**3GPP TSG RAN WG2 #119bis-e *draft R2-22xxxxx***

**Online, 10 - 19 Oct, 2022**

**Source:** Huawei, HiSilicon

**Title:** Report of [Offline-302][NES] Cell Selection/Reselection and SSB/SIB-less (Huawei)

**Agenda Item:** 8.3.2

**Document for:** Discussion and decision

# Introduction

This document is a report of the following offline discussion:

* [AT119bis][302][NES] Cell Selection/Reselection and SSB/SIB-less (Huawei)

- Discuss and agree aspects of cell selection/reselection based on contributions submitted to meeting (including both legacy and NES capable devices)

- Discuss and agree on aspects of SSB adaptation/SIB-less based on contributions submitted to meeting (both SSB/SIB-less and adaptation are included)

Deadline: to be set by rapporteur so agreeable proposals can be ready by Monday morning for review.

Since time is limited, in this offline we will focus on the issues proposed by multiple companies and more likely to achieve some progress. The situation in the post119-e email discussion is also taken into account [1].

Please share your comments before Friday 2022-10-14 10:00 UTC.

Please note that for the sake of progress, we will use the same principle for all NES candidate techniques, i.e., we focus on RAN2 impacts for these techniques and do not debate on whether this is RAN1-led or RAN2-led techniques. This is exactly what we have done for DTX/DRX discussion.

1. Contact Information

To make it easier to find the contact delegate for potential follow-up questions, delegates are encouraged to provide their contact information in the following table:

|  |  |  |
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# Discussion

## Cell selection/reselection

During the post119-e email discussion, the solution of cell selection/reselection was summarized as follows:

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| Introduction | NES cells can be (de-)prioritized for NES capable UEs or legacy UEs during cell selection/reselection, optionally, UE is made aware of cell state (NES or non-NES). |
| Scenario | Single-carrier, multi-carrier; UEs in Idle/Inactive |
| NES gain | Reduced time domain SSB symbols if the cell is in NES state. Legacy UEs can avoid reselecting to an NES cell. |
| Impact to legacy UEs | 1. In case legacy mechanism (frequency priority, or adding frequency/cell-specific offsets) is used, there is no impact on legacy UEs
2. In case cell state (NES, or non-NES, or other states) is introduced, legacy UEs are not aware. The NES cells can be barred to legacy UEs for backward compatibility.
 |
| UE assistance needed | No |
| RAN2 impact | Cell selection/reselection enhancement etc. |

Some companies indicated that the solution itself does not provide NES gain, but it can assist other solution to minimize negative impacts to legacy UEs.

Based on companies’ contributions submitted to RAN2 #119bis-e, there is plenty of discussion on the following:

1. Legacy UEs: prevent legacy UEs camping on NES cells
2. NES capable UEs: (de)prioritization (including per-frequency, or per cell)

For legacy UEs, it is proposed in [2][3][5][10][11][12][19][27] to prevent legacy UEs camping on NES cells for backward compatibility. From the rapporteur’s observation, for some NES techniques, the legacy UEs cannot camp on the NES cells automatically, e.g., SSB-less, cells potentially using NES WUS. Therefore, this discussion should be based on the assumption that there is a need to have additional enhancement to prevent legacy UEs camping on NES cells when legacy UEs can identify these NES cells as usual.

**Q1: Do you agree that there is a need to prevent legacy UEs from camping on NES cells, when legacy UEs can identify these NES cells as normal cells?**

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| **Company** | **Yes/No** | **Comments** |
| Apple | Yes, but.. | We agree the need to allow NES cell to prevent legacy UEs, at least from backward compatibility perspective. However, we think the current formulation of this proposal / question may cause below misunderstanding: 1) The wording "a need to prevent legacy UE" may cause misunderstanding that NES cell must prevent legacy UE camping. However, we believe NES cell should have flexibility to decide whether to bar legacy UE or not (e.g. legacy UE may still be served by NES cell if this NES cell just uses sparse reference signal). 2) We are not sure what is intention of 2nd sentence (**when legacy UEs can identify these NES cells as normal cells).** It looks obvious and unnecessary.Thus, we suggest below wording change:**there is a need to allow NES cells to prevent legacy UEs from camping ~~on NES cells, when legacy UEs can identify these NES cells as normal cells~~** |
| MediaTek | Yes | When the NES-capable cell behaves as a normal cell to legacy UEs, it is nature to have such prevention enhancement in NW side. |
| Ericsson | Yes |  |
| CATT | Yes | Considering we support starting with the multi-carrier configuration (see Q5), we assume legacy UEs will camp on an anchor cell, not on a NES cell. |
| vivo | Maybe | From network perspective, if the cell needs to serve both legacy UE and NES capable UE, the network may not be able to get NES gain as expected, so the network may prevent the legacy UE to camp on the NES cell. From UE perspective, we want to emphasize that the NW should not prevent legacy UEs to camp on NES cell in the poor coverage condition.  |
| Nokia | Yes | Maybe terminology could be confusing – NES cell: We could have some features implemented that do not impact legacy UEs e.g. some features only used in CONNECTED. But in this context we assume we talk about features that may have impact to legacy UEsAnyway it seem obvious we need to ensure legacy UEs need to prevented on camping on cells using features that make it unusable/degrade legacy UE experience.@CATT – even legacy UEs may perform cell selection to frequency that is rserved for release 18 UEs. We need to have mechanism(s) that prevent legacy UE on camping on that frequency (although it could be achieved implicitly e.g. if one does not transmit SSB) |
| BT | Yes but | We agree with Apple. Network has to be capable to prevent legacy UEs from camping or reselecting a NES cell. That capability needs to be flexible due to a NES cell is a normal cell that temporarily applies energy saving techniques. Therefore, network requires dynamic mechanisms to activate or deactivate the prevention.  |
| Vodafone | Yes | In general, the most saving are achieved if the cell is completely off, inc. hardware components. If it is not completely off, the degree of energy savings is already smaller, but if the amount of the UEs camping on and potential able to trigger service is high, it is not clear which savings can be achieved at all. In our view there is a strong need to introduce barring mechanism for legacy UEs to camp on NES cell if such a cell is recognisable from the UE perspective, but we also should evaluate even if NES capable UEs (whatever they will be at the end) could be kept out of NES cell as the aim is to save energy of the cell… |
| Fraunhofer | Yes | In order to define some NES state with large energy savings such state may actually not be backward compatible. And if it is not backward compatible legacy UEs should be prevented to access it. This is also the case for intermittent SSB which could be triggered by other UEs (SSB on demand solution).  |
| Interdigital | Yes, but | Agree with Apple that it should be up to NW configuration whether to prevent legacy UEs from accessing a cell employing NES. Legacy UEs may still be able to access the NES cell in some cases, e.g., with less frequent occasions or higher latencies. That said, the NW should be able to configure per cell whether legacy UEs are barred or not. |
| OPPO | Yes | But we also think the second sentence is obvious and not needed. |
| Intel | Maybe | If there are NES cell that legacy UE can identify but cannot use as normal cell, there is a need to prevent legacy UEs from camping on the cell. But such prevention will be done by legacy mechanism such as existing cell barring, existing excluded list etc.  |
| Qualcomm | Yes, pending definition NES cell | Currently we have no mechanisms for NES that need to be hidden from legacy, for example, NW DTX/DRX can coexist with camping legacy UEs, but given there may be mechanisms in the future that a NES-cell can apply which are not compatible by legacy UEs, we can accept the rewording by Apple. Also, it is unclear now whether an NES cell always operates as an NES cell or whether NES-cell is only a state to opportunistically activate in no/low load conditions, we think the design should be broad enough to accommodate the latter option whereby the cell can selectively admit NES-capable UEs.This is with the understanding that the legacy UE may still camp on an NES-cell applying legacy-compatible techniques such as NW DTX/DRX (possibly), so this should be a feature the NW can apply only when needed. |

