**3GPP TSG RAN WG1 Meeting #103-e R1-2009344**

**Oct 26th – Nov 13th, 2020**

**Agenda item: 8.2.2**

**Source: Moderator (Qualcomm Incorporated)**

**Title: FL summary for channel access mechanism for 52.6GHz-71GHz band**

**Document for: Discussion and Decision**

# Introduction

This paper summarizes the channel access related proposals submitted to agenda item 8.2.2

# Summary of contributions

The section summarises key proposals and observations from submitted contributions. A few proposals and questions to resolve based on the general leaning of the companies are captured in Section X.

The contributions

## Channel bandwidth, nominal bandwidth, and LBT bandwidth

A few papers discussed the definition of channel bandwidth, nominal bandwidth and LBT bandwidth.

### Nominal Bandwidth

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| **Company** | **Key Proposals/Observations/Positions** |
| Huawei, HiSilicon | Proposal 1: For operation in NR-U-60, multiple nominal channel BWs can be defined for a device as follows:A) Single carrier operation with K BWPs: K nominal channels are defined each with a BW equal to that of the corresponding BWP.B) CA with N non-contiguous CCs: N nominal channels are defined each with a BW equal to that of the corresponding CC.C) CA with M contiguous CCs: Defined nominal channels correspond to every contiguous subset of the M CCs where each nominal channel BW is equal to the sum of the BWs of the CCs in the corresponding subset. |
| Ericsson | Proposal 1 The nominal channel bandwidth should map to the channel bandwidths supported by the UE/gNB. |
|  | OCB RequirementsProposal 2: RAN1 shall further clarifies the OCB requirement as follows: For each declared nominal channel bandwidth, * If the channel is used for DL transmission, RAN1 design should support at least one DL physical layer signal/channel transmission that occupies at least 70% of the nominal channel bandwidth.
* If the channel is used for UL transmission, RAN1 design should support at least one UL physical layer signal/channel transmission that occupies at least 70% of the nominal channel bandwidth.

Proposal 3: RAN1 shall further clarifies that the “nominal channel bandwidth” in the OCB requirement refers to the channel bandwidths supported for each NR band, as defined in TS 38.101-X.  |
| NTT Docomo | Observation 1: There has been no clear definition in NR which is well relevant to the Nominal Channel Bandwidth defined in BRAN.* Although a unit of bandwidth for channel access (or a RB set) may be considered as the NCB, the unit of bandwidth for channel access (and channel access mechanism itself) is not clear at this stage.
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| Charter | Proposal 1: No special consideration is necessary for nominal channel bandwidth in EN BRAN 302 567 and mapping to NR bandwidth definitions. |

### LBT Bandwidth

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| **Company** | **Key Proposals/Observations/Positions** |
| Huawei, HiSilicon | Proposal 2: For operation in the 60 GHz band, the LBT BW can be greater than the carrier BW. Proposal 3: For operation in NR-U-60, the EDT formula adopted from draft v2.1.20 of EN 302 567 as a baseline should be adjusted to account for an LBT BW other than 2 GHz. |
| Apple | Observation 2: The possibility of an CCA measurement bandwidth that is larger than the transmission bandwidth may require a change to the basic LBT mechanism.  |
| CAICT | Proposal 4: One mode that aligns with or comparable WiFi 11ad channels of 2.16GHz bandwidth could be supported by CA and multiple LBT bandwidth.Proposal 5: Multiple LBT bandwidth could be considered for unlicensed band operation within 52.6-71GHz. |
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### Channel bandwidth

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Observation 5: For NR unlicensed bands between 52.6 GHz and 71 GHz, applicability of DFS based channel access schemes is dependent up on the channelization bandwidth and corresponding availability of number of such channels in different regionsProposal 5: For NR unlicensed bands between 52.6 GHz and 71 GHz, for further consideration of DFS as a potential channel access mechanism, either the channelization bandwidths need to be agreed first or BWPs switching could be considered to be associated with DFS |
| Nokia, Nokia Shanghai Bell | Proposal 3: Channelization based on 2.16 GHz is assumed in the channel access mechanism design. Proposal 4: Transmissions with a (channel) bandwidth smaller than 2.16 GHz, such as 400 MHz, are also supported by the channel access mechanism design |
| ZTE, Sanechips | Proposal 2: The channel bandwidth supported by UE and defined in NR can be regarded as the nominal channel bandwidth. Proposal 3: If coexistence with Wi-Fi is considered, or the absence of Wi-Fi node cannot be guaranteed, the following options can be further studied:* Option 1: Align the channelization of Rel-17 NR with Wi-Fi design at least in unlicensed band (e.g. 57 GHz - 71 GHz) and support 2.16 GHz channel bandwidth
* Option 2: No need to align the channelization of Rel-17 NR with Wi-Fi design. Study and evaluate how the coexistence is achieved between NR-U and Wi-Fi under different channel bandwidth.
 |
| Sonly | Proposal 1: NR devices support 2.16 GHz bandwidth in 60GHz spectrum as one of nominal channel bandwidths. |
| Apple | Proposal 3: Channel Access Mechanisms for single-carrier and multi-carrier modes should be supported.* When LBT is used, study channel access mechanisms assuming CCA on a bandwidth greater than the operating bandwidth
	+ Allow support for multi-carrier CCA where each carrier is smaller than the CCA bandwidth.
	+ Allow support for single-carrier CCA which is smaller than the CCA bandwidth
 |
| CAICT | Proposal 4: One mode that aligns with or comparable WiFi 11ad channels of 2.16GHz bandwidth could be supported by CA and multiple LBT bandwidth. |
| NTT Docomo | Observation 7: Channel bandwidth and assignment for IEEE 802.11ad/ay may need to be considered for channel bandwidth and assignment for NR in 57 – 71 GHz |

### Heterogeneous Channel bandwidths

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| **Company** | **Key Proposals/Observations/Positions** |
| Nokia, Nokia Shanghai Bell | Proposal 9: Consider the need for LBT ensuring fairness between cells with different bandwidths while maintaining efficient spatial reuse between cells of same bandwidth |
| Intel | Proposal 7: When operating in unlicensed 60 GHz band, in order to allow fair coexistence among incumbent systems, the ED threshold calculation shall account not only for the maximum output power, but also at least for the bandwidth used. |

### Discussion

On the definition of nominal bandwidth, though it may not have any spec impact, but a common understanding of it may help clarify the OCB requirement

FL proposal:

It is RAN1 understanding that nominal bandwidth is equivalent to channel bandwidth supported by UE or gNB as defined if 38.101.

