**3GPP TSG RAN WG1 Meeting #103-e R1-20xxxxx**

**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 following email discussion

[103-e-NR-52-71-Channel-Access] Email discussion/approval on channel access mechanisms including aspects related to system level simulations until 11/3; address any remaining aspects by 11/11 – Jing (Qualcomm)

# Summary of contributions and discussions

The section summarises key proposals and observations from submitted 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.
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| 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
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| 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.

During the online session, the language is updated to the following

Proposal:

* RAN1 understanding is that nominal bandwidths at the UE are the subset of UL channel BWs supported by the UE from the set of channel BWs (carrier) to be defined in 38.101.
* RAN1 understanding is that nominal bandwidths at the gNB is the subset of DL channel BWs supported by the gNB from the set of channel BWs (carrier) to be defined in 38.104.

Alternate Proposal:

* RAN1 understanding is that nominal bandwidths at the UE is the maximum UL channel BW supported by the UE.
* RAN1 understanding is that nominal bandwidths at the gNB is the maximum DL channel BW supported by the gNB.

Please provide additional comments.

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| **Company** | **View** |
| Ericsson | Agree to FL proposal. channel bandwidth which is equivalent to the carrier bandwidth from RAN1 perspective |
| Huawei/HiSilicon | We could be flexible about this and agree in principle with the majority to base the “nominal channel BW” on the “channel BW” defined in 38.101. However, assuming similar principles as in 38.101-1 for FR1 and 38.101-2 for FR2 are followed to define “channel BW” for FR-X, there are two points that need to be clarified:1. 38.101 define UE channel BWs only and, unlike what FL proposal suggests, are quiet about the channel BWs at the gNB side. Based on our understanding, these nominal channel BWs are defined mainly for spurious energy test and, as such, it seems necessary that they are also defined at the gNB side. However, defining nominal channel BWs at the gNB side seems to be out of RAN1 scope and whether and how to define nominal channel BWs at the gNB seems to be in RAN4 scope. Sending an LS to RAN4 regrading this issue may be required.
2. Not all defined channel BWs in 38.101-1 for FR1 and 38.101-2 for FR2 for UEs are actually supported by the UE. UE’s actual supported channel BWs can be a subset of the defined channel BWs in 38.101 and can be reported in UE capability signalling in *channelBWs-UL* and *channelBWs-DL*. For the nominal channels at the UE side, only *channelBWs-UL* wherein UE transmits are relevant.

To summarize, we can propose the following:Proposal:* RAN1 understanding is that nominal bandwidths at the UE side are the UE’s subset of supported UL channel BWs from the set of defined channel BWs in 38.101.
* Send an LS to RAN4 requesting to define nominal channel BWs at the gNB side if necessary.
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| LG | Agree to the FL proposal. |
| Nokia, NSB | Agree with the FL proposal.  |
| vivo | Our understanding is that nominal channel bandwidth should be equivalent to channel bandwidth supported by UE as defined by RAN#4. One UE can have multiple nominal channel bandwidths. If BWP is adopted, the bandwidth of each BWP equals to one of the nominal channel bandwidth. |
| Futurewei | Nominal channel bandwidth term is used in ETSI for two purpose: 1) to limit the spurious emission 2) to define OCB.3GPP 38.101-1 defines the Channel related bandwidth as follows:Figure 5.3.1-1: Definition of the channel bandwidth and the maximum transmission bandwidth configuration for one NR channelBased on 38.101 language the Channel Bandwidth is equivalent to Nominal Channel Bandwidth. The OCB requirement should be interpreted (based on Figure 5.3.1-1) as the requirement on the Transmission Bandwidth with respect to Channel Bandwidth. For the multi-carrier operation, we should consider the nominal channel bandwidth as the aggregated channel bandwidth (38.101), which is the bandwidth for intra-band contiguous carrier aggregation.Nevertheless, we think that these definitions and understandings should be used just as working assumptions and there is no need to be captured in the TR. If necessary, they can be later refined in RAN4.  |
| Charter Communications | Fine with the alternate proposal |
| Intel | Our view is that at a given time the nominal channel bandwidths is the actual channel bandwidth used by the UE or the gNB for an UL or a DL transmission, respectively. When mapping this concept into the OCB requirement, when a device performs a transmission given that is configured to operate on a specific channel bandwidth, then at least 70% of that bandwidth should be used.  |
| Qualcomm | Agree with the first proposal.  |
| CATT | Nominal channel bandwidth is the UE or the gNB channel bandwidth. In 38.101, it states “The UE channel bandwidth supports a single NR RF carrier in the uplink or downlink at the UE. From a BS perspective, different UE channel bandwidths may be supported within the same spectrum for transmitting to and receiving from UEs connected to the BS.”. The location of UE channel bandwidth could be flexible with the gNB channel bandwidth in 38.101“The placement of the UE channel bandwidth for each UE carrier is flexible but can only be completely within the BS channel bandwidth.” |
| NTT DOCOMO | Given the conclusion on OCB requirement in the last e-meeting and since we understand that OCB requirement in 60 GHz is for the purpose of out of band emission testing, we are ok with the alternate proposal.  |
| Samsung | Support the following:Proposal:* RAN1 understanding is that nominal bandwidths at the UE are the subset of UL channel BWs supported by the UE from the set of channel BWs (carrier) to be defined in 38.101.

RAN1 understanding is that nominal bandwidths at the gNB is the subset of DL channel BWs supported by the gNB from the set of channel BWs (carrier) to be defined in 38.104. |
| ZTE, Sanechips | If no considering coexistence with Wi-Fi, we tend to support the first proposal.However, if considering coexistence with Wi-Fi, or the absence of Wi-Fi node cannot be guaranteed, and further, if the channel bandwidth supported by gNB or UE(that is, the nominal channel bandwidth) is different with that of defined in Wi-Fi, then seems it is necessary to further consider the following issue:* Whether need to force the gNB and UE to support 2.16GHz, in order to ensure the friendly and fair coexistence with Wi-Fi.
* If gNB/UE can be allowed not to support 2.16GHz channel bandwidth, then need to consider whether to allow multiple NR channel bandwidth aggregation method to achieve the alignment with Wi-Fi supported channel bandwidth. For this case, whether each NR channel bandwidth (that is, each nominal channel bandwidth) of aggregated channel bandwidths should meet at least 70% OCB requirement, respectively.
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| LG (2) | We support the original proposal. |
| Lenovo,MotorolaMobility | We agree with the first proposal from FL |
| Apple | Based on the new proposals, the nominal BWs should be defined as the subset of UL channel BWs rather than the maximum UL channel BW supported by the UE i.e. a UE can have multiple nominal channel BWs. In the case that only the maximum channel BW is supported, the OCB definition will limit (a) narrowband transmission and (b) non-contiguous CA  |
| NTT DOCOMO v25 | Actually we do not have any big objection to Alt 1. We just think that, since we understand that OCB requirement would be for the purpose of our of band emission testing, NCB is the maximum CBW would be sufficient. As we already concluded that only one mode to ensure OCB is sufficient, Alt 2 is also acceptable even if we consider OCB requirement for actual transmissions in our view. And Alt 2 seems simpler definition than Alt 1. But if majority is Alt 1, we can also support Alt 1.  |
| Sony | We support the first proposal. |

Summary of discussion:

On nominal bandwidth definition for OCB requirement purpose:

* Alt 1: Ericsson, HW, LG, Nokia, Vivo, FW, Qualcomm, Intel, CATT, Samsung, ZTE, Lenovo, Apple, Sony
	+ RAN1 understanding is that nominal bandwidths at the UE are the subset of UL channel BWs supported by the UE from the set of channel BWs (carrier) to be defined in 38.101.
	+ RAN1 understanding is that nominal bandwidths at the gNB is the subset of DL channel BWs supported by the gNB from the set of channel BWs (carrier) to be defined in 38.104.
* Alt 2: Charter, DCM
	+ RAN1 understanding is that nominal bandwidths at the UE is the maximum UL channel BW supported by the UE.
	+ RAN1 understanding is that nominal bandwidths at the gNB is the maximum DL channel BW supported by the gNB.

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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| **Company** | **View** |
| Ericsson | In our view, the LBT bandwidth is the minimum of the channel bandwidth and the transmission bandwidth.  |
| Huawei/HiSilicon | In our view, two issues need to be clarified first: 1. Based on our reading of t-docs of different sources, we think it is necessary to clarify what we mean by “channel BW” here. Do we mean “transmission BW” (e.g., set of PRBs occupied by PDSCH or set of PRBs occupied by PUSCH) or the set of “UE channel BW” that are going to be defined in 38.101, or the “carrier BW” that is configured to the UE?
2. gNB may perform FDM transmission to multiple UEs. However, FDM transmission from a UE to two gNBs (in scenarios such as DAPS-HO) seems to be unlikely. Therefore, LBT bandwidth at the gNB side and the UE side may need to have two different treatments.

Considering the above two issues, we believe that LBT BW should be wider than the transmission BW and can be wider than the channel BW (as defined in 38.101) and carrier/cell BW (as configured to the UE). The reason for LBT BW being larger than transmission BW is clear. In our view, LBT BW can also be wider than the carrier BW and UE channel BW in the case of CA and when gNB serves multiple UEs in the FDM manner. In such scenarios, having a LBT BW larger than carrier BW/UE channel BW facilitates a single LBT mechanism instead of having multiple LBT mechanisms running in parallel in the frequency domain.  |
| LG | We think that the LBT bandwidth can be configured based on the UE capability or by the gNB. Therefore, it can be larger than channel bandwidth or smaller than the channel bandwidth. |
| Nokia, NSB | We agree with the Ericsson proposal at least as the baseline.  |
| vivo | Our preference is to have the LBT bandwidth equal to the bandwidth of BWP or the nominal channel bandwidth. |
| Futurewei | The answer to this question depends on the channel bandwidth definition. In the context of LBT we propose to define the channel bandwidth as the maximum channel bandwidth which is discussed in 8.2.1. and to agree that this is a supported LBT bandwidth.The question of “LBT bandwidth wider than the channel bandwidth” can be interpreted as LBT necessary for multi-channel access operation as defined in the TS37.213, Section 4.1.6. In this case, the LBT should be done per each channel, and the multi-channel operation from TS 37.213 may be used as reference design. For the question of “LBT bandwidth narrower than the channel bandwidth” we prefer to leave it for FFS. |
| Intel | We agree that the LBT bandwidth should be decoupled with the channel bandwidth. However, whether the LBT bandwidth would be wider or narrower than the channel bandwidth depends on the specific channelization and maximum channel bandwidth supported, especially for carrier aggregation cases, where performing an LBT measurement for each carrier, rather than a single wideband measurement may be beneficial from a channel access perspective, allowing a device to perform a transmission even when a carrier is particularly congested. Therefore, we prefer to make a conclusion on this topic only after the supported channelization would be better understood. |
| Qualcomm | From RAN1 perspective, LBT bandwidth can be BWP bandwidth. Other alternative, such as associating LBT bandwidth with transmission bandwidth, may have further subtleties that require further clarity and have added complications. For example, it may mean that when the gNB transmission or the UE’s transmission resource allocation changes, the LBT bandwidth and the LBT procedure may have to change. Further, we believe that LBT bandwidth wider than channel bandwidth is not necessary for gNB or UE, - any sensing done outside of channel bandwidth should not have a bearing on success or failure of channel access.  |
| CATT | LBT is used to mitigate the potential co-channel interference. Thus, the LBT BW should be the channel BW used for transmission. For UE transmission, UE channel BW is the subset of the gNB channel BW. Thus, LBT BW for gNB could be narrower than its channel BW (gNB channel BW is wider than UE channel BW).  |
| NTT DOCOMO | We think that LBT bandwidth should basically be the one used for transmission. At the same time, it is a bit unclear for us if quite unmatched LBT BW among devices can be allowed or work well. In this sense, we are ok with supporting the 1st bullet while further study would be necessary.  |
| Samsung | More discussion seems needed. At least we need to clarify the benefit of supporting a LBT bandwidth different from channel bandwidth.  |
| ZTE, Sanechips | In our view, at least the LBT bandwidth should be the minimum and supported channel bandwidth, not transmission bandwidth. Due to transmission bandwidth has no consider guardband on both sides of channel bandwidth. |
| Lenovo,MotorolaMobility | We agree with Ericsson’s suggested proposal |
| Apple | We should allow for the case where the LBT bandwidth is wider than the channel BW. This allows a scenario in which a UE with a smaller channel BW can fairly compete with a UE/STA with a larger channel BW e.g. to perform an LBT to match a 2.16 GHz channel. It also allows for the scenario in which the UE operates in a CA mode.  |

Summary of discussion:

On the LBT bandwidth relative to channel bandwidth (as defined in RAN4), the following has been captured

* Alt 1: LBT bandwidth equals channel bandwidth
* Alt 2: Min of channel bandwidth and the transmission bandwidth
* Alt 3: LBT bandwidth can be wider than channel bandwidth
	+ Alt 3.1. For CA purpose, where LBT bandwidth is the total bandwidth across multiple CCs
	+ Alt 3.2. For coexistence purpose, where LBT bandwidth is common across nodes configured with different channel bandwidth and center frequency within the LBT bandwidth
* Alt 4: LBT bandwidth can be narrower than the channel bandwidth, with multiple LBT subband within a channel

Please provide additional views below:

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| Company | View |
| NTT DOCOMO | The intention of our comment above was Alt 1 and Alt 3. As the summary above just says “the following has been captured” and our view is surely captured, we are ok with the summary itself. We think Alt 2 would be an extreme case of Alt 4, which we think could be ok from transmitter’s perspective. On the other hand, LBT BW can be the same as transmission BW would mean LBT BW itself could be varied dynamically. We are not sure if such dynamic LBT BW could be ok or not from system perspective. For example, if we follow the current BRAN requirement on ED threshold which doesn’t consider BW, then LBT BW for wider BW transmission and narrower BW transmission could be much different, and such the results of such LBT for each transmission could be unfair. If we go with the Alt 2, we think further consideration on ED threshold may be necessary (but such direction would also be ok for us).  |
| OPPO | Support Alt-4. LBT bandwidth can be narrower than or equal to the channel bandwidth. |
| Xiaomi | Agree with Alt1. And we also understand that LBT bandwidth is nominal bandwidth. |
| LG | We think that the LBT bandwidth can be configured based on the UE capability or by the gNB. Therefore, it can be larger than channel bandwidth or smaller than the configured channel bandwidth. |
| Spreadtrum | Support Alt-1. From coexistence point of view, the LBT bandwidth should be equal to channel bandwidth. |
| ZTE, Sanechips | In our view, we tend to support Alt.4 that LBT bandwidth can be narrower than the channel bandwidth. Only if the supported channel bandwidth is equal to the defined LBT bandwidth, we can agree Alt.1.For the configured channel bandwidth is relatively large, according to the definition of LBT bandwidth for Alt1, then the device needs to perform a wide LBT operation on such large channel bandwidth, which can reduce the probability of the channel access and cause some unnecessary waste of resources. In contrast, it will be more suitable to define the LBT bandwidth smaller than the channel bandwidth, that is, support Alt4.In CA scenario, LBT bandwidth can be narrower than each CC of multiple CCs according to the definition of LBT bandwidth of Alt.4.For coexistence with Wi-Fi, if the channel bandwidth defined in NR is different with that of Wi-Fi, then we can consider multiple channel bandwidths aggregation method to achieve the alignment with Wi-Fi supported channel bandwidth. For this case, Alt.4 is still available. |
| Lenovo, Motorola Mobility | We are okay to capture the above alternatives |
| Apple | We agree with Docomo on Alt 1 and Alt 3. |
| vivo | In our understanding, RAN4 will define the supported channel bandwidth for UE. Different UE may have different capability to support a subset of the above channel bandwidth, which could be considered as nominal channel bandwidth declared by this UE. Besides, this subset of supported channel bandwidth will be reported to gNB by UE capability bits. Then gNB could only configure the reported channel bandwidth as BWP bandwidth. So from UE side, LBT bandwidth is the UL BWP bandwidth. From gNB side, LBT bandwidth could be equal or less than the channel bandwidth. |
| Sony | We support Alt 1, 3, and 4. We think LBT bandwidth can be wider than channel bandwidth in order to support LBT in CA. |
| Convida Wireless | We could consider the case when LBT wider than the carrier BW and/or UE channel BW in the case of CA. We could consider Alt 3 and are open for other alternatives. |

Discussion point:

