**3GPP TSG-RAN WG2 Meeting #116bis-e R2-220XXXX**

**Electronic meeting, 17 January – 25 January 2022**

**Agenda Item:** 8.20.2 (NR\_ext\_to\_71GHz-Core)

**Source:** Lenovo, Motorola Mobility

**Title: [AT116bis-e][211][71 GHz] LBT aspects for 71 GHz (Lenovo)**

**Document for:** Discussion and Decision

# Introduction

This document discusses the impact of directional LBT and LBT mode change on consistent LBT failure detection/recovery procedure and CG HARQ retransmissions based on the documents submitted to A.I. 8.20.2.

**Deadline:**

* **Comment deadline, 1st phase:** Thursday W1, 0500 UTC (for collecting views)
* **Rapporteur proposals, 1st phase:** Thursday W1, 2000 UTC (proposed resolution of issues)
* **Document deadline, 1st phase:** Friday W1, 0500 UTC (report, agreed CRs,final approved LS, etc.)

       Intended outcome: Discussion summary in R2-2201709.

# Discussion

Following RAN1 agreements have been made w.r.t directional LBT/per-beam LBT sensing:

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| *Agreements in RAN1#107e:*  *For a COT with MU-MIMO (SDM) transmission, support both Alt 1 and Alt 2 below:*   * *Alt 1: Single LBT sensing at the start of the COT with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold* * *Alt 2: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT, if the node can perform simultaneous sensing in different beams*   *Note: On UE side, no UE capability will be introduced for this purpose.*  *Agreement*  *Within a COT with TDM of beams with beam switching, at least support Alt 1*   * *Alt 1 (from previous agreement): Single LBT sensing with wide beam ‘cover’ all beams to be used in the COT*   *Agreement*  *Within a COT with TDM of beams with beam switching, Alt 2 is supported if the node has the capability to perform simultaneous sensing in different beams. Alt 3 is allowed as node implementation choice if the node also supports Cat 2 LBT. The use of Alt 2 or Alt 3 is based on node’s implementation.*   * *Alt 2 from previous agreement: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT* * *Alt 3 from previous agreement: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT with additional requirement on Cat 2 LBT before beam switch*   *Agreement in RAN1#104bis-e:*  *For a COT with MU-MIMO (SDM) transmission,*   * *Alt A: The per-beam LBT for different beams is performed in TDM fashion* * *Alt B: The per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams*   *Within a COT with TDM of beams with beam switching,*   * *Alt A: The per-beam LBT for different beams is performed one after another in time domain* * *Alt B: The per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams* |

In the following some related RAN1 agreements w.r.t to supported LBT modes are listed:

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| Agreement in RAN1#105-e:  For regions where LBT is not mandated, gNB should indicate to the UE this gNB-UE connection is operating in LBT mode or no-LBT mode   * Support both cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) and UE specific (can be different for different UEs in a cell as part of UE-specific RRC configuration) gNB indication |

## LBT failure indication from PHY (per beam/UL transmission)

The assumption for Rel-16 is basically that UE is performing only omni-directional LBT. However, for the NR operation in higher frequency bands up to 71GHz in Rel-17, RAN1 introduced the support of per-beam LBT sensing, e.g. also referred to as directional LBT, according to the RAN1 agreements listed above.

For SDM transmissions, UE may either perform a single LBT sensing at the start of the COT with a wide beam ‘covering’ all beams to be used in the COT or may perform independent per-beam LBT sensing simultaneously at the start of COT for beams used in the COT. One straightforward question is how the LBT failure counting and LBT failure indication from PHY to MAC is performed for Rel-17. This will have an immediate impact to the LBT procedures in RAN2, i.e. LBT failure detection/recovery procedure.

If LBT sensing with a wide beam covering all Tx beams is used, once LBT fails, UL transmissions cannot be performed within the COT. In this case, Rel-16 LBT failure detection/recovery may be reused and no changes are necessary.

For the case that independent simultaneous per-beam LBT sensing is performed for all beams, the LBT status of each beam may be different as mentioned in various contributions, e.g. [8]. Here the question is whether LBT failure is counted and indicated to MAC per beam or still per UL transmission, i.e. PHY indicates to MAC whether an UL transmission could be performed as a result of directional LBT sensing. If the first option is adopted, LBT failure should be counted and indicated per beam, which has some impacts on LBT operation in MAC. Otherwise, Rel-16 LBT failure detection/recovery may be reused.