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| **Company** | **View** |
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Discussion point:

Naturally we will support LBT bandwidth equal to channel bandwidth. Shall we further support

* LBT bandwidth narrower than the channel bandwidth
* LBT bandwidth wider than the channel bandwidth

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Discussion point:

Shall we support one mode to align the channelization between 11ad/ay and NR in 60GHz band

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## No-LBT

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| **Company** | **Key Proposals/Observations/Positions** |
| ZTE, Sanechips | Observation 1: According to regulation of ETSI EN 302 567 v2.1.20, at least LBT operation should be supported in Europe area for above 52.6 GHz. |
| Ericsson | Referring to Baseline LBT procedures based on 302567 v 2.1.20Observation 1 LBT is not mandated by any regional regulations for 57-71 GHz frequency band.Observation 2 In all three indoor scenarios (A, B and C), operating with LBT degrade the performance in terms of DL and UL throughput, as compared with operating without LBT.Observation 3 Ideal receiver assisted LBT does not show performance improvement as compared to no LBT.Observation 4 The effectiveness of LBT as medium access mechanism for co-existence in unlicensed spectrum in 60 GHz band is questionable.Observation 5 Good link adaptation algorithm is sufficient to cope with occasional interference in 60 GHz bandObservation 6 In outdoor Scenario B, operating with LBT degrade the performance in terms of DL and UL throughput, as compared with operating without LBT.Observation 7 ECC Report 288 concludes that in the 57-66 GHz band, system performance is reduced when LBT enabled, even with proper ED setting.Observation 8 Inter-/intra technology network operating with LBT procedure as specified in EN 302 567 is not harmed by a coexisting NR-U network that access the channel without LBTObservation 9 The benefit from directional LBT in 60GHz spectrum is not clear.Proposal 3 For operation in 60GHz, it is not beneficial to mandate operation with LBT as a medium access mechanism. |

### No-LBT mode

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 1: The study should clarify the No LBT conditions of usage. |
| Lenovo, Motorola Mobility | Observation 8: For NR unlicensed bands between 52.6 GHz and 71 GHz, long-term channel sensing could be useful for both LBT and without LBT based channel access mechanism:- For LBT based channel access mechanism, long-term sensing at the UE could be utilized for receiver assisted LBT at the gNB- For no LBT based channel access mechanisms, long-terms sensing could provide interference statistics in terms of potential interference from WiFi as well as interference from other NR operatorsProposal 8: For NR unlicensed bands between 52.6 GHz and 71 GHz, long term sensing could be supported for both LBT based and without LBT based channel access mechanism to consider potential interference |
| Huawei, HiSilicon | Observation 7: When No-LBT is used in regions where LBT is not mandated by regulations, the hidden node issue would still persist. |
| CATT | Proposal 1: Only when the local regulation makes it clear that LBT is not mandatory, gNB /UE can initiate channel occupancy directly without LBT.Proposal 5: The interference mitigation of beamforming based operation needs to be investigated in place of LBT based operation for distributed channel access scheme. |
| ZTE, Sanechips | Observation 3: No LBT can be considered to be used in COT sharing case and interference controlled environment.Observation 4: No LBT should be workable only if some interference elimination mechanisms are applied on top of it. If no LBT is supported, the spec impact of introducing such enhancement should be further studied and evaluated.Proposal 4: Release 17 NR-U should consider supporting different channel access modes for above 52.6 GHz, e.g., directional LBT and No LBT.  |
| Samsung | Proposal 4: It is beneficial to support an implicit or explicit indication of the operation mode to the UE: either channel access is operated with LBT or without LBT |
| OPPO | Proposal 3: the enhancement of no LBT transmission, e.g., interference mitigation mechanisms should be studied. |
| Sony | Observation 1: In EU, no-LBT mode cannot be operated at least under the ‘C1’ for indoor and outdoor deployment.Observation 2: No-LBT mode works in the uncongested environment.Observation 3: Congestion could be measured by average RSSI and channel occupancy which have been already introduced in NR-U.Proposal 6: No-LBT mode is configured in the environment where both average RSSI and channel occupancy are low. |
| Qualcomm | Observation 1: Shared spectrum operation with high directivity systems experiences low interference and good performance on the aggregate. Moreover, the gain of LBT schemes over no LBT schemes is minimal on the aggregate.  |

### Long Term Sensing

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 11: The study should clarify the term of “long-term sensing” and its usage. |
| Lenovo, Motorola Mobility | Observation 8: For NR unlicensed bands between 52.6 GHz and 71 GHz, long-term channel sensing could be useful for both LBT and without LBT based channel access mechanism:- For LBT based channel access mechanism, long-term sensing at the UE could be utilized for receiver assisted LBT at the gNB- For no LBT based channel access mechanisms, long-terms sensing could provide interference statistics in terms of potential interference from WiFi as well as interference from other NR operatorsProposal 8: For NR unlicensed bands between 52.6 GHz and 71 GHz, long term sensing could be supported for both LBT based and without LBT based channel access mechanism to consider potential interference |
| Huawei, HiSilicon | Proposal 7：For operation in the 60 GHz band, in regions where LBT is not mandated, a gNB/UE can initiate a channel occupancy access using a channel access mechanism without LBT if it is used in conjunction with a short-term or a long-term interference mitigation scheme.Observation 5：The long-term interference mitigation schemes such as ATPC or DFS would be implemented as specified by the region-specific regulations and do not need to be specified by 3GPP. - Rel-16 NR-U specifications did not capture the DFS requirements and procedures specified by the ETSI BRAN HS for 5GHz (EN 301 893) |
| CATT | Proposal 2: To obtain channel occupancy condition which help Tx node to configure channel access mode , a periodic and long term RSSI or CCA measurements procedure can be introduced.  |
| OPPO | Proposal 3: the enhancement of no LBT transmission, e.g., interference mitigation mechanisms should be studied. |
| Convida | Re: Exposed node issue : Proposal 5: Study methods to enhance resource utilization and interference in 52.6 GHz and above. Proposal 6: Enhancement of beam operation should be investigated to mitigate interference |
| NTT Docomo | Observation 6: On mechanism to switch channel access mechanism, the following two options could be studied• Option 1. To determine channel access mechanism by itselfo Indication of determined channel access mechanism to its communication partner(s) may be necessary• Option 2. To follow indication/reporting from other devicesProposal 1: On condition to switch channel access mechanism, even if LBT is not mandatory, at least long-term channel condition such as congestion situation should be considered. * To observe the long-term channel condition, sensing the channel with longer periodicity such as RSSI/channel occupancy measurement could be possibility
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| Charter | Observation 1: Existing NR features appear to be sufficient for supporting ATPC, DFS, long-term sensing, etc. |
| Qualcomm | Proposal 3: Consider measurements intervals for long term sensing as designated transmission opportunities for detection of potentially interfered nodes and enabling collision resolution selectively. The collision resolution techniques can be per-COT LBT, TX power limitation, and/or duty cycle limitation. |

