**3GPP TSG-RAN WG4 Meeting #97-e R4-2016962**

**Electronic meeting, 2nd – 14th November 2020**

**Agenda item:** 9.1

**Source:** Apple Inc.

**Title:** Email discussion summary for [97e][118] NR\_n48\_LTE\_48\_coex

**Document for:** Information

# Introduction

Dynamic spectrum sharing is an important feature that allows for sharing existing spectrum between the LTE and NR carriers, thus enabling smoother transition from LTE and faster adoption of NR. After the RAN#86 meeting, a new WI was agreed aiming to analyse and introduce, if needed, changes to support dynamic spectrum sharing in band 48/n48 frequency range.

This document aims at capturing outcome of the email discussion focusing on required changes, if any, needed to support the aforementioned functionality.

# Topic #1: LTE/NR spectrum sharing in band 48/n48

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2014174 | Qualcomm | Proposal 1: Choose option1 (*MODERATOR NOTE: RB blanking*) and blank 1st RB position to increase the effective guard band of the shifted RB allocation. |
| R4-2014890 | Apple Inc., Comcast | Proposal 1: Shifting the centre frequency by -/+100kHz does not require any specification changes and is up to the network and operator configuration.  Proposal 2: Introduce A-MPR for the 5MHz and 10MHz edge RB allocations when the centre frequency is shifted.  Proposal 3a: Introduce NS signalling to indicate explicitly to the UE that the centre frequency is shifted and thus the guard bands are smaller.  Proposal 3b: If RAN4 concludes that A-MPR is needed for the centre frequency shift, then a new NS flag can also activate the corresponding maximum power back-off values. |
| R4-2015086 | Nokia, Nokia Shanghai Bell | Proposal 1: Option C (keep the same MPR/A-MPR for 100 kHz shift) is proposed. If it is not possible to agree Option C, Option B (1 PRB blanking) can be also considered.  Proposal 2: No new NS value is introduced.  Proposal 3: The support of 7.5 kHz UL subcarrier shift and MPR/A-MPR with 100 kHz NR channel raster shift is mandatory for UE. |
| R4-2015350 | OPPO | Proposal 1: Option 3 Keep existing SCS based raster. Support frequency shift. Introduce a new signalling and UE capability.  Proposal 2: Option 1 Keep existing sync pattern C  *MODERATOR NOTE: Referring to Proposal 2, further discussions on the sync pattern are descoped from the WI objectives as agreed at the RAN#89 meeting*. |
| R4-2016140 | Ericsson GmbH, Eurolab | Observation 1: 100 kHz shift may be needed for alignment between LTE and NR carriers which will result in smaller internal guard band and risk of violation of the CBRS unwanted emissions.  Proposal 1: Network performs blanking of the outermost PRB blanking to enable compliance with CBRS unwanted emissions if alignment between LTE and NR carriers are necessary  Proposal 2: No change to specifications is needed |
| R4-2016372 | Google Inc. | Proposal: Do not introduce a new NS value and/or a new UE capability signaling to n48 for the shifted center channel frequency. |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Channel raster

The 3GPP band 48/n48 (also known as the CBRS band) spectrum is managed dynamically by a so-called SAS entity based on requests from CBRS operators and incumbent services. Thus, an operator does not know in advance how much spectrum the SAS entity will allocate and in which frequency range within the band. Furthermore, since the NR band n48 uses the SCS based 15/30kHz raster, and the LTE band 48 uses 100kHz raster, it is not straightforward to align NR and LTE center frequencies.

One of the most straightforward solutions is to use 300kHz "raster", which is effectively the least common multiple of the LTE 100kHz raster and NR 30kHz raster. However, since spectrum allocation is done by SAS and is not controlled by operator, there is no guarantee that allocated spectrum will be on the 300kHz raster. It has been suggested to apply, when needed, -/+100kHz shift to the NR center frequency so that NR and LTE raster points are aligned. This approach does not require any specification changes, but there is a risk of failing existing emission requirements due to shrunk guard bands.

