3GPP TSG-RAN WG1 Meeting #118 R1-240nnnn

Maastricht, NL, August 19th – 23rd, 2024

**Agenda Item: 9.6.3**

**Title: FL summary #1 on LP-WUS operation in CONNECTED mode**

**Source: Moderator (NTT DOCOMO)**

**Document for: Discussion, Decision**

# 1 Introduction

The core part of the Rel-19 LP-WUS/WUR WI [1] has the following objective:

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| The objectives of the work item are the following:   * To specify an LP-WUS design commonly applicable to both IDLE/INACTIVE and CONNECTED modes (RAN1, RAN4)   + Specify OOK (OOK-1 and/or OOK-4) based LP-WUS with overlaid OFDM sequence(s) over OOK symbol     - The LP-WUS design shall ensure that for IDLE/INACTIVE operation, the same information is delivered irrespective of LP-WUR type. The OFDM sequence can carry information.   + At least duty-cycled monitoring of LP-WUS is supported * For IDLE/INACTIVE modes   + Specify procedure and configuration of LP-WUS indicating paging monitoring triggered by LP-WUS, including at least configuration, sub-grouping and entry/exit condition for LP-WUS monitoring (RAN2, RAN1, RAN3, RAN4)   + Specify LP-SS with periodicity with Yms for LP-WUR, for synchronization and/or RRM for serving cell. (RAN1, RAN4)     - LP-SS is based on OOK-1 and/or OOK-4 waveform with or without overlaid OFDM sequences. Further down selection between with and without overlaid OFDM sequences is to be done within WI.     - Note: For LP-WUR that can receive existing PSS/SSS, existing PSS/SSS can be used for synchronization and RRM instead of LP-SS.     - Y will be decided within WI. 320ms is the start point.   + Specify further RRM relaxation of UE MR for both serving and neighbor cell measurements, and UE serving cell RRM measurement offloaded from MR to LP-WUR, including the necessary conditions (RAN4, RAN2) * For CONNECTED mode, specify procedures to allow UE MR PDCCH monitoring triggered by LP-WUS including activation and deactivation procedure of LP-WUS monitoring (RAN2, RAN1)   + Check in RAN#105 for potential TU adjustment in RAN2   + Note: In CONNECTED mode, UE MR ultra-deep sleep is not considered, and UE RRM/RLM/BFD/CSI measurements are performed by MR * Note: The target coverage of LP-WUS and LP-SS shall be the coverage of PUSCH for message3. * Note: The optimization of LP-WUS signal design for idle/inactive mode is prioritized over the optimization for connected mode. * Specify the necessary RAN4 core requirement(s) to support the feature (RAN4).   + Specify UE low-power wake-up receiver requirements, at least REFSENS, ACS and ASCS requirements with consideration of possible new methodology to assess the low-power wake-up receiver performance     - Define guard RBs for ACS and ASCS cases     - Study testability of above requirements     - Consider impacts of different architecture and impairments, and set requirements that enable all types of reasonable implementation   + Study and if necessary specify or support by declaration, the corresponding BS requirements, e.g., dynamic range for LP-WUS/LP-SS.     - Current NR BS requirements is baseline   + Specify necessary RRM requirements |

This document summarizes contributions [4] – [27] submitted to agenda item 9.6.3 (LP-WUS operation in CONNECTED mode).

# 2 Proposals for Online Sessions

### 2.1 Proposals for 1st Online

To be updated

# 3 LP-WUS Procedures to trigger PDCCH monitoring

### 3.1 High-level procedures

As captured in TR38.869, four options of LP-WUS high-level procedures to trigger PDCCH monitoring have been discussed in Rel-18 SI.