The solutions proposed are mainly divided into the below two directions:

* Option 1: Use Intra/InterFreqExcludedCellList [2][4]

This is basically using the legacy frequency list or black cell list to indicate whether those NES frequencies or cells are disabled. It would be good that proponents can clarify the exact specification impact as this seems already supported by legacy mechanism.

* Option 2: Use *cellBarred* in MIB and add a new *cellBarred-NES* in SIB1[3]

This is basically to reuse the legacy mechanism adopted for NTN and IAB-MT.

**Q2: Which is the preferred option to bar legacy UEs:**

* **Option 1: Use Intra/InterFreqExcludedCellList [2][4]**
* **Option 2: Use *cellBarred* in MIB and add a new *cellBarred-NES* in SIB1 (similar to NTN) [3]**

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| **Company** | **Option** | **Comments (including technical views, specification impacts etc.)** |
| Apple | Option 2 with comments(Option 1 needs clarification) | We think the direction of option 2 makes more sense. However, it includes stage 3 details (e.g. whether new barring bit needs to include in SIB1, considering SIB1 is already quite heavy). Besides the barring solution of NTN, we have another barring mechanism of Redcap with some difference of signalling details. Since it is study item phase, we think RAN2 only need a high level agreement. For example:***NES cells may bar legacy UEs, and allow NES capable UEs to camp via new barring bit in MIB/SIB.*** For Option 1, we understand there is no spec impact because legacy UE can only read existing intra/interFreqExcludedCellList (i.e. can't read new NES dedicated list if introduced). So, it requires some clarifications. However, we think a new NES dedicated cell list can be introduced to enhance cell reselection of NES capable UEs (i.e. if NES cells are prioritized by NES capable UE, it can only consider cells in this new list during cell reselection)  |
| MediaTek | Option 2 | Existed OSI reusability could be preserved to some extent, hence lower impact to legacy UE power consumption. |
| Ericsson | At least Option 2 | The solutions are essentially for different cases, Option 2 is mainly for cell selection while Option 1 is for cell reselection. Option 2 could work for cell reselection as well, so we should have at least Option 2. However, Option 1 would be more optimal for cell reselection than Option 2 (e.g., the UE would not need to perform the measurements needed for Option 2), so it could be good to have both. |
| CATT | Option 2, if visible | Alternately such NES cells may not be visible at all by idle/inactive UEs (e.g. SSB/MIB/SIB-less NES cell). |
| vivo | Option 2, FFS Option 1 | Option 2 is a mature solution to bar legacy UE from camping on a cell applying new features that may affect legacy UE. For Option 1, we cannot conclude whether the NES techniques are applied per cell or per frequency for now. From our perspective, both are possible. Therefore, we think it should be FFS.  |
| Nokia | Both | Firstly one needs to be able to control cell reselection to NES cell this includes intra and inter-frequency cases as we think it is likely that only subset of cells on frequency utilize NES features. Thus option 1 seems necessary. @apple – we thought one needs to be able to prevent NES UEs also to select some cells thus we need possibility to exclude different set of cells for NES and legacy UEs.Secondly one needs to be able to control camping via cell selection and barring is way to do that in legacy. Option 2 seems logical approach to achieve barring allowing NES UEs to camp on cell and prevent legacy UEs camping. |
| BT | Option 2 but | Since we are in the study item phase, for us it is enough to agree that:* 1. it should be possible for NES capable cells to bar legacy UEs and NES capable UEs to camp/reselect on it.
	2. it should be possible for NES capable cells to bar legacy UEs while NES capable UEs may be able to camp/reselect on it.
	3. Barring on NES capable cells should be dynamically configurable.