According to expressed views, no company proposes to change existing sync raster design, and instead we can rely upon the network "shifting" the NR centre frequency by -/+100kHz to align with the LTE raster. Based on simulation results from Qualcomm and Apple, 5MHz and 10MHz channel bandwidth may need increased MPR/A-MPR, if a UE is scheduled with a single RB transmitting at full power i.e. having maximum PSD. To mitigate it, two major options are identified: handle it in the network specific implementation way by e.g. not scheduling edge RBs, or allow for higher MPR/A-MPR with the corresponding NW-to-UE signalling;

**Issue 1-1: Simulation results for MPR/A-MPR when the center frequency is shifted.**

- Proposals:

- Endorse simulation results for MPR/A-MPR from R4-2014174 (Qualcomm) and R4-2014890 (Apple);

- Conclude that increased MPR/A-MPR may be needed only for the 5 and 10MHz channels when the centre frequency is shifted;

**Issue 1-2: Solutions to mitigate increased MPR/A-MPR when the center frequency is shifted**

- Proposals:

- Option 1: Use RB blanking for edge RBs;

- Option 2: Add MPR/A-MPR for 5 and 10MHz channel bandwidths:

- Option 2a: Introduce only NW-to-UE signaling (e.g. a new NS value), which will indicate that the center frequency is shifted and thus increased MPR/A-MPR is allowed;

- Option 2b: Introduce both UE capability, which will indicate that a UE supports increased MPR/A-MPR, and NW-to-UE signaling, which will indicate that the center frequency is shifted and thus increased MPR/A-MPR is allowed;

- Recommendation for further discussion:

- **Further discussion**: For proponents of Option 1, it is worth checking whether RB blanking will be captured in the specification to ensure that the network will take care of the emission requirements. For proponents of Option 2, to clarify further potential MPR/A-MPR values.

- NOTE: While expressing a view against or in favour of a particular option, it is suggested to provide a short summary or reasons for a particular view (especially how it addresses concerns from other companies).

## Companies views’ collection for 1st round

### Open issues

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| **Company** | **Comments** |
| XXX | THIS IS A TEMPLATE – DO NOT REMOVE OR ALTER IT  Issue 1-1 (Simulations results for MPR/A-MPR):  - Endorse simulation results for MPR/A-MPR from R4-2014174 (Qualcomm) and R4-2014890 (Apple);  - Conclude that increased MPR/A-MPR may be needed only for 5 and 10MHz channels when the centre frequency is shifted (see also to Annex A);  Issue 1-2 (Solutions to mitigate increased MPR/A-MPR):  - Option 1: Use RB blanking for edge RBs when the centre frequency is shifted;  - Option 2: Add MPR/A-MPR for the 5 and 10MHz channel bandwidths:  - Option 2a: Introduce only NW-to-UE signaling (e.g. a new NS value), which will indicate that the center frequency is shifted and thus increased MPR/A-MPR is allowed;  - Option 2b: Introduce both UE capability, which will indicate that a UE supports increased MPR/A-MPR, and NW-to-UE signaling, which will indicate that the center frequency is shifted and thus increased MPR/A-MPR is allowed;  Other comments (if applicable): |
| Qualcomm | Issue 1-1: I don’t think RAN4 can “endorse” simulation results. Simulation results are usually only noted since they represent the study from one company. For example, I don’t think Company A can endorse results that Company B generated. It is also unnecessary to conclude that MPR/A-MPR may only be needed for 5 and 10 MHz channels. You can say that simulation results from XXX and YYY show that MPR/A-MPR is only needed.  Issue 1-2: We prefer option 1 as it is much simpler than option 2 and our understanding is that option 1 is also acceptable to the operator of interest. |
| Nokia | Issue 1-1: We support no additional MPR/A-MPR with 1 PRB blanking, i.e., option1 in Issue 1-2.  Issue 1-2: Support option 1. |
| Samsung | Issue 1-2: Support option 1. Both RB blanking and power reduction may have impact on system configuration. However, power reduction will result in more work in RAN4. From this angle option 1 should be preferred. |
| Huawei | Issue 1-2: Support option 1.  Option 1 mainly depends on BS implementation and has less impact on specifications. Besides, according to Table 2.2-3 in R4-2014890, the centre frequencies of both LTE and NR are shifted by -100/+100KHz together and aligned. It may also result in the smaller guard bands for LTE on one edge. Thus the same emission issue as for NR would also exist for LTE. At current stage, it seems difficult to change LTE. Thus we think RB blanking would be a clean solution for both LTE and NR.  One may argue that the centre frequency of LTE may not need to be aligned with NR. But in such case, the inter-distance between LTE centre frequency and NR’s should be multiple of 300KHz, which may also result in shifting LTE centre frequency from the centre of available spectrum and thus may cause the imbalanced guard band on two edges. |
| Google | Issue 1-2: We prefer option 1. Compared to introduce a NS value and a UE capability, the RB blanking can be a more simple method to avoid violating the emission requirement. We are fine to capture the RB blanking description in the specification. |
| Ericsson | Issue 1-2: Support option 1. |
| Apple | Issue 1-1: The intention was to make sure that companies do not have disagreements and/or concerns with the simulations results presented in Qualcomm and Apple papers, which we can use in further technical discussions.  Issue 1-2: We prefer Option 2 and are open to discuss further its flavors seeking to find the compromise.  Option 1 may look like a simple and efficient way to address the issue with smaller guard bands. It is indeed true that it does not require any specification changes as it is up to the scheduler when and how to blank RBs. However, blanking (at least) 1 RB will reduce the overall system capacity by approximately 2% in case of 10MHz channel and 4% in case of 5MHz channel. On the contrary to it, informing the UEs about the shrunk guard band will still allow the network to schedule those RBs, whereupon according to our simulation results the UE MPR might exceed existing margins only in extreme cases. Nevertheless, the biggest concern is with Option 1 is that this approach is identical to "using next larger channel bandwidth" solution considered in the ongoing Study on Efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths [FS\_NR\_eff\_BW\_util]. It is also proposed to blank edge RBs to support smaller channel bandwidth, but as expressed by a number of companies, it is not understood whether all the emission requirements can be met. So, in light of the fact that RAN4 has not yet completed this analysis, agreeing to Option 1 may result in having no solution at all.  Referring back to comments from Huawei on LTE, the LTE 10MHz channel has larger guard bands and according to the simulation results from Qualcomm, it does not require any power back-off. Only the NR 10MHz channel might need additional power back-off because it has 52RBs. And 10MHz channel is the basic PAL allocation according to the FCC rules. 5MHz channel can be discussed further, whereupon one potential conclusion could be that DSS cannot be supported with the 5MHz channel when the center frequency is shifted, if RAN4 concludes that the LTE RB blanking cannot guarantee emission requirements. |
| Comcast | Issue 1-2: We understand Option 1 is the simplest approach but would like the proponents of the solution to confirm that all the emission requirements can be met. As noted in Tdocs in the FS\_NR\_eff\_BW\_util study (e.g. R4-2015724) the emission requirements based RB blanking may not meet regulatory emission requirements as the minimum guard band assumptions are not being met in deployments with channel raster shift.  If emission requirements considerations cannot be met, we would prefer a solution to change the MPR/A-MPR requirements for UEs supporting n48 DSS. |
| CableLabs | Issue 1-2: we have the same concern with Comcast. Do the emission requirements based on option 1 (RB blanking with +/- 100 kHz shift) meet regulatory emission requirements? |