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

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| **Company** | **View** |
| Ericsson | No. Actually it is not clear what is meant by align the channelization, is it about (1) mandating same channel bandwidth (2.16 GHz) or only about (2) making sure that the NR channels is fully contained within .11ad channel and crosses the channel boundary ?If its about (1) this is not the correct place to discuss this. The maximum carrier bandwith is discussed in the other email thread. And if it is about (2): In our contribution (R1-2007982), we have provided an extensive analysis about the drawback of aligning the channelization with .11ad. The main drawbacks are: 1. extensive evaluation results from different companies shows there are no coexistence issues even without deploying LBT
2. If NR adopts the same channelization design as IEEE 802.11ad/ay, large wastage of spectrum would occur in many regions:
* 240 MHz at the lower edge of the band is unused in all regions
* 800 MHz at the upper edge of the band is unused in USA and Europe
* 680 MHz of the 5 GHz allocation in China is unused
	+ In recognizing the need to have at least three channels for cell planning, IEEE 802.11aj standard defined four 1.08 GHz channels nested within the two 2.16 GHz channels for the 60 GHz band in China. As a result, the spectrum wastage issues are left unaddressed in the 802.11aj channelization.
* 280 MHz of the 7 GHz allocation in Canada/Brazil/Mexico is unused
* In the IMT (licensed) allocation in Europe, one out of the 2 available 2.16 GHz channels is unusable since it extends outside the IMT allocation
1. If .11ad channelization is used, only 2 non-overlapping 2.16 GHz channels are available, and 680 MHz would be wasted. Instead, NR can divide the 5GHz allocation into 3 non-overlapping 1.6 GHz nominal channels which (1) increase the number of available channels, and (2) full use of the allocation.
2. the 802.11ad standard itself supports partially overlapping channels for channel bandwidths >2.16 GHz
3. In R1-2007982, we demonstrate that misaligned channels do not create a coexistence problem either. We evaluated Coexistence scenario between two operators (a) both operators use aligned 2 GHz channels, and (b) Operator #2 uses three 1.6 GHz channels misaligned with the two 2 GHz channels used by Operator #1. We show that misaligned channels do not cause any coexistence issue.
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| Huawei/HiSilicon | We think it is better to first to clarify what we mean by aligning the channelization to 11 ad/ay. In our view two choices may be considered :1. Supporting a 2.16 GHz single channel BW with the centre frequency located at one of the 6 locations {58.32, 60.48, 62.64, 64.80, 66.96, 69.12} GHz.
2. Supporting multiple channels with a smaller BWs nested inside one 2.16 GHz BW channel with a centre frequency located at one of the 6 locations {58.32, 60.48, 62.64, 64.80, 66.96, 69.12} GHz.

If the intention is 1 above, then this discussion needs to be made in another Email thread concerning 8.2.1 as it is directly related to the maximum supported channel BW. In any case, even if a 2.16 GHz single channel BW is agreed, we do not see such an alignment results in a noticeable inter-RAT interference reduction.If the intention is 2 above, although we are in general supportive of the idea of having a few smaller BWs to cover a 2.16 GHz BW (using CA), we do not see such an alignment results in a noticeable inter-RAT interference reduction. |
| LG | No. Since, the regional regulatory does not mandate supporting the same bandwidth as in 802.11ad/ay, aligning the channelization with 11ad/ay cannot be justified. If performance requirements (such as BLER, system throughput, coexistence) can be met in a reasonable range, we think CA based approach could be sufficient to coexist with 11ad/ay. |
| Nokia, NSB | If aligning the channelization with 11ad/ay means that we support at least one mode where no NR-U channel overlaps with two 2.16 GHz 11ad/ay channels, we are ok. Note that this still allows for using for NR-U parts of the spectrum that 11ad/ay is currently not utilizing.However, the exact channelization must obviously take into account the supported subcarrier spacings and channel bandwidths, and may need to be discussed jointly with AI 8.2.1.  |
| vivo | Not clear about what does it mean by align the channelization of 11ad/ay. If the intention is to have the exact same channel bandwidth and bonding as in 11ad/ay, we don’t think that’s necessary.If the intention is to support large bandwidth similar to the channel bandwidth used in 11ad/ay, we are supportive.  |
| Futurewei | The alignment of the channelization with 802.11ad/ay is not necessary. Whereby alignment we understand the same exact channel bandwidth as 802.11ad/ay (2.16GHz). Channel bandwidth of about same bandwidth as 802.11ad, for instance 2GHz, may be obtained through CA. |
| Charter Communications | We support defining large carrier bandwidths that allow a NR cell to operate with the same bandwidth (or greater) than an 802.11ad/ay system. This is motivated by a technology equivalence perspective, and does not necessitate the exact same channelization. |
| Intel | We believe that in order to maintain competitiveness and coexistence with 11ad/11ay design, we should indeed support a bandwidth equal or similar to that supported by 11ad (~2.16 GHz). In terms of alignment, we would like to clarify that channelization should be done such that a single NR carrier bandwidth do not straddle one or more boundaries of 2.16 GHz channelization. In our opinion, this is as critical as selection of the bandwidths for NR.As for whether this should be achieved through a single carrier or through CA, our preference is the former. The main reason is that having multiple CCs lead to increased complexity in building a proper RF subsystem, since multiple filtering is likely required, compared to the case when a single wideband RF is used, which is equipped with a single wider FFT. The uplink transmissions become more simplified with use of a single carrier versus multiple carriers for ~2 GHz band operation. Additionally, by supporting a wider single carrier bandwidth close to 2 GHz allows the possibility to use CA to bond even more 2 GHz channels to achieve a higher aggregate bandwidth. |
| Qualcomm | Yes. (Note that the proposal is not to enforce a channelization aligned to 11ad/11ay numerology but to permit operation – if desired – under a channelization aligned as proposed.).  |
| CATT | It is not necessary to align the NR channels with 802.11 ad/ay. The key aspect of the NR operation in 52.6 – 71 GHz is to align the channelization, numerology, and configuration (e.g., raster) with existing NR specifications.  |
| NTT DOCOMO | As pointed out by E/// and HW, whether to support 2.16 GHz channel BW will be discussed in another email thread. On whether to make sure any NR 60 GHz channel is nested inside a 11ad/ay channel, its necessity is questionable to us.  |
| Samsung | Yes, 3GPP should provide the feasibility to support the same channelization as 11ad/ay, although, obviously, we should also provide more flexible channelization other than that.  |
| ZTE, Sanechips | Firstly, our understanding is this issue can be discussed in A.I. 8.2.1.Then, if the absence of Wi-Fi node cannot be guaranteed, the following methods can be considered:* Option1: 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
* Option2: No need to align the channelization of Rel-17 NR with Wi-Fi design, and allow to support 400/800/1600MHz bandwidth, and combining 2.16GHz by the aggregation of supported 400/800/1600MHz bandwidth(s).
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| Lenovo,MotorolaMobility | Yes, we think that one mode should be supported to align the channelization between 11ad/ay and NR-U in 60GHz |
| Apple | Our understanding of alignment with a 2.16 GHz channel is that we may support multiple channels nested within a 2.16 GHz channel with the condition that they do not staddle the 802.11ad/ay 2.16 GHz channel boundaries. Actual channel BW can be less than or equal to 2.16 GHz. CA can be used to achieve 2.16 GHz transmission bandwidth if needed. |

Summary of discussion

On if we should support a mode to align the channelization between 11ad/ay and NR in 60GHz band, including NR channels are “nested” within WiFi channels (Note this does not intend to rule out other channelizations not align with 11ad/ay)

* Yes: HW, Nokia, Vivo, Intel, Qualcomm, Samsung, ZTE, Lenovo, Apple, LG, SPRD, Sony
* No: Ericsson, FW(?), Charters, CATT, DCM

Please provide additional views below:

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| Company | View |
| OPPO | No. We think that it is not necessary to define NR channel bandwidth based on WIFI’s system. As pointed out by the companies, the co-existence issue is not decided by the aligned channel bandwidth or channelization. |
| Xiaomi | Agree with DCM. This question should be discussed in another email thread |
| LG | If it is identified that the benefit or the necessity, e.g., for fair coexistence with the incumbent system or the performance requirement can be met. |
| Spreadtrum | Yes. gNB should be a good neighbour to WIFI’s AP. |
| Sony | Yes, we think at least one mode to align the channelization between 11ad/ay and NR-U in 60 GHz band should be supported. Other modes can be supported for an environment where 11ad/ay doesn’t exist. |

## 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. |
| 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.Observation 8: Receiver-only directional LBT outperforms No-LBT in terms of both coverage and capacity across the different loading conditions in the indoor scenario. |

### 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)Proposal 8：For operation in the 60 GHz band, receiver-only directional LBT can be considered as an optional short-term interference mitigation scheme. |
| 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 itself* 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
 |
| 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. |
| Apple | Long term measurements can be performed for the transmitter to decide whether LBT is performed or not, and what LBT schemes are used or not.  |

### 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 6：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 itself* 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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| **Company** | **View** |
| Ericsson | To start with, the formulation of this discussion is contradicting, for regions where LBT is not required, naturally no LBT is a default, and the discussion should be if LBT should be used in certain conditions. We prefer to discuss the points below before agreeing to this proposal. |
| Huawei/HiSilicon | Agree. We think it needs to be clarified in the FL proposal that this is only applicable for regions that LBT is not mandated.  |
| LG | We think that gNB can indicate the supported channel access mode of the system based on the local regulation as part of system information. For example, the gNB can indicate whether the no-LBT mode is supported or not by the SIB. |
| Nokia, NSB | It is yet premature to say whether the UE needs to know if the gNB performs LBT or not.  |
| Vivo | Even in regions where no-LBT mode is allowed, we think the channel access mode can be semi-statically or dynamically changed according to the interference at the receiver, the channel occupancy time at the transmitter, traffic priority, etc. And the channel access mode can be device-specific, e.g., if a UE suffers constant severe interference, gNB can operate in receiver-assisted LBT mode for that UE. For other Ues, gNB may operate in no LBT or non- receiver-assisted LBT mode |
| Futurewei | Where the indication would be used? If this is used in the LBT mandated region it could be simply signalled to UE whenever the situation dictates. For the No LBT region, it can be used as the default operation until instructed by gNB otherwise. |
| Charter Communications | Can be left to the WI phase based on SI conclusions. |
| Intel | Our view is that it would be indeed beneficial to define two modes of operation and indicate to the UE the specific mode used. However, agreeing at this point on the details of how the specific mode of operation used should be signalled is too premature.Furthermore, from our point of view, it may be also beneficial to give to the gNB the ability within a mode of operation to decide on whether or not to enable LBT under certain circumstances (e.g., COT sharing) where compliance with the local regulatory requirements would be still met, but the use of LBT or no-LBT may lead to better system performance.  |
| Qualcomm | Agree with the proposal. This is just saying gNB should indicate, so UE can deterministically know the mode to operate. |
| Convida Wireless | It is beneficial to have two channel access modes defined. For regions where LBT is not nforma, gNB could indicate to UE which channel access mode to operate – LBT mode or no-LBT mode. This could result in performance optimization. |
| CATT  | It is beneficial to support both LBT mode or non-LBT mode with indication by system nformation.. |
| NTT DOCOMO | Agree with Nokia. Other aspects (e.g. channel access procedure under LBT mode or details of no-LBT case) should be discussed at first. Then we can discuss whether/how to configure/indicate which procedure to be used.  |
| Samsung | We support the proposal. Other than system information, for Scell, the indication should also be included in RRC parameter.  |
| ZTE, Sanechips | In SI, we think it is not necessary to discuss too much detailed design. |
| Lenovo,Motorola Mobility | In our view, the FL proposal could be further updated as follows:**For regions, where the regulations don’t mandate LBT, gNB should be able to configure or switch between LBT mode and no LBT mode.**We are also fine to leave this discussion for the WI phase |
| Apple | Clarify that this proposal is for the regions in which LBT is not mandated. The gNB can signal whether LBT-mode or no-LBT mode is used. Whether it is broadcast in the SIB or indicated per UE can be discussed in the WI. |
| Xiaomi | Agree with LG and Nokia. gNB can indicate whether no-LBT mechanism is supported or not. But as to whether the gNB is operating based on no-LBT can be discussed later. |
| Sony | We agree to leave this discussion for the WI phase. |

Summary of discussion:

On if gNB should indicate the system is operating in LBT mode or no-LBT mode as part of system information (in other words, the LBT mode decision is made at gNB and indicated to UE)

* Support: HW, LG, Vivo, Intel, Qualcomm, Convida, CATT, Samsung, Apple
* Delay the discussion: Ericsson, Nokia, Charters, FW, DCM, ZTE, Lenovo, Apple, Sony

Seems that this topic is too early to discuss.

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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| **Company** | **View** |
| Ericsson | It should be left for implementation. None of the evaluations showed coexistence issues in regular scenarios. In fact, LBT degraded the performance in most cases. Therefore, it should be left for implementation when it should be used. Artificial restrictions should not be added to the specs unless there is a strong justification. FCC on the other hand does not mandate any Adequate spectrum sharing mechanism. The requirement by CEPT is to implement any Adequate spectrum sharing mechanism. Besides, CEPT recommends ATPC and DFS as the most effective and cost-efficient mechanisms. NR by design support power control schemes. And DFS can be done by implementation.It is the operator’s responsibility to make sure that the regional regulations are fulfilled using any of the tools supported by the system.  |
| Huawei/HiSilicon | Leave it to gNB implementation. However, some sensing/measurement can be defined to assist the gNB in deciding between LBT and no-LBT mode wherever LBT is not mandated. It is up to the NW how to use the reported sensing/measurement. |
| LG | Even for the regions where LBT is not required, the channel access with LBT can be the basic channel access mechanism. The channel access mechanism can be switched to the no-LBT mode based on the conditions when it can assume a low interference environment e.g., by estimating interference level or by using HARQ information of (consecutive) successful transmissions. |
| Nokia, NSB | It would be good to clarify how this question differs from the next one. It seems they are virtually the same. |
| Vivo | Some conditions based on long term sensing/measurement or report can be used to determine the suitable channel access mode when LBT is not mandated. |
| Futurewei | Leave it for gNB implementation.  |
| Charter Communications | We do not support having additional restrictions or conditions in the specification for no-LBT to be used. The existing NR framework with various measurements (e.g., RSSI) can be utilized for such a determination via implementation. |
| Intel | If LBT is not mandated, it can be left up to the gNB’s on how to operate, and no additional conditions need to be defined and implemented in the specification.  |
| Qualcomm | We should at least define the mechanism, but let gNB to enable/disable the mechanism. ( Note that having defined useful mechanisms which permit constrained no-LBT operation may benefit 3GPP to consider and keep pace with scenarios where the regulatory bodies are re-evaluating unlicensed spectrum channel access and where the regulations are under evolution (e.g. the ongoing ETSI effort 303 753) .) |
| Convida Wireless | Either introducing conditions for no-LBT to be used or gNB implementation could be fine. Conditions could be based on long term sensing. |
| CATT | If LBT is not mandated, it would be beneficial to define a standardized methodology for distributed interference mitigation.  |
| NTT DOCOMO | We share Nokia’s view.  |
| Samsung | It can be left for NW’s implementation to decide which mode to operate with, but combining with the question above, after NW decides, it should indicate the mode to the UE.  |
| ZTE, Sanechips | Tend to support introducing additional conditions for no-LBT to be used compared to the method for leaving it for gNB implementation. |
| Lenovo,Motorola Mobility | It is not fully clear to us what is the intention of this discussion point. Is the intention to say that only when no LBT based schemes can ensure adequate spectrum sharing, then the system can use them, otherwise LBT should be used?  |
| Apple | This can be left to gNB implementation. Measurement, signaling and feedback may be used to assist with this. The specifics can be discussed within the WI. |

Summary of discussion

For regions where LBT is not mandated,

* Alt 1. Introduce additional conditions/mechanisms for no-LBT to be used
	+ LG, Qualcomm (define mechanism and let gNB choose), Convida, CATT, ZTE, SPRD, Lenovo, Motorola Mobility
* Alt 2. Leave it for gNB implementation to determine if LBT or no-LBT is used
	+ Ericsson, HW, FW, Charters, Intel, Convida, Samsung, Apple, Sony

Please provide additional view:

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| OPPO | Alt 1. |
| Xiaomi | Support Alt 1.  |
| Spreadtrum | Support Alt 1.  |
| Lenovo, MotorolaMobility | Support Alt. 1 |
| Apple | We assume signaling and measurement will be defined to enable this. It is not clear if this is a mechanism and belongs in Alt 1 or Alt 2.  |
| Sony | Support Alt 2 (leave it for gNB implementation to determine if LBT or no-LBT is used). gNB can handle it by using existing measurement such as RSSI. |

