**3GPP TSG-RAN WG2 Meeting #130 R2-25xxxxx**

Malta, 19th – 23rd May 2025

**Agenda item: 8.4.1**

**Source: Huawei/HiSilicon**

**Title: Report of [Post129bis][218][LPWUS] UE Capabilities (Huawei)**

**WID: NR\_LPWUS-Core**

**Document for: Discussion and Decision**

# Introduction

This document aims to collect views from companies for the following email discussion:

* [Post129bis][218][LPWUS] UE capabilities (Huawei)

Intended outcome: Summary with proposals on RAN2 UE capabilities for LP-WUS

Deadline: Long

Companies are invited to provide input by May 2nd 10:00 UTC. Rapporteur will provide the summary with proposals by May 6th 10:00 UTC and companies can further comment until May 8th 10:00 UTC; Rapporteur will finalize the report to submit on May 9th.

Please provide your contact information when responding.

|  |  |
| --- | --- |
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# Discussion

RAN2 had an initial discussion on UE capabilities based on the contribution R2-2502098 in RAN2-129bis. Below is the related excerpt from the chairman notes:

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| R2-2502098 Discussion on UE capability for LP-WUS Huawei, HiSilicon discussion Rel-19  *Subgrouping capability*  *Proposal 1: Support of LP-WUS in IDLE/INACTIVE (either OOK-based or OFDM-based) indicates support of UE ID-based subgrouping by default.*  *Proposal 2: The capability of LP-WUS in IDLE/INACTIVE (coupled with UE ID-based subgrouping capability) is included in UE-RadioPagingInfo-r17 in RRC UECapabilityInformation message. The granularity (such as per band) and other details for capability of LP-WUS in IDLE/INACTIVE depends on RAN1 features list.*  *RRM measurement capability*  *Proposal 3: RAN2 capability defines RRM measurement fully offloading and RRM measurement relaxation for LP-WUS.*  *Proposal 4: Define RRM measurement capability as “Conditionally mandatory features without UE radio access capability parameters”. It is mandatory to support RRM measurement fully offloading and RRM measurement relaxation in RRC\_IDLE/RRC\_INACTIVE for UEs which support LP-WUS.*  DISCUSSION  P1  - Xiaomi ok with this.  - Ericsson agree, think we do not need a spereate UE capability only for UE-ID based subgrouping.  - QC wonders what is the difference for OOK-based or OFDM-based. QC think the wording ‘support of LP-WUS’ is not that clear.  P3, P4  - Xiaomi think they are discussed in R1, think we can just wait. Vivo agree.  - vivo think we can discuss whether we need separate capabilities for offloading and relaxation.  - QC want to separate the capabilities for LPWUS reception and offloading/relaxation.  - Ericsson think there is no much power saving gain if we only support LPWUS monitoring but not relaxation. |

As the assigned email discussion suggests, we discuss only RAN2 related UE capabilities. Based on the progress so far in RAN2, we think that the UE capabilities related to subgrouping, and RRM measurement relaxation and fully offloading are RAN2 related.

## Subgrouping capability

**CN-assigned subgrouping**

For PEI, UE reports the support of CN-assigned subgrouping to CN by NAS signalling (i.e., in the Registration Request message), and CN decides whether to use it and assigns the subgrouping ID to the UE if it is used. For LP-WUS, SA2 agreed to use the same procedure as for PEI. The UE capability reporting of CN-assigned subgrouping for LP-WUS was captured by SA2 [3] as shown below:

|  |
| --- |
| 5.4.12a.2 Core Network Assistance for LP-WUSPS  To support the LP-WUSPS, LP-WUS Paging Subgrouping Support Indication and the LP-WUSPS Assistance Information is used by the AMF and NG-RAN to help determine whether LP-WUSPS applies to the UE and which paging subgroup is used when paging the UE (see TS 38.300 [27]).  In the Registration Request message, the UE includes the LP-WUS Paging Subgrouping Support Indication if the UE supports LP-WUS Paging Subgrouping. If the UE includes LP-WUS Paging Subgrouping Support Indication, the UE may also include the paging probability information to assist the AMF. The AMF supporting LP-WUSPS stores the UE provided LP-WUS Support Indication in the UE context and the AMF determines AMF LP-WUSPS Assistance Information based on this indication. The AMF may further consider the local configuration, the UE's paging probability information if provided, information provided by the RAN (e.g. any of the Information On Recommended Cells And RAN nodes For Paging), and/or previous statistical information for the UE to determines AMF LP-WUSPS Assistance Information. The AMF LP-WUSPS Assistance Information includes the Paging Subgroup ID. |

**UE\_ID based subgrouping**

For PEI, UE\_ID based subgrouping capability is coupled with PEI capability. That is if a UE supports PEI reception, it shall also support UE\_ID based subgrouping.