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

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| **CR/TP number** | **Comments collection** |
| R4-2014891 (TS 38.101-1) | Qualcomm: Do not agree with this CR. |
| Nokia: Instead of introducing a new NS, a note can be added in TS 38.101-1 that UE emission compliance is only met with blanking PRB to fulfil the minimum UE guardband requirement |
| Samsung: CR should be revised according to consensus of topic #1. |
| Ericsson: not agreeable. No change is needed in specifications with RB blanking solution. |
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## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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|  | **Status summary** |
| **Issue 1-2** | Summary of comments:  - 6 companies prefer Option 1 (RB blanking based solution):  - 3 companies are the network side vendors, and 3 companies are the OEM/chipset vendors;  - 1 company indicated explicitly that no changes to the specification are needed at all;  - 2 companies indicated that they would be ok, if needed, to capture RB blanking restriction in the specification;  - 1 company explicitly elaborated on the fact that RB blanking is needed for LTE and thus RB blanking can/should be also adopted for NR;  - 4 companies prefer Option 2:  - 2 companies are the CBRS operators and 2 companies are the UE vendors;  - MODERATOR NOTE: 1 company indicated preference for Option 2 in the discussion paper but did not comment explicitly during the 1st discussion round; the moderator sent a request to clarify the company view;  - 3 companies raised a concern that blanking edge RBs will not necessarily always ensure emission requirements as being discussed in the "Efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths" SI.  Recommendations for the 2nd round:  - Main issue: Moderator’s understanding is that one of the fundamental questions is that whether we can proceed with Option 1, RB blanking, because this solution is being discussed now in the "*Efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths*" SI, for which already several companies expressed a concern that it might not work for legacy UEs and thus emission requirements will not be met; refer to R4-2015724 (Ericsson), R4-2014487 (Qualcomm), R4-2014507 (Skyworks), R4-2014895 (Apple), R4-2016111 (ZTE). Agreeing to Option 1 means that we make a tentative assumption for the outcome of that SI without final RAN4 conclusion.  *-* Secondary issues:  *-* For Option 1, the open question is whether we need/can capture the RB blanking restriction in the specification;  *-* For option 2, the open question is how to address LTE 5MHz channel (LTE 10MHZ channel is not an issue when the center frequency is shifted). While we can make the NR UE aware of the center frequency shift on the 5MHz channel, we cannot change legacy LTE UEs. |

*Recommendations on WF/LS assignment*

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| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

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| **CR/TP number** | **CRs/TPs Status update recommendation** |
| R4-2014891 (TS 38.101-1) | Moderator’s recommendation: Wait for the conclusion of the discussion on which option to choose before deciding which changes, if any, are needed. |

### Outcome of the GTW session (November 6h, 2020)

**Agreement**:

Option 1, subject to further discussion on whether a note is needed in 38.101-1/38.104.