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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| **Company** | **View** |
| Ericsson | CEPT regulations requires Adequate spectrum sharing mechanism to be implemented. the regulations state: ”Among dynamic mechanisms, ATPC and DFS are the most effective and cost-efficient mechanisms. ATPC is particularly important as MGWS equipment are naturally motivated to implement ATPC to control self-interference.”NR by design support power control schemes that can serve as “ATPC” mechanism. In additional, NR has link adaptation which also can serve as a “Adequate spectrum sharing mechanism” (e.g. in good link conditions, transmission time is reduced (higher MCS) which promotes for better coexistence)DFS can be done by implementation, that has also been the case for sub-6GHz spectrum.Therefore, we do not think more restrictions are needed specially that the interference at 60GHz is not expected to be critical.  |
| Huawei/HiSilicon | We are in principal supportive of discussing additional restrictions when no-LBT is used. However, some of these restrictions may not have any specification impact. For instance, Rel-16 NR-U specifications did not capture the DFS requirements and procedures specified by the ETSI BRAN HS for 5GHz. Not specifying DFS in Rel-17 seems to be a reasonable approach as well. Current UL PC mechanism should be able to handle an ATPC-like mechanism at the UE side and we are not sure ATPC-like mechanism at the gNB side is within RAN1 mandate.  |
| LG | No-LBT mode can be used along with ATPC or duty cycle restriction or transmit power restriction mechanism. The gNB can configure or indicate the mechanism to be used for UL transmission in combination with no-LBT mode. |
| Nokia, NSB | No. For now, we do not see a need to design specific RAN1 support for the aforementioned schemes. Naturally, if strict restrictions for the use of no-LBT are specified by a regulatory body, we can revisit this issue. However, we may consider some definition for e.g. minimum antenna gain (including element and beamforming) or maximum TX power that is allowed in the case of no-LBT.Possible RAN4 impact (e.g. power control range requirements, etc.) may be considered separately, if needed. |
| vivo | As we commented to the question above, some conditions based on long term sensing/measurement or report can be used to determine the suitable channel access mode when LBT is not mandated. Along with those conditions, we’re open to discuss potential restrictions but the questions on detail method are premature to answer right now.  |
| Futurewei | We should not consider the region specific requirements unless they cannot be supported with the actual design. We should leave the features to the gNB implementation |
| Charter Communications | As noted in our contribution, existing NR features appear to be sufficient for supporting ATPC, DFS, duty-cycling, long-term sensing, etc. |
| Intel | From our point of view, the use of ATPC, DFS or other mitigation techniques can be supported transparently from the specification, and they can be a gNB’s implementation choice.  |
| Qualcomm | We should define the mechanism but allow the gNB to enable/disable the mechanism. (Please see the comment to the previous discussion. This ‘revisiting’ of the issue mentioned by Nokia can perhaps be anticipated/shaped – so as to prevent future issues that may need large scale redesign. ) |
| CATT | We support standardized interference mitigation methods. Feature lead’s examples could be the potential candidate and other interference mitigation methods should also be considered. |
| NTT DOCOMO | On ATPC or transmit power restriction mechanism, we agree with E/// that NR already supports the mechanism for transmit power control. Additional specification effort wouldn’t be necessary in 3GPP. If any regulatory requirement is found, then we can just follow it. DFS could also be covered by the existing NR. We think even when no LBT is possible, as far as in unlicensed spectrum, it could be beneficial to try to detect the presence/absence of others to make sure interference mitigation. Long term sensing, as a tool, could be useful for this purpose.  |
| Samsung | As responded to the last question, the conditions can be up to implementation.  |
| ZTE, Sanechips | We agree to introduce additional restrictions when no-LBT is used but it seems that some auxiliary interference cancellation methods can be used based on the existing ETSI specification and no need introducing additional design into 3GPP. |
| Lenovo,MotorolaMobility | Main point is similar to last discussion point. Maybe it can be updated as follows:**For no-LBT mode, should the following mechanisms need to be specified or can be left upto gNB implementation**Then further on specific mechanisms, we tend to agree with Ericsson that DFS and ATPC arethe most effective mechanisms. Furthermore, we think that long term sensing (interference management) could be an additional tool to better facilitate ATPC and DFS, rather than being a standalone mechanism. For ATPC, it should be further investigated that if the current power control schemes can be directly applied for ATPC or some enhancements are needed. |
| Apple | As has been noted, NR features such as the UL PC mechanism can be used to support ATPC. Additionally, features such as search space configuration can be used for duty cycle restriction and gNB scheduling can be used for DFS. All these can be handled by gNB implementation. |

Summary of discussion: (with the questions rephrased to reduce confusion)

For regions where LBT is not mandated, and when no-LBT mode is used

* Alt 1. Introduce additional restrictions. For example, DFS needs to be on, ATPC needs be on, long term sensing needs to be applied, certain duty cycle limitation, certain transmit power limitation, etc
	+ HW (some of the restriction may not have spec impact), LG, Vivo, Qualcomm (with gNB control), CATT, DCM, ZTE, SPRD
* Alt 2. No restrictions (Leave it for gNB implementation)
	+ Ericsson (ATPC and DFS can be done by implementation), Nokia, FW, Charter, Intel, Samsung, Lenovo, Apple, Sony

Please provide additional view

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| Company | View |
| OPPO | Alt 1. |
| Xiaomi | Support Alt 1.  |
| Spreadtrum | Support Alt 1. |
| ZTE, Sanechips | Support Alt 1, but we don’t think all these additional restrictions need to be specified in 3GPP spec, and suggest to reuse the existing ETSI design as much as possible. |
| Sony | Although interference mitigation mechanism such as DFS and ATPC would be beneficial for no-LBT mode, these can be handled by gNB. |

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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| **Company** | **View** |
| Ericsson | No. it should be left for implementation. A smart gNB implementation should aim for a good performance. In the rare case of a device stuck in a severe interference situation, the gNB would of course try to resolve the issue. It could change the channel, adjust the Link adaptation parameters, change the RX-TX beam, etc…. Activating LBT does not necessarily solve the issue, specially if the interferer is not using LBT, or using LBT according to EN ETSI HS 302 567 with ED -47 dBm (which rarely backs off to any interference). The gNB is equipped with tools other than LBT to cope with interference. Which one of those tools (including LBT) is used as a fall back, should be left for implementation.  |
| Huawei/HiSilicon | Leave it to gNB implementation. However, some sensing/measurement can be defined to assist the gNB to decide between LBT and no-LBT mode wherever LBT is not mandated. It is up to the NW how to use the reported sensing/measurement. |
| LG | As we mentioned in the above, 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. Once the channel access mechanism is switched to one without LBT, the timer can be started and the channel access mode can be fallback to the channel access mode with LBT mechanism when the timer is expired or at least one of the specific conditions (e.g., when NACKs were received consecutively for the PDSCH/PUSCH transmitted without LBT) for switching the channel access mechanism is met. |
| Nokia, NSB | No. Regulations do not require this, and it is unclear if there would be any benefit in such fall-back. Moreover, it is important to support guaranteed no-LBT operation for e.g. fixed links. |
| vivo | Yes, mechanism fall back to LBT mode is necessary. Since the deployments in unlicensed band cannot be controlled, there may exist a scenario where some severe interference from other RATs or operators exist. LBT mode operation helps to enhance system performance. |
| Futurewei | Should be left for implementation. |
| Charter Communications | It is unclear if such a fall-back is always even feasible, for example, UEs deployed in a certain region may not support LBT functionality at all. |
| Intel | It may be beneficial in some special cases to fall back to LBT mode and use this mechanism as an interference mitigation mode. Therefore, a mechanism that allow switching from one mode to another would be preferred.  |
| Qualcomm | We should define the mechanism but allow the gNB to enable/disable the mechanism |
| Convida Wireless | We could consider to define fallback mechanism or switch mechanism between the two modes – LBT and no-LBT.  |
| CATT | No. It should be left to the gNB implementation. |
| NTT DOCOMO | Something resistant to heavy collision environment could be considered, but we are not sure if such system can (or should) be called as “fall back to LBT”.  |
| Samsung | As responded to the last question, the conditions can be up to implementation.  |
| ZTE, Sanechips | Support to define mechanism from No LBT fall back to LBT mode, but specific detailed design can be left to WI phase. |
| Lenovo,MotorolaMobility | I think we need further discussion if it the fall back to LBT mode can be simply implementation or some specification enhancements are needed. In our view, the receiver and transmitter should be aligned in terms of channel access mechanism and for that purpose, some indication or mechanism for switching back to LBT mode might be needed. |
| Apple | There should be signaling and measurement to allow the gNB to convert one or more UEs to/from LBT-mode but the actual implementation/conditions should be left to the gNB implementation. Details on the signaling and measurements etc may be left to the WI. |
| Xiaomi | Operation with LBT should be a default channel access mechanism. We can define some conditions, for example, interference/ statistics on ACK/NACK, If a transmitter is currently operating based on no-LBT, and it can satisfy the condition, it can switch to LBT. |
| Sony | Although switching between LBT mode and no-LBT mode should be considered for the case when interference condition changes, it can be handled by gNB. |

Summary of discussion

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

* Yes: LG, Vivo, Intel, Qualcomm, Convida, ZTE, Lenovo
* No: Ericsson, HW, Nokia, FW, Charter, CATT, DCM, Samsung, Apple, Sony

Seems to be too early to discuss

## LBT Types and COT

|  |  |
| --- | --- |
| **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
 |

### 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 9：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 10：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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| **Company** | **View** |
| Ericsson | CAT4, by definition, includes CW adjustment which is not part of the CCA check procedure in EN 302 567. So to avoid any confusion, we prefer not to refer to it as CAT4. We disagree with the second and third FFSs. there is a justification for having CAPC, CWS adjustment in 5GHz because simply the propagation characteristics and coverage of this frequency range might result in interference issues. So it was important to make sure that high priority data is prioritized in this case (via CAPC) and collisions are resolved via CWS adjustment. Now, the situation is very different in 60GHz. Most companies have shown that the LBT is inducing unnecessary deferral that reduces throughput performance. Differentiating between traffic types would mean inducing even larger unnecessary latencies. In general, LBT in 60GHz may or may not bring gains for the 5th perc. UEs, but what all companies agree on is that it has a negative impact on the aggregated system performance. Therefore, there is no justification to increase the LBT overhead by introducing CAPC and CW adjustment, especially that they are not mandated by the HS. The work should be focused on what is needed to enhance the performance and not to re-specifying the 5GHz LBT aspects in 60GHz without a strong motivation.  |
| Huawei/HiSilicon | We are OK to use the CCA check procedure in EN 302 567 as the baseline for the Cat 4 LBT design. However, we believe the following aspects related to CCA energy/EDT should be further discussed.1. Dependency of EDT to LBT BW.
2. Aspects related to the sensing/Tx beam, e.g., how the CCA energy/EDT takes into account the sensing antenna gain, Receive (sensing) beamforming gain, and the beamforming gain of the subsequent transmission after acquiring the COT.

We are also supportive of discussing CAPC and CWS adjustment. However, we believe that CAPC and CWS are less essential discussions than the above two aspects.  |
| LG | It was agreed in RAN1#102-e to use the CCA check procedure in EN 302 567 as the baseline for system evaluation with LBT. Therefore, it can be the baseline for the Cat-4 LBT design for 60GHz, and enhancements such as the introduction of contention window adjustment and CAPC can be considered. The procedure for CWS adjustment for the Type 1 channel access procedure in Rel-16 NR-U can be reused with modifications to the parameters. |
| Nokia, NSB | We agree with Ericsson on the terminology. Actually, the LBT scheme in EN 302567 is rather Cat3 than Cat4 (TS 36.889: *Category 3: LBT with random back-off with a contention window of fixed size*).As for the FFS points, 3GPP should firstly aim at following ETSI’s definition. We do not see a need for the 2nd and 3rd FFS points. The first one we may keep open until the work item, e.g. depending on the exact decisions on directionality of LBT, channelization etc.  |
| vivo | No further enhancement (all FFS) is necessary. |
| Futurewei | We agree to use the EN 302 567 as the baseline as it was agreed already in RAN#102, and we agree with the first bullet. We do not see the second and third bullet as necessary. |
| Charter Communications | The CCA scheme in EN 302 567 is a Cat-3 LBT mechanism. There is no need based on current simulation evidence to further enhance it into a pseudo-Cat-4 scheme. |
| Intel | We are OK to use the CCA procedure defined in EN 302 567 as a baseline, and we are supportive in further discussing the introduction of CAPC and mechanisms for CWS adjustment, which based on our observation of the system level evaluations may become beneficial in highly congested scenarios. Additionally, RAN1 is not conducting evaluation for all possible deployments and use cases, and one can easily formulate a scenario where interference between NR and potentially WiGig can create problems. One may argue it could be a corner case, but for that particular user if we know there could be persistent problems, we think it is better for the specification to support features that can help these even “corner case” users, especially given that most of the functionality is already specified in Rel-16 NR-U. This also helps to keep same design commonality from MAC layer perspective. |
| Qualcomm | CAPC and CW adjustment are not necessary. We are open for parameter change, such as the range of the random number. But this may not be necessary |
| CATT  | We agree to use EN 302 567 as the baseline. 2nd and 3rd FFS points are not needed.  |
| NTT DOCOMO | We agree with Ericsson and Nokia on terminology, i.e. we support not to use the wording “CAT4”. As for FFSs, since actual LBT mechanism is still under discussion, just to have them as FFS should be ok from our perspective.  |
| Samsung | Random back-off without CWS adaptation should be “Cat3 LBT”, so the wording “Cat4 LBT” may not be accurate in the proposal. We don’t need to “change” parameters, but should “define” exact value of some parameter, e.g. CW\_max.  |
| ZTE, Sanechips | Based on the CCA check procedure in EN 302.567, we think the following need to be considered:* When the absence of the Wi-Fi cannot be guaranteed
	+ If different bandwidth is used for NR-U and Wi-Fi, how to determine the ED threshold for NR-U.
	+ CAPC and CWs adjustment need to be considered due to these have been supported in 802.11ad/ay
	+ Parameters change also be considered to align Wi-Fi.
* Otherwise, if the absence of the Wi-Fi can be guaranteed, we are open for these FFSs.
 |
| Lenovo,MotorolaMobility | We generally agree with the FL proposalDepending upon if directional LBT is adopted for 60GHz NR-U operation, we think that certain changes might be needed including how the CCA is applied across multiple beams, CAPC across multiple beams, contention window adjustment depending upon beam switching |
| Apple | 3GPP should focus on following ETSI’s definition. The 2nd and 3rd FFS can be de-prioritized. However, there is a need to incorporate the transmission BW and the antenna gain into the CCA ED calculation. |

After online discussion, the proposal is updated to the following:

Updated proposal:

Use the CCA check procedure in EN 302 567 (per RAN1 understanding as from RAN1 #102-e) as the baseline for channel access for 60GHz band when LBT is applied. The following can be discussed further during normative work.

* Whether CAPC and contention window adjustment mechanisms are introduced
* Whether ED threshold change is needed, e.g., due to changes in bandwidth
* Whether contention window range needs to be adjusted

Please provide additional view

|  |  |
| --- | --- |
| Company | View |
| NTT DOCOMO | We support the Updated proposal.  |
| OPPO | We support the updated proposal. |
| LG | Support the updated proposal. |
| Spreadtrum | We support the updated proposal |
| ZTE, Sanechips | Support the updated proposal. |
| Lenovo, Motorola Mobility | We support the updated proposal |
| Apple | We support the proposal |
| vivo | Fine with the updated proposal. However, the motivation for further enhancements to CAPC and CWS is not very clear. |
| Sony | We support the updated proposal. |

EN 302 567 defines the MCOT to be 5ms.

FL proposal:

MCOT is 5ms, including all the gaps inside

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| **Company** | **View** |
| Ericsson | Agree with FL proposal (we propose the additional wording for the proposal “when LBT is performed, MCOT is 5ms, including all the gaps inside”) |
| Huawei/HiSilicon | Agree. |
| LG | Agree with the FL proposal. |
| Nokia, NSB | Agree with the FL proposal. Ericsson’s clarification is also fine to us. |
| Qualcomm | Agree with the proposal |
| Convida Wireless | Agree with the FL proposal. |
| CATT | Agree with FL’s proposal.  |
| ZTE, Sanechips | Agree with the FL proposal. |

The above discussion is agreed as follows:

Agreement:

At least when operating with LBT, MCOT is 5ms, including all the gaps inside

Note: Discussions related to further reductions in MCOT due to potential definition of CAPC will be handled separately.