### DFS

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 5: For NR unlicensed bands between 52.6 GHz and 71 GHz, for further consideration of DFS as a potential channel access mechanism, either the channelization bandwidths need to be agreed first or BWPs switching could be considered to be associated with DFS |
| Huawei, HiSilicon | Observation 5：The long-term interference mitigation schemes such as ATPC or DFS would be implemented as specified by the region-specific regulations and do not need to be specified by 3GPP. - Rel-16 NR-U specifications did not capture the DFS requirements and procedures specified by the ETSI BRAN HS for 5GHz (EN 301 893) |
| Nokia, Nokia Shanghai Bell | Proposal 2: Consider DFS as channel mechanism without LBT for use cases not limited to fixed network equipment but not requiring LBT either.  |
| Charter | Observation 1: Existing NR features appear to be sufficient for supporting ATPC, DFS, long-term sensing, etc. |

### ATPC

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Observation 6: For NR unlicensed bands between 52.6 GHz and 71 GHz, in order to adopt ATPC as potential channel access mechanism, receiver feedback such as long-term sensing would be needed |
| Huawei, HiSilicon | Observation 5：The long-term interference mitigation schemes such as ATPC or DFS would be implemented as specified by the region-specific regulations and do not need to be specified by 3GPP. - Rel-16 NR-U specifications did not capture the DFS requirements and procedures specified by the ETSI BRAN HS for 5GHz (EN 301 893) |
| CATT | Observation 2: APTC function for uplink and downlink transmission can be supported base on R15 power control/allocation frame work. |
| Nokia, Nokia Shanghai Bell | Proposal 1: NR for 60 GHz band shall be able to fulfil the EN 303 722 requirements for spectrum sharing based on automatic transmit power control and/or automatic link adaptation. Needed specification changes, if any, are to be studied along with EN 303 722 progress. |
| Spreadtrum Communications | Proposal 3: The medium access mechanism of ATPC and DFS should be studied in 60GHz unlicensed band. |
| Charter | Observation 1: Existing NR features appear to be sufficient for supporting ATPC, DFS, long-term sensing, etc. |

### No-LBT/LBT switching

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI |  |
| Xiaomi | Proposal 2: For CG-PUSCH, mechanism and condition(s) switching between LBT and LBT-free channel access should be studied. |
| CATT | Proposal 3: When initialing the channel occupancy, gNB shall determine the channel access mode according to the relationship between the result of measurements and configured threshold. |
| Nokia, Nokia Shanghai Bell | Proposal 15: Channel access mechanism is part of cell configuration. Proposal 16: Flexible selection of channel access mechanism per gNB beam is considered. |
| Ericsson | Proposal 5 The condition to use/skip LBT is left for implementation. 3GPP needs to only design signaling to communicate the support of LBT |
| LG Electronics | Proposal #4: The channel access with LBT mechanism can be switched to a channel access mechanism without LBT during limited time only when the local regulation allows initiating channel occupancy without LBT and the specific conditions such as low interference environment are met. |
| Spreadtrum Communications | Proposal 3: The medium access mechanism of ATPC and DFS should be studied in 60GHz unlicensed band. |
| Samsung | Proposal 4: It is beneficial to support an implicit or explicit indication of the operation mode to the UE: either channel access is operated with LBT or without LBT |
| Sony | Observation 1: In EU, no-LBT mode cannot be operated at least under the ‘C1’ for indoor and outdoor deployment.Observation 2: No-LBT mode works in the uncongested environment.Observation 3: Congestion could be measured by average RSSI and channel occupancy which have been already introduced in NR-U.Proposal 6: No-LBT mode is configured in the environment where both average RSSI and channel occupancy are low. |
| Apple | Proposal 1: The mechanism and condition(s) to switch between channel access with LBT and channel access without LBT should allow:* Switching between LBT-based and non-LBT based access based on the regulatory environment only or based on the interference environment the UE(s) experience when regulation allows.
* For LBT channel access, non-LBT transmission for specific channels (e.g. SSB) can occur in at most 10% of the COT.
 |
| NTT Docomo | Observation 5: Even if LBT is NOT mandatory to access channel, some operation restriction for channel access without LBT may be beneficial in some scenario• However, unless LBT mechanism for 60 GHz is clarified, how much LBT is helpful in such scenario is unclearObservation 6: On mechanism to switch channel access mechanism, the following two options could be studied• Option 1. To determine channel access mechanism by itselfo Indication of determined channel access mechanism to its communication partner(s) may be necessary• Option 2. To follow indication/reporting from other devices |
| Potevio | Proposal 4: At least network density and traffic load could be studied as conditions to switch between channel access with LBT and channel access without LBT. |
| Charter | Observation 2: The need to switch between channel access with LBT and channel access without LBT is not well motivated. |

### Discussion

For regions where LBT is not required, it has been discussed if additional conditions can be introduced in 3GPP spec to enable no-LBT mode and what are the conditions.

FL proposal:

gNB should indicate the system is operating in LBT mode or no-LBT mode as part of system information

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Discussion point:

For regions where LBT is not mandated, shall we introduce additional conditions for no-LBT to be used, or leave it for gNB implementation

* The condition can be based on DFS, long term sensing, etc

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Discussion point:

For regions where LBT is not mandated, shall we introduce additional restrictions when no-LBT is used, or leave it for gNB implementation

* Shall we design ATPC-like mechanism to be used in no-LBT mode
* Shall we design DFS-like mechanism to be used in no-LBT mode
* Shall we design long term sensing type mechanism to be used in no-LBT mode
* Shall we design duty-cycle restriction mechanism to be used in no-LBT mode
* Shall we design transmit power restriction mechanism to be used in no-LBT mode

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Discussion point:

For regions where LBT is not mandated, when operating in no-LBT mode, shall we further define mechanism for the system to fall back to LBT mode

