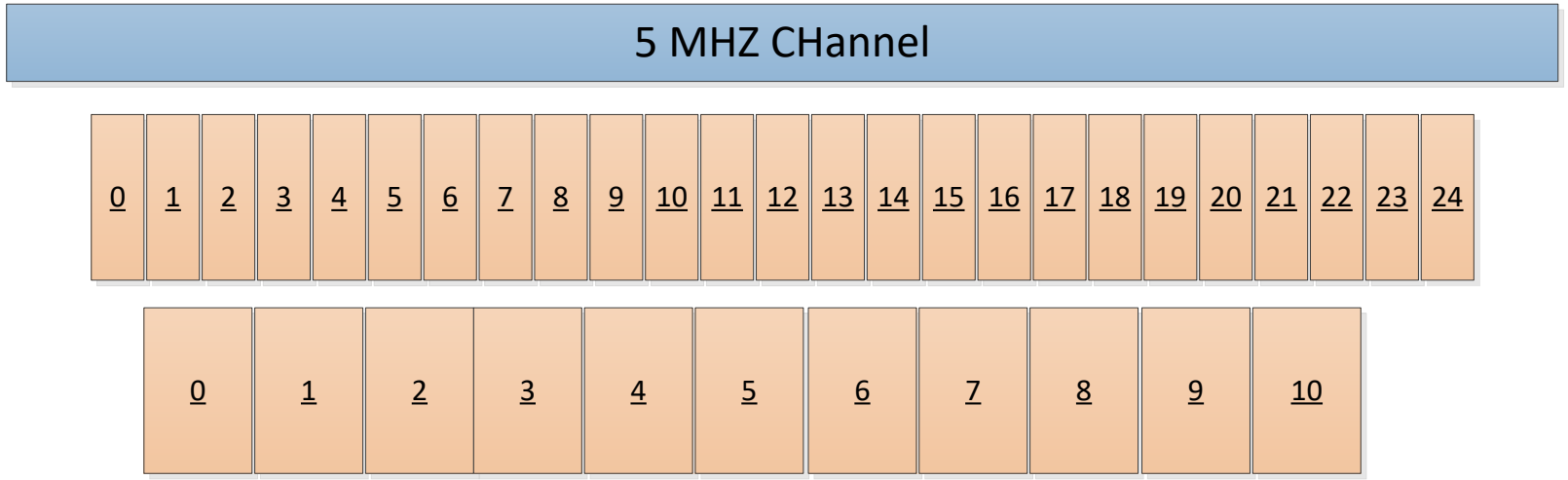
QUALCOMM®

100kHz raster

- Perceived advantage of symmetric guardband
  - This advantage is valid only for lowest numerology, guardband becomes asymmetric for higher numerologies because of RAN1 agreement on subcarrier alignment. This is explained in R4-1708606, see also next slide
- Leads to more sync raster entries compared to RB based raster
  - Up to 9x(18x for 30kHz SCS)
  - Up to only 3x with “floating sync”, see slide 11 for explanation on this
- Creates problems with CA and forward compatibility when adding new channel bandwidths, see next slide
  - This is explained in detail in R4-1707366
- 100kHz raster creates many forward compatibility problems, should not be used at least in bands where CA and addition of new channels is likely to happen
  - Preferably there should be a unified design covering all bands

Guardband becomes asymmetric for higher order SCS

- Picture below show an example with placement of RBs based on RAN1 agreement that subcarrier 0 of an RB of a higher numerology has to be aligned with subcarrier 0 of an RB of a lower numerology
  - 15kHz and 30kHz SCS shown based on agreed spectral utilization numbers
- Depending on the number of RBs(even number of multiple of 4) this happens for different numerologies



100kHz raster and addition of new channel bandwdiths

- Examples in Figures show 2x100MHz CA and a 200MHz channel that could be defined in a future release
- If wideband CC, CC1 and CC2 are only subcarrier aligned(like intra-band contiguous CA in LTE), the wideband CC will have a “hole” somewhere around the center
  - This is shown in Figure 2 as the black block where some REs will not be used
  - Ugly design that leads to many complications in baseband design and drop in preformance
- CCs have to be RB aligned as in Figure 1
  - The raster of all CCs has to be on multiples of RB size and 100kHz -> 1.8MHz for 30kHz SCS
- It will be impossible to achieve full spectral utilization based on the tentative numbers agreed now
- Example in Figure 2, the 200MHz CC will violate the SEM because it cannot be placed in the middle of the spectrum allocation
  - If 200MHz CC is placed in the middle of the channel, CC1 and CC2 will have to overlap