From online session, the following possible conclusion is discussed.

Possible Conclusion:

There is no maximum channel occupancy time defined when gNB and all UEs are operating without LBT.

Please provide view:

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| --- | --- |
| **Company** | **View** |
| vivo | Agree |
| Futurewei | We think that with this wording this conclusion is obvious as COT and MCOT were defined only for the LBT case. Maybe we could either remove the word “defined” or re-phrase it as a question “Do we need to define COT when no LBT is used for channel access?” |
| Charter Communications | Agree |
| Intel | With the aim to harmonize the specification a maximum channel occupancy time could be also defined when both gNb and all its associated UEs are operating without LBT. However, in this case its meaning may be lost.  |
| Huawei/HiSilicon | We think it should first be clarified that 1) whether or not it is allowed to have a mixture of LBT/No-LBT in a system (one pair of initiating/responding pair with LBT and one initiating/responding pair with No-LBT); and 2) How dynamic LBT can switch to/from No-LBT for an initiating/responding device pair.For instance, if the mixture of LBT/No-LBT is allowed, the “No-LBT pair” communication my need to be restricted by a maximum channel occupancy time to facilitate a fair channel access for the “LBT pair”. |
| Qualcomm | COT by definition is associated with channel access. For considerations that even in no LBT mode, we should still enable some relatively frequent channel sensing, this can be captured as some minimum periodicity of longer term sensing or RSSI measurement. |
| CATT | Agree with FL’s proposal. |
| NTT DOCOMO | We support the possible conclusion.  |
| Samsung | OK with the conclusion |
| ZTE, Sanechips | We would like to confirm whether this conclusion means No LBT cannot initiate a COT for all gNB/UE, or if No LBT is used, then it is no limit the length of transmission for all gNB/UE. |
| LG (2) | If we don’t define the MCOT for operating without LBT, there may have a problem with the fair coexistence among incumbent systems because all the initiating devices are allowed to transmit the signal without a time limit. As QC’s mentioned, even No LBT may also require a transmission time limit for something like long-term sensing.  |
| Lenovo,MotorolaMobility | Agree with the conclusion |
| Apple | Agree |
| Ericsson | The conclusion implies that operation mode with or without LBT is a system configuration which is not decided yet. In our view, it should be enough to say, If the device accesses the channel without performing LBT, there is no maximum channel occupancy time. “COT” and “COT sharing” is a concept that is only applicable when LBT is being used. Going back to 37.213, it defines the following: - A *channel occupancy* refers to transmission(s) on channel(s) by eNB/gNB/UE(s) after performing the corresponding channel access procedures in this clause.- A *Channel Occupancy Time* refers to the total time for which eNB/gNB/UE and any eNB/gNB/UE(s) sharing the channel occupancy perform transmission(s) on a channel after an eNB/gNB/UE performs the corresponding channel access procedures described in this clause. For determining a *Channel Occupancy Time*, if a transmission gap is less than or equal to , the gap duration is counted in the channel occupancy time. A channel occupancy time can be shared for transmission between an eNB/gNB and the corresponding UE(s).I don’t think it is contradicting to say that COT/MCOT are not applicable for the no LBT case. Since by definition, COT refers to the total time after performing “the channel access procedure, i.e. LBT”Response to LG: the evaluated scenarios are supposed to reflect a worst-case scenario in which multiple operators (uncoordinated) are using the same channel and even there no company was able to show that there is an issue with operating without LBT. Otherwise, if the nodes using no LBT are within the same network, it can be fully managed by the gNBs. Related to the statement “fair coexistence among incumbent system”. regardless of what NR will be doing, we need to keep in mind that the other RATs will be using EN BRAN 302 567 with ED -47 dBm, which all companies have shown that it is equivalent to no sensing from interference avoidance perspective (very high ED threshold so that the deferral is almost never happening). Naturally the gNB will ask the UE to report measurements to keep track of UE performance and if any change should be done. This is something we even do on the licensed spectrum. We do not need to add a transmit limit to make that happen.  |
| LG | Since it can be harmful to the performance of NR system (also for incumbent system coexist with NR) on operating without limit in a particular scenario such as cell-edge UE in high traffic load or persistent high-interference situation, long-term sensing may be needed to measure the interference environment around the gNB or UE even for operating no-LBT. |

Summary of discussion:

Possible conclusion:

There is no maximum channel occupancy time defined when gNB and all UEs are operating without LBT. (Note this is not about transmission without LBT in LBT mode, like COT sharing or short control signalling)

* Support: Vivo, FW, Charter, Qualcomm, CATT, DCM, Samsung, ZTE, Lenovo, Apple, Ericsson, SPRD, Sony
* Can also consider defining MCOT for no LBT: Intel, HW, LG

Please provide additional view:

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| --- | --- |
| Company | View |
| OPPO | Support. |
| Xiaomi | Agree with HW’s comment. If the mixture of LBT/No-LBT is allowed, a UE may not be able to know whether other UE in the cell is in LBT or no-LBT mode. |
| Spreadtrum | Support |
| vivo | Support. MCOT should only be related to LBT. In the scenario where LBT is not mandated, the device can transmit as it like. If companies have concerns on the channel occupancy time in this case, the device can switch to LBT mode. |
| Sony | Support |

From online session, the following possible conclusion is discussed.

Possible Conclusion:

There is no COT sharing defined when gNB and all UEs are operating without LBT.

Please provide view:

|  |  |
| --- | --- |
| **Company** | **View** |
| vivo | Agree |
| Futurewei | We think that with this wording this conclusion is obvious as COT sharing was defined only for the LBT case in 5GHz band. Maybe we could either remove the word “defined” or re-phrase it as a question “Do we need to define COT sharing when no LBT is used for channel access?” |
| Charter Communications | We understand the motivation here, but in RAN1#102-e agreements the notion of channel occupancy also covers the no-LBT case (“For gNB/UE to initiate a channel occupancy, both channel access with LBT mechanism(s) and a channel access mechanism without LBT are supported.”) So a more consistent phrasing would be: There is no restriction on COT sharing when a channel occupancy is initiated without LBT. |
| Intel | Similarly as the previous proposal, we believe that with the am to harmonize the specification the concept of COT sharing could be also defined when both gNb and all its associated UEs are operating without LBT, but in this context the COT sharing mechanism loses its meaning. |
| Huawei/HiSilicon | We think it should first be clarified that 1) whether or not it is allowed to have a mixture of LBT/No-LBT in a system (one pair of initiating/responding pair with LBT and one initiating/responding pair with No-LBT); and 2) How dynamic LBT can switch to/from No-LBT for an initiating/responding device pair.For instance, if the mixture of LBT/No-LBT is allowed, then COT sharing may need to be defined between the (gNB, UE(s)) pair that communicate without LBT to facilitate a fair channel access for the “LBT pair”. |
| Qualcomm | When no LBT is applied, a node does not need to do per transmission burst(s) channel access. Therefore we don’t need COT. If a node does not perform channel access to win a COT, it has nothing to share. |
| CATT | Agree |
| NTT DOCOMO | Support in general. Charter Communication’s suggested modification would also be fine.  |
| Samsung | OK with the conclusion.  |
| ZTE, Sanechips | Agree this conclusion, but need to further confirm what is the length of transmission for a transmission for a gNB/UE if No LBT is used, is it still 584us? |
| Lenovo,MotorolaMobility | Agree with the conclusion |
| Apple | Agree |
| Ericsson | “COT” and “COT sharing” is a concept that is only applicable when LBT is being used. The whole idea is to allow the responding device to perform a faster/shorter LBT procedure if its transmission falls within the initiated COT for which full LBT was performed. Going back to 37.213, it defines the following: - A *channel occupancy* refers to transmission(s) on channel(s) by eNB/gNB/UE(s) after performing the corresponding channel access procedures in this clause.- A *Channel Occupancy Time* refers to the total time for which eNB/gNB/UE and any eNB/gNB/UE(s) sharing the channel occupancy perform transmission(s) on a channel after an eNB/gNB/UE performs the corresponding channel access procedures described in this clause. For determining a *Channel Occupancy Time*, if a transmission gap is less than or equal to , the gap duration is counted in the channel occupancy time. A channel occupancy time can be shared for transmission between an eNB/gNB and the corresponding UE(s).I don’t think it is contradicting to say that COT/MCOT are not applicable for the no LBT case. Since by definition, COT refers to the total time after performing “the channel access procedure, i.e. LBT” |

Summary of discussion:

Possible Conclusion (with updated text)

There is no COT sharing when a channel occupancy is not initiated with LBT

* Support: Vivo, FW, Charter, HW, Qualcomm, CATT, DCM, Samsung, Lenovo, Apple, Ericsson, LG, SPRD, ZTE, Sanechips, Sony

Please provide additional view

|  |  |
| --- | --- |
| Company | View |
| OPPO | Support. |
| Xiaomi | Agree with the updated proposal. |
| LG | Support the updated proposal. |
| Spreadtrum | Agree with the updated proposal. |
| ZTE, Sanechips | Support the updated proposal. |
| Apple | Agree |
| Sony | Agree with the updated proposal. |

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 from an initiating node performed LBT to responding device without performing LBT, do we need to define a maximum gap between the initiating node transmission and responding node transmission?

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| **Company** | **View** |
| Ericsson | No. such restriction is not required by EN 302 567 and there is no coexistence issue. As long as there is no evidence that there is an issue to resolve, we do not accept adding those restrictions.Besides, the gap is any way restricted since, unlike 5GHz, all the gaps are counted as part of the COT. Hence, a gap can never exceed 5ms.  |
| Huawei/HiSilicon | We do not see a compelling reason to define a maximum gap within COT.  |
| LG | The definition of the gap allowed for COT sharing without LBT can be discussed together with the type of channel access procedures (e.g., Type 2A/2B/2C in Rel-16 NR-U) even the restrictions are not specified in EN 302 567.  |
| Nokia, NSB | No need to define such gap. |
| vivo | Maximum gap definition without LBT is not necessary. Any gap is applicable since the regulation does not have any restriction on this. “*An equipment (initiating or not initiating transmission), upon correct reception of a packet which was intended for this equipment, can skip the CCA Check, and immediately proceed with the transmission in response to received frames. A consecutive sequence of transmissions by the equipment, without a new CCA Check, shall not exceed the 5 ms Channel Occupancy Time as defined in step 5) above*” |
| Futurewei | The maximum gap definition is not necessary.  |
| Charter Communications | Any such maximum gap limit should be motivated based on simulation evidence. |
| Intel | In case LBT is not used by both the gNB and all its associated UEs, the concept of gap is not needed.  |
| Qualcomm | We prefer not to introduce a maximum gap. |
| CATT | The maximum gap is not needed without LBT |
| NTT DOCOMO | As far as no such restriction in the regulation, the necessity is questionable to us.  |
| Samsung | No, since it is not required by regulation.  |
| ZTE, Sanechips | If the maximum gap is not defined, whether it means the responding device can transmit immediately after initiating device transmission ends, or it can any gap length between the initiating node transmission and responding node transmission even if gap is enough large so that the channel is lost. |
| Lenovo,MotorolaMobility | We are open to discussion if there is need for defining maximum gap for COT sharing. |
| Apple | There are three scenarios:* scenario 1: For scenarios where both devices are in no-LBT mode, there is no concept of a COT. Mechanisms such at ATPC or DFS should be limiting interference (addressed by the conclusion above)
* scenario 2: For scenarios where the initiating device is in LBT mode and shares its COT with a responding device without LBT, there should be no maximum gap for the responding device (current question).
* scenario 3: For scenarios where both devices are in LBT mode, a maximum gap should be set only if there is a performance benefit from introducing the gap. If none, there should be no gap.

Summary: No maximum gap. |

Summary of discussion:

For COT sharing from an initiating node performed LBT to responding device without performing LBT, do we need to define a maximum gap between the initiating node transmission and responding node transmission?

* No: Ericsson, HW, Nokia, Vivo, FW, Charter, Qualcomm, CATT, DCM, Samsung, Apple, SPRD, Lenovo, Motorola Mobility, Sony
* Further discussion: LG, ZTE

Please provide additional view

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| Company | View |
| OPPO | Further discussion. For example, at least a gap for UL transmission by considering Rx-Tx switching time at UE side should be considered. |
| Xiaomi | Not necessary to define this gap. |
| Spreadtrum | No. there is no restriction on maximum gap in the regulation. |
| Lenovo, MotorolaMobility | Considering the support from companies that it is not needed to define a maximum gap, we are okay to agree to not support the maximum gap. |
| Sony | We think it is not necessary to define the maximum gap. |

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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| **Company** | **View** |
| Ericsson | No. EN 302 567 all transmissions within the COT (responding or initiating device) to be transmitted without any LBT. As long as there is no evidence that there is an issue to resolve, we do not accept complicating the procedure.  |
| Huawei/HiSilicon | Not supportive. We don’t see any necessity to define Cat 2 LBT within COT.  |
| LG | The introduction of Cat-2 LBT for COT sharing can be discussed and the initiating device can transmit other transmission in its own COT by supporting multiple switching points when the conditions such as the gap is met. For the definition of Cat-2 LBT, the Type 2 channel access procedure in Rel-16 NR-U can be reused with possible modifications to the parameters. |
| Nokia, NSB | We see no need for this as EN 302 567 does not mandate this (and other HS’s do not even require LBT) |
| vivo | Follow the regulation in EN 302 567, no need. |
| Futurewei | Not necessary.  |
| Charter Communications | Same view as E//, Nok, vivo, etc |
| Intel | Our view is that in the context of COT sharing, the introduction of a single shot LBT may be beneficial, and could be composed by a 8us measurement period, within which either one or two measurement windows could be defined. |
| Huawei/HiSilicon2 | To further clarify our earlier view, Cat2 LBT at the responding device is not necessary only when COT has already been acquired using transmitter side LBT only and the responding device is transmitting data to the initiating device. In the case of receiver-assisted LBT or receiver-only LBT, COT may be acquired by the initiating device and RTS-like signal is sent to the responding device. Then, the responding device may need to perform Cat 2 or Cat 4 LBT within the acquired COT before sending the CTS-like signal to the initiating device. |
| Qualcomm | We think in some cases, cat 2 LBT can be helpful under hidden node scenario. Cat 2 LBT should be defined, but gNB should control if it is used for not for COT sharing |
| CATT | Not support |
| NTT DOCOMO | As far as no such restriction in the regulation, the necessity is questionable to us.  |
| Samsung | It can be further discussed. Although it’s not required by regulation, since it’s there in LBT framework for Rel-16 NR-U, carrying over this concept may ease specification impact.  |
| ZTE,Sanechips | Share same views with HW and Qualcomm  |
| Lenovo,MotorolaMobility | Yes, we should consider CAT2 LBT for 60GHz as the initiating device might transmit multiple bursts on multiple beams, if directional LBT is adopted |
| Apple | From EN 302 567, we have the following relevant clauses:“The UUT is allowed to respond to transmissions of the companion device and the channel occupancy time shall be less than or equal to the maximum channel occupancy time on the current operating channel.” “An equipment (initiating or not initiating transmission), upon correct reception of a packet which was intended for this equipment, can skip the CCA Check, and immediately proceed with the transmission in response to received frames. A consecutive sequence of transmissions by the equipment, without a new CCA Check, shall not exceed the 5 ms Channel Occupancy Time as defined in step 5) above.” From the statements above, a consecutive sequence of transmissions is allowed but the term “immediately” is used. The meaning of the word “immediately” should be discussed in the context of the question.  |

Summary of discussion:

When LBT is used, shall we introduce Cat 2 LBT 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.

* Yes: LG, Intel (8us), HW (rx assisted LBT), Qualcomm, Samsung, ZTE, Lenovo, SPRD, Sony
* No: Ericsson, HW (except rx assisted LBT), Nokia, Vivo, FW, Charter, CATT, DCM

Please provide additional view:

|  |  |
| --- | --- |
| Company | View |
| OPPO | Yes. |
| Xiaomi | Prefer to introduce Cat 2 LBT for responding device in COT sharing |
| Spreadtrum | Yes, at least Cat 2 LBT performed by the responding device is beneficial in the hidden node scenario. |
| Sony | Yes, at least Cat 2 LBT for responding device in COT sharing would be useful for the hidden node scenario. |

Discussion point:

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

|  |  |
| --- | --- |
| **Company** | **View** |
| Ericsson | We do not support LBT at responding device |
| Huawei/HiSilion | The discussion point is not very clear for us. It needs to be clarified which of the following scenarios (or any other scenario) is concerned in the question:1. COT is acquired after a successful receiver assisted LBT (e.g., RTS/CTS-like mechanism) and is shared between the initiating device and the responding device.
2. COT is acquired by the initiating device and shared with a responding device. The responding device performs LBT during the COT before transmission.