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## LBT Types and COT

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| **Company** | **Key Proposals/Observations/Positions** |
| CAICT | Proposal 1: CAT2 based directional LBT could be considered for 52.6-71GHz.Proposal 2: The mechanism of CAT2 based directional LBT for DRS and data transmission within a COT could be different.Proposal 3: The mechanism for CAT4 based directional LBT should be considered and the detail design could be FFS. |
| NTT Docomo | Observation 3: On sensing timing of LBT (event-driven manner such as LBE, or periodic manner such as FBE), following aspects need to be taken into account:* Robustness against congestion with coexisting systems
	+ Event-driven sensing with random back-off has higher robustness, but highly congested situation in higher frequency may be a corner case
	+ Periodic sensing may cause potential unfairness issue in highly congested situation
* Resource utilization efficiency
	+ Event-driven sensing would provide lower efficiency especially in case of less congested situation
	+ Periodic sensing would provide higher efficiency especially in case of less congested situation
* Latency
	+ Event-driven sensing may lead larger latency at least in less congested situation
	+ Periodic sensing may lead smaller latency at least in less congested situation
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### LBT Parameters, COT duration, Gaps

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 2: For LBT channel access the maximum COT shall be 5ms.Proposal 3: For LBT channel access the default maximum time gap between consecutive transmissions in the COT without additional LBT should be at least 13 us.Proposal 4: NR should support configuration of larger gaps between consecutive transmissions in a COT without LBT required. |
| vivo | Proposal 2: The channel access mechanism can be selected based on the channel occupancy time, channel access rate, transmission priority, service requirement, or feedback information from the receiver, etc. |
| Nokia, Nokia Shanghai Bell | Proposal 11: gNB can serve multiple beams in TDM manner, resulting in transmissions gaps on a beam, within a COT after sensing the channel on the corresponding directions at the beginning of the COT. |
| Intel | Proposal 3: For a system operating in unlicensed 60 GHz band, the maximum channel occupancy time (MCOT) should never exceed 5 ms.  |
| Sony | Proposal 5: Channel access parameters (such as LBT category, ED threshold, CWS adjustment, CAPC, etc.) need to be studied in order to fit with 60 GHz channel conditions. |

### ED threshold adaptation

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 7: The value of Pout in the CCA Check before initiating a COT should correspond to the maximum EIRP of the transmissions during that COT. |
| Intel | Proposal 8: When operating in unlicensed 60 GHz band, the ED threshold calculation shall account for the type of LBT mechanism used. |

### COT Sharing

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| **Company** | **Key Proposals/Observations/Positions** |
| Intel | Proposal 4: When a COT is acquired by an initiating device, this can be shared with any other device for which the transmission of the initiating device is targeted to. Proposal 5: It is up to the gNB on whether to mandate or not the use of LBT before attempting any transmission from any device within an initiating device’s acquired COT |
| ZTE, Sanechips | Observation 3: No LBT can be considered to be used in COT sharing case and interference controlled environment. |
| LG Electronics | Proposal #6: It would be beneficial for coexistence that channel occupancy acquired by directional LBT is shared only for DL and UL signals/channels having spatial QCL relationship. |

### CWS and CAPC

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| **Company** | **Key Proposals/Observations/Positions** |
| Huawei, HiSilicon | Proposal 8：The procedures specified for CWS adjustment and multi-channel access in Rel-16 NR-U should be considered for operation in the 60 GHz band with necessary modifications when LBT is used.Proposal 9：For operation in the 60 GHz band, when LBT is used within the COT, NR-U should consider to reuse the corresponding channel access procedures for 5/6GHz and modify the channel access parameters in accordance with the ETSI BRAN Harmonized Standard. |
| CATT | The LBT schemes studied in Rel-16 NR-U focusing in sub-6GHz frequency and included the following categories, • Category 1(Immediate transmission after a short RX/TX switching gap), • Category 2(LBT without random back-off, the duration time is more than 16us and less than 25us)• Category 4( LBT with random back-off with a contention window of variable size) Proposal 4: For NR operation in 52.6 - 71GHz, these three LBT categories can be considered as the starting points for proposal and evaluations. The setting of LBT parameters for NR operation in unlicensed spectrum should use those defined in 802.11ad as the reference for the study of the coexistence.  |
| Intel | Proposal 6: RAN1 should discuss and identify the values Zmin and Zmax for the CCA procedure agreed and captured in TR 38.808 [5]. Further RAN1 should investigate on whether these values should depend on the type of transmission and physical channel that the device performs, and/or on the type of traffic and. |

### Discussion

EN 302 567 only defines the CCA check at the initiating device, which can be consider as a Cat 4 LBT type mechanism.

FL proposal:

Use the CCA check procedure in EN 302 567 (per RAN1 understanding as from RAN1 #102-e) as the baseline for the Cat 4 LBT design for 60GHz band.

* FFS: Any parameter change needed
* FFS: Do we need to introduce CAPC
* FFS: Do we need to introduce contention window adjustment

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EN 302 567 defines the MCOT to be 5ms.

FL proposal:

MCOT is 5ms, including all the gaps inside

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The EN 302 567 does not explicitly define the gap allowed for COT sharing. Shall we define maximum gap or allow any gap with the COT

Discussion point:

For COT sharing without LBT at responding device, do we need to define a maximum gap?

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Discussion point:

Shall we introduce Cat 2 LBT for 60GHz band for responding device in COT sharing and/or initiating device transmits another burst in its own COT. If yes, how to define Cat 2 LBT.

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Discussion point:

For COT sharing with LBT at responding device, do we need to define a maximum gap?

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Discussion point:

Should ED threshold be a function of LBT bandwidth

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## CET and short control signalling

### Short Control Signalling with CET

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| **Company** | **Key Proposals/Observations/Positions** |
| Ericsson | Proposal 2. When operating with LBT, a node can access the channel for up to 10% without LBT for control signal/channel transmission(s) |
| Apple | For LBT channel access, non-LBT transmission for specific channels (e.g. SSB) can occur in at most 10% of the COT. |
| Nokia | Proposal 6: LBT procedure for 60 GHz band supports channel access without channel sensing for UE responding within a gNB initiated shared COT. Proposal 7: Support LBT exempt transmissions for SSBs and other reference signals critical for cell operation.Proposal 8: Support LBT exempt UL transmissions with a low Tx power (e.g. 10 dBm or less) and with a certain minimum beamforming gain for better support of low latency PRACH, SR or CG-PUSCH |

### Discussion

Discussion point:

Shall we support short control signalling based contention exempt transmission in 60GHz band?

* Any restriction to the transmission, on duty cycle (10%?), content (control signalling only? SSBs? CSI-RS?), TX power

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Discussion point:

If we support short control signalling based transmission, do we apply Cat 2 LBT or Cat 1 LBT?