On option c) above, dynamically means that network can match without delay changes on NES states cell and NES neighbour states cells. We can discuss different ways to achieve such behaviour during study phase, but it is in the normative phase when we should take a decision.From option 1, we would like to understand from proponents:How current signalling can prevent legacy UEs to camp in a NES capable cell while NES capable UEs are allowed. |
| Vodafone  | Option 2 | Needs to bar legacy UEs at least from selecting/reselecting to the NES cells. On option 1 we would like to understand better the advantages, but in my view option 2 provides a clear mechanism to bar legacy UEs  |
| Fraunhofer | Both (FFS) | In principle both options could work. For study phase we would prefer to leave this open and list both options in the TR. Then there is enough time to thoroughly evaluate and compare the options until the standardization phase |
| Interdigital | Option 2 | This is similar to barring legacy UEs in IAB and NTN cells.  |
| OPPO | Option 2 | Option 2 is the most straightforward way to implement what we want here and can work for both cell selection and reselection.  |
| Intel | See comments for legacy UEOption 2 for NES capable UE | If there are NES cell that legacy UE can identify but cannot use as normal cell, all legacy mechanisms for preventing a legacy UE to a NES cell/frequency can be used (cell barring in MIB, excluded list, cell reselection priority/dedicated priority etc.). Option 1 & 2 are to include a further mechanism to bar NES capable UE from the NES cell rather than to bar legacy UE. Option 2 is sufficient. We are not sure how dynamic the NES mode of a cell can change and Option 1 may not be suitable.  |
| Qualcomm | Both | Agree with Ericsson that option 1 and option 2 are targeting cell (re)selection and initial cell selection, respectively. The guiding principle is that there should be a coarse way for the NW to bar legacy UEs from accessing a NES-cell, then a finer way to control selection in NES-compatible Rel-18 UEs. Thus, initial cell-selection (option 2) is needed as the basic way of preventing legacy UEs for camping. In this case we agree with Apple not specifying SIB1 as the new location for cellbarred-NES information as this can be left FFS as a stage 3 detail. Also, cell blacklisting for legacy needs the same two-level separation as mentioned by Nokia, when we need legacy blacklisting for legacy UEs but also another dynamic blacklisting/whitelisting mechanisms for NES-cells that instruct the UEs on the cell reselection mechanism based on the dynamic NES-cell state.  |

For NES capable UEs, it is proposed in [4][5][6][8][12] to discuss (de)prioritization of NES cells. However, there is no general rule that NES cells should always be prioritized for NES capable UEs, or always deprioritized. Further, it is mentioned by [8] that UEs’ cell reselection prioritization should be under network’s control, and reselection prioritization for NES can be handled per frequency, but not per cell. [6] also wants to clarify whether it is per frequency or per cell.

**Q3: For NES capable UEs, whether there is a need to prioritize or deprioritize the cell reselection for NES cells? If so, whether it is frequency level or cell level?**

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| **Company** | **Need for (de)prioritize NES cells (Yes/No)** | **Frequency level or cell level** | **Detailed Comments if any** |
| Apple | Yes | At least frequency level. FFS Cell level  | **On the need:** **1.** As legacy UE may be barred by NES cell,some NES capable UEs may be configured by NW to prioritize to camp in NES cells for load balancing. 2. Some NES capable UEs (e.g. UE with high priority traffic) may be configured by NW to prioritize non-NES cell for better performance. **On frequency level or cell level:**We think at least frequency level works, i.e. the NES capable UE may regard the frequency with NES cells as highest priority. RAN2 has specified similar solutions for V2X/eMBMS. We don't see any technique issue to introduce similar solution for NES.On Cell level, we think it can be FFS because best cell principle (i.e. UE has to pick cell with best radio condition in intra-frequency) shall be followed. However, LTE Rel-13 NB-IoT has introduced a dedicated Qoffset. So, if time allows, we think RAN2 can study similar solution (i.e. NES dedicated Qoffset).  |
| MediaTek | Yes | both | We think it is also related to which kind of NES technique is working and corresponding NW deployment strategy. It is better to keep flexibility in this stage. |
| Ericsson | No |  | Cell reselection should be based on cell quality, and hence there is no need to include further procedures. We think there is no particular issue if the NES capable UE cell reselection procedure is untouched, and we should rather focus on handling legacy UEs. |
| CATT | No |  | Even if NES capable UEs can camp on a NES cell (TBC from RAN1), there is no strong motivation or it is not easy to conclude that there is a need to always prioritize or deprioritize the cell reselection for NES cells for NES capable UEs. For example: If NES cells are prioritized for NES capable UEs to camp on, the load of NES cells in support of Idle/Inactive UEs (e.g. in terms of paging, on-demand SI, RACH) could become heavy and it is not preferred for energy saving. On the other hand, if NES cells are deprioritized for both NES capable UEs and legacy UEs to camp on, the benefit that NES cells are visible to idle/inactive UEs is less. |
| vivo | Yes, but see comments | cell level, FFS frequency level | **1. Need or Not:**From the NW side, if the network wants to reduce the number of UE camping on NES cell, the network may deprioritize the NES cell for all NES UE. For load balance purpose, as the legacy UEs can only camp on normal cell which could increase the load of normal cell, the network may prioritize the NES cell for all NES UE . From the UE side, the NES UE may prefer to camp on normal cell with high probability. While, we are open to find any potential benefit at the UE side brought by NES techniques. **And if found, the NES UE can be allowed to choose NES cell with high priority, and how to achieve this can be further studied, e.g., UE implementation or under NW control.** **2. per cell level/per frequency level:**As comment in Q2, we think both levels are possible, there is no need to exclude either of them. |
| Nokia | Maybe |  | Confusing question – we only support priority based reselection between frequencies but then one talks about cell level prioritization? Anyway we think it should be possible to control cell reselection to NES/non-NES cells via priorities separately for legacy and Nes capable UEs. It should be noted that we already support dedicated priorities thus probably nothing is needed to support this already in existing specifications. |
| BT | Yes | Both | **On the need:** It is possible that an operator wants to keep NES capable UEs under NES capable cell if this is the best cell. The fact that NES capable UEs may camp on NES cells are based on multiple conditions, one of them is the NES cell state.**On frequency level or cell level:**Our understanding of this proposal is that cell level means intra-frequency and frequency level means inter-frequency.Based on that, different deployments have different requirements, e.g.:1. For small cells scenario with an umbrella frequency, cell level (intra-frequency) is more suitable.