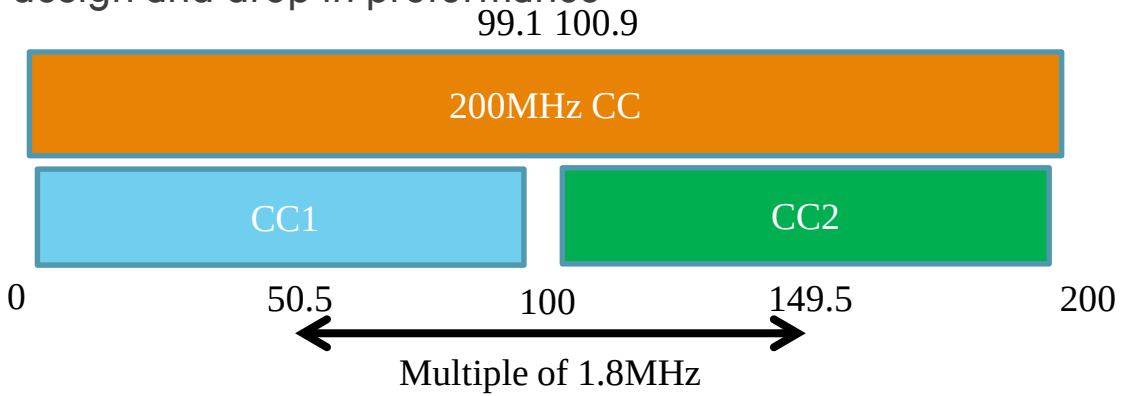


Figure 1 Wideband and CA operation with 100kHz raster and RB alignment

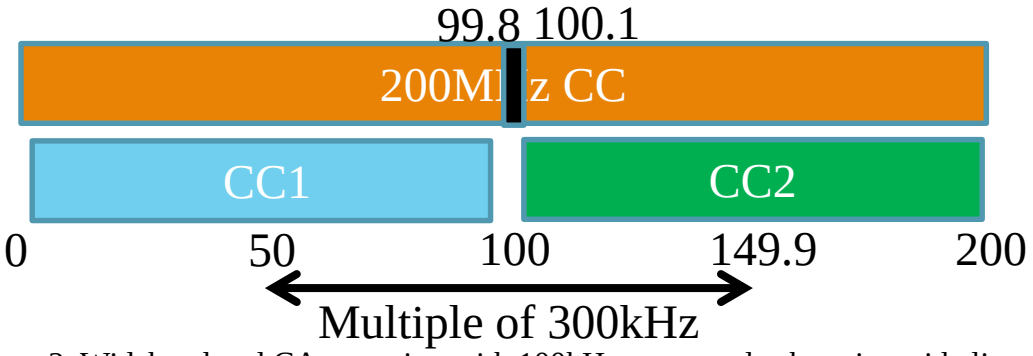


Figure 2. Wideband and CA operation with 100kHz raster and subcarrier grid alignment