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## Direction LBT

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 9: The study should clarify the definition of “omni-directional LBT” or remove it. |
| Lenovo, Motorola Mobility | Observation 1: For NR unlicensed bands between 52.6 GHz and 71 GHz, for LBT based channel access mechanism, if only omni-directional LBT is supported, then the exposed node problem could result in reduce spatial reuse. Observation 2: For NR unlicensed bands between 52.6 GHz and 71 GHz, for LBT based channel access mechanism, if only omni-directional LBT is supported, then the coverage of the beamformed transmissions/receptions could be limited for fair coexistence by having similar range as with omni-directional LBTObservation 3: For NR unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, if directional LBT is agreed to be supported, then the beam-management and directional LBT procedures are expected to be tightly coupled or inter-dependent. Observation 4: For NR unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, if directional LBT is supported, then performing LBT only at the transmitted side may not guarantee an interference-free reception due to hidden nodes to the transmitterProposal 1: For NR unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, directional LBT operation at both the gNB and UE should be supportedProposal 2: For NR unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, if directional (beam-based) LBT operation is agreed to be supported, then the omni-directional LBT procedures and corresponding beam-based transmission and reception procedures specified for unlicensed bands in FR1 in NR Rel-16 should be enhanced to adapt accordingly for facilitating beam-based LBT operation |
| Huawei, HiSilicon | Observation 1: It should be clarified whether antenna gain is counted in the received energy when comparing with the EDT.Proposal 4: For operation in NR-U-60, the EDT formula adopted from draft v2.1.20 of EN 302 567 as a baseline should be adjusted to account for the beamforming gain of the potential following transmission.Observation 2: (Quasi-)omni-directional simplifies the implementation and allows for reusing Rel-16 NR-U LBT procedures but could lead to an ‘over protection’ problem and thus reduction of spatial reuse. Observation 3: Directional LBT potentially improves the channel access probability and enhances the spatial reuse. However, when performed at the transmitter side, the hidden node problem could be more severe due to limited sensing direction. Observation 4: Compared to (quasi)-omni-directional LBT, directional LBT increases complexity and overhead for gNB to serve multiple UEs in different directions. Proposal 5：For operation in the 60 GHz band, in regions where LBT is mandated, transmitter side (quasi)-omni-directional LBT and directional LBT should be considered for different scenarios.  |
| Xiaomi | Proposal 1: Directional CCA can increase network efficiency compared to omnidirectional CCA. Directional CCA both at transmitter and receiver side should be studied. |
| vivo | Proposal 1: If directional LBT is used in 60 GHz band, the CCA energy should be calculated as one specific beamforming direction including beamforming gain. |
| Interdigital | Observation 1: Omni-directional LBT in unlicensed spectrum from 52.6GHz to 71GHz can under-represent interference in the direction of the associated transmission and over-represent interference in other directions.Observation 2: Dynamic scenarios with some level of mobility increases the likelihood of transmitter-receiver pairs interfering with each other even when using narrowbeams.Observation 3: Directional LBT provides benefits over no LBT for dynamic scenarios with some level of mobility, while reducing the drawbacks associated with omni-directional LBT.Proposal 1: Directional LBT is supported for channel access from 52.6GHz to 71GHz.Proposal 2: A single directional LBT process can be performed on a beam whose parameters are determined from the parameters of the Tx beam of one or more associated transmissions. |
| CATT | Observation 1: The energy detection algorithm of LBT based on the assumption of omni antenna is not feasible for the beamforming based Tx/Rx operation. Proposal 6: The mechanism of LBT enhancement for beamforming operation in 52.6-71 GHz can be studied as follows, • The procedure of directional LBT with same beamwidth of PDCCH/PDSCH. .• The handshake mechanism (e.g. measurement and report) with UE feedback of channel status at the receiver in helping gNB in determining the clear channel status.  |
| TCL | Proposal 1: RAN1 shall study channel access mechanisms based on directional LBT.Proposal 3: RAN1 shall study solutions to mitigate the effect of LBT deafness, beam orthogonality and beam imbalance in order to enable directional LBT at UE side without harming NR-U channel access efficiency.Proposal 4: RAN1 shall consider the usage of directional LBT at gNB side. |
| ATT | Support of directional LBT |
| Nokia, Nokia Shanghai Bell | Observation 1: Both omnidirectional and directional LBTs need to be considered on the channel access design.(but prefer gNB implementation to choose which one)Proposal 10: Beamforming for gNB’s LBT is left for implementation as much as possible and only necessary requirements are specified.Proposal 11: gNB can serve multiple beams in TDM manner, resulting in transmissions gaps on a beam, within a COT after sensing the channel on the corresponding directions at the beginning of the COT. |
| Intel | Observation 1: Omni-directional LBT may act in many cases overprotectively and may prevent from fully exploiting spatial reuse under highly directional transmissions. This issue may be mitigated through directional LBT. However, directional sensing exacerbates the well-known hidden node issue, and leads to scenarios where the system could suffer from deafness.Proposal 1: Both directional and omni-directional LBT are supported, and it may be up to the network which LBT to use based on the specific use case and scenario.Observation 2: Receiver-aided LBT is able to mitigate the issues introduced by directional LBT and offers a mean to better assess the correct level of interference at the receiverProposal 2: If directional LBT is supported, a receiver-aided LBT should complement its CCA procedure. FFS: details on how to support this feature.Proposal 8: When operating in unlicensed 60 GHz band, the ED threshold calculation shall account for the type of LBT mechanism used. |
| ZTE, Sanechips | Observation 2: Compared to omni-directional LBT, directional LBT is beneficial to increase the probability of channel access and the spatial reuse efficiency for NR-U, and the impact on the performance of the existed Wi-Fi system is negligible. Proposal 4: Release 17 NR-U should consider supporting different channel access modes for above 52.6 GHz, e.g., directional LBT and No LBT.  |
| Ericsson | Observation 9 The benefit from directional LBT in 60GHz spectrum is not clear. |
| LG Electronics | Proposal #3: If directional CCA procedure with beam based transmission is identified as beneficial, the followings for directional CCA procedure can be considered:* CCA threshold setting
* Relationship between transmission direction and CCA direction
* Directional LBT for broadcast/unicast transmission
* CWS management