For CA, same umbrella frequency can be used where different frequencies (inter-frequency) configured for CA can apply NES. Note that different frequencies used for CA may perform different NES states. |
| Vodafone | No |  | The main point is that in my view also as stated by Nokia we have dedicated priorities and it is sufficient to decide to prioritise particular frequencies or not and this is possible today, so e.g.For NES RedCAP UE which does not transmit a lot of data and if, not very frequently the NW could provide other frequency priority compared to NES capable device which acts as XR device,  |
| Fraunhofer | Yes - both | Frequency level should be enough | There is both the need that NES-aware UEs can prioritize or de-prioritize NES cells. By barring legacy UEs, the network will have a lesser degree of freedom on load balancing. Therefore the network may need to direct NES-aware UEs to NES cells for the sake of load balancing. But it can also be possible, when there are mostly NES-aware UEs that the network needs to direct such UEs to a regular cell, so that NES cells can remain on NES state. Agree with [8] that it should be under network´s control. |
| Interdigital | Yes | both | At a given time, it is possible (depending on the load in the network), some cells of a certain frequency could be in NES state while others are operating in non-NES state. It is therefore not optimal to apply absolute prioritization at a frequency level and per cell differentiation is necessary.For the multi-carrier, frequency level differentiation can be useful in case NES is employed only a given frequency band. |
| OPPO | Yes | At least frequency level | We understand the NES cell can be prioritized or deprioritized for the NES capable UE based on e.g. different scenarios and network strategies. Also, it may relate to what the UE behaviour allowed on the NES cell.On the frequency level or cell level, we think at least the frequency level can be considered. In one implementation, the network can use the legacy frequency priority to indicate whether to (de)prioritize the frequency of NES cells. In other implementations, the NES-capable UE can adapt/regard the frequency of the NES cells as (de)prioritized. |
| Intel | No |  | We think that this is too early to discuss, since it is not clear what type of NES cell will be defined. What we need is a mechanism which allow cell to bar legacy UE but allow NES capable UE from accessing a NES cell (as the like Option 2 in Q2) |
| Qualcomm | Yes | Both | **On the need**Prioritization would be the key mechanism to achieve NES gains by performing load balancing, i.e., selectively nudging Rel-18 NES-capable UEs to prioritize or deprioritize some cells. One example would be to discourage UEs from camping on a cell with very low-load in-order to maintain this cells opportunity of occasional sleep, conversely, we can also encourage the UE to camp on a cell that has already some medium load, or an NES-cell that can utilize other NES techniques such as DTX or spatial domain savings to bring down the total energy required to serve all UEs in the cell. **Cell level vs Frequency level**Frequency level prioritization makes sense to allow the NW as mentioned above to load-balance or direct the Rel-18 UE to a cell which contributes to the overall NES gains of the network in some way. For this case, existing methods, and new methods perhaps for deprioritization should allow the UE to do just that. We also think cell-level ranking or incentivization (not prioritization) should be included. In this case, once the UE has performed the prioritization step, the UE can further rank the cells according to their quality and their NES-state. The UE can then select from those inter-frequency cells based on UE implementation or some configured rule to balance the NES and coverage trade-off.  |

In [6][8], it is proposed to have (de)prioritization per frequency or per cell. [8] mentions that in MBS, the UE can prioritize the frequency which provides the service(s) of UE’s interest, and the similar solution can be adopted for NES. On the other hand, it is proposed in [7] that in the current spec, there are already several ways of re-distribute the UEs from a particular frequency layer to other frequency layers:

* Change the Frequency Priority
* Change the settings of offset values within Reselection Criteria, so that reselections would happen faster
* Provide/priorities particular frequencies within RRC Release
* Even the use of specific slicing for energy savings might be considered, resulting in reselections to a particular frequency layer

The above is about frequency (de)prioritization. Similarly, we already have cell offset, or the allowed/excluded list today, and if some cells are in NES state, this can be adjusted by these parameters.

Therefore, companies are invited to share their views on whether any enhancement is needed for cell (de)prioritized.

**Q4: if the answer to Q3 is Yes, whether there is any need to enhance the existing mechanism?**

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| **Company** | **Need for enhancements (Yes/No)** | **Comments (please be clear whether there is specification impacts)** |
| Apple | Yes | For above listed solutions by Rapporteur, we don't think it works well for cell (re)selection because these solutions need to either frequently update SIB (1/2) or force UE to CONNECTED state (3). We think a similar solution like existing eMBMS/V2X is sufficient: **"The NES capable UEs may regard the frequency with NES cells as highest priority"** |
| MediaTek | No | * + - 1. RAN2 can consider introducing NES specific parameters/settings but doesn’t have to enhance existed frameworks.
			2. We don’t think that NW power saving gain would be good if NES state is toggled frequently. Even if it is, we don’t think it should be reflected immediately over Uu interface because such a state transition could mean nothing changed to normal service providing (i.e., changed from NES cell to normal cell) so that it could be transparent to NES-capable UE.
 |
| vivo | See comment | We prefer pending this discussion for now considering the following reasons:1. We haven’t conclude whether (de)prioritization of NES cell reselection is per cell level or per frequency level or both are supported.2. As we commented in Q3, we are not sure whether NES cell (de)prioritization is left to UE implementation or configured by the NW.Enhancement may be needed, but clarification should be made for the above mentioned concerns. |
| Nokia | Maybe | But now one talks about solutions for mixed deployements in Q4 but Q3 seems to be targeted to frequency. Very confusing and difficult to answer. Probably it would be more beneficial to focus on scenarios first before going for solutions. |
| BT | Yes | NES cell states are key, so it is important to consider that aspect for intra-frequency and inter-frequency prioritization. It is possible that a NES capable cell accepts NES capable UEs based on its own NES state.In CA scenario with more than 1 CC, different NES states may apply per CC. This granularity needs to be considered. |
| Vodafone | No | All possible enhancements will not be available for legacy UEs anyway and for NES capable UEs, it is already possible e.g. within RRCRelease to provide them other priorities compared to legacy UEs, e.g. taking into account a device type or activities they had in the current cell. |
| Fraunhofer | Yes | As explained in Q3 some extra flexibility may be needed for new UEs. Sometimes even the opposite behaviour to legacy UEs.  |
| InterDigital | Yes | Changing the frequency priority or the reselection criteria offset setting values when the cell goes into an NES state can only happen after a SIB update.Regarding Apple’s comment about applying absolute prioritization similar to MBS/V2X, the scenario here is not service dependent (i.e., an NES capable UE can be served by a legacy cell or an NES cell, depending on the cell’s measured quality.) Absolute prioritization of cells in NES state can even be detrimental to the UE’s performance (e.g., UE camping and then establishing/resuming a connection towards a cell that is in NES that is not the best cell or not in full active operation).The UE can instead be provided cell selection/re-selection offsets for NES, where the offset is applied dependent on the cell’s NES state. |
| OPPO | See comments | The solutions mentioned by Rapporteur can be used and we are open discuss other solutions, e.g. the NES UE consider the NES cell/frequency as the highest priority, or the NES UE considers the NES cell/frequency priority based on the cell NES state. |
| Qualcomm | Yes | As mentioned in the last few questions, we now have two levels of frequency prioritization: 1. The legacy mechanism which is suitable for a static slow-changing rule to, in our context, steer legacy UEs away from NES-cell that can degrade their performance or apply NES mechanisms not compatible with the UE. 2. The Rel-18 more frequent and possibly finer and more flexible mechanisms which control the selection rules of Rel-18 UEs based on NES-rules that can be dynamically changing. As Apple mentioned the legacy methods would not work well for the Rel-18 NES context, and also, they would not be broad enough to accommodate NES-state aware frequency or cell prioritization that we think is a key NES method.  |