RB based raster

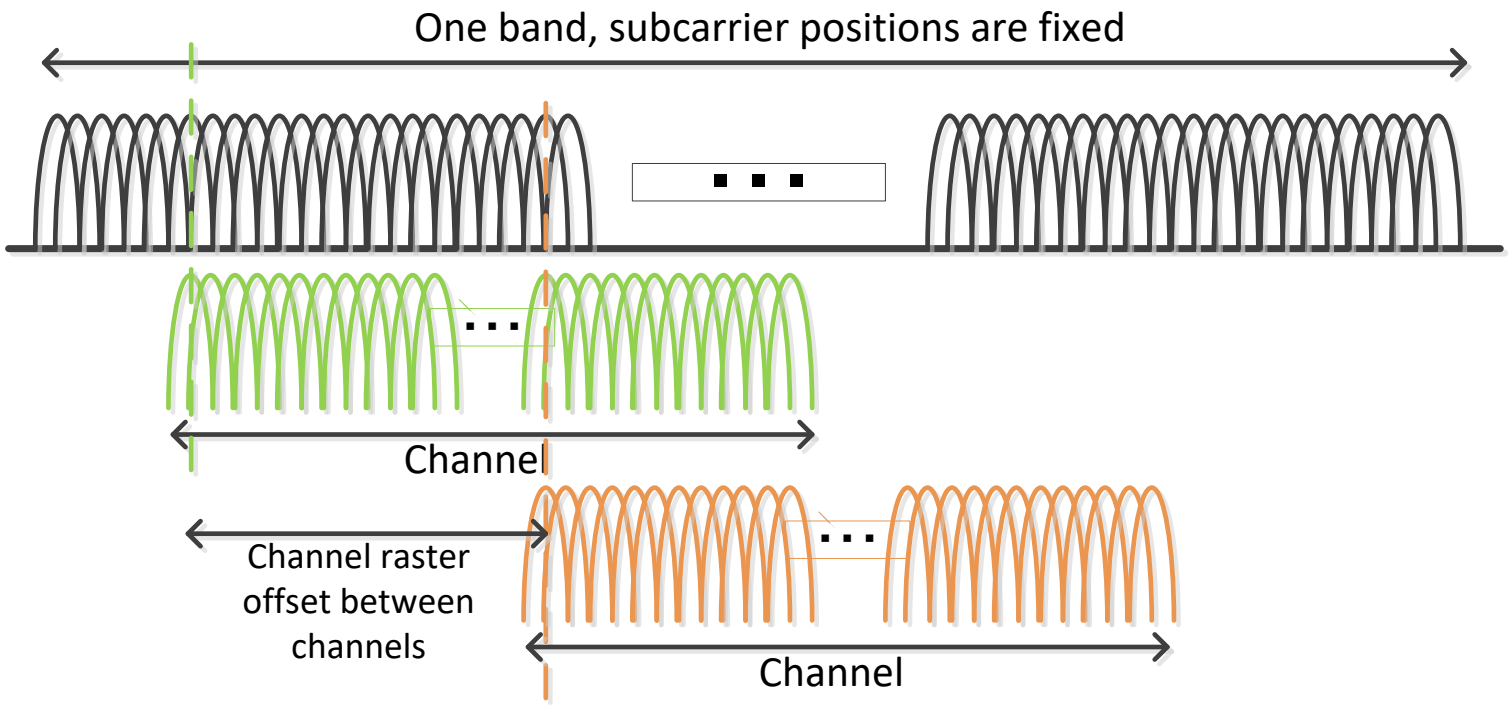
- RB based raster leads to 1RB less spectral utilization in many channels
  - Asymmetric guardband and large granularity (180kHz) lead to this problem pointed out in previous meetings
- RB based raster enables simple operation of contiguous CA(0 guardband) and addition of new channel bandwidths because all channels in a band are RB aligned

Subcarrier Based Raster

- RB based raster has spectral utilization disadvantage because of large granularity (180kHz)
- Subcarrier based raster is an enhancement to RB based raster to reduce granularity
  - Granularity becomes 15kHz(or 60kHz for mmWave) instead of 180kHz(or 720 for mmWave)
  - Current analysis for spectral utilization can be reused, 7.5kHz(maximum deviation from the channel center) should not make a difference
- How it works?
  - Placement of subcarriers in a band is fixed from the start (this is similar to the RB based raster)
  - A channel can be placed anywhere in the band on this raster
    - All CCs in a band will be on the same subcarrier raster – all CCs are subcarrier grid aligned
    - Channel raster granularity is same as SCS
  - Different channels can be placed on the same RB grid (can be RB grid aligned) if the distance between the channel rasters is multiple of 12 subcarriers (1 RB)
    - Enables 0 guardband operation and addition of new channel bandwidth
  - See next slide for an intuitive understanding