If the intention is 1 above, we don’t see any reason defining a maximum gap. If the intention is 2 above, we do not support LBT by the responding device during the COT.  |
| LG | The definition of the gap allowed for COT sharing with LBT can be also discussed together with the type of channel access procedures (e.g., Type 2A/2B/2C in Rel-16 NR-U) even the restrictions are not specified in EN 302 567. |
| Nokia, NSB | As said above, we see no need for Cat 2 for the responding device |
| vivo | Our understanding is that any transmission within the COT can proceed immediately if COT sharing. |
| Futurewei | This is a re-phrase of a previous question. There is no need to define a maximum gap based on ETSI regulations. |
| Charter Communications | Same view as vivo |
| Intel | Given that per regulation no LBT is actually needed for a responding device, but performing an additional interference measurement during a COT may be beneficial under highly contended medium, a minimum observation time of 8us could be used as a maximum gap.  |
| Qualcomm | We don’t think a maximum gap is needed. Note that the key use case to consider while working with COT sharing is the sharing of the COT from UL to DL – helping gNB win the medium.  |
| CATT | We don’t support COT sharing with LBT at responding device |
| NTT DOCOMO | As far as no such restriction in the regulation, the necessity is questionable to us.  |
| Samsung | No need to have the limitation.  |
| ZTE, Sanechips | If LBT is supported for responding device, our understanding is at least the time gap to perform LBT procedure should be defined/reserved. |
| Apple | Re-phrase of the last-but-one question. (1) only valid if the responding device performs LBT (2) should be introduced only if there is a performance benefit. |

Summary of discussion:

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

* No LBT at responding device in the beginning: Ericsson, HW, Nokia, Vivo, Charter, CATT, DCM
* No gap limit: FW, Qualcomm, ~~DCM,~~ Samsung, Apple, SPRD, Sony
* Yes: Intel (8us), ZTE
* Discuss further: LG, Lenovo, Motorola Mobility

This certainly depends on the previous discussion. Please provide additional view

|  |  |
| --- | --- |
| Company | View |
| NTT DOCOMO | Our view is more similar to the 1st bullet, which is reflected above.  |
| OPPO | If RAN1 can confirm that for COT sharing, a responding device can start LBT to share the initiated COT from anywhere in the COT, then the gap is not needed. But if RAN1 cannot confirm this, gap needs to be discussed. |
| Xiaomi | Prefer to define this gap, but also agree with LG to discuss further |
| Spreadtrum | No need to have a limitation on maximum gap. |
| Lenovo,Motorola Mobility | Agree with LG that it can be further discussed |
| Sony | We think LBT is supported but definition of a maximum gap is not necessary. |

Discussion point:

Should ED threshold be a function of LBT bandwidth

|  |  |
| --- | --- |
| **Company** | **View** |
| Ericsson  | ETSI BRAN EN 302 567 has been recently updated. The updates included changes related to the LBT procedures (CW, MCOT, etc..) but yet the ED threshold was not changed to reflect the LBT bandwidth.  |
| Huawei/HiSilicon | Yes. One reason is that if two operators with different BWs interfere with each other, the one with a higher BW is in disadvantage if the EDT does not depend on the LBT bandwidth.  |
| LG | It is necessary to enhance the method of determining the ED threshold with consideration of the maximum output power and the unit LBT bandwidth applied in NR for the fair coexistence with the incumbent system (e.g., WiGig). |
| Nokia, NSB | We are open to study this further once the channelization becomes more clear. ED threshold adaptation should be standardized only if meaningful benefits are shown.  |
| vivo | The ED threshold for different LBT bandwidth can be further studied. |
| Futurewei | The PSD depends on the bandwidth therefore ED threshold should be adjusted accordingly. |
| Charter Communications | Open to study this further. |
| Intel | Our view is that to allow fair coexistence among systems operating with different bandwidths, the ED threshold calculation shall account not only for the maximum output power, but also at least for the bandwidth used. In this matter, we would like to highlight that the ETSI BRAN provides some minimum requirements that should be met for compliance, but does not mandate or restrict us from supporting additional features as long as those minimum requirements are met and those features help improving the performance of the system. |
| Qualcomm | Yes. It can be studied further whether such mechanism can be used to encourage or discourage narrow/wideband interference. |
| CATT  | Yes. It can be further studied |
| NTT DOCOMO | Open to discuss further |
| Samsung | Yes, similar principle as Rel-16 NR-U should be applied.  |
| ZTE, Sanechips | Yes, ED threshold consider the impact of different Bandwidth |
| Apple | Yes, for coexistence between NR deployments of different BWs and for different RATs. |

Summary of discussion

Should ED threshold be a function of LBT bandwidth

* Yes: Ericsson(?), HW, LG, FW, Intel, Samsung, ZTE, Apple, Sony
* Further study: Nokia, Vivo, Charter, Qualcomm, Charter, DCM, SPRD, Lenovo, Motorola Mobility

Please provide additional view

|  |  |
| --- | --- |
| Company | View |
| NTT DOCOMO | It could depend on the detailed definition on LBT BW.  |
| OPPO | Open to study further. But it seems reasonable to make ED threshold as a function of LBT bandwidth or transmit power. |
| Xiaomi | Agree to discuss further |
| LG | In addition to LBT bandwidth, the ED threshold can be a function of transmit power. |
| Spreadtrum | Agree to further study |
| Lenovo, MotorolaMobility | Agree to further study |
| Sony | Yes, ED threshold should depend on LBT bandwidth if multiple LBT bandwidths are supported. |

## 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 100 msec. |
| 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

|  |  |
| --- | --- |
| **Company** | **View** |
| Ericsson | Yes. Since there is no coexistence issue in majority of the scenarios, we think it is beneficial to assume that control signals (especially SSB and PRACH) can be send without performing LBT up to 10% of the time. Even if LBT is performed, it will rarely fail. we do not see the need to support any channel design changes to cope with the LBT procedure, if we know that LBT will rarely make difference.  |
| Huawei/HiSilicon | We can accept such an exemption as long as the following conditions are met:1. The exempted signal/channel has a low duty cycle. 10% can be a reasonable choice. However, it should be clarified the x% duty cycle only accounts for the amount of signal outside of COT or also includes the amount of signal inside COT.
2. The exempted signal/channel is unicast and not broadcast so it has a small “interference footprint” (e.g., only UCI or unicast DCI).
 |
| LG | The contention exempt for short control signalling can be considered based on the requirements described in EN 302 567. The type of short control signals (e.g., SSB, CSI-RS) and the requirements (e.g., TX power) for the transmission without contention can be determined through further discussion. |
| Nokia, NSB | Yes, we should plan for that. ETSI BRAN is expected to update EN 302 567 in this respect, and the NR-U design should make use of the allowance. |
| vivo | Some clarifications are needed.1, what is a duty cycle? A COT or a constant time?2, the restriction applies only to the short control signalling outside the COT or also inside a COT?3. Shall we update the regulation regarding the short control signalling? Since there is no short control signalling in EN 302 567 now. |
| Futurewei | Same as Vivo mentioned. How a duty cycle is defined? It is not clear. Is it 10% of a COT duration or 10% of MCOT? How short the short control transmissions need to be? More details are necessary. In principle we are OK of having contention exempt transmissions. |
| Intel | From a close look to EN 302 567, we believe that the ETSI BRAN does not support or hint for any short control signalling exemption. The text that many companies are referring to (which is copied below) describes the test conditions for the adaptivity mechanisms, but does not dictate or indicates the channel sensing mechanism itself, which is only described in Sec. 4.2.5, where no concept of short control signalling is defined. Note that the duty cycle of 10% is only introduced in Sec. 5.3.8 as part of the test conditions and refers to the time synchronization and beam forming frames transmissions as part of a specific measurement setting.  **Step 4: Verification of reaction to the interference signal*** The analyser shall be used to monitor the transmissions of the UUT and the companion device on the selected operating channel after the interference signal was injected. This may require the analyser sweep to be triggered by the start of the interfering signal.
* Using the procedure defined in clause 5.3.8.3, it shall be verified that:

a) The UUT stops transmissions on the current operating channel within a period equal to the maximum *Channel Occupancy Time* defined in clause 4.2.5.3. The UUT is allowed to respond to transmissions of the companion device and the channel occupancy time shall be less than or equal to the maximum channel occupancy time on the current operating channel.b) Apart from transmission of the frames for short control signalling (such as, for example, ACK/NACK signals, beacon frames, other time synchronization frames and frames for beamforming) no frame shall be initiated.c) The time synchronization and beam forming frames transmissions shall be less than or equal to 10 % within an observation period of 100 ms.d) On removal of the interference signal the UUT may start transmissions again on this channel. However, this is not a requirement and, therefore, does not require testing. |
| Qualcomm | Yes. Short control signalling is helpful. This can be used for DRS and control only transmission. The duty cycle should be limited to 10% per regulation. Our understanding is that the duty cycle for short control signalling is measured *outside*  of COTs won by contention for data transmission, and is measured over a time-window much longer than MCOT. We don’t think TX power restriction is needed. |
| CATT | Short control signal is useful.  |
| NTT DOCOMO | We are ok to consider short control signalling based contention exempt transmission. Restrictions need to be studied further, if supported.  |
| Samsung | Can support such feature as long as regulation is satisfied.  |
| ZTE, Sanechips | Firstly, short control signalling has not been explicitly specified in EN 302 567, So if supported, suggest to revise the current EN 302 567 first before discussing how to support short control signalling. And more detailed designs can be left to WI phase. |
| Lenovo,MotorolaMobility | We don't see a need to exclude such short control signaling at this point. There should certainly be restrictions on the duty cycle and content, but these could be part of the WI discussion. |
| Apple | Yes, there should be an allowance for short control signaling based on the 10% rule defined in the ETSI standard. We may want to restrict this to SSBs, maybe CSI-RS, PTRS but no data only transmissions. Note that if there is a transmission of short control signaling, other information may be FDMed if resources as available. BTW, the proposal should be 10% of a 100 msec burst and not 10% of the COT.The restriction applies to short control signaling outside the COT only.The specific Short Control signals allowed needs to be defined. |

Summary of discussion

Shall we support short control signalling based contention exempt transmission in 60GHz band? If yes, any restriction to the transmission, such as, on duty cycle (say 10% of the air time measured over a relatively long period of time, say 100ms), content (control signalling only? SSBs? CSI-RS?), TX power

* Yes: Ericsson, HW, LG, Nokia, Qualcomm, CATT, DCM, Samsung, Lenovo, Apple, SPRD, Sony
* No: Intel
* Further study: Vivo, FW, ZTE

Please provide additional view

|  |  |
| --- | --- |
| Company | View |
| OPPO | Open to study. Propose to have a common understanding of EN 302 567 first. Intel’s cited text should be controversy point.  |
| Xiaomi | Support short control signalling based contention exempt transmission in 60GHz band. |
| Spreadtrum | We support short control signalling based contention exempt transmission in 60GHz band. |
| Sony | Short control signalling would be beneficial. At least the limitation of 10% duty cycle should be considered as defined in EN 302 567. Other limitations such as content and Tx power is further studied. |

Discussion point:

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

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| **Company** | **View** |
| Ericsson | Can be performed without LBT as allowed by EN 302 567 (we prefer to avoid referring to CAT1 here since cat1 as specified for 5GHz has certain restrictions and requirements that are not applicable here) |
| Huawei/HiSilicon | If the exempted signal has a low duty cycle and is unicast, Cat 1 LBT seems to be sufficient. |
| Nokia, NSB | LBT is not required for Short Control Signaling transmissions.  |
| vivo | If short control signalling based transmission is supported, Cat 1 LBT should be applied. |
| Futurewei | It depends on the definition of “short signalling”. In principle, we would prefer for shorter signalling shorter or no LBT. The actual CAT should be left to gNB decision and configuration based on deployment scenarios and traffic situations. |
| Intel | Please refer to the reply above. |
| Qualcomm | Either no LBT, or relaxed LBT requirement. An example for the relaxed LBT requirement is a pseudo-omni LBT for multi-beam sweeping transmission like DRS. |
| CATT | No LBT for short control signals |
| Samsung | Simply follow the regulation.  |
| ZTE,Sanechips | Suggest to revise the current EN 302 567 first before discussing how to support short control signalling. And more detailed designs can be left to WI phase. |
| Lenovo,MotorolaMobility | We assume that no LBT can be used provided that sufficient limits like duty cycle and content are agreed. |
| Apple | No |
| Sony | Cat 1 LBT |

Summary of discussion:

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

* Without LBT: Ericsson, HW, Nokia, Vivo, FW, Qualcomm, CATT, Samsung, Lenovo, Apple, Sony
* Cat 2 LBT: Qualcomm

Since we don’t have any decision on if short control signalling is supported or not, the follow up discussion can wait.

## Directional 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. Observation 5：It should be clarified whether antenna gain is counted in the received -side LBT of the receiver-assisted LBT mechanism and provides an efficient tradeoff as it aims at increasing the spatial reuse while mitigating the hidden node issue. |
| 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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| --- | --- |
| **Company** | **View** |
| Ericsson | EN 302 567 does not define it, neither should 3gpp do that. It can be left to implementation.  |
| Huawei/HiSilicon | 3GPP spec should define the relationship between the LBT beam and the transmission beam. A relation between the LBT sensing beam and the transmission beam should be defined as simulations results of multiple companies show that directional LBT (at the receiver and/or transmitter) can improve coverage compared to omni-directional LBT. From our perspective, an “ideal” directional LBT covers only a spatial continuum of the subsequent transmit beam(s) in the COT while an omni-directional LBT does not have any correspondence with the subsequent transmit beams(s) in the COT and, in particular, may be have a much wider beam width than the spatial continuum of the subsequent transmit beam(s) in the COT.We understand that one beam covering a spatial continuum of multiple other beams is not defined in 3GPP so far. This is an exercise that seems necessary to do in WI.  |
| LG | We should clarify the meaning of directional LBT and omnidirectional LBT first because the omnidirectional LBT can be seen as just a case of directional LBT. Moreover, we think the transmission beam should have a spatial relation with the LBT beam. |
| Nokia, NSB | To our understanding, although EN 302 567 does not have a related requirement, there is a test case that verifies that: “*The UUT may be connected to a companion device during the test. When performing this test of a UUT with directional antenna (such as array antenna system capable of beam-forming), the wanted communication link (between the UUT and the companion device) and the interference signal shall be aligned to the direction corresponding to the UUT's maximum EIRP.”*One way or another NR-U devices will need to comply with the requirement, but that will likely not affect RAN1 standards (but possibly RAN4).  |
| vivo | The directional LBT operation should be first discussed, in the case with beam correspondence, without beam correspondence, with a beam “cover” the transmission beams, etc. When we have clear view on the directional LBT, we can further discuss if there is spec impact. |
| Futurewei | We should study and define the relationship between sensing beam for LBT and transmission beam. We should consider the CCA ED adjustment based on the sensing beam and transmission beam imbalance. |
| Intel | We believe that within the specification the relationship between the CCA measurement and the transmission beam should be defined. If no relationship is defined, in theory the listening device can abuse the definition where CCA measurement is performed with null beamforming or in directions where its knows there is severe attenuations (e.g. backside of the panel) and leverage this measurement to transmit. At the very least, there should be some reasonable guides on how CCA measurements are performed to make sure devices are behaving as intended by the system. |
| Qualcomm | We believe some restriction is needed. It does not make sense to allow the node to do LBT to the left and transmit to the right. We should at least require the LBT beam ‘covers’ the transmission beam. The specific detail of how directional sensing and LBT be performed may be suspended to the work item phase. Also note that a directionality in sensing may be accompanied by a change in ED threshold affected by beamforming gain of the sensing unit. Under such adjustment to ED threshold to use, it is crucial to get the notions of directional sensing/LBT right.  |
| CATT | It is very challenged to define the LBT beam since receiver performs maximum ratio combining without prior reference. The transmission beam is an implementation.  |
| NTT DOCOMO | Whether to support directional LBT should be discussed at first. If supported, we think the relationship between the LBT beam and the transmit beam would be somehow necessary.  |
| Samsung | If the feature is supported, it cannot be fully up to implementation. There should be at least some limitation on the transmission direction and sensing direction, and more aspects can be discussed.  |
| ZTE,Sanechips | We think this issue should be further studied in WI phase. Besides, we think it is necessary to specify the relationship between the LBT beam and the transmission beam in order to evaluate the current channel condition more accurately. |
| Lenovo, MotorolaMobility | We support directional LBT for NR-U at 60 GHz due to the reasons discussed in our contribution [2]. And if directional LTB LBT is adopted, then the directional LBT and beam-management procedures need to be tightly coupled. Therefore, 3GPP should define the relationship between LBT beam(s) and transmissions/reception (beams). Especially from a UE point of view, it is necessary that it is indicated/configured with a relation between the LBT beam and its RX/TX beam |
| Apple | There is a need to discuss the relationship between directional and “omni-directional LBT. Once understood, we can decide if the corresponding CCA ED adjustments should be left to implementation or defined in the specification. From our understanding, directional-LBT means listening with the beam (or similar beam) that will be used to transmit. The CCA ED is specific to a beam. Omni-directional LBT (or Quasi-omni) means listening with a beam that covers all possible directional beams (may not be perfectly omni-directional) and the CCA ED is constant for all beams. |

Summary of discussion:

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?