## Discussion on 2nd round (if applicable)

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| **Company** | **Comments** |
| XXX | THIS IS A TEMPLATE – DO NOT REMOVE OR ALTER IT  Issue 1-1: A clarification (e.g. a NOTE) capturing edge RB blanking when the center frequency is shifted:  - Exemplary wording: “*NOTE: For the dynamic spectrum sharing operation in band 48/n48 frequency range, if the number of configured RBs does not meet minimum guardband specified in this clause, then edge RB(s) should be blanked to ensure UE emission requirements*”  Issue 1-2: Where to capture the NOTE on edge RB blanking (e.g. TS 38.101-1, TS 38.104, or both)  Other comments (if applicable): |
| Apple | Issue 1-1: We do not have any particularly strong view on the exact wording, but we do have preference to capture something in the specifications, e.g.:  NOTE: For the dynamic spectrum sharing operation in band 48/n48 frequency range, if the number of configured RBs does not meet minimum guardband specified in this clause, then edge RB(s) should be blanked to ensure UE emission requirements  Issue 1-2: Since agreed Option 1 assumes that a UE does not even know whether guardbands smaller, it makes more sense to capture this clarification in TS 38.104 because edge RB blanking will be performed by the network in a way completely transparent to the UE. The aforementioned NOTE can be captured in 5.3.3 as follows (the highlighted text already exists in sub-clause 5.3.3, TS 38.104)  The number of RBs configured in any *BS channel bandwidth* shall ensure that the minimum guardband specified in this clause is met.  NOTE: For the dynamic spectrum sharing operation in band 48/n48 frequency range, if the number of configured RBs does not meet minimum guardband specified in this clause, then edge RB(s) should be blanked to ensure UE emission requirements |
| Google | Issue 1-1: We also do not have any particularly strong view on the exact wording.  Issue 1-2: According to the annex A simulation results, it seems that LTE 5MHz may suffer power back-off from the +/-100KHz shift to follow the emission requirement. Since the legacy LTE UE behavior cannot be changed, we are not sure whether a note for the edge RB blanking also need to be captured in TS 36.104. |
| Nokia | In TS 38.104, there is already a text explaining,  “The number of RBs configured in any *BS channel bandwidth* shall ensure that the minimum guardband specified in this clause is met.“  and  “All PRBs falling within BS channel bandwidth not covering the minimum guard band can be used.”  Therefore, we think a CR to 38.104 is unnecessary. |
| Comcast | Issue 1-1: We are fine with the proposed wording from Apple.  Issue 1-2: We are ok to capture this in 38.104. Since CBRS allocations are 10MHz granularity, we think the 5MHz issue with legacy LTE may not be in many deployments, so we don’t feel its necessary to include it in 36 series. |

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

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| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Annex A: MPR/A-MPR simulation results for 5 and 10MHz channels

Table A.1: MPR/A-MPR results for DFT-s-OFDM (source: R4-2014174 Qualcomm).

# A picture containing clock Description automatically generated

Table A.2: MPR/A-MPR results for CP-OFDM and DFT-s-OFDM (source: R4-2014890 Apple).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Channel bandwidth | Modulation | | MPR (dB) | | |
| Edge RB allocations | Outer RB allocations | Inner RB allocations |
| 5MHz | DFT-s-OFDM | QPSK | ≤ [3.5] | ≤ 1 | 0 |
| 16 QAM | ≤ [3.5] | ≤ 2 | ≤ 1 |
| 64 QAM | ≤ [3.5] | ≤ 2.5 | |
| 256 QAM | ≤ 4.5 | | |
| CP-OFDM | QPSK | ≤ [3.5] | ≤ 3 | ≤ 1.5 |
| 16 QAM | ≤ [3.5] | ≤ 3 | ≤ 2 |
| 64 QAM | ≤ 3.5 | | |
| 256 QAM | ≤ 6.5 | | |
| 10MHz | DFT-s-OFDM | QPSK | ≤ [2] | ≤ 1 | 0 |
| 16 QAM | ≤ 2 | | ≤ 1 |
| 64 QAM | ≤ 2.5 | | |
| 256 QAM | ≤ 4.5 | | |
| CP-OFDM | QPSK | ≤ 3 | | ≤ 1.5 |
| 16 QAM | ≤ 3 | | ≤ 2 |
| 64 QAM | ≤ 3.5 | | |
| 256 QAM | ≤ 6.5 | | |