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| ***pei-SubgroupingSupportBandList-r17***  Indicates whether the UE supports receiving paging early indication in DCI format 2\_7 as specified in TS 38.304 [21] for a list of frequency band. The UE shall support UEID based subgrouping for a frequency band if it indicates supporting of paging early indication reception for the frequency band. The set of OFDM symbols within a slot where UE can monitor the PEI PDCCH in Type 2A CSS is the same as the requirement for paging PDCCH in Type 2 CSS for IDLE and INACTIVE mode UEs. |

As LP-WUS is also used to wake-up one or several groups of UEs, the principle of PEI can be applied to LP-WUS. The reception of LP-WUS is supported by either OOK-based LR or OFDM-based LR which are defined as separate UE features in RAN1. RAN1 UE features are provided in Appendix. Hence, support of LP-WUS reception in IDLE/INACTIVE by any type of LR indicates supporting UE\_ID based subgrouping by default and there is no need to define a separate capability for supporting UE\_ID based subgrouping.

#### Q1. Do companies agree that a UE supporting LP-WUS in IDLE/INACTIVE supports UE\_ID based subgrouping by default and thus there is no need to define a separate capability for the support of UE\_ID based subgrouping?

|  |  |  |
| --- | --- | --- |
| Company | Answer (Yes or No) | Comments |
| Ericsson | Yes |  |
| vivo | Yes |  |
| Lenovo | Yes |  |
| OPPO | Yes |  |
| CATT | Yes |  |
| Samsung | Yes |  |
| Qualcomm | See comment | It is unclear whether UE supports LP-WUS in IDLE/Inactive should support both of LP-WUS monitoring and RRM relaxation/offloding.  Prefer to change the question to “UE supporting LP-WUS monitoring in IDLE/INACTIVE” |

**Summary:**

**Proposals:**

## RRM related capabilities

As Rel-16 and Rel-17 RRM measurement relaxation capabilities are defined as RAN2 capabilities, capability of RRM measurement relaxation and RRM measurement fully offloading for LP-WUS can also be considered as RAN2 capabilities.

#### Q2. Do companies agree that RRM measurement relaxation and RRM measurement fully offloading are defined as RAN2 capability?

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| --- | --- | --- |
| Company | Answer (Yes or No) | Comments |
| Ericsson | Yes |  |
| Vivo | See comments | We are fine to discuss/define it in RAN2.  At the same time, RAN1 is also discussing whether to include RRM relaxation/offloading in the basic feature of LP-WUS, i.e. as one of component. We think it could be also discussed/determined in RAN1. |
| Huawei/HiSilicon | Yes |  |
| Lenovo | Yes |  |
| CATT | Yes |  |
| Samsung | Yes |  |
| Qualcomm | See comments | Should coordinate with RAN1 to avoid duplicated discussion. |

### 2.2.1 Different Use Cases

After the discussion in RAN2-129bis, we think that it’s better to have a common understanding on the supported use cases regarding UE supporting LP-WUS reception, and RRM measurement relaxation and fully offloading. The following are possible uses cases:

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| --- | --- |
| Case # | Description |
| Case 1 | UE supports LP-WUS reception, and supports RRM measurement relaxation and RRM measurement fully offloading |
| Case 2 | UE supports LP-WUS reception, but does not support RRM measurement relaxation and RRM measurement fully offloading |
| Case 3 | UE supports RRM measurement relaxation and RRM measurement fully offloading, but does not support LP-WUS reception |
| Case 4 | UE does not support LP-WUS reception and does not support RRM measurement relaxation and fully offloading |

Rapporteur understands that at least Case 1 and Case 4 need to be supported. Case 4 means that LP-WUS reception and RRM measurement relaxation and fully offloading is optional feature for UEs.