* Yes: HW, LG, FW, Intel, Qualcomm, DCM, Samsung, ZTE, Lenovo, Apple, SPRD, Sony
* No (the LBT beam and transmission beam relationship is implementation): Ericsson, Nokia(?), CATT
* Further study: Vivo

Please provide additional view

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| Company | View |
| OPPO | In our view, it should be defined in RAN1, even if it might not impact the specification at the end, it is indeed necessary to have a common understanding on the LBT beam. Hopefully, everyone in the group should align the language. From our point of view, if the LBT beam has no relationship with the transmission beam at all, it does not make sense to perform this directional LBT. Therefore, we believe there is some kind of relationship between LBT beam and Tx beam. |
| Xiaomi | Agree with DCM’s opinion, whether directional LBT is supported should be discussed first. |
| Spreadtrum | As many companies have pointed out, a relationship between LBT beam and transmission beam should be defined, otherwise the LBT procedure is meaningless. |
| Sony | We think the relationship between the LBT beam and the transmission beam should be defined in 3GPP spec. |

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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| **Company** | **View** |
| Ericsson | Is the assumption to allow higher ED threshold than what BRAN allows if directional LBT is used? but then doesn’t that violate EN 302 567?  |
| Huawei/HiSilicon | Both sensing (LBT) beamforming gain and subsequent transmission beamforming gain should be taken into account in the EDT threshold. In our view, this is independent of whether or not 3GPP spec defines the relationship between the LBT beam and the transmission beam. |
| LG | The ED threshold for directional transmission may need to be different from the case of omni-directional transmission since the coverage and interference from a directional transmission will be different from an omni-directional transmission. Therefore, the ED threshold can be adjusted by the LBT beam and/or TX beam choices. |
| Nokia, NSB | This aspect will require further study during the WI. |
| vivo | If the LBT beam and the transmission beam are different, the ED threshold should take into account the different antenna gain. |
| Futurewei | Sensing and transmission beams, especially when a gNB serves multiple UEs in a COT may be quite different therefore the ED may require adjustments.  |
| Intel | As shown by the SLS simulations, based on the CCA beam used and deployment, one ED threshold may be more suitable and offer better system level performances than another. Therefore, it may be beneficial to account within the ED threshold for the LBT beam used. |
| Qualcomm | We believe some ED adjustment is needed if the LBT beam and TX beam are not matching. To answer Ericsson’s question, we are not trying to violate EN 302 567, but we can apply “tighter” ED threshold under some conditions. Some of the results show that ED thresholds lower than those mandated by ETSI – may provide performance improvements. – In these cases, choosing the thresholds to adapt to directionality and beamforming gain of sensing – may further facilitate the medium access for nodes transmitting narrower beams that have reduced interference footprints. |
| CATT | This question is invalid.  |
| NTT DOCOMO | Whether to support directional LBT should be discussed at first. Even if supported, we think 3GPP needs to follow BRAN regulations. As long as BRAN regulations are met, we can enhance the relation between characteristics of LBT beam and ED threshold.  |
| Samsung | The ED threshold for directional LBT should be different from the one for omni-directional LBT, to take into consideration of the coverage of the sensing beam.  |
| ZTE, Sanechips | We think this issue should be further studied in WI phase. But, for this issue, we tend to define ED threshold considering the impact of a certain LBT beam and transmission beam, especially for the different between transmission beam and sensing beam |
| Apple | Should be defined based on type of LBT (directional or omni). Can be discussed in detail during WI. |
| Xiaomi | We don’t quite see why need different ED threshold. Fixed threshold will be OK. |
| Sony | ED threshold should be taken into account the antenna gain. |

Summary of discussion:

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?

* Yes: HW, LG, Vivo, FW, Intel, Qualcomm, Samsung, Lenovo, Motorola Mobility, Sony
* No: Ericsson, DCM
* Further study: Nokia, ZTE

This discussion depends on the previous discussion, and can be discussed later.

## Rx Assisted LBT

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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, receiver-side directional LBT should be supported.Observation 8: Receiver-only directional LBT outperforms No-LBT in terms of both coverage and capacity across the different loading conditions in the indoor scenarioObservation 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, and please also comment on if there is better way to define classes.

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| **Company** | **View** |
| Ericsson | We agree with the moderator’s proposal to clarify companies’ expectation when it comes to receiver assisted LBT. Companies that evaluated Receiver assisted LBT are asked to indicate which RAL category did they evaluate.In our view, we see benefits in providing long term measurement to assist the interference situation. We do not see the benefits or need to support a receiver assisted LBT with information exchange per COT.   |
| Huawei/HiSilicon | Support Class A as it is more practical. In our view, Receiver-only LBT as a simple yet effective sub-category of receiver-assisted LBT should be supported. Our simulations in our updated t-doc R1-2008976 show the performance of receiver-only LBT.  |
| LG | We agree with the moderator’s proposal. In the actual implementation of the UE or gNB, the receiving direction and the transmitting direction may not match well. Moreover, applying the same spatial direction as transmission direction for CCA may not be effective since interference to the receiver will be estimated in the opposite direction to the transmission direction. In this sense, the receiver assisted LBT can be considered but there is a need to clarify which aspect is additionally required to support receiver assisted LBT in terms of above categorized class of receiver assisted LBT. |
| Nokia, NSB | First of all, in our view receiver assisted LBT schemes, if any, should be a complementary solution that can be used based on gNB discretion when benefits are there. There should be convincing simulation results with realistic assumption before such schemes are specified.The practical feasibility of Class B and Class C schemes is questionable, while the gains are unclear.Class A could in principle include schemes resembling existing CSI reporting mechanisms with some enhancements, and those may help the network in understanding the instantaneous interference conditions. Practical challenges related to e.g. UE processing times will still need to be considered, and related information should be provided along with the proposals and evaluation results. |
| vivo | As a starting point, we should focus on class A. All the UEs in the cell can detect the request sent from the gNB, but only the target UEs will feed back with response. In the case of UE-initiated COT, only gNB provides response to the initiating UE.In the future, the scheme can be extended to class B if necessary. Class C should not be considered. |
| Futurewei | Use Class A as the starting point. For the benefits of Class B and Class C, it is not clear for instance, what type of signalling can be used between RAT and if this signalling is reciprocal between RAT. |
| Intel | Our preference is for a receiver-assisted LBT of class A, which is a simpler and more practical solution. All other classes may require information exchange with inter-operator devices, which may complicate implementation. |
| Qualcomm | We believe at least Class A RX assistance is beneficial to introduce for “stuck” scenarios. Long term measurement from receiver can provide some benefit for stuck scenario, but not as dynamic as the per COT RX assistance. It is also possible to facilitate some forms of receiver assistance (intra-NR, inter-operator) under a long term sensing framework on top of Class A – which helps inter-operator discovery of victim receivers. This can further help scenarios with catastrophic beam collisions considerably. We are open to Class-B type receiver assistance but it can be re-visited for study if needed in future release.  |
| Convida Wireless | Class A could be considered as baseline. Class B and C could be for further study. |
| CATT | Class A is the practical proposal.  |
| NTT DOCOMO | We agree the baseline of the discussion is clarified at first. Case A could be a starting point. Case B1 can also be considered.  |
| Samsung | To comply with the NR system, it is more practical to support Class A only.  |
| ZTE, Sanechips | Support Class A, it seems to be more intuitive and reasonable. Other classes can be further evaluated and studied in WI phase. |
| Lenovo, Motorola Mobility | In our view, we support Class A of receiver assisted LBT and also tend to agree with Ericsson on the reliance on long term measurement to assist the interference management from other systems and operators.  |
| Apple | We think this means Class A. |

Summary of discussion:

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.

For the support of (the study of) receivers assisted LBT classes in Rel.17

* No RX assisted LBT: Ericsson
* Class A: HW (receiver only LBT), Nokia, Vivo, FW, Intel, Qualcomm, Convida, CATT, DCM, Samsung, ZTE, Lenovo, Apple, LG, SPRD, Sony
* Calss B1: ~~DCM~~

Please provide additional view

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| Company  | View |
| NTT DOCOMO | Ok not to consider Class B1 in Rel.17.  |
| Xiaomi | Agree with FL’s updated classification. At least class A can be supported. |
| LG | At least supporting class A could be considered. |
| Spreadtrum | From our point of view, at least class A can be supported. |
| Sony | At least class A can be supported. |

## 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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| **Company** | **View** |
| Ericsson | The support of LBT should not add restriction on gNB scheduling behaviour. EN 302 567 does not disallow spatial multiplexing of multiple beams (MU-MIMO) within a COT. Also, it does not require additional LBT requirements.  |
| Huawei/HiSilicon | Support spatial multiplexing of multiple beams (MU-MIMO) as long as a directional LBT is used before COT that covers all the subsequent transmission beams in the COT. |
| LG | As we mentioned in 2.5.1, the transmission beam is closely related to the LBT beam. Therefore, if we want to support spatial multiplexing of multiple beams within a COT, the corresponding LBT should be performed for the multiple beams accordingly. |
| Nokia, NSB | MU-MIMO should be supported as long as requirements related to EIRP etc. are met. It is unclear if MU-MIMO puts any further requirements to the LBT design. |
| vivo | Spatial multiplexing of multiple beams should be supported. But the LBT requirements need further discussion. There are some options as below:1. Perform LBT with a beam “cover” the transmission beams to obtain the COT
	1. Transmit without further LBT in each transmission direction within the COT
	2. Perform one-short LBT before each transmission within the COT
2. Perform LBT for each transmission beam immediately before the transmission and obtain COT for each beam.
	1. Some rules should be considered to break LBT procedure if some beam direction is always detected as busy. The device can then switch to another beam to perform LBT and transmission.
 |
| Futurewei | Support spatial multiplexing. For the LBT requirement part , it may be related to the relation between sensing and transmission beams. CCA should cover the potential transmission area. |
| Intel | Our view is that spatial multiplexing could be supported. However, given a set of CCA beams which cover different or overlapping areas, every time a transmission is attempted over a specific direction an independent COT should be initiated, and before an actual transmission could be initiated a CCA procedure would need to be cleared. In this context, it should be discussed and further studied how the CWS adjustment should be performed when there are overlapping CCA beams. |
| Qualcomm | SDMA is a useful feature to increase mmW system capacity and should be supported in unlicensed band. For LBT, we can either do multi-beam LBT at the beginning of the COT, or we can do a wider beam LBT that covers all component beams in the COT |
| Convida Wireless | Spatial multiplexing of multiple beams or MU-MIMO could be supported. |
| CATT | Multi-beam operation (dynamic TCI state) should be enhanced to be useful for LBT if LBT is supported |
| NTT DOCOMO | We agree to consider spatial mux of multiple beams within a COT.  |
| Samsung | MU-MIMO should be supported, and the LBT aspect can be further discussed after the basic aspect of directional LBT is clear.  |
| ZTE,Sanechips | We are not sure whether MIMO project has supported multiple beam transmissions simultaneously. If supported, seems multiple-LBT can refer to multiple-channel access procedure specified in TS37.213 or will it as a starting point of study. |
| Lenovo, MotorolaMobility | Yes, we should support different multiplexing schemes including TDM on multiple beams and depending upon the gaps between transmissions/beams, we should consider LBT in the middle. If directional LBT is adopted, then anyways we expect to perform beam specific LBT.Also agree with Huawei’s view. |
| Apple | Yes, MU-MIMO can be supported. LBT can be directional (i.e. per beam) or “omni-directional” (i.e. over all beams). This is similar to the directional/omni-directional question and we should have a consistent solution. |

Summary of discussion:

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

All companies support SDM multi-beam operation.

LBT requirement for SDM multiple beam transmission:

* No additional LBT requirement: Ericsson, Nokia,
* LBT covers all beams: HW, LG, Vivo (widebeam LBT or multiple beam LBT), FW, Qualcomm, Lenovo, Apple, SPRD, Sony
* Further study: Intel, Samsung, DCM, ZTE, Sanechips

This may not need to be decided now. But please provide additional view if any

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| NTT DOCOMO | Our view is same as Intel and Samsung, i.e. further study.  |
| OPPO | This discussion is somewhat relevant to the relationship between directional LBT, e.g. LBT beam and transmission beam. From our view, if the LBT beam covers multiple Tx beams, no additional LBT is needed between these Tx beams. |
| Xiaomi | Prefer LBT covers all beams. But it can be further discussed. |
| Spreadtrum | We support LBT beam covers all beams. |
| Sony | As similar discussion in sec 2.5, the relationship between LBT beam and transmission beam should be considered. All multiple beams should be covered within the LBT beam. |

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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| **Company** | **View** |
| Ericsson | The support of LBT should not add restriction on gNB scheduling behaviour. EN 302 567 does not disallow TDM multiplexing of multiple beams within a COT. Also, it does not require additional LBT requirements.  |
| Huawei/HiSilicon | Support TDM multiplexing of multiple beams as long as long as a directional LBT is used before COT that covers all the subsequent transmission beams in the COT. In such a case, there is no need to do an extra LBT within the COT by any of the responding nodes or initiating node. |
| LG | It is noted that the interference environment can be different for each beam direction. For example, if gNB’s transmission is beamformed to Beam A for the first three slots but the last slot is redirected to Beam B, it may collide with other nodes (e.g., WiGig AP) that has transmitted in the direction of beam B after the success of directional LBT to Beam B. Therefore, it should be further studied how to perform omnidirectional or directional CCA for multiple-beam sweeping transmission. |
| Nokia, NSB | TDM multiplexing of beams should be supported. The exact LBT schemes require further study. |
| vivo | Both options can be considered. If no LBT procedure fulfils the requirements of the regulation, it can be adopted for multiplexing of multiple beams within the COT. |
| Futurewei | The LBT during COT is not required as long the LBT that precedes COT covers the potential transmission area (solid angle) |
| Intel | Our view is that it would be highly beneficial to support TDM multiplexing of multiple beams, since given the directional nature of the transmissions without multiplexing only a very limited number of UEs could be served. If TDM multiplexing of multiple beams is supported, the LBT scheme and procedure and how to handle beam switching should be further discussed and studied.  |
| Qualcomm | TDM scheduling with different beams allows more flexibility in gNB scheduling, and should be supported. For LBT, we can either do multi-beam LBT at the beginning of the COT, or we can do a wider beam LBT that covers all component beams in the COT |
| Convida Wireless | TDM multiplexing of multiple beams could be supported |
| CATT | TDM of multi-beam operation should be supported (e.g., SSB sweeping) |
| NTT DOCOMO | Technically agree with Nokia, FW and Intel. Further study would be needed in our view. |
| Samsung | TDM multiplexing should be supported, and the LBT aspect can be further discussed after the basic aspect of directional LBT is clear.  |
| ZTE,Sanechips | TDM multiplexing of multiple beams could be supported. Further, we can also consider some other methods such as same beam direction can be used for consecutive transmission, or introduce gap for LBT between DL/UL consecutive transmissions with different beams within COT. |
| Lenovo, MotorolaMobility | Yes, we should support different multiplexing schemes including TDM on multiple beams and depending upon the gaps between transmissions/beams, we should consider LBT in the middle. If directional LBT is adopted, then anyways we expect to perform beam specific LBT.  |
| Apple | TDM multiplexing can be supported. Ideally, we should perform LBT at the beginning of the COT. We may have the LBT over the directions of the constituent beams (either per beam or as a group). |

Summary of discussion:

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?