The rapporteur assumes that there are basically two general options on how LBT failure may be counted and indicated from PHY to MAC.

* **Option 1:** **LBT failures are counted and indicated to MAC independently per beam**
* **Option 2: LBT failures are counted and indicated to MAC per UL transmission**

**Question 1: Do you agree that following two general options can be considered for LBT failure counting and indication (from PHY to MAC) for the case of a COT with MU-MIMO (SDM) transmission and independent per-beam LBT sensing.**

* **Option 1: LBT failures are counted and indicated to MAC independently per beam**
* **Option 2: LBT failures are counted and indicated to MAC per UL transmission**

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| Company | Yes/No | Detailed Comments |
| Nokia | Yes | There does not seem to be really any justification to make this unnecessarily complex. We can follow existing procedure with option 2 and I hope companies realize there is no time to design new way of doing LBT anymore. |
| Xiaomi | Yes | To clarify, option 1 should be per beam per UL transmission. And the case of a COT with MU-MIMO (SDM) transmission is only for gNB LBT.  BTW, we would also like to hear company’s view on whether LBT for PUSCH beam and PUCCH beam should be considered separately given that they use different beams. |

The rapporteur thinks it would be good to understand better the impacts of the two options for the RAN2 LBT procedures and to also discuss whether there would be from RAN2 point of view a preference for one of the options given certain potential benefits.

As mentioned in [8] with Option 2 there may be no impact to the RAN2 LBT procedures, i.e. current LBT failure detection and recovery procedure can be reused. Per-beam LBT sensing would be basically invisible to MAC layer.

**Question 2: Do companies agree that with Option 2, i.e. LBT failures are counted and indicated to MAC per UL transmission, current Rel-16 LBT procedures can be reused, i.e. no change to LBT failure detection and recovery procedure needed?**

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| --- | --- | --- |
| Company | Yes/No | Detailed Comments (in case of No) |
| Nokia | Yes |  |
| Xiaomi | Yes |  |

It’s one question whether the current LBT failure detection and recovery procedure would be also suitable for a per-beam LBT failure indication. In Rel-16 consistent LBT failure is detected per UL BWP by counting LBT failure indications, for all UL transmissions, from the lower layers to the MAC entity. RRC configures an LBT counter and a timer (i.e. lbt-FailureDetectionTimer). LBT counter is initialized to zero and incremented for every LBT failure indication from PHY. The timer is restarted every time the LBT counter is incremented. When the timer expires LBT counter is reset to 0. If the LBT counter reaches a preconfigured threshold (i.e. lbt-FailureInstanceMaxCount), consistent LBT failure is detected.

[5] discusses what’s the criteria for declaring consistent LBT failure for cases when LBT failure is indicated per beam. In one approach MAC entity does not increment the LBT\_COUNTER when at least one beam is LBT-successful. The consistent LBT failure will be declared only when LBT for all beams on the active BWP is failed concurrently. In an alternative approach MAC entity increments LBT\_COUNTER whenever LBT fails for at least one beam. Thus, MAC entity may declare a consistent LBT failure even if the physical layer can transmit data using the LBT-successful beam on the active BWP.

[1] discusses whether the consistent LBT failure detection and recovery procedure needs to be adapted when granularity of LBT failure indication is changed to per-beam. It proposed that LBT\_COUNTER and lbt-FailureDetectionTimer are maintained per beam in order to avoid the situation that consistent LBT failure may be triggered even though none of the multiple beams experiences consistent LBT issues.

In [2] the scenario of the network switching UE’s transmission beam due to UE’s movement or rotation is brought up. Here it’s questioned whether the counter for consistent LBT failure detection for the original direction shall be continued or reset when reusing the Rel-16 mechanism.

Based on companies input, it is the rapporteur’s understanding that some changes/enhancements to the LBT failure detection and recovery procedure may be necessary in case LBT failure are indicated per-beam from PHY to MAC. RAN2 would need to further discuss the criteria when consistent LBT failure is declared.