## SSB/SIB-less

During the post119-e email discussion, we discussed SSB/SIB-less and the solution was summarized as follows:

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| Introduction | Some NES Cells do not transmit SSB and/or SIB, UE receives SSB and/or SIB from a different cell (e.g. anchor cell).“anchor cell” refers to the cell transmitting SSB and SIB. |
| Scenario | Multi-carrier (FFS inter-frequency or intra-frequency), FFS single carrier; UEs in all states (Connected/Idle/Inactive) |
| NES gain | Reduced time domain symbols for SSB/SIB-less NES cell. Possibly increased power consumption for anchor cell when the anchor cell broadcasts system information for other NES cells. |
| Impact to legacy UEs | legacy UEs can access from anchor cell |
| UE assistance needed | No |
| RAN2 impact | extended SIB for anchor cell, cell selection/reselection, RACH, etc |

Several companies commented during email discussion that multi-carrier case should be prioritized. Among the contributions submitted to RAN2 #119bis-e, there are also proposals for prioritizing the multi-carrier case [17][18][21] [22][24].

**Q5: For SSB/SIB-less solution, do you agree that RAN2 starts with multi-carrier case?**

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| **Company** | **Yes/No** | **Comments** |
| Apple | Yes | RAN2 study of single-carrier case will highly depend on RAN1 design (e.g. DRS, WUS) because SSB and/or SIB1 is absent. Without details of RAN1 design, we don't think RAN2 can make progress.  |
| MediaTek | - | We see a very limited energy saving gain for CA use cases with higher data activity [26]. |
| Ericsson | Yes | Single carrier case seems to have more impact on legacy UEs, and thus it makes sense to focus on multi-carrier case. |
| CATT | Yes | Same view as Apple |
| vivo | Yes, but | We think SSB/SIB1-less impact is different for single carrier and multi carrier case. **Study of single carrier case can be combined with on-demand SSB/cell activation request by UE WUS for IDLE UE case**, since the impact of SSB/SIB-less in single carrier (e.g. capacity boosting cell) does not affect legacy UE (e.g. legacy UE can camp on the coverage cell) and we can further study RAN2 impact for NES capable UE when UE WUS is applied. |
| Nokia | Yes | Mixed carrier case is quite much involving RAN1. RAN2 could at this point focus on how to handle multi-carrier case. |
| BT | Yes | But as part of the study item phase, single carrier needs to be analysed. There are areas covered with a single frequency, e.g. rural areas. If single carrier is not considered, it will be impossible to apply NES in these scenarios.  |
| Vodafone | yes | Should avoid impact to legacy UEs.  |
| Fraunhofer | Yes | Multi-carrier is already supported intra-band. So it makes sense to start by analysing what else is needed to support it in inter-band. Also, in our understanding a single carrier SSB/SIB-less solution will end up being akin to what is discussed under SSB on demand + wake-up signal. Thus, the single carrier scenario can be treated on that scope instead. |
| Interdigital | Yes | It has less impact on legacy UEs. |
| OPPO | Yes | Single-carrier case should be discussed and decided by RAN1 firstly, since it impacts idle/inactive UE on the procedure e.g. DL sync and initial access. |
| Intel | Yes | We think single carrier deployment may create coverage hole for legacy UEs, and thus more impact to legacy UE. |
| Qualcomm | Yes | Agree with Apple, Nokia and OPPO. We think single carrier DRS/WUS is a promising mechanism, but we can’t make progress without RAN1 FFS specifics.  |

### SSB-less

In [14][16][17][24], it is mentioned that SSB-less SCell is already supported for intra-band CA in the current spec, and it is proposed to extend it to inter-band case.

Cited from 38.331:

|  |
| --- |
| ***FrequencyInfoDL* field descriptions** |
| <skip> |
| ***absoluteFrequencySSB***Frequency of the SSB to be used for this serving cell. SSB related parameters (e.g. SSB index) provided for a serving cell refer to this SSB frequency unless mentioned otherwise. The cell-defining SSB of the PCell is always on the sync raster. Frequencies are considered to be on the sync raster if they are also identifiable with a GSCN value (see TS 38.101-1 [15]). If the field is absent, the SSB related parameters should be absent, e.g. *ssb-PositionsInBurst*, *ssb-periodicityServingCell* and *subcarrierSpacing* in *ServingCellConfigCommon* IE. If the field is absent, the UE obtains timing reference from the SpCell or an SCell if applicable as described in TS 38.213 [13], clause 4.1. This is only supported in case the SCell for which the UE obtains the timing reference is in the same frequency band as the cell (i.e. the SpCell or the SCell, respectively) from which the UE obtains the timing reference.For cells supporting RedCap, on handover, corresponds to the cell-defining SSB. |
| <skip> |

Cited from 38.306:

| ***scellWithoutSSB***Defines whether the UE supports configuration of SCell that does not transmit SS/PBCH block. This is conditionally mandatory with capability signalling for intra-band CA but not supported for inter-band CA. | FS | CY | N/A | N/A |
| --- | --- | --- | --- | --- |

In is further analysed in [16] that to support SSB-less SCell for inter-band case, RAN2 impacts include

* introduce a new UE capability to indicate the support of inter-band SCell without SSB; and
* small clarification in the specification (e.g. to extend the field description of the *absoluteFrequencySSB* IE to inter-band case).