For Case 2, there is almost no power saving gain since UE still needs to turn on the MR frequency to perform the normal RRM measurement on either serving cell or neighbour cell, as stated in TR 38.869.

Motivation for Case 3 is not clear as if the UE has implemented LR, it should be able to support LP-WUS. In RAN2#127 meeting, we had the following agreement:

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| * RAN2 only discuss RRM measurement offloading/relaxation for LP-WUS UEs. |

Only the LP-WUS capable UE will support and perform RRM measurement relaxation and fully offloading. Thus, UE supporting RRM measurement relaxation and fully offloading should also support LP-WUS.

However, would like to hear views from companies on what cases need to be supported.

#### Q3: Which of the above use cases do you think should be supported?

|  |  |  |
| --- | --- | --- |
| Company | Supported Cases | Comments |
| Ericsson | Case 1 (and 4) | There is no/negligible power saving gains with case 2 and 3, i.e. we do not see a need to support these cases. Furthermore there is no capability signalling in idle/inactive, i.e. it is possible to make a UE implementation for case 2 and 3 without impact on 38.306.  Not sure if there is a need to discuss case 4, i.e. this case is supported by the UE by default. |
| vivo | Case 1 and 4 | We understand there is no power saving gain for case 2 and case 3 based on the evaluation in TR during SI.  With this, we understand the RRM relaxation/offloading should be one of components of basic feature for LP-WUS. |
| Huawei/HiSilicon | Case 1 and 4 | Agree with Vivo and Ericsson |
| Lenovo | Case 1 and Case 4 | We also have the same understanding as the Rapporteur and Ericsson. We do not see any power saving benefit in supporting Case 2 or Case 3. Since it is also agreed that the network can configure either one of RRM relaxation or offloading or both, we do not see the need to separate LP-WUS reception from RRM relaxation or offloading as a capability.  For Case 4, our understanding is that a UE equipped with LR may or may not perform LP-WUS reception and RRM relaxation/ offloading, but we do not think that there is a case where a LR equipped UE would never support LP-WUS reception and RRM relaxation/ offloading. If a UE does not support this at all, it becomes a legacy UE so we are not sure how case 4 means that this is an optional feature. |
| OPPO | Support all cases | From UE vender perspective, we prefer to define two separate UE capabilities for LP-WUS monitoring and for RRM relaxation and offloading and leave more flexibility to UE. From functionality perspective, these two features are not dependent and there is no need to bundle these two features. |
| CATT | Case 1 | We share the same view with Rapporteur that Case 2 and 3 are not necessary to be supported.  But for Case 4, not sure it’s needed to be supported, since Case 4 seems as a legacy UE which do not support LP-WUS feature at all. |
| Samsung | Case 1 and 4 | We share the same view as Vivo, Huawei, and others that the introduction of RRM relaxation/ offloading is primarily aimed at enabling energy savings for LP-WUS/WUR. |
| Qualcomm | See comments | There are three sub-features in IDLE/INACTIVE state: LP-WUS monitoring, LP-WUS offloading, RRM measurement relaxation. It could be possible that UE only supports LP-WUS monitoring and offloading for power saving.  Regarding to whether there is power saving benefit if UE only supports LP-WUS power saving, we would like to ask RAN1 and RAN4 to evaluate the power saving benefit if only using LP-WUS replacing PEI. |

If only Case 1 and Case 4 need to be supported, then RRM measurement relaxation and fully offloading can be defined as “Conditionally mandatory features without signalling”, as described by Option 1 below. If all use cases need to be supported, then separate optional capability for RRM measurement relaxation and fully offloading is needed, as described by Option 2 below.

**Option 1:** Define RRM measurement capability as “Conditionally mandatory features without UE radio access capability parameters”. It is mandatory to support RRM measurement relaxation and RRM measurement fully offloading in RRC\_IDLE/RRC\_INACTIVE for UEs that support LP-WUS.

**Option 2:** Define separate optional capability for “RRM measurement relaxation and RRM measurement fully offloading” in RRC\_IDLE/RRC\_INACTIVE.