**Question 3: Do companies agree that with Option 1, i.e. LBT failures are counted and indicated to MAC independently per beam, certain changes/enhancements to the Rel-16 LBT procedures, i.e. LBT failure detection and recovery procedure, are required? RAN2 would need to further discuss for example the condition for declaring consistent LBT failure when considering directional LBT sensing results.**

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| Company | Yes/No | Detailed Comments |
| Nokia | Yes | Quite a few changes are likely required and lengthy discussions. |
| Xiaomi | Yes | Currently, *LBT\_COUNTER* is counted per BWP, not per beam. If multiple Tx beams are used in parallel, LBT failure indications from different beams will be counted together. Consistent LBT failure may be triggered even without any of the beams whose LBT failure reaches the maximum value. In fact, there may be no consistent LBT issues on any beam. To solve the issue, *LBT\_COUNTER* and *lbt-FailureDetectionTimer* can be run per beam. |

As mentioned before it would be good to also understand if companies see some necessity/benefit (from RAN2 point of view) if MAC layer is aware of directional LBT results, i.e. per-beam LBT failure indication. [2] argues that since the main spec impacts for LBT failure detection when involving directional LBT results can be foreseen in RAN2, RAN2 should discuss whether consistent LBT failure procedure shall involve directional LBT results. In [3] it is e.g. mentioned that UE may inform have a more finer control transmission resources if directional LBT results are known in MAC layer, e.g. NW if a certain Tx beam experiences consistent LBT issues so that NW may not use this Tx beam for subsequent UL transmission/COT. Hence the question is whether NW or the system benefits from having more detailed information of LBT issues, i.e. directional LBT results.

On the other hand, in [4] it is stated that for NR 71 GHz, LBT failure is a generally a rare or even non-existent event. Further considering also the limited time for RAN2 in Rel-17, they think it is unnecessary for RAN2 to spend efforts to improve the LBT failure detection and recovery procedure and propose hence to RAN2 to down-prioritize optimization of consistent LBT failure handling for NR operation with 71 GHz in Rel-17.

**Question 4: Do companies see a benefit from RAN2 point of view if MAC layer is aware of directional LBT results, i.e. per-beam LBT failure indication from PHY to MAC?**

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| Company | Yes/No | Detailed Comments |
| Nokia | No | Difficult to see motivation at this point of time |
| Xiaomi | Yes | See our comment for Q3 |

[1][5][9] proposed to send an LS to RAN1 in order to ask whether per-beam LBT sensing assumes per-beam LBT failure indication or per-UL transmission LBT failure indication as in the legacy and whether RAN1 sees any issues with the LBT failure detection and recovery procedure for the case of directional LBT.

It is the rapporteur’s understanding that it would be good to have a common understanding on whether RAN2 sees some motivation/necessity for making MAC aware of directional LBT results before deciding to send an LS to RAN1. Such information should be provided to RAN1 in the LS. RAN1 has so far not discussed any changes to the LBT failure indication to MAC.

**Question 5: Do companies see a need to send an LS to RAN1 asking about LBT failure indication from PHY to MAC for the case of per-beam LBT sensing?**

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| Company | Yes/No | Detailed Comments (In case of Yes please provide some more information on what to ask RAN1) |
| Nokia | No | We can naturally indicate that RAN2 prefers not to specify this at this point of time |
| Xiaomi | Yes |  |

## LBT Mode (LBT/no-LBT) switching

According to RAN1 agreements for NR operation in unlicensed bands between 52.6 GHz and 71 GHz, switching between LBT and no-LBT based channel access mechanism is supported for regions where LBT is not mandated. gNB should indicate to the UE in which channel access mode to operate. The background for supporting a no-LBT mode is that shared spectrum operation with high directivity systems experiences low interference and good performance on the aggregate. Moreover, the gain of a LBT based channel access mechanism over the no-LBT scheme seems to be rather small. The signaling will support whether a cell or UE uses LBT (via the IE LBT-mode) which can also change during an RRC connection [7].