All companies support TDM different beams in a COT

On LBT requirement:

* Support and has no LBT impact: Ericsson
* Directional LBT at the beginning covers all TDM beams with no LBT in the middle: HW, Vivo, FW, Qualcomm, Apple, SPRD
* Perform LBT at the beginning of COT and additional LBT for each beam switching in the middle: Vivo, ZTE, Lenovo
* Further study: LG, Nokia, Intel, DCM, Samsung, Sony

This may not need to be decided now. But please provide additional view if any

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| OPPO | Further study. |
| Xiaomi | Prefer directional LBT at the beginning covers all TDM beams with no LBT in the middle, but it can be discussed further. |
| LG | We agree to support TDM multiplexing after omnidirectional LBT for the signals and channels that are broadcasted in all directions through multiple beams, such as SSB, but whether this is possible for data bursts also needs further discussion. |
| Spreadtrum | We support directional LBT at the beginning covers all TDM beams with no LBT in the middle, but it can be discussed further. |
| Lenovo, Motorola Mobility | We propose following update to the second and third bullet and are then okay to support both options:* **Directional LBT at the beginning covers all TDM beams:**
	+ **FFS: Whether further LBT is needed in the middle (for example depending upon the gaps between the beams, if any)**
* **Perform LBT at the beginning of COT and additional LBT for each beam switching in the middle, if needed (depending upon transmissions gaps on same beam)**
 |
| Sony | At least LBT beam at the beginning of COT should cover all transmission beam in the COT. It is further studied whether it is allowed to perform LBT in the middle of COT for the purpose of beam switching. |

## 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.
 |

### Discussion

Discussion point:

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

|  |  |
| --- | --- |
| **Company** | **View** |
| Ericsson | No. First of all, the LBT failure is not a common issue in 60GHz. Hence, it is not justified to do PHY design changes to handle LBT failure. Besides, if short control signalling is supported, SSB can be transmitted without LBT even when operating with LBT.  |
| Huawei/HiSilicon | Yes to handle the LBT failure. However, details should be discussed in 8.2.1 |
| Nokia, NSB | If Short Control Signaling is supported, SSBs should be transmitted preferably as SCS, and further candidate positions are not needed. |
| Intel | Given the possible impact of an LBT failure, additional candidate SSB positions should be introduced.  |
| Qualcomm | We don’t think it is necessary to introduce additional candidate positions. We may not have extra bits in MIB in the beginning, and the benefit if limited, especially if we can do short control signalling for DRS transmission |
| CATT | Yes. According to SID, the study needs to support up to 64 beams operation. For operation in unlicensed spectrum, we need additional SSB index in case interruption in beam sweeping.  |
| NTT DOCOMO | As we described in our tdoc, it can be discussed after LBT mechanisms.  |
| Samsung | Yes, even short control signalling is supported, it’s not guaranteed that the limitation is always satisfied. As long as there is scenario where the transmission of SSB needs LBT, additional candidate SSB positions are needed.  |
| ZTE,Sanechips | This issue should be placed in A.I.8.2.1 to discuss. |
| Apple | With no-LBT for short control signalling, it may not be necessary unless there may be a reason to exceed the 10 % of 100 msec rule. |
| Xiaomi | Yes, the reason is same as NR-U in Rel\_16 if LBT is needed for SSB transmission. |
| Spreadtrum | Yes, additional candidate SSB positions should be introduced to handle potential LBT failure. |
| Sony | Yes, it can be beneficial for handling LBT failure. |

Summary of discussion

For SSB transmission, do we need to introduce additional candidate SSB positions to handle potential LBT failure?

* Yes: HW, Intel, CATT, Samsung, Spreadtrum, Lenovo, Motorola Mobility, Sony
* No: Ericsson, Nokia (use short control signalling), Qualcomm, Apple (use short control signalling)
* Further study: DCM, ZTE, Sanechips(This issue should be placed in A.I.8.2.1 to discuss)

##  Misc issues

|  |  |
| --- | --- |
| **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.
 |

# Simulation study observations

## System Level Simulation Sources

The system level simulation observations are obtained from contributions from the following sources:

[20, Ericsson], [4, Huawei/HiSilicon] [40, Huawei/HiSilicon] , [6, Vivo], [16, Intel] , [14, Nokia] , [36, Qualcomm], [18, ZTE/Sanechips] , [34, Docomo], [39, Charter], [25, Samsung]. [[27, Oppo]]

8 companies have presented results for Indoor Scenario A ([20, Ericsson], [4, Huawei/HiSilicon] [40, Huawei/HiSilicon] , [6, Vivo], [16, Intel] , [14, Nokia] , [36, Qualcomm], [18, ZTE/Sanechips], [25, Samsung]),.

1 company has presented Indoor scenario B ([20, Ericsson]),.

7 companies for Indoor scenario C ([20, Ericsson], [4, Huawei/HiSilicon] [40, Huawei/HiSilicon] , [14, Nokia] , [18, ZTE/Sanechips] , [34, Docomo], [39, Charter],[[27, Oppo]]).

2 companies have presented results for Outdoor scenario B ([20, Ericsson], [4, Huawei/HiSilicon] [40, Huawei/HiSilicon]).

## Flavors of Channel Access

The following flavors of channel access schemes have been modeled.

* ‘NLBT’: No LBT Dynamic TDD : NR operation with no restrictions on channel access mechanism.
* ‘NoBackOff’: Dynamic TDD with some extra contention overhead, modelled by setting very high ED threshold to Tx side ED based LBT
* ‘TxED-omni’: Tx side ED Based LBT with Omnidirectional Sensing (‘Tx Omni LBT): Baseline LBT with sensing at the transmitter is expected to closely follow the ETSI En 302567 based medium access procedure
* ‘TxED-Dir’, Tx Side ED Based LBT with Directional Sensing (‘Tx Directional LBT’)
* Rx Assisted LBT Flavors: Multiple flavors of Rx Assistance have been modelled
	+ RxA-1: [20, Ericsson], Receiver assisted LBT: the LBT procedure is evaluated at the receiver instead of transmitter. The LBT result is assumed to be available instantly at the transmitter without accounting any overhead for exchanging this information between the transmitter and the receiver
	+ RxA-2: [4, Huawei/HiSilicon] [40, Huawei/HiSilicon]: Receiver performs directional LBT but transmitter performs Omni LBT
	+ RxA-3: [4, Huawei/HiSilicon] [40, Huawei/HiSilicon]: Only Receiver performs directional LBT
	+ RxA-4: [6, Vivo], RTS and CTS type mechanism is deployed after winning contention before transmission, both RTS and CTS are used for silencing contending transmitters within range (Verify.)
	+ RxA-5: [36, Qualcomm] : Rx Assistance takes the form of protecting ongoing transmissions by silencing based on sensing at the transmitters and protecting intended transmission by silencing based on sensing at the receiver. The receiver also assists by sending silencing signals. Omni and directional sensing is applied.
* Other LBT Flavors:
	+ ‘Dyn-RxA’: Dynamic LBT [20, Ericsson], Dynamic LBT: a node operates without LBT unless the receiver experiences a failure in reception due to a drop in SINR, which reflects a presence of interferer. Only then, the node switches to LBT. Besides, when the LBT is switched on, the RAL described in section 2.1.4 of R1-2007983 is used

Deployments:

The following deployments have been simulated for 2 operator scenarios. In all cases except those described below use the same channel access mechanisms for both operators.

* ‘Mixed’ (LBT + NoLBT) : [20, Ericsson],
* Omni+Dir : [18, ZTE/Sanechips]

## Deployment Assumptions

Following tables depict the key simulation assumptions and modelling assumptions across companies which can have significant impact on the relative analysis.

Table 1 Indoor Scenario A

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **SCS,BW**  | **DL:UL** | **File (MB)** | **LBT Flavors**  | **ED Thresholds (dBm) /CW (min,max)** | **Remarks** |
| **Ericsson** | 960K/2G | 1:1 | 27 | NLBT, TxED-Omni, TxED-Dir, RxA-1, Dyn-RxA,  | {-47, -68} for TxED-Omni,{-32/41} for TxED-Dir,(0,3) | Also: Mixed |
| **Huawei** | {960K/2G}(InHOpen){120K/400M} (InH mixed) | 1:1 | 27(InHOpen)8(InH mixed) | No LBT, TxED-Omni, TxED-Dir, RxA-2, RxA-3 | {-47/-32}/(127,127) | InHOpen, InH Mixed, Rank1 Transmissions |
| **Qualcomm** | 960K/2G | 1:1 | 2,8 | NoBackOff, TxED-Omni, TxED-Dir, RxA-5-Omni, RxA-5-Dir | {-47, -67,-72}(0,3) | Two Antenna Config. at gNB |
| **Vivo** | 960K/2G |  | 27 | NLBT, TxED-Omni, TxED-Dir, RxA-4-Omni, RxA-4-Dir | {-47} (0,3) |  |
| **ZTE**  | 960K/2G |  | 8 | TxED-Omni, TxED-Dir,  | {-47, -62,-72,-82}(0,10) | Also: Dir+Omni,  |
| **Nokia** | 960K/2G | 1:11:0 |  | NLBT, TxED-Omni, TxED-Dir, | {-47}(0,3) |  |
| **Samsung** | 960K/2G | 1:! |  | NLBT, TxED-Omni, TxED-Dir, | {-47}(0,3) |  |
| **Intel** | 960K/2G | 1:! | 2 | NLBT, TxED-Omni, TxED-Dir, | {-48,-55,-65}, (0,15) | Two Antenna Config. at UE |

Table Indoor Scenario C <To Be Completed>

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SourceScenario C | SCS,BW | Traffic | File | LBT Flavors  | CW  | Remarks |
| Ericsson |  |  |  |  |  |  |
| Huawei |  |  |  |  |  |  |
| ZTE |  |  |  |  |  |  |
| OPPO |  |  |  |  |  |  |
| Nokia |  |  |  |  |  |  |
| DCM |  |  |  |  |  |  |
| Charter |  |  |  |  |  |  |

Table 3 Outdoor B <To Be Completed>

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | SCS,BW | Traffic | File | LBT Flavors  | CW  | Remarks |
| Ericsson |  |  |  |  |  |  |
| Huawei |  |  |  |  |  |  |

## Observations

Preliminary observations for system level studies are presented below.

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

<To Be Completed: (1) Quantitative Analysis of gains and losses in performance (2) TR friendly language>

### Indoor Scenario A

* Comparison of No-LBT (NLBT) with Baseline LBT and Tx Side ED based Omnidirectional Sensing (TxED-Omni): 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. In other cases Omni LBT scheme under performs. All results are at ED threshold -47.
	+ Ericsson, HW, Nokia show loss for omni LBT
	+ 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
	+ Ericsson results show that No-LBT outperforms Dyn-LBT at -47 and -68 dBm at all loading levels
	+ Qualcomm Results show that for TxED-Omni LBT, the performance degrades with lowering ED threshold
* Comparison of No-LBT with LBT methods other than omni-directional
	+ Directional LBT vs No-LBT:
		- Ericsson results show No-LBT outperforming directional LBT with fixed and adjusted thresholds
	+ Receiver assisted LBT vs No-LBT
		- Omni sensing , Ericsson results do not show Receiver Assistance outperforming No-LBT.
	+ ‘Receiver-only’ LBT vs. No-LBT: According to Huawei, this is a form of directional Rx assisted sensing.
		- Huawei shows Receiver-only LBT Tail UPT and mean UPT gain compared to No-LBT and in low, medium, and high traffic loads with InH Open Office channel model [R1-2008976 Fig. 9] and InH mixed channel model [R1-20088976 Fig. 10].
	+ Qualcomm results show Rx Assistance outperforming No-Back-off Schemes as loading levels increase. Further, as directionality increases at the gNB, the relative benefits of Rx-Assistance are larger, overcoming overhead penalties of No-Back-off with respect to No-LBT.
* Directional vs Omni LBT
	+ For same threshold (-47 dBm) , directional LBT, Vivo shows loss relative to Omni LBT, for both TxED and Rx Assistance
	+ 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
	+ Nokia shows median loss and tail gain for directional LBT for 100% DL 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
	+ Ericsson results show that directional LBT with adjusted thresholds (-47+x) outperform omni LBT with better threshold (-68 dBm)
* Rx-Assisted vs Tx Sensing LBT
	+ Multiple flavors of Rx Assistance have been modelled as described earlier
	+ HW, Qualcomm, show benefits for DL and UL in the tail and median, primarily at higher loading 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
* Other Comparisons: Receiver-only LBT vs. No-LBT/Receiver-assisted LBT
	+ Huawei shows Receiver-only LBT Tail UPT and mean UPT gain compared to both No-LBT and receiver-assisted LBT in low, medium, and high traffic loads with InH Open Office channel model [R1-2008976 Fig. 9] and InH mixed channel model [R1-20088976 Fig. 10].

### Indoor Scenario B

### Indoor Scenario C

* No-LBT vs Omni LBT
	+ Ericsson and HW show loss for Omni LBT, 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.

### Remarks

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.

Please check the if the above observations are correct and provide your view below.

|  |  |
| --- | --- |
| **Company** | **View** |
| Ericsson | 1. Even though multiple companies submitted results for scenario A, not all of them assumed the same deployment assumptions.
2. The observations as they are written now highlight benefits shown by a certain LBT scheme in certain metrics, but fail to capture that the same LBT scheme causes losses in other metrics (e.g. Vivo’s results show improvement in DL, but also show degradation in UL).
3. Staying “benefit/gain/losses” is not accurate representation of the results. It is preferred that the gains and losses are quantified.
4. Question to ZTE: most of ZTE’s evaluations are done using an ED threshold below noise level. How can a device sense below the noise level? shouldn’t that mean that the device will never get the chance to transmit?
5. Ericsson’s Directional LBT, no LBT and omni directional LBT comparison are not captured
6. Ericsson’s result for dynamic enabling of LBT are not captured.
7. The evaluated Receiver assisted LBT by different companies is not explained. For example, none of the companies explain if realistic assumptions related to UE processing are assumed, and if the signalling of the handshake messages is explicitly modelled in the simulations. Qualcomm also assumes silencing of neighbouring nodes however it is not clear how that can be achieved. Our receiver assisted LBT assumed very idealistic setup and therefore the shown results represent an upper bound of achievable performance and not a realistic one.
8. Even though the main bullet says:” Comparison of No-LBT with LBT” , the sub-bullets are discussing the performance of directional LBT. It is preferred that each LBT scheme is discussed separately.
9. What we observed from the submitted results for scenario A is that:
	* 6 Companies have compared No-LBT with Tx Side ED based Omni sensing LBT
		+ 5 out of 6 companies (Ericsson, HW, Nokia, Samsung, Intel) show loss for omni LBT for tail, median and mean at all load points in both DL and UL directions
		+ 1 out of 6 companies (Vivo) shows tail and median benefits of using omni LBT on DL, and tail benefit in UL high load. However, loss for omni LBT for all other UL metrics at all load points.
	* Directional vs. no LBT
		+ 3 companies (HW, Ericsson, Intel) shows that no LBT outperforms directional LBT at all load points for tail, median and mean DL and UL
		+ 1 company (Nokia) shows that directional LBT provides benefits in the tail in a 100% DL only scenario. But also show losses in the median and mean as compared to no LBT in the same scenario
		+ 1 company (Vivo) shows directional LBT provides benefits at high load for DL, and losses at all loads in UL and low and medium load for DL
		+ 1 company (Samsung) shows that directional LBT provides benefit at medium and high load, but losses at low load.
	* Directional vs. omni LBT
		+ 4 companies (Ericsson, HW, Intel, Qualcomm) marginal difference between omni- and directional LBT using same ED threshold.
		+ Vivo: omni-directional is better than directional LBT
		+ Nokia: in DL only scenario, directional outperforms omni-directional
		+ Samsung shows gain in tail and median in medium and high loads for directional LBT over omni-LBT variants
		+ ZTE: for appropriate ED threshold (higher than noise level) marginal gains are observed for load and medium load. Higher gains for high load.