**Option 3: …**

The final RRM measurement relaxation and RRM measurement fully offloading capability proposal(s) will be based on the response to Q3.

**Summary:**

**Proposals:**

## Any other?

#### Q4: If there are any other issues, please provide them below.

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| --- | --- |
| Company | Comments |
| Ericsson | RAN2 agreed that LP-WUS is supported with eDRX, i.e. if the UE supports LP-WUS and the UE supports eDRX, then the UE supports LP-WUS with eDRX, i.e. no need for separate UE capability (similar as with PEI). RAN2 agreed that LP-WUS is supported with CA/DC, i.e. no need for separate UE capability signalling for the combination of LP-WUS and CA/DC.  RAN2 agreed:   * For NR-DC, the LP-WUS in MCG and SCG can be configured independently.   We assume that the support of LP-WUS on both MCG and SCG is an optional feature with UE capability signalling.  We assume that a UE supporting LP-WUS in connected mode is able to signal the minimum offset in the UE capabilities. But that UAI signalling of the preferred offset is an optional feature with UE capability signalling.  RAN1 agreed that UE can signalling LP-WUS support in idle/inactive and/or connected. And whether OFDM and/or OOK-based WUR is supported. Furthermore the UE can indicate LP-WUS support per band. Further discussion is needed whether the band support should be fully flexible, e.g. UE can indicate OFDM support in band A and OOK support in band B. Perhaps the capabilities can be signalled from the number of WURs the UE supports. |
| Huawei/HiSilicon | Regarding Ericsson’s comment on CONNECTED state LP-WUS capability: our understanding is that RAN1 is considering whether band combination level or band level is needed and they will further discuss. We think RAN2 can wait for RAN1 discussion on band combination level. |
| Qualcomm | For LP-WUS with eDRX, the impact is still FFS, and there could be RAN4 impact. We would like to keep this UE capability open until the impact in RAN2 and RAN4 is clear. |

**Summary:**

**Proposals:**

# Conclusions

Based on the inputs from companies, the following proposals are made:

# References

1. R2-2502098 Discussion on UE capability for LP-WUS, Huawei, HiSilicon
2. RAN2-129bis Chairman Notes
3. 3GPP TS 23.501, System architecture for the 5G System (5GS); Stage 2 (Release 19).

# Appendix – RAN1 UE features

The following are taken from R1-2502966 Session Notes of AI 9.15.5, Ad-Hoc Chair (NTT DOCOMO)

**1.1 UE features for LP-WUS/WUR for NR**

For reference:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 62-1 | LP-WUS operation in IDLE/INACTIVE mode based on OOK signal | 1. LP-WUS operation in IDLE/INACTIVE mode to trigger paging monitoring based on OOK  [2. The support of LP-SS based RRM measurement ~~and/or SSB-based measurement, corresponding to component 1~~]  [3. The support of further RRM relaxation of UE MR]  [4. The support of serving RRM measurement offloading]  [5. The supported wake-up delay]  FFS: M values  FFS: Other components and/or further FG separation |  | YES | n/a | LP-WUS operation in IDLE/INACTIVE mode based on OOK signal is not supported | [Per Band] | n/a | n/a | n/a | ~~Component 1 candidate values: {OOK-based, OFDM-based, both}~~  Component 5 candidate values: FFS  ~~[For UE supporting both X-1 and X-2, UE is not allowed to report different candidate values for component 1]~~ | Optional with capability signalling |
| 62-1a | LP-WUS operation in IDLE/INACTIVE mode based on OFDM [overlaid] sequence | 1. LP-WUS operation in IDLE/INACTIVE mode to trigger paging monitoring based on OFDM  [2. FFS: The support of LP-SS based RRM measurement ~~and/or~~  [X. FFS: The support of SSB-based RRM measurement]  [3. The support of further RRM relaxation of UE MR]  [4. The support of serving RRM measurement offloading]  [5. The supported wake-up delay]  FFS: M values  FFS: Other components and/or further FG separation |  | YES | n/a | LP-WUS operation in IDLE/INACTIVE mode based on OFDM is not supported | [Per band] | n/a | n/a | n/a | ~~Component 1 candidate values: {OOK-based, OFDM-based, both}~~  Component 5 candidate values: FFS  ~~[For UE supporting both X-1 and X-2, UE is not allowed to report different candidate values for component 1]~~ | Optional with capability signalling |
| 62-2 | LP-WUS operation in CONNECTED mode based on OOK signal | 1. LP-WUS operation in CONNECTED mode based on OOK signal  2. The supported procedure(s)  3. Minimum time gap between LP-WUS reception and UE to start PDCCH monitoring in CONNECTED mode  FFS: M values  FFS: SCS  FFS: Other components and/or further FG separation |  | YES | n/a | LP-WUS operation in CONNECTED mode based on OOK signal is not supported | [Per band] | n/a | n/a | n/a | Component 2 candidate values: FFS  Component 3 candidate values: FFS | Optional with capability signalling |
| 62-2a | LP-WUS operation in CONNECTED mode based on OFDM overlaid sequence | 1. LP-WUS operation in CONNECTED mode based on OFDM overlaid sequence(s)  2. The supported procedure(s)  3. Minimum time gap between LP-WUS reception and UE to start PDCCH monitoring in CONNECTED mode  FFS: M values  FFS: SCS  FFS: Other components and/or further FG separation |  | YES | n/a | LP-WUS operation in CONNECTED mode based on OFDM overlaid sequence is not supported | [Per band] | n/a | n/a | n/a | Component 2 candidate values: FFS  Component 3 candidate values: FFS | Optional with capability signalling |