**Q6: Do you agree with the following:**

**To extend the current SSB-less SCell from intra-band CA to inter-band CA, RAN2 impacts include** **a new UE capability and some essential field description clarification. The existing procedure defined for intra-band case can be re-used in general.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Apple | No | 1. Whether inter-band SSB-less SCell is feasible is being actively discussed in RAN1 and RAN4. We are not sure why RAN2 can make this decision directly.2. Even RAN1/RAN4 can conclude it is feasible, we identify at least below potential extra RAN2 impacts: 1) The timing of PCell and SSB-less SCell of inter-band may have slot/frame level offset. How to indicate such timing offset to UE? Please note that different from intra-band case, this timing offset may not be zeros. In Rel-16 async CA, RAN1/RAN4 has specified complex RRC signaling for the offset (as numerology of PCell and SCell may be different). 2) For cell quality evaluation (i.e. RRM), will UE use SSB based measurements in PCell or allow to use CSI-RS based measurement in SSB-less SCell? Please note that different measurement quantities may be resulted because reference signal type is different.  3) For RLM, will UE use SSB based RLM in PCell or allow to use CSI-RS based RLM in SSB-less SCell? Please note CSI-RS based RLM seems not to be deployed yet. 4) For BFR, will UE use SSB based BFD in PCell or allow to use CSI-RS based BFD in SSB-less SCell? If BFD is allowed in SSB-less SCell, will UE can trigger BFR in this SCell? 5) In NR, RACH resource selection is based on selected SSB. However, if SSB is only present in PCell, it will be difficultly to ensure QCL b/w PCell and SSB-less SCell of inter-band. Then, does it mean UE always needs to retune to PCell if RACH is triggered ? [Rapp] Most of the questions are not in RAN2 scope. It is unclear to us why the existing mechanism of intra-band SSB-less SCell cannot be reused.Note that we are only discussing the RAN2 impacts. If other WGs identify other impacts, they can add to TR as well.[Apple2] First, the above list of questions are RRC signalling for timing offset, RRM, RLM, BFR and RACH. All of them are RAN2 scope and require RAN2 spec impact (at least 38.321 and 38.331). Maybe Rapporteur can clarify which of them are not in RAN2 scope. Maybe Rapporteur want to say RRM/RLM/RACH also has RAN1 impacts. However, as Rapporteur clarified multiple times: "*we focus on RAN2 impacts for these techniques and do not debate on whether this is RAN1-led or RAN2-led techniques",* right?Secondly, on Rapporteur question "why existing mechanism of intra-band SSB-less SCell cannot be reused". We do have technique justification. The RAN4 timing difference requirement for inter-band CA and intra-band CA are different. For SSB-less inter-band CA, as you copied 38.331, the timing difference between SCell and PCell is always 0. However, this is not valid in inter-band CA case. That is also why Rel-16 async CA (where one use scenario is also inter-band CA) specified mechanism to indicate timing difference between PCell and SCell. Meanwhile, some spec impact on 38.331 and 38.321 were agreed (including how to determine timing reference for FR2 gap, DRX and CG).[HW] We think even though SSB-less is based on CA framework, it does not mean the requirements are the same. If you check RAN4 spec, you can find that for FR1, intra-band CA requires the RTD is within 3us, inter-band requires the RTD is within 33us, while SSB-less SCell requires the RTD is within 260ns.RAN4 will evaluate the requirements for inter-band SSB-less SCell, if anything is needed from RAN2 perspective, we can add later.As for async CA, we don’t understand why inter-band CA must imply async CA as you indicated. To say the least, async CA has already specified the signalling for indicating timing difference, why can’t they be reused? Can you conclude anything additional is needed?The statement of the questions is “RAN2 impacts include”, rather than “only include”.To progress efficiently, companies are welcome to:1) Comment on whether the listed RAN2 impacts (i.e., UE capability and field description modification) are valid;[Apple2] To make it clear, we agree with vivo that capability should not be discussed at this stage. And we disagree the statement " **The existing procedure defined for intra-band case can be re-used in general** ". We have list the technique reasons above why it is not a valid assumption. 2) Complement other RAN2 impacts if any.[Apple2] We are actually positive for this study (SSB-less in multi-carrier). That is why we list above other RAN2 impacts. We hope these potential RAN2 impacts can be captured in TR for further study in Rel-18. |
| MediaTek | No | We understand RAN2 impact is probably limited as long as RAN1/RAN4 could conclude and update their spec.. However, we may still need additional UE capabilities, for example the CSI-RS RRM measurement for inter-freq. SCell without SSB, therefore we should wait for RAN1/RAN4 conclusion to assess RAN2 impact.[Slightly off-topic but comment in this question where the reference listed]In [16] we learnt that the ES gain claimed to be up to 30% is achieved for low load case (e.g., <10% RU) while we have a very limited ES gain for light load (15% - 30%) in CA use cases with higher data activity [26]. Since the SSB-less technique is further clarified to be deployed as SCell specific [16], so we think the simulation result in [26] is closer to the practical deployment of SSB-less technique. Although the RAN2 impact seems limited but it may end up gaining ES in the initial access stage only. RAN2 should not rush to do early decision until the benefit(trade-off) is justified.[Rapp] The NES gain evaluation is performed in RAN1, and not in the scope of this offline discussion.Please note that for the sake of progress, we will use the same principle for all NES candidate techniques, i.e., we focus on RAN2 impacts for these techniques and do not debate on whether this is RAN1-led or RAN2-led techniques. This is exactly what we have done for DTX/DRX discussion. |
| Ericsson | Yes, but | Further details may depend on RAN4 as well, e.g., there may be more than one capability and/or capability dependencies. |
| CATT | See comment | We prefer to leave the SSB and MIB part to RAN1 to decide/design. And RAN2 decides on SIB1 and other SI (i.e. Q7). |
| vivo | See comment | We think it’s premature to discuss UE capability for this case in RAN2:1. we need to first ensure that SSB-less Scell for inter-band CA is feasible, this is pending RAN1/4 discussion.2. If it is feasible, the potential RAN2 impacts mentioned by Apple are basically all depending on RAN1/4 inputs.Therefore, we suggest to postpone the discussion. |
| Nokia |  | interesting to start discussing capability at this point. Maybe we should first discuss how this works! |
| BT | Not yet | Basic features need further study until RAN2 decides on this.Agree with Nokia |
| Vodafone | Yes | In general, the changes seems to be restricted in case of SSB-less and the ES cell might be activated as a capacity booster if needed. It would be good to understand the reasons why it was limited to intra CA case before. Also agree with Nokia we should focus on how it works and not on a capability needed at this stage |
| Fraunhofer | No | In our understanding, in the inter-band CA case the time synchronization to the anchor cell can only be valid at a coarse level to the SSB-less cell (not at a signal level). Also, the UE needs to obtain frequency synchronization. These aspects mean that the procedure may need some modification and the UE may need to request some kind of activation of the SCell, either via signalling to the anchor cell or wake-up signal to the SCell. The RAN 2 impacts would be clearer after RAN1 and RAN4 evaluate this solution.  |
| Interdigital | No | These seem to be stage-3 impacts. They can be discussed later if the feature is agreed. Also agree that the issues mentioned by Apple should be considered. |
| OPPO | No | It is a bit early to discuss the capability issue, as the feasibility of inter-band SSB-less SCell is not concluded in RAN1 and RAN4. RAN2 is better to wait for the RAN1/RAN4 progress and then discuss the RAN2 impact.  |
| Intel | Maybe | Inter-band CA with SSBless requires RAN4 input. Hence we think that this can wait for other group progress. |
| Qualcomm | No | Agree with Apple on the possible RAN2 impacts that would need discussion if this was to be extended to interband. This is not by any means a small extension and would need definitive input from RAN1/RAN4 on the UE capability to synchronizeThere are also potential issues that impact performance of the scheme e.g., * Reliability of the time/frequency/spatial information from one carrier to be used for SSB-less carrier
* Requirements for MRTD and carrier collocation between secondary cells and associated primary cell,
* Band requirements for secondary cells and associated primary cell,