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| **Table 7.3.2.3-1: LP-WUS operation methods in RRC\_CONNECTED**   |  |  |  |  | | --- | --- | --- | --- | | **LP-WUS application** | **Details** | **Start PDCCH monitoring condition** | **Stop PDCCH monitoring condition** | | **Direction 1: LP-WUS monitoring occasion is determined based on timer(s) related C-DRX** | Option 1: similar to Rel-16 DCP, i.e. the LP-WUS monitoring occasion is located before *drx-onDurationTimer*. | If LP-WUS addressed to UE or UE's subgroup is detected and the legacy *drx-onDurationTimer* is started | It could follow legacy, i.e. at expiration of a C-DRX timer, e.g. C-DRX *drx-OnDurationTimer* or when the UE receives Rel-17 PDCCH skipping indication (if supported and configured). | | Option 2: the LP-WUS monitoring occasion is located at any time outside DRX active time to indicate UE to enter into active time | If LP-WUS addressed to UE or UE's subgroup is detected | | **Direction 2: LP-WUS monitoring occasion is not determined based on timer(s) related C-DRX** | Option 4: the LP-WUS monitoring occasion is located at any time regardless of whether DRX is configured or not. | | **Direction 3: LP-WUS is transparent to current MAC operation** | The LP-WUS monitoring occasion should be determined based on physical layer design/restriction.  This direction may not have any impact on MAC. | N/A | N/A |   Note: The above directions/solutions are NOT Mutually Exclusive absolutely, e.g. some overlap may exist between direction 3 and direction 2, or between option 2 and option 4, based on the detailed design for each direction/option. The detailed design would be further determined in WI, if included.  In direction 1 above, LP-WUS is used in conjunction with C-DRX. LP-WUS could be configured outside the DRX active time with either of the following two options.  - Same function as Rel-16 DCP to indicate whether to start the next *drx-onDurationTimer* (i.e. option 1 above)  - To indicate UE to enters into active time for PDCCH monitoring (i.e. option 2 above)  Some examples for different options in direction 1 are shown as illustrated in the below figures.  For option 1: LP-WUS is used similar as Rel-16 DCP, an example is shown as below (note that a longer time offset may likely have to be applied to cover the MR transition time compared to DCP):    **Figure 7.3.2.3-1: Example for option 1**  For option 2: LP-WUS could be used at any time outside C-DRX active time to indicate UE to enter into active time, different examples for both 'duty-cycled' and 'continuous' mode are shown as below:    **Figure 7.3.2.3-2: Example for option 2 with 'duty-cycled' LP-WUS**    **Figure 7.3.2.3-3: Example for option 2 with 'continuous' LP-WUS**  In direction 2 above, LP-WUS is used in conjunction with C-DRX as the direction 1 or without C-DRX. In the latter case, the LP-WUS is used to indicate UE to activate/resume PDCCH monitoring. Some other solutions used to indicate UE to stop the PDCCH monitoring should be used in conjunction with LP-WUS, e.g. Rel-17 PDCCH monitoring adaptation.  For option 4: LP-WUS could be used at any time regardless of whether C-DRX is configured or not, different examples for both 'duty-cycled' and 'continuous' mode are shown as below:    **Figure 7.3.2.3-4: Example for option 4 with 'duty-cycled' LP-WUS**    **Figure 7.3.2.3-5: Example for option 4 with 'continuous' LP-WUS**  In direction 3, the detailed design should be determined based on physical layer design/restriction.  The corresponding pros/cons for the above options on LP-WUS using in RRC\_CONNECTED are summarized in the below table.  **Table 7.3.2.3-2: Pros and Cons of LP-WUS using options in RRC\_CONNECTED**   |  |  |  | | --- | --- | --- | | LP-WUS options | Pros | Cons | | Option 1: LP-WUS is used similar as Rel-16 DCP | More Power Saving gain is expected compared to legacy DCP due to the difference on power consumption between LP-WUS monitor and PDCCH monitor;  Less specification impact and complexity from reuse of DCP functionality compared to other solutions, e.g. option 2 option 3. | It would result in having redundant mechanism for the same purpose.  Artificially limiting WUR duty-cycle to the C-DRX cycle length (can easily be avoided using separate configuration parameters). | | Option 2: LP-WUS could be used at any time outside C-DRX active time to indicate UE to enter into active time | Power saving gain is excepted compared to current C-DRX mechanism.  LP-WUS configuration is more flexible than option 1 and option 3, e.g. since WUR duty-cycle is not locked to C-DRX cycle;  If a shorter WUR duty-cycle is compared to a longer C-DRX cycle, or continuous mode is used, DL data transmission latency could be reduced compared to C-DRX mechanism and option 1 by not limiting the DL data transmission to a C-DRX onDuration. | More complexity: how to coexist with current C-DRX mechanism;  More specification impacts: new PDCCH monitoring mechanism needs to be captured, e.g. separate WUR duty-cycle (different from C-DRX cycle), and WUR-specific on-duration timer for PDCCH monitoring must be introduced. | | [Option 3: LP-WUS could be used after the beginning of *drx-onDurationTimer*] | Power Saving gain is expected by reducing unnecessary PDCCH monitoring for XR traffic than legacy C-DRX if there is one-stream XR traffic with a non-changing fps which can be matched by the DRX cycle. | More specification impacts considering it may change the current PDCCH monitoring behaviour  Given the ramp-up time from micro/deep sleep, it may be useable in the limited cases, e.g., long *drx-onDurationTimer*. | | Option 4: LP-WUS could be used at any time regardless of whether C-DRX is configured or not | Power Saving gain is expected compared to current C-DRX mechanism and DCP since LP-WUS monitoring consumes less power than PDCCH monitoring;  LP-WUS configuration is more flexible than other options above;  DL data transmission latency could be reduced compared to current C-DRX mechanism. | More complexity: we need to discuss how to stop the PDCCH monitoring and how to configure the LP-WUS; | |

This issue has been discussed in RAN1#116bis and following agreement was made. As a result, RAN1 will not discuss Case 2 when C-DRX is not configured.