Proposal #5: It should be studied that how to indicate the direction of LBT (e.g., omni-directional LBT or directional LBT) and the type of LBT (e.g., Type 1 or Type 2A/2B/2C channel access procedure in NR-U) when scheduling a UL transmission inside or outside of a channel occupancy.Proposal #6: It would be beneficial for coexistence that channel occupancy acquired by directional LBT is shared only for DL and UL signals/channels having spatial QCL relationship. |
| Spreadtrum Communications | Proposal 1: The directional LBT should be studied in 60GHz unlicensed band. |
| Samsung | Proposal 5: RAN1 shall study the channel access mechanism with directional channel sensing.Observation 1: Directional LBT performs better than omni-directional LBT. Observation 2: Directional LBT performs better than no LBT in high load case, and performs worse than no LBT in low load case. Observation 3: Directional LBT has higher performance gain for 5% tile UEs. |
| OPPO | Proposal 2: the feasibility of directional LBT should be studied.  |
| Sony | Proposal 2: Directional LBT should be supported on 60 GHz unlicensed operationProposal 4: Relationship between the sensing beam and transmission beam should be considered if directional LBT is supported. * Beam of all transmissions on a COT should be contained within the sensing beam used for acquiring the COT.
 |
| Apple | Observation 1: The large propagation losses in the 60 GHz range mandate the need for beam-based transmission and the need for LBT schemes that account for these beams.Proposal 4: RAN1 to support directional LBT in scenarios where LBT is mandated.  |
| CAICT | Proposal 2: The mechanism of CAT2 based directional LBT for DRS and data transmission within a COT could be different.Proposal 3: The mechanism for CAT4 based directional LBT should be considered and the detail design could be FFS. |
| Convida | Proposal 1: Directional LBT and interference mitigation should be studied.Proposal 2: Omni-directional LBT and directional LBT should be considered and supported. |
| NTT Docomo | Observation 2: On directivity of LBT, following aspects need to be taken into account:• The different sensing area between omni-directional LBT and directional LBT would lead different sensitivity to presence/absence of transmission from surrounding device Omni-directional LBT can only detect presence of transmission from surrounding device in proximity but in all directions so that unnecessary LBT failure may happen Directional LBT can only detect presence of transmission from surrounding device in the transmission direction• Appropriate approach could depend on types of the intended transmission in the acquired channel occupancy. |
| ITRI | Proposal 1: Directional LBT should be supported in R-17 NR-U. |
| Potevio | Proposal 1: For LBT based channel access mechanism in 60GHz unlicensed band, directional LBT combining with receiver-assisted LBT should be studied in comparison to no-LBT based access mechanism.Proposal 3: For channel access mechanism with directional LBT, simultaneous LBT procedures for different directions should be studied to mitigate the transmission latency and increase channel access probability. |
| Qualcomm | Proposal 2: Consider the use of antenna gain of sensing beam and transmission beam to determine the suitability of using a given sensing beam in conjunction with another transmission beam.  |

### Discussion

There is strong support to support or study directional LBT. On the other hand, in mmW system, likely there is no true “omni-directional” LBT in the beginning. When we discuss “directionality” of LBT, we should discuss its relationship with transmission beam.

Discussion point:

Should 3GPP spec defines the relationship between the LBT beam and the transmission beam or leave it as implementation. For example, should we define something like the LBT beam should “cover” the transmission beam?

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If we define the relationship between LBT beam and TX beam, another question to answer is if ED threshold should be adjusted by the LBT beam and TX beam choices. For example, given a fixed TX beam, using a pseudo-omni beam or the same TX beam for LBT will produce different LBT ED measurement given the same interference.

Discussion point:

If 3GPP spec defines the relationship between the LBT beam and the transmission beam ,shall we also define the impact to ED threshold given a certain LBT beam and transmission beam, or use a fixed ED threshold?

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## Rx Assistance in LBT process

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 10: Receiver assisted LBT is an LBT operation that relies both on channel measurements at the transmitter and on channel measurements at the receiver |
| Lenovo, Motorola Mobility | Observation 6: For NR unlicensed bands between 52.6 GHz and 71 GHz, in order to adopt ATPC as potential channel access mechanism, receiver feedback such as long-term sensing would be neededObservation 8: For NR unlicensed bands between 52.6 GHz and 71 GHz, long-term channel sensing could be useful for both LBT and without LBT based channel access mechanism:- For LBT based channel access mechanism, long-term sensing at the UE could be utilized for receiver assisted LBT at the gNB- For no LBT based channel access mechanisms, long-terms sensing could provide interference statistics in terms of potential interference from WiFi as well as interference from other NR operatorsProposal 4: For NR unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, receiver assisted LBT could be supported along with directional LBT to take into account the potential interference at the receiver |
| Huawei, HiSilicon | Proposal 6：For operation in the 60 GHz band, in regions where LBT is mandated, receiver-assisted LBT with directional LBT should be supported.Observation 6: Receiver-assisted directional LBT is beneficial for cell-edge users in indoor scenario especially in medium and high traffic load. |
| Xiaomi | Proposal 1: Directional CCA can increase network efficiency compared to omnidirectional CCA. Directional CCA both at transmitter and receiver side should be studied. |
| vivo | Observation 1: For cell edge UEs, compared to no-LBT scheme, the ED-based LBT schemes cause some UPT performance loss when the traffic load is low. In high load, there’s some slight performance gain.Observation 2: The receiver-assisted LBT is not observed with apparent gain compared with ED-based LBT for cell edge UEs but slight performance gain for average UPT in indoor scenario A.Observation 3: The receiver-assisted LBT shows significant gain in severe interference scenarios.Proposal 2: The channel access mechanism can be selected based on the channel occupancy time, channel access rate, transmission priority, service requirement, or feedback information from the receiver, etc. |
| CATT | Proposal 6: The mechanism of LBT enhancement for beamforming operation in 52.6-71 GHz can be studied as follows, • The procedure of directional LBT with same beamwidth of PDCCH/PDSCH. .• The handshake mechanism (e.g. measurement and report) with UE feedback of channel status at the receiver in helping gNB in determining the clear channel status.  |
| AT&T | Enhancements for receiver assisted LBT |
| Nokia, Nokia Shanghai Bell | Observation 2: Considerable benefits from Rx assistance should be shown in a reasonable range of different situations and with realistic UE feedback delays given the considerable implementation effort involved.Proposal 12: Rx assistance, if supported, should be configurable per UE, so that it could be used only with UEs frequently detecting high interference.Proposal 13: If Rx assistance is supported, UE processing time similar to PDSCH processing time (N1) or CSI computation time (N2/Z1Z2) should be considered for providing Rx assistance.Proposal 14: If Rx assistance is supported, Rx assistance should not be limited to the beginning of COT only.  |
| Intel | Observation 2: Receiver-aided LBT is able to mitigate the issues introduced by directional LBT and offers a mean to better assess the correct level of interference at the receiverProposal 2: If directional LBT is supported, a receiver-aided LBT should complement its CCA procedure. FFS: details on how to support this feature. |
| Ericsson | Proposal 4. For operation in 60GHz, it is not beneficial to support receiver assisted LBT. |
| Spreadtrum Communications | Proposal 2: The receiver assisted LBT should be studied in 60GHz unlicensed band. |
| Samsung | Proposal 6: RAN1 shall study the channel access mechanism with handshake between transmitter and receiver.  |
| Sony | Proposal 3: Receiver assisted LBT should be supported on 60 GHz unlicensed operation.  |
| Apple | Proposal 5: RAN1 to support an RTS/CTS-like mechanism to help in mitigating directional interference or potential hidden node issues in scenarios where LBT is mandated. |
| Convida | Proposal 4: Receiver assisted LBT should be supported in 52.6 GHz and above.Re: Exposed node issue : Proposal 5: Study methods to enhance resource utilization and interference in 52.6 GHz and above. Proposal 6: Enhancement of beam operation should be investigated to mitigate interference |
| NTT Docomo | Observation 4: On receiver-assisted LBT, * It is beneficial to detect channel condition at Rx device which would be more invisible from Tx device in higher frequency
* It needs more procedure burden while how it is actually beneficial in higher frequency is questionable
 |
| Potevio | Proposal 1: For LBT based channel access mechanism in 60GHz unlicensed band, directional LBT combining with receiver-assisted LBT should be studied in comparison to no-LBT based access mechanism. |
| Qualcomm | Observation 2: Aggregate performance may not be representative of individual drops due to the highly directional nature of links. In the events where interference becomes an issue, Rx-assistance based LBT schemes outperform Tx-only LBT schemes as well as not doing LBT at all.Observation 3: Under scenarios with low interference diversity, there can be scenarios (depends on locations of transmitters and receivers) persistent interferers present and cause significantly reduced SINR or outage. A receiver assisted LBT mechanism can help those scenarios.Proposal 1. Consider receiver assisted LBT mechanism for scenarios with low interference variation. |