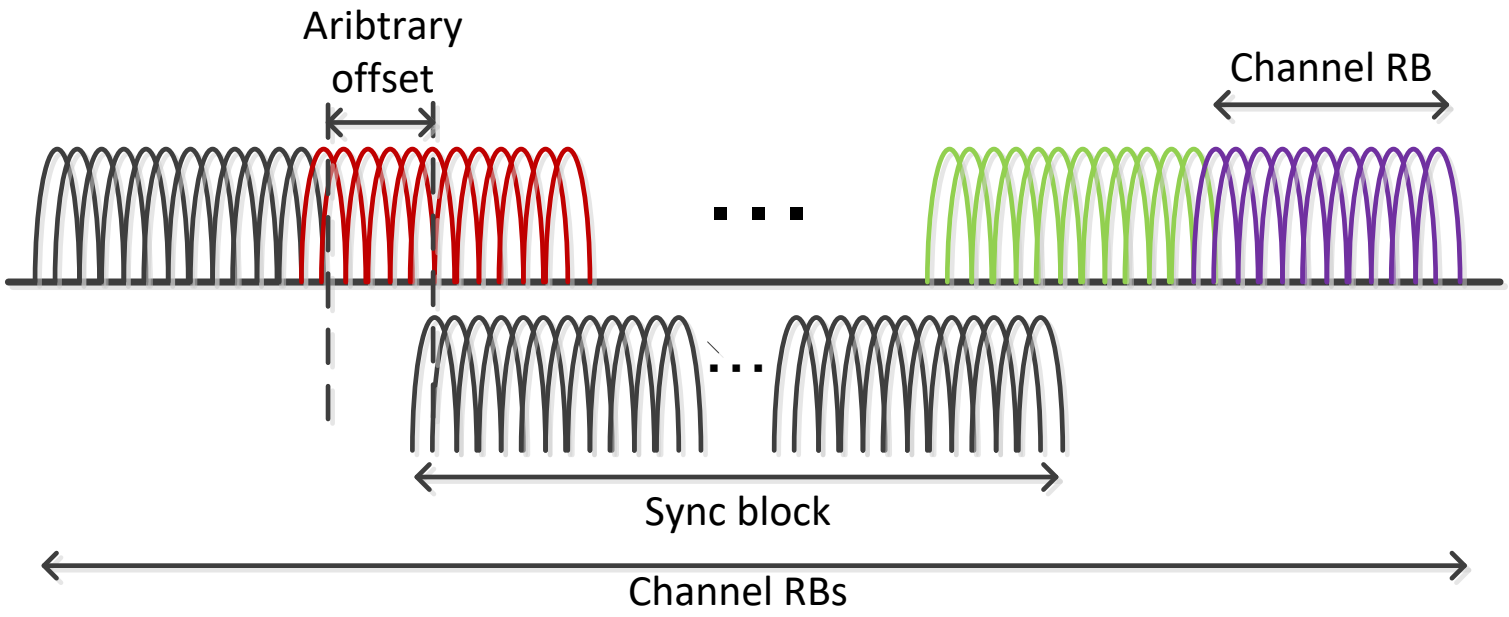
Subcarrier Based Raster

- Channels within a band are placed such that they are aligned with the fixed subcarrier positions (like green or orange)
- If the channel raster offset between channels is an RB multiple(multiple of 12 subcarriers), the channels are RB aligned and 0 guardband CA can be deployed
  - Channels can be deployed such that the guardband is symmetrical (almost perfect symmetry) when they stand alone
  - Channels can be moved on this raster such that they become RB aligned(multiple of 12 subcarriers) and 0 guardband CA is enabled



Sync raster with subcarrier based raster

- One major advantage of RB based raster is optimal downselection of sync based raster
  - If every subcarrier offset has to be covered by sync block position, increase in sync raster entries is 12x(REs in 1 RB) compared to RB based raster
- With “floating sync” design, optimal downselection is possible
  - 1 sync block position can cover all subcarrier offsets
  - Any channel that has an arbitrary RB edge offset compared to edge of sync block can re-use the same sync block location
  - Similar design would be needed in case of 100kHz raster to reduce the number of sync raster entries to 3x