Furthermore, it is not clear how FR2 beam management could work especially in FR2 if RS for beam management in SSB-less carrier is borrowed from another carrier which was refer (after several meetings discussions, RAN 4 concluded to move forward on NR RF Enhancements WI without Common Beam Management (CBM) at FR2). Even though these would be related to RAN1 scope, the assumptions on these issues would be essential knowledge for RAN2 to cover their impact. Thus, we do not agree on the inter-frequency extension to SSB-less Scell needs RAN2 attention now, until more specifics are determined by RAN1 and RAN4.  |
| China Unicom | Yes | In our view, the existing procedure of SSB-less solutions defined for intra-band case can be re-used as baseline for inter-band CA case.  |

### SIB-less

Based on [16][17][18][24][27], the SIB-less solution can be summarized as: NES cell does not transmit SIB, and the anchor cell transmits SIB and other necessary information for UEs to access to NES cell directly.

RAN2 impacts mainly include

1. enhancements to System Information (of anchor cell) to include the necessary information to access via NES cell [16][18][27], the necessary information can be:
* SIB1 of NES cell [16][24]
* Common DL/UL parameters of NES cell [18]
* Measurement configuration of the NES cell; conditions for selecting the NES cell for access; radio resources of the NES cell [27]
1. RACH procedure on NES cell [16][22]