### Discussion

There is strong support to support or study RX assisted LBT, mainly to solve the hidden node issue. However, there may not be a common understanding on what is RX assisted LBT. Might be good to clarify the definition first

Discussion point

Receiver assisted LBT can the categorized into the following classes

* Class A. Receiver provides assistance information (signalling) to transmitter only, but does not provide information to other NR transmitter/receivers
	+ Eg. UE provides information to serving gNB, and gNB provides information to COT initiating UE
	+ In this case, cross link coexistence is based on ED.
* Class B. Receiver provides assistance information (signalling) to other NR nodes, including non-serving nodes
	+ In this case, cross RAT coexistence is based on ED
	+ Class B1. Intra-operator only
	+ Class B2. Also including inter-operator signalling
		- In this case, cross operator coexistence is based on ED
* Class C. Receiver provides assistance information (signalling) to other NR nodes and nodes from other RAT

Note that for the case receiver provides long term measurement information, we can consider it in the no-LBT design.

Please provide your view on which class you are supporting

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## Multibeam operation

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| **Company** | **Key Proposals/Observations/Positions** |
| Xiaomi | Proposal 3: Multi-beam transmission should be studied to fully take advantage of spatial diversity. |
| CATT | Proposal 7: For increasing the channel access opportunities, the scheme of multi-beam ED measurement in a sensing slot can be studied. Proposal 8: In order to alleviate the hidden node problem in directional LBT, a method of Multi-DCI transmission in different beam direction for a PDSCH scheduling should be considered. |
| Nokia, Nokia Shanghai Bell | Proposal 11: gNB can serve multiple beams in TDM manner, resulting in transmissions gaps on a beam, within a COT after sensing the channel on the corresponding directions at the beginning of the COT. |
| ZTE, Sanechips | Proposal 5: For multiple transmission(s) with different beams case, channel condition difference for different beams should be considered when designing the channel access schemes for COT sharing in NR unlicensed spectrum. |
| Potevio | Proposal 3: For channel access mechanism with directional LBT, simultaneous LBT procedures for different directions should be studied to mitigate the transmission latency and increase channel access probability. |

### Discussion

Discussion point:

Within a COT, shall we support spatial multiplexing of multiple beams (MU-MIMO), and what is the LBT requirement?

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Discussion point:

Within a COT, shall we support TDM multiplexing of multiple beams? If we do, shall we perform LBT at the beginning of the COT with no LBT in the middle, or shall we perform LBT at the beginning, and perform additional LBT for each beam switching in the middle?

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## SSB related

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| **Company** | **Key Proposals/Observations/Positions** |
| Convida | Proposal 8: Increasing the number of SSB candidate positions to above 64 to increase transmission opportunities to cope with LBT failure should be studied. |
| CATT | Proposal 9: The enhancement of LBT mechanism for SSB transmission shall be studied for narrow beamwidth beamformed operation up to 71 GHz. |
| NTT Docomo | Proposal 2: Regarding potential required changes considering NR operation in unlicensed band, * LBT related issues, e.g. SSB candidate position and non-consecutive RO, may need to be discussed after the discussion on LBT mechanisms.
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### Discussion

Discussion point:

For SSB transmission, do we need to introduce additional candidate SSB positions?