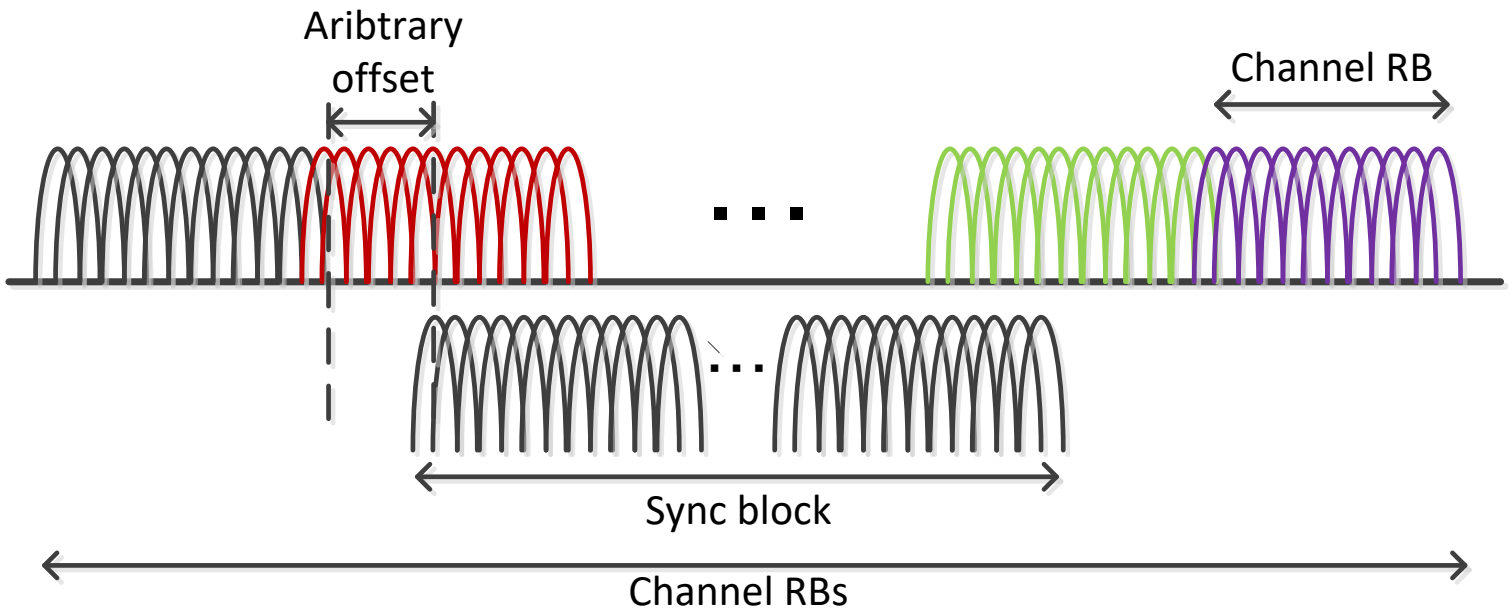
Comparison of Different Proposals

- Both 100khz raster and RB based raster have drawbacks
- We propose a further refinement to the RB based raster that leads to a subcarrier based raster
- Subcarrier based raster has the advantages of both 100kHz raster and RB based
  - Subcarrier based raster leads to 1 RB loss in sync block symbols but this would also happen in 100kHz raster if we optimize the sync raster to 3x entries (proposed in last meeting by E/// and Huw)
- **We propose to adopt subcarrier based raster for all frequency ranges**

	100kHz raster	RB based raster	Subcarrier based raster
Channel edge guard band	Symmetric/becomes asymmetric for certain numerologies	Asymmetric	Symmetric(up to 7.5kHz offset compared to 100kHz)/ becomes asymmetric for certain numerologies
0 guardband CA	Can be supported but only on some raster entries. Loss in flexibility(raster granularity is multiple of RB size and 100kHz)	Supported, with raster granularity of RB size(180kHz, 360kHz, etc)	Supported
Addtion of new channel bandwidths	Difficult (leads to loss of RBs)	Supported	Supported
Sync raster down selection	Multiple entries needed (sub-optimal), 3x RB based raster with “floating sync”	Smallest possible number of entries (Optimal)	Smallest possible number of entries with “floating sync”

Specifications

- Subcarrier positions are fixed in each band, offset from left edge is based on largest supported SCS
- Sub6 band:
  - Subcarrier 0 in the band is 30kHz(0.03MHz) offset from band edge(F_{DL_low})
  - Channel raster entries are F_{DL}=0.03+0.015*N_{DL}
  - Sync raster entries: F_{DL_sync}= 0.03+0.18+2*0.18*N_{DL_sync} for 15kHz SCS and 5MHz minimum channel bandwidth
    - 0.03 ->offset from band edge of first subcarrier
    - 0.18 ->first sync entry is offset by 1RB from the band edge
    - 2*0.18 -> sync raster step size is 2RBs (25-24+1)
- mmWave band:
  - Subcarrier 0 in the band is 60kHz(0.06MHz) offset from band edge(F_{DL_low})
  - Channel raster entries: F_{DL}=0.06+0.06*N_{DL}
  - Sync raster entries: F_{DL_sync}=0.06+8*1.44+9*1.44*NDL_sync
    - 0.06 ->offset from band edge of first subcarrier
    - 8*1.44 -> first sync entry is offset by 8 RBs from the band edge
    - 9*1.44 -> sync raster step size is 9RBs (32-24+1)

“Floating Sync”

- Sync block is not RB aligned with the data RBs in the channel
  - There is an arbitrary offset as shown in the figure
- Enables multiple channels that are subcarrier grid aligned but not RB grid aligned to use the same sync block location
  - This is needed for 100kHz raster to reduce the number of sync raster entries to 3x(instead of 9x or 18x)
- Drawback is that this arbitrary offset needs to be known by the UE (some sort of signaling is needed)
- 1 RB around the sync block is lost in symbols in which SS block is transmitted
  - Essentially makes the SS block 1 RB wider