**Q7: Do you agree with the following:**

**For SIB-less solution, RAN2 understanding is that an NES cell does not transmit SIB, and the anchor cell transmits SIB and other necessary information for UEs to access to NES cell directly.**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Apple | No | We are confused by the proposal: is the UE in CONNECTED state or IDLE/INACTIVE state? We can discuss separately: 1) If UE is in CONNECTED state (i.e. NES cell is added as SCell via CA after camping in anchor cell), the existing CA already allows SCell not to send SIB and provide UE SIB via dedicated RRC signalling. We think this solution can be supported without any spec impacts. 2) If UE is in IDLE/INACTIVE state (i.e. although UE can receive SIB via anchor cell, it chooses to camp in another NES cell). We are confused why this scenario can happen? A much simpler solution without spec impact can be: UE first camps in the anchor cell, enter CONNECTED state and then anchor cell redirects this UE to NES cell. Maybe proponent can clarify what is NES gain of this complex solution over this simpler solution without spec impact. |
| MediaTek | No | We understand the intention but do not see further clarification regarding to OSI part, should we revise the topic to be not “SIB-less” but “SIB1-less”? Then we can better assess the RAN2 impact scope.For paging in SIB1-less technique, would we have RAN2 impact to paging search space on ES cell since the search space for SIB1 acquisition is changed?Similarly, we saw a very limited ES gain result for SIB1-less technique [26]. |
| Ericsson |  | We understand the intention is to say that the network is not required to transmit SIB, but it is not prevented to do so either. Hence, the wording could be revised with the following addition in red “does not have to transmit SIB”. |
| CATT | Yes | Answering Apple: in legacy, the UE needs to enter CONNECTED state in the anchor cell. The difference here would be that the UE could enter CONNECTED state (i.e. perform the RACH procedure) in the NES cell directly. Thus alleviating the RACH load and associated signalling of the anchor cell. So UE needs to acquire necessary info of the NES cell from the anchor cell, while in Idle/Inactive.[Apple2] Thanks for discussion. However, what you mentioned is only UE impact, right? My question is why Network energy consumption can be further reduced? Note that in the simpler solution without spec impact (i.e. UE first enters CONNECTED in anchor cell and then anchor cell redirects this UE to NES cell), the NES cell can also not broadcast SIB1. |
| vivo | Yes | 1. The spec has supported this for intra-band CA.2. Similar mechanism was introduced for NB-IOT, therefore it is surely feasible for applying it to this scenario.We can start from studying the impacts from SSB/SIB1-less non-anchor cell for both IDLE and CONNECTED UE, e.g. RACH, paging, etc. |
| Nokia | Not sure what is asked | What scenario we are targeting here? UE in CONNECTED, UE in IDLE, Something else? |
| BT | Yes | We are fine with the sentence. A different discussion is what is required if at the end, RAN2 decides that something is required or SIB-less is required as a whole.We consider it is necessary to clarify if this is for IDLE/INACTIVE, CONNECTED or both. |
| Vodafone | No | I agree it is not very clear what is the intention of the question. Of course SIB less cell does not send SIBs and someone (e.g. Anchor cell does it), to us:The impact on legacy UEs is not very clear. Are e.g. legacy UEs going to detect such a SIB less NES cell? Is MIB broadcasted on such cells? In general, the NES cells should have as less as possible users to perform savings more efficiently.Which UEs are targeting to be served in such SIB less NES cell?  |
| Fraunhofer | No | First and foremost the text should be a bit clearer what is meant by SIB-less. Some of the discussions have been using the term SSB/SIB-1-less, which means that SSB omission implies SIB-1 omission (SSB-less implies SIB-less). Here, given the references, SIB-less here seems to mean that SSBs are transmitted but SIBs are not. Second, we suggest this solution should be renamed to “SIB-less with anchor”, so that implicit things get more explicit.Third, as Mediatek we have concerns about the ES gains of this solution. Conceptually, it does not create large time gaps on NES cells (limiting the achievable ES gain) and it adds to anchor cell consumption (which eliminates part of the gain).  |
| Interdigital | No | The NES gain and the impact on legacy UEs is not clear. There are no issues as long as the UE can camp on the anchor cell. |
| OPPO |  | The scenario targets IDLE/INACTIVE, CONNECTED, or both? If it targets IDLE/INACTIVE, what the impact is on the legacy UE should be clarified. If it targets CONNECTED UE, we wonder why the current mechanism in CA is not sufficient. |
| Intel | No | It seems quite complicated and power consuming for the UE to read the SIB from the anchor/coverage cell and then camp on the cell. It is also not clear whether RACH and paging will be on the NES cell or the UE has to receive paging from the anchor cell. |
| Qualcomm  | No  | We are also struggling to understand this solution. Assuming it’s SIB1-less non-anchor cell, and focusing on SIB1, is it assumed that anchor cell and non-anchor cell have the same content? Perhaps not, since it is mentioned that RACH information is specific to the NES anchor cell.  Thus, it is assumed that an IDLE/INACTIVE UE listens to SSB (that may belong to anchor cell or non-anchor cell depending on the adoption of SSB-less access) and then receives a SIB1 from the anchor cell referring to the non-anchor cell numerology, frequency, BWP configurations, etc. Now it is unclear how the UE can retrieve this “non-anchor” SIB1 as opposed to the SIB1 that comes from the other cell. We would hope proponents may clarify the foreseen operation as well as the expected NES-gains as opposed to accessing the anchor cell then activating the non-anchor cell as an Scell.  |

**Q8: Do you agree with the following:**

**For SIB-less solution, RAN2 will further study which are the necessary information for UE to access to NES cell, and the impacts on RACH procedure on NES cell.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Apple | Premature to discuss | First, we think the motivation of this solution requires clarification as we discussed in Q7. And its NES gain is not clear to us (sending SIB1 alone seems not quite energy consuming in our understanding. And existing NR system already allows gNB to only send SIB1 with all other SIBs as on-demand). Then, why RAN2 need to study the impact on RACH procedure on NES cell is also not clear to us. In our understanding, the UE just needs to acquire RACH configuration from SIB. According to clause 5.1 of TS 38.321, the RACH procedure itself doesn't need to detect SIB, and only selected SSB will impact RACH procedure. So, as long as SSB is still sent in NES cell, we don't see why RACH procedure is impacted. For SSB-less SCell, we agree its RACH impact should be studied as we mentioned in Q6. |
| MediaTek | No | Based on our ES gain estimation shared in Q7, we do not see a strong motivation to support further study in RAN2. |
| Ericsson | Yes |  |
| CATT | Yes |  |
| vivo | Yes | This should be based on the working assumption that the answers to Q5/Q7 are yes. |
| Nokia | premature | Maybe we should understand solutions first |
| BT | Yes but | We consider it is important to analyse what can be achieved with legacy mechanism to set the baseline.To capture legacy analysis, we proposeFor SIB-less solution, RAN2 will further study ~~which are the~~ if additional ~~necessary~~ information for UE to access to NES cell, and the impacts on RACH procedure on NES cell if any.  |
| Fraunhofer | Yes | See Q7. We propose to change it to “**For SIB-less with anchor solution, RAN2 will further study which are the necessary information for UE to access to NES cell, and the impacts on RACH procedure on NES cell.”** |
| Interdigital | premature | These parameters to access the NES cell can be studied once the motivation and solution is clear. |
| OPPO | premature | Maybe scenarios of SIB-less solution need to be clarified first. |
| Intel | Premature | It is still not clear to us how such a cell works, particular when UE needs to receive the SIB from anchor cell when camping on non-anchor cell and also where is paging received, anchor cell or non-anchor cell? |
| Qualcomm | premature | We don’t have a full grasp on the current proposed solution so we would like to clarify that first.  |

# Conclusion

To be completed

# Reference

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3. R2-2210369, Network energy saving techniques, Qualcomm Incorporated
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5. R2-2209810, cell (re)selection and handover considering network energy saving, vivo
6. R2-2209886, Aspects on Network energy savings, VODAFONE Group Plc
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9. R2-2210337, UE awareness by gNB and coexistence with legacy UEs for NES, NEC Telecom MODUS Ltd.
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For SSB/SIB-less

1. R2-2210666, Techniques in various domains and UE assistance information for network energy saving ZTE corporation, Sanechips
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6. R2-2209759, Discussion on Network energy saving for IDLE and INACTIVE UE - cell (re)selection and SSB-less, Apple
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8. R2-2210105, Consideration on network energy saving, Fujitsu
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12. R2-2210653, SSB/SIB/Paging and Group HO, LG Electronics Finland
13. R2-2210772, Considerations on Network Energy Saving techniques, MediaTek Inc.
14. R2-2210665, Supporting access via NES cell, ZTE corporation, Sanechips
15. R2-2210252, Energy Saving from RRC Idle Operation, Lenovo