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##  Misc issues

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Configured grant: Observation 7: Depending on the configuration, a collision on CG resources can cause systematic collisions between corresponding subsequent retransmissions causing transmission failure of affected packets.Proposal 7: Adopt CG retransmission collision avoidance techniques such as retransmission deferral or additional retransmission resources. |
| Xiaomi | Proposal 2: For CG-PUSCH, mechanism and condition(s) switching between LBT and LBT-free channel access should be studied. |
| TCL | Coexistence: 11ad Proposal 2: RAN1 shall study directional LBT at UE side to guarantee fair coexistence with 802.11ad. |
| ZTE, Sanechips | Proposal 1: The key regulation rules for above 52.6 GHz, including channel access mechanism, OCB, COT, EIRP and PSD should be supported and enhanced to achieve good spectrum sharing with other systems, especially for Wi-Fi 802.11ad/ay. |
| LG Electronics | Proposal #2: It is necessary to enhance the method of determining ED threshold with consideration of the maximum output power and the unit LBT bandwidth applied in NR and the fair coexistence with the incumbent system (e.g., WiGig) operating in frequency range from 52.6GHz to 71 GHz. |
| Samsung | Proposal 1: The design of channel access mechanism shall comply to the regulation requirement, if applicable, and guarantee fair coexistence with 802.11 ad operating on the 60 GHz unlicensed spectrum. OCB RequirementsProposal 2: RAN1 shall further clarifies the OCB requirement as follows: For each declared nominal channel bandwidth, * If the channel is used for DL transmission, RAN1 design should support at least one DL physical layer signal/channel transmission that occupies at least 70% of the nominal channel bandwidth.
* If the channel is used for UL transmission, RAN1 design should support at least one UL physical layer signal/channel transmission that occupies at least 70% of the nominal channel bandwidth.
 |
| Apple | Observation 3: Unlicensed access for NR operating between 52.6 GHz and 71 GHz in the unlicensed band will have to co-exist with existing RATs such as IEEE 802.11ad and IEEE 802.11ay that require an operating bandwidth of 2.16 GHzProposal 2: Support at least one mode that aligns with WiFi 11ad/11ay channels of 2.16GHz bandwidth* Both single carrier and multi-carrier modes should be supported
* Allow an operating channel BW < 2.16 GHz bandwidth
 |
| Convida | Proposal 7: Wideband operation and coexistence with other RAT should be investigated considering UE power consumption and complexity.  |
| Convida | More SSB Candidates |
| LGE | LBT Mode indication |
| Intel, HW | Introduce CAPC and CW  |
| AT&T  | FBE |
| AT&T | Licensend CC assisted LBT |
| Lenovo | Observation 1: For NR unlicensed bands between 52.6 GHz and 71 GHz, for LBT based channel access mechanism, if only omni-directional LBT is supported, then the exposed node problem could result in reduce spatial reuse. Observation 2: For NR unlicensed bands between 52.6 GHz and 71 GHz, for LBT based channel access mechanism, if only omni-directional LBT is supported, then the coverage of the beamformed transmissions/receptions could be limited for fair coexistence by having similar range as with omni-directional LBTObservation 3: For NR unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, if directional LBT is agreed to be supported, then the beam-management and directional LBT procedures are expected to be tightly coupled or inter-dependent. Observation 4: For NR unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, if directional LBT is supported, then performing LBT only at the transmitted side may not guarantee an interference-free reception due to hidden nodes to the transmitterDirectional LBT Coupled with Beam Management |
| FUTUREWEI | Multi-Channel Operation: Proposal 5: Consider the multi-channel operation described in TS 37.213 as the baseline multi-channel NR operation. |
| Interdigital | Configuration signaling: Proposal 6: The UE receives configuration and indication of the channel access mechanism to use (omni-directional, directional, receiver based, no LBT) from the gNB. FFS if configuration/indication is by RRC or L1 signaling.Proposal 7: RAN1 to consider if a UE can select a channel access mechanism as a function of measurements or prior LBT success or failure |
| CATT | Proposal 8: In order to alleviate the hidden node problem in directional LBT, a method of Multi-DCI transmission in different beam direction for a PDSCH scheduling should be considered. |
| TCL  | Beam Transition/Switching:Proposal 5: It is proposed to investigate the mechanisms which can avoid collisions due to double ownership of the shared carrier at beam transition events. |
| NTT Docomo | OCB: Proposal 2: Regarding potential required changes considering NR operation in unlicensed band, * LBT related issues, e.g. SSB candidate position and non-consecutive RO, may need to be discussed after the discussion on LBT mechanisms.
* Given the PSD and OCB related requirements and concluded interpretation, interlaced UL transmission in Rel.16 NR-U would not be needed.
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# System Level Simulation studies

Preliminary observations for system level studies are presented below.

* 8 companies have presented results for Indoor Scenario A, 6 companies for Indoor scenario C. 1 company has presented Indoor scenario B,
* 2 companies have presented results for Outdoor scenario B.

From the simulations submitted, we have the following (tentative) observations)

* Indoor Scenario A with 2 operators
	+ Comparison of No-LBT with LBT
		- 6 Companies have compared No-LBT with Tx Side ED based Omni sensing LBT
			* (Vivo, show tail and median benefits of using omni LBT on DL, at high loading
			* (Ericsson, HW, Nokia show loss for omni LBT). Nokia shows median loss and tail gain for directional LBT for 100% DL
			* Samsung shows loss in median and tail for omni LBT. They also show gain in tail and median in medium and high loads for directional LBT
			* Intel shows mostly loss of omni and directional LBT over no LBT at high loads for a threshold of -48 dBm
	+ Directional vs Omni LBT
		- For same threshold, directional LBT
			* Vivo shows loss relative to Omni LBT, using Tx side and Rx assisted LBT
		- ZTE shows that an operator using directional LBT benefits in the presence of an operator using Omni LBT
		- For 100% DL traffic, ZTE shows gains in directional LBT for tail users for high ED thresholds. The gains are for tail and median users for lower ED thresholds. The gains are also present in DL+UL Traffic
		- Samsung shows gain in tail and median in medium and high loads for directional LBT over no-LBT and omni-LBT variants
		- Intel shows directional LBT gains relative to omni LBT for low ED threshold ( -55 and -65 dBm) but loses for high thresholds (-48 dBm). The gain of directionality increases with more directional UE beams
		- Qualcomm simulations show largely a comparable performance for omni and directional sensing using equal threshold, with small benefit of directionality under gNBs with narrower beams
	+ Rx-Assisted vs Tx Sensing LBT
		- HW, Qualcomm, show benefits for DL and UL in the tail and median, primarily at higher loding levels
		- Vivo shows benefits in the tail DL and UL users
		- Ericsson shows gains of Rx Assistance over Tx only sensing but both are shown to lose relative to no-LBT, at high loading levels
* Indoor Scenario C
	+ No-LBT vs Omni LBT
		- Ericsson and HW show loss, Charter shows roughly comparable performance
	+ Directional vs Omni
		- For equal ED threshold Directional sensing and omni sensing are comparable
		- ZTE show gains for directional LBT in median and tail for very low ED thresholds for 100% DL traffic
	+ Rx Assistance
		- Shows benefits over omni LBT but loss relative to no-LBT
* Outdoor Scenario B
	+ Ericsson shows loss for LBT schemes with respect to no-LBT, for two ED thresholds (-47 and -68 dBm) . -68 dBm ED has marginally better performance than -48 dBm
	+ HW shows loss for LBT schemes with respect to no-LBT for 1-site and 7 -site scenarios. Directional and omni LBT are comparable.

Note that fair comparisons of LBT schemes, especially those comparing directional vs omni LBT, must be presented with the right ED threshold pairs. A collection of proposals for directional LBT propose to change the ED threshold with directivity of the sensing beams.

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