When channel access mechanism is configured as no-LBT, it means for the MAC protocol operation that no LBT failure indications will be received from the lower layer. For the MAC procedures/timers which are impacted based on LBT outcome the rapporteur doesn’t foresee any specific issue when no LBT failure indications are received. Therefore, it is the understanding that current specifications already support the no-LBT mode implicitly.

**Question 6: Do companies agree that the “no-LBT mode” is already implicitly supported by Rel-16 specifications?**

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| Company | Yes/No | Detailed Comments |
| Nokia | Yes |  |
| Xiaomi | Yes | From MAC point of view, current MAC specification can support the no-LBT mode implicitly. |

[8] raises the issue that in Rel-16 NR-U, cg-RetransmissionTimer is always configured for operation with shared spectrum channel access. However, in Rel-17 for the no-LBT mode autonomous retransmisisons are not needed. Therefore, they propose that cg-RetransmissionTimer should be optional for operation in the shared spectrum in FR2-2.

**Question 7: Do companies agree that cg-RetransmissionTimer should be optional for operation in the shared spectrum in FR2-2?**

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| Company | Yes/No | Detailed Comments |
| Nokia | Maybe | This looks logical to be optional. We will check this in more detail but if agreed to be optional of course then it is always possible to configure it properly. So safe option is to set it optional or just ignored by UE if no-LBT is configured. |
| Xiaomi | Yes, but nothing need to be specified | In R17 NR IIoT URLLC, cg-RetransmissionTimer is already optionally configured as agreed in RAN2 #112 below:  - cg-RetransmissionTimer can be configured optionally for shared spectrum  - When cg-RetransmissionTimer is configured, Rel-16 NR-U mechanism is used for HARQ process ID and RV selection.  - When cg-RetransmissionTimer is not configured, Rel-16 URLLC mechanism may be used for HARQ process ID and RV selection. |

In [8][3] some detailed MAC protocol aspects, e.g. LBT related timer handling, when switching the LBT mode, e.g. from no-LBT to LBT and vice versa, are discussed. One issue mentioned is the initializing of the *LBT\_Counter* to zero when switching the LBT mode. Furthermore, [8] proposed that when LBT mode is changed from LBT to no-LBT, lbt-FailureDetectionTimer is stopped, if running. All triggered consistent LBT failure(s) are canceled. If there is ongoing RACH procedure which is related to consistent LBT failure, it should be stopped. [3] further proposes to discuss whether pending autonomous retransmissions are being continued after LBT mode is switched to no-LBT etc.

**Question 8: Do companies agree that RAN2 should further discuss some detailed MAC protocol aspects for the case of a LBT mode switch, e.g. LBT related timer/procedure handling, pending autonomous retransmissions?**

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| Company | Yes/No | Detailed Comments |
| Nokia | No | We trust proper UE implementations here. anyway mode change is unlikely to happen (at least frequently) |
| Xiaomi | No | First, no need to stop *lbt-FailureDetectionTimer* when switched to no-LBT mode, as no failure indication will be received from PHY any more, then *lbt-FailureDetectionTimer* can expire and LBT\_COUNTER can be reset.  Second, regarding ongoing RACH procedure triggered by consistent LBT failure, UE should not stop it, because UE switched its UL BWP, RACH procedure is needed to tell network the used UL BWP.  Third, regarding triggered consistent LBT failure(s), it would still be useful for UE to send LBT failure MAC CE for network to better understand the situation. |

# Conclusion

TBF later

# References

[1] R2-2200274, Consideration on support of directional LBT, Xiaomi

[2] R2-2201682, Discussion about RAN2 impacts of Ext 52-71GHz, Huawei, HiSilicon

[3] R2-2200706, Discussions on potential LBT impacts, Lenovo, Motorola Mobility

[4] R2-2200941, Remaining protocol aspects, Ericsson

[5] R2-2201425, Discussion on LBT impact based on RAN1 conclusions, LG Electronics Inc.

[6] R2-2201438, Discussion on Consistent LBT Failure Detection for Beyond 52.6GHz, Vivo

[7] R2-2200718, List of issues for completion of FR2-2 Work (Rapporteur Input), Qualcomm

[8] R2-2201032, Discussion on LBT impact, ZTE Corporation, Sanechips

[9] R2-2201014, Impacts of directional LBT on MAC procedure, Oppo