 |
| Huawei/HiSilicon | A few comments regarding observations:1. We are not sure why under the bullet “Comparison of No-LBT with LBT”, only the omni-directional LBT is compared to no-LBT. Based on our simulations, in most scenarios, omni-directional LBT provides the worst mean and tail UPT results among all LBT methods (omni, directional, receiver-assisted, and receiver-only). WE believe that this is also corroborated by the results of a few other companies. We think that to draw a conclusion in regards to no-LBT vs. LBT, the best (and not the worst) LBT method should be compared with no-LBT.
2. We have also simulated receiver-only LBT (where the directional sensing is performed only at the receiver side) in our updated t-doc R1-2008976 which show considerable performance gains in both UL and DL main and tail UPT compared to both receiver-assisted LBT and No-LBT. We would to request that this observation be included in the set of observations in Section 3.
 |
| Intel | Observations summarized by the FL are correct. We would like to point out that we are working internally to provide additional SLS results. We will share as soon as we can. |
| Huawei/HiSilicon2 | 1. **General comments regarding the structure of the observation:**
	1. We are not sure why under the bullet “Comparison of No-LBT with LBT”, only the omni-directional LBT is compared to no-LBT. Based on our simulations, in most scenarios, omni-directional LBT provides the worst mean and tail UPT results among all LBT methods (omni, directional, receiver-assisted, and receiver-only). WE believe that this is also corroborated by the results of a few other companies. We think that to draw a conclusion in regards to no-LBT vs. LBT, the best (and not the worst) LBT method should be compared with no-LBT. As such, we suggest the following changes:
		* change the sub-bullet from “Comparison of No-LBT with LBT” to “Comparison of No-LBT with Omnidirectional LBT”
		* Add another sub-bullet “Comparison of No-LBT with LBT methods other than omni-directional” and ask companies to provide their inputs for this sub-bullet. Our comment 2-A) below can be included in this new sub-bullet.
2. **Comments regarding Huawei/HiSilicon’s simulation results:**
	1. Suggest to include following observation
		* Receiver assisted LBT vs No-LBT: Huawei shows Receiver-assisted LBT Tail UPT gain in DL with high traffic load and with InH mixed channel model [R1-2008779 Fig. 22]. Moderate Tail UPT gain is also observable for Indoor open office channel model [R1-2008779, Fig. 18].
	2. Under Indoor Scenario A with 2 operators, Suggest to add the following sub-bullet
		* Receiver-only LBT vs. No-LBT/Receiver-assisted LBT

Huawei shows Receiver-only LBT Tail UPT and mean UPT gain compared to both No-LBT and receiver-assisted LBT in low, medium, and high traffic loads with InH Open Office channel model [R1-2008976 Fig. 9] and InH mixed channel model [R1-20088976 Fig. 10]. |
| Samsung | First of all, the comparison of No-LBT with LBT is a little bit vague. Should have two different categories of “No-LBT v.s. omni-directional-LBT” and “No-LBT v.s. directional-LBT”To clarify for our evaluation results, although we only show figures of mean and 5%, the gain observed is not limited to mean and 5% only. A complete set of results are shown in the table. So we propose to revise Samsung’s observations by removing “mean and tile”. We’ll provide further feedback after the proposal is further organized.  |
| Nokia, NSB | We share the observation made by a few other companies that when comparing No-LBT with LBT, one should elaborate what type of LBT (omni, directional…) was assumed.We also agree with Ericsson on points 1, 2, 3, and 7 in their reply:* the deployment assumption and potential modifications to them emphasizing e.g. interference situations should be clarified to facilitate apples to apples comparison
* both gains and losses of different schemes should be reported, without emphasizing gains
* gains/losses should be quantified (e.g. in %)

For RX assisted schemes, one should state what the underlying assumptions are related to e.g. signalling and the associated delays and overhead. Otherwise the results may be interpreted too optimistically. |
| ZTE, Sanechips | Response to Ericsson’s question:Thanks for the careful review on our simulation results. For the issue on why the device can access the channel when ED threshold such as -82dBm is higher than noise level, we checked the simulation platform and it turns out that noise level was not included in sensing calculation, which only counted the energy of the interference signals. Thus there might be some mismatch between the ED threshold set in the simulation and the actual ED threshold when the set threshold is below the noise level, that is, the actual ED threshold will be higher than or almost equal to noise level. Nevertheless, the results for the threshold above the noise level should be reasonable. The similar observation between Directional vs. Omni LBT can be supported by the evaluation results based on -72dBm ED threshold (as can be found in R1-2007967 Table A3-3).Therefore, we would like to keep the original observations summarized by the FL on our simulation results, probably just adding the note that the observations are made based on appropriate ED threshold (higher than noise level) so as to exclude the results -82dBm for now. |
| Ericsson | We appreciate the updated input related to the receiver assisted LBT (RAL). But it is still not clear what is explicitly modelled in the evaluations: In RxA-2/3: how does the transmitter know about the LBT result at the receiver side ? is this done both at gNB and UE ? is the LBT results at the receiver reported to the transmitter ? and if yes, what is the assumed processing and feedback delay that is assumed ? In HW’s results, the UL has almost the same performance as the DL, and sometimes UL is better than DL. All other companies show performance difference between the DL and UL performance (DL always better than UL) which is mainly due to the scheduling and processing delays. We would like to understand how come that UL performance can be better than DL in HW’s results. Is it so that no processing delays are modelled? As I understand that the R1-2008976 includes new set of results with receiver only LBT, and those results show performance gain even at low load. It is not clear how that can happen since your BS-BS and UE-UE interference link CDF shows that you don’t have any interference links equal or higher than -47/-32 dBm (I expect at low load there is not much “aggregated interference”). So at least at low load, I would expect that the LBT even if you will do it at the receiver side, you will not see any gains. In fact, you should see the losses due to the back-off which should be significant since your max CW is set to 127 slots. That is still not accounting for any overhead to report the LBT results to the transmitter. RxA-4: same questions as above. Is the actual RTS/CTS transmission modelled, and if yes, what is the feedback latency assumptions? RxA-5: in the tables from Qualcomm, it is mentioned “Rx-Assistance: Silencing signals sent by gNB and UE after winning the medium. Only gNBs perform extended CCA.” Then what type of sensing done at the receiver? How is the silencing procedure implemented? I mean, do you explicitly model the “RTS/CTS-like transmissions” ?Related to the observation we have two points: * it should be clarified that the ED threshold used. And in case of -72, that the ED detection alone is not enough as mentioned in the contribution
* RxA-5 observation should not be captured under comparison of “No-LBT with LBT methods… “ since the simulated “no back off ” scheme is not equivalent to no LBT and the observation that there is gains is not necessary true when comparing to no LBT. RxA-5 observation should be captured under (Rx-Assisted vs Tx Sensing LBT)
* To my understanding, case 1 (ED -47) still outperforms case 3,4,7, and 8 (Rx assisted) and that is not captured in the observations
 |
| Huawei/HiSilicon3 | We have added/changed some values of Huawei/HiSilicon entry in “Table 1 Indoor Scenario A” to correctly represent our simulation set up. Further, we request following modifications in the observations of Section 3.4.1. * **Section 3.4.1. sub-bullet “Receiver assisted LBT vs No-LBT”**
	+ **Suggested modification:**
		- Please add the following observation:
			* “Huawei shows Receiver-assisted LBT Tail UPT gain in DL with high traffic load for InH open office channel model. Also, Huawei shows Receiver-assisted LBT Tail UPT gain in DL with moderate and high traffic load for InH mixed channel model”
	+ **Reason:**
		- Please see Table H1 below that shows more than 9% coverage gain in high load scenario for open office channel model and Table H2 below that shows more than 10% and 20% coverage gains for moderate and high traffic load in InH mixed channel model.

 Table H1: 5%ile DL UPT (Mbps) results for No-LBT and Rx-Assisted LBT for indoor Scenario A open office channel model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scheme | Reference | Low load10%~25% BO  | Medium load35%~50% BO | High loadabove 55% BO |
| No-LBT | [4] Table 01 | 2690.3 | 1015.6 | 222.3 |
| Rx-Assisted LBT | [4] Table 02 | 2587.9 | 994.5 | 242.7 |
| Rx-assisted gain compared to No-LBT[ |  | -3.8% | -2.1% | 9.2% |

Table H2: 5%ile DL UPT (Mbps) results for No-LBT and Rx-Assisted LBT for indoor Scenario A InH mixed channel model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scheme | Reference | Low load10%~25% BO  | Medium load35%~50% BO | High loadabove 55% BO |
| No-LBT | [4] Table 09 | 346.9 | 150.2 | 62.9 |
| Rx-Assisted LBT | [4] Table 10 | 350.1 | 165.6 | 76.05 |
| Rx-assisted gain compared to No-LBT[ |  | 0.9% | 10.2% | 20.9% |

* **Section 3.4.1. sub-bullet ‘Receiver-only’ LBT vs. No-LBT**
	+ **Suggested modification:**
		- Please modify the description of ‘receiver-only’ LBT to below for further clarification:
			* “‘Receiver-only’ LBT vs. No-LBT: According to Huawei, this is a form of directional Rx assisted sensing wherein energy sensing is performed only at the receiver side (RxA-3)”.

**Answers to Ericsson’s questions:****Ericsson:** In RxA-2/3: how does the transmitter know about the LBT result at the receiver side ? is this done both at gNB and UE ? is the LBT results at the receiver reported to the transmitter ? and if yes, what is the assumed processing and feedback delay that is assumed ? **Huawei:** We have simulated our Receiver-assisted and receiver-Only LBT mechanisms as follows: 1. When UE is the receiver, UE receives a RTS from the gNB. Then, UE sends a “message B” to the gNB with CCA measurements results (dBm value of the measured interference). The latency from the reception of RTS to the transmission of “message B” is calculated equal to 4 slots for 120 kHz SCS and 22 slots for 960 kHz SCS. Note that this includes the required time at the UE side for CCA. Then, gNB transmits PDSCH to the UE. The PDSCH processing time is calculated as 3 slots for 120 kHz and 13 slots for 960 kHz.
	1. Note: In the case of receiver-assisted, a CAT4 LBT is performed at the gNB side before RTS transmission. In the case of receiver-only LBT, there is no LBT at the gNB before RTS transmission.
2. When gNB is the receiver, first gNB performs energy measurement at the directions of the UEs that have UL data. Then, gNB selects the UE with the lowest interference level. After, gNB sends PDCCH to schedule PUSCH transmission of that UE. Finally, PUSCH is transmitted after a successful CAT2 LBT. In our simulations, we have considered the preparation time from PDCCH reception to PUSCH transmission equal to 4 slots for 120 kHz SCS and 22 slots for 960 kHz SCS. We have not considered a processing time for PUSCH at gNB.

**Ericsson:** In HW’s results, the UL has almost the same performance as the DL, and sometimes UL is better than DL. All other companies show performance difference between the DL and UL performance (DL always better than UL) which is mainly due to the scheduling and processing delays. We would like to understand how come that UL performance can be better than DL in HW’s results. Is it so that no processing delays are modelled? **Huawei:** In our simulation, Rank 1 transmission is considered for both UL and DL. If some other sources have used rank-2 link adaptation in their simulations, it is more likely that the transmission is carried out with rank-2 in DL and with rank-1 in UL due to the different antenna number assumption at the gNB and UE side. As a side note, there are also two symbols for PDCCH and one symbol for DMRS in the DL while there is only one DMRS symbol in UL. This also helps the UL UPT increase in comparison with DL UPT.**Ericsson:** As I understand that the R1-2008976 includes new set of results with receiver only LBT, and those results show performance gain even at low load. It is not clear how that can happen since your BS-BS and UE-UE interference link CDF shows that you don’t have any interference links equal or higher than -47/-32 dBm (I expect at low load there is not much “aggregated interference”). So at least at low load, I would expect that the LBT even if you will do it at the receiver side, you will not see any gains. In fact, you should see the losses due to the back-off which should be significant since your max CW is set to 127 slots. That is still not accounting for any overhead to report the LBT results to the transmitter. **Huawei:** ED threshold (-47/-32 dBm) is only used when LBT is performed at the transmitter side. As you correctly observed, very few BS-BS or UE-UE links have equal or higher than -47/-32 dBm RSRP. That is why omni-LBT and directional LBT have similar performances in our simulation results. However, in receiver assisted LBT or the receiver-only LBT for DL transmission, UEs only send interference measurement results to the gNB and gNB selects the UE with the lowest interference level to which it transmits DL data. UEs only use a short fixed time interval to measure the interference (CAT2-like mechanism) and the random back-off is not used at the UE side. Furthermore, although we have used a large CWS of 127 for LBT cases when applicable, we have also used a large MCOT of 5ms and, therefore, the CWS value is not a large overhead for such a long channel occupancy time. Note that CAT2 LBT can be used for HARQ feedback during the 5ms COT.  |
| vivo | Regarding the question to Rx-4, the actual RTS-CTS mechanism is not modelled. In our evaluation, the transmitter will send a request and the receiver feedbacks a confirmation if the request could be successfully decoded. Both the request and confirmation will not silent any other node.Regarding Directional vs. omni LBT, the observation from vivo’s result should be:Vivo: omni-directional is better than directional LBT in tail and median performance, and marginal difference in other cases. |

## RSRP distribution from system simulations<To be Completed>

* Extensive RSRP statistics are available in separate figures from the companies
* Indoor Scenario A has some variation in the RSRP Distributions from serving gNB
* The following extracted table of DL RSRP statistics from serving cell can indicate some main source of performance differences seen in the SLS across companies <To be refined via simulation data collection>

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Pecentiles | Ericsson | HW | Vivo | ZTE | Samsung | Intel | Qualcomm |
| Median | -45 | -48 | -52 | -56 | -49 | -48 | -62 |
| 10%ile | -52 | -55 | -59 | -66 | -57 | -51 | -72 |
| 90%ile  | -38 | -38 | -42 | -45 | -38 | -42 | -52 |

## Delay spread from system simulations

|  |  |
| --- | --- |
| **Company** | **Key Proposals/Observations/Positions** |
| Vivo (R1-2007654) | DS distribution is generated for typical indoor scenes by using the SLS. We can see that the DS of almost 80% users are less than 30ns.  |
| Ericsson(R1-2007982) | Proposal 7. In TR 38.808, change the system level evaluation assumption for Factory Scenario A from Dense Clutter & Low BS (InF-DL) to Dense Clutter & High BS (InF-DH) to be consistent with ceiling mounted gNBs.Proposal 8. Capture the following observation in TR 38.808. Factory Scenario A (InF-DH) results in post-beamforming delay spreads that are a significant fraction of the CP duration for 960 kHz SCS.Observation 3.For selection of suitable SCS for the 52.6 – 71 GHz frequency range, it is important to perform link level evaluations with sufficiently large post-beamforming RMS delay spreads that are representative of a suitable range of deployment scenarios including the indoor factory scenario analyzed above (e.g., up to at least 40 ns using the agreed TDL-A model). It is important to consider the margin left over for other sources of time synchronization error such as initial timing error, timing advance setting, timing advance adjustment granularity, and timing differences expected in multi-TRP deployments. |
| Intel(R1-2007943) | SIR as a function of maximum detected tap and offset for FFT window place wrt the tap is studied for multiple channels.Proposal 1: Use root mean square effective channel delay spread at the receiver as a metric for system level evaluation of NR in 52.6–71GHzProposal 2:* Use intersymbol interference signal to interference ratio as a metric for system-level evaluation of NR in 52.6–71GHz
* Assume the acceptable intersymbol interference level criteria is having 80% of links with intersymbol of 30dB SIR or higher

Proposal 3: Assume the dynamic FFT window placement based on the 40% CP length offset from the detected CIR peak for intersymbol interference SIR calculationObservation 4: 85% of UEs experience RMS delay spread smaller than SCS 1.92MHz CP length (36.6 ns). |
| Qualcomm(R1-2008615) | SINR caused by ISI is studied in SLS. Observation: for small range indoor hotspot deployment, the channel delay spread is not an issue with NCP. For outdoor scenarios with larger ISD and at moderate to high SNR – this may be produced by higher EIRP or smaller BW – NCP demonstrates SINR degradation compared to ECP. However, for such large coverage, high EIRP, and small BW use cases, we can choose to use a small SCS, e.g., 120kHz, with NCP. |
| InterDigital(R1-2007790) | Shows the CDF of RMS delay spread for Indoor Factory B, Indoor Office C and Outdoor C based on the system level simulations with the agreed evaluation assumptions. Observation 4: While each scenario experiences different amounts of RMS delay spread, regardless of scenarios, most of UEs experience smaller RMS delay spreads than normal CP of 960 kHz. |
| DCM(R1-2009062) | Reported the distribution of RMS delay spread (DS) of the channel for those UEs whose RSRP is larger than the specified threshold for outdoor-B scenario with the following observation.Observation 8: The mean RMS DS of 60 GHz system in Outdoor-B scenario is about 23 ns and the 95%-tile DS value is about 80 ns.* More than half of UE experiences channels with DS larger than 20 ns, which should be referred to in the link performance evaluation with large DS configurations.
 |
|  |  |

These observations and proposals are related to SCS selection and CP length choices. These will be further discussed in 8.2.1 email discussion.

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