**Agreement:**

* Define new FG 62-3 for the support of LP-WUS frequency resource outside active DL BWP for LP-WUS operation in CONNECTED mode
* Add a component in FG 62-2/2a for the support of LP-WUS frequency resource within active DL BWP

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| 62-3 | LP-WUS frequency resource outside active DL BWP ~~in addition to the one within active DL BWP~~ for LP-WUS operation in CONNECTED mode | 1. Support of LP-WUS frequency resource outside active DL BWP ~~in addition to the one within active DL BWP~~ for LP-WUS operation in CONNECTED mode | FG 62-2 or 62-2a | YES | n/a | LP-WUS frequency resource outside active DL BWP for LP-WUS operation in CONNECTED mode is not supported | [Per band] | n/a | n/a | n/a |  | Optional with capability signalling |

**Agreement:**

Adopt “Per band” for FG 62-1 and 62-1a:

**Agreement:**

Update FG 62-1 and 62-1a as follows:

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 62-1 | LP-WUS operation in IDLE/INACTIVE mode based on OOK signal | 1. LP-WUS operation in IDLE/INACTIVE mode to trigger paging monitoring based on OOK  [2. The support of LP-SS based RRM measurement ~~and/or SSB-based measurement, corresponding to component 1~~]  [3. The support of further RRM relaxation of UE MR]  [4. The support of serving RRM measurement offloading]  [5. The supported wake-up delay]  FFS: M values  FFS: Other components and/or further FG separation |  | YES | n/a | LP-WUS operation in IDLE/INACTIVE mode based on OOK signal is not supported | Per Band | n/a | n/a | n/a | ~~Component 1 candidate values: {OOK-based, OFDM-based, both}~~  Component 5 candidate values: FFS  ~~[For UE supporting both X-1 and X-2, UE is not allowed to report different candidate values for component 1]~~ | Optional with capability signalling |
| 62-1a | LP-WUS operation in IDLE/INACTIVE mode based on OFDM overlaid sequence | 1. LP-WUS operation in IDLE/INACTIVE mode to trigger paging monitoring based on OFDM overlaid sequence  [2. FFS: The support of LP-SS based RRM measurement ~~and/or~~  [X. FFS: The support of SSB-based RRM measurement]  [3. The support of further RRM relaxation of UE MR]  [4. The support of serving RRM measurement offloading]  [5. The supported wake-up delay]  FFS: M values  FFS: Other components and/or further FG separation |  | YES | n/a | LP-WUS operation in IDLE/INACTIVE mode based on OFDM overlaid sequence is not supported | Per band | n/a | n/a | n/a | ~~Component 1 candidate values: {OOK-based, OFDM-based, both}~~  Component 5 candidate values: FFS  ~~[For UE supporting both X-1 and X-2, UE is not allowed to report different candidate values for component 1]~~ | Optional with capability signalling |