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| **Agreement**  Update the following agreement in RAN1#116 in red:  **Agreement**   * For RRC CONNECTED mode, from RAN1 perspective, further study following LP-WUS procedures to trigger PDCCH monitoring:   + Case 1: PDCCH monitoring is triggered by LP-WUS with C-DRX configuration     - Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.       * This option may replace DCP functionality     - Option 1-2: LP-WUS monitoring outside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.       * PDCCH monitoring possibly irrespective of drx-onDurationTimer         + Option 1-2-1: PDCCH monitoring may be additionally triggered based on legacy C-DRX cycle and drx-onDurationTimer when monitoring LP-WUS   If this is adopted, it should be configured together with Option 1-1 to achieve power saving gain compared to legacy C-DRX   * + - * + Option 1-2-2: PDCCH monitoring is not triggered by legacy C-DRX cycle and drx-onDurationTimer when monitoring LP-WUS     - Option 1-3: LP-WUS monitoring inside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.   + ~~Case 2: PDCCH monitoring is triggered by LP-WUS without C-DRX configuration. LP-WUS can be monitored at any time according to the LP-WUS monitoring configuration~~     - ~~FFS duty-cycled and/or continuous LP-WUS monitoring~~ * Combination of options in Case 1 ~~and combination of options in Case 1 and Case 2 are not precluded~~ should be considered. * RAN1 does not discuss C-DRX related timers other than drx-onDurationTimer, this topic is up to RAN2 * Note: Above does not preclude to support fallback mechanism to trigger PDCCH monitoring, if any |

In RAN1#117, no down selection has done since RAN2 started the discussion on Procedures for LP-WUS in RRC\_CONNECTED from May RAN2 meeting, and it was better to wait for RAN2 progress before further down-selection among the options.

Accordingly, RAN2 made some progress in May RAN2 meeting as follows, and RAN1 can make further down-selection at least from RAN1 perspective.

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| * In RRC\_CONNECTED mode, RAN2 to further discuss the impacts of LP-WUS operation methods identified in RAN1. * For Option 1-1 (as described in RAN1 agreement), the LP-WUS monitoring occasion locates at a configured time offset before the start of drx-onDurationTimer. The range of time offset can be determined by RAN1. * For Option 1-1, RAN2 assumes the solutions/ operations introduced for DCP mechanism is taken as baseline. * RAN2 assume that legacy DCP and Option 1-1 is not configured simultaneously for a UE. * The LP-WUS related configuration for RRC CONNECTED state UE is provided via dedicated RRC message. |

Many companies provided their view on the pros/cons of these options

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|  | **Pros** | **Cons** |
| **Option 1-1** | * Can be enabled in the same way as for Rel-16 DCP * legacy RRC parameters for C-DRX configuration can be re-used * significant power saving gain for FR2 | * no power saving gain brought by WUS during DRX active time * no traffic latency reduction outside DRX active time * shorter DRX cycle increases the MR power consumption for RLM/BM/BFD/RRM measurements |
| **Option 1-2** | * Can enable more flexible triggering for PDCCH monitoring * Can essentially be realized by Option 1-1 if the RRC parameters are set such that more granular start occasions of DRX-ON durations are enabled * Simple fallback behaviour to legacy C-DRX with some new LP-WUS exit criteria/trigger * Relax Legacy cDRX setting to reduce power consumption for ongoing MR measurements | * loss of power-saving benefit of C-DRX for measurement * same as Option 1-1 with shorter DRX cycle length configuration * Cause significant complexity and impacts RAN2 aspects |
| **Option 1-2-1 (configured together with Option 1-1)** |  | * no power saving gain brought by WUS during DRX active time * complicated UE procedures, e.g. either legacy C-DRX or additional timer is triggered for PDCCH |
| **Option 1-2-2** | * More power saving gain with simplified UE procedure * keep the configurations of DRX cycle and DRX related timers and thus does not have impacts on the measurement * works standalone, can obtain more power saving and reduce latency | * the timeline of PDCCH monitoring and some other behaviors is scattered, which is not conducive to UE power saving * Unclear measurement behaviors within the new PDCCH monitoring timer triggered by LP-WUS |
| **Option 1-3** | * Can enable more flexible triggering for PDCCH monitoring starting from the middle of DRX Active Time for power saving * Beneficial for traffic with jitter * legacy RRC parameters for C-DRX configuration can be re-used * Relax Legacy cDRX setting to reduce power consumption for ongoing MR measurements (Nokia) | * Cannot reduce latency in case the traffic arrives outside the C-DRX active time * use case is limited to traffic with jitter, e.g., XR traffic, where the power saving gain of WUS is minor * same as Option 1-1 with shorter DRX cycle length configuration * Legacy cDRX sets upper bound on MR power consumption for ongoing measurements * Need to clarify the relationship between LP-WUS and C-DRX related timers |

Many companies also provided their view on the preference of these options as follows:

* Option 1-1
  + Apple, CATT, Samsung, Pana, Lenovo, Sony, ETRI, QC, E///, DCM, CMCC, NEC, LGE, [ZTE], Nokia, Sharp
* Option 1-2
  + [QC]
  + Need progress in RAN2: Samsung
  + Option 1-2-1 (configured together with Option 1-1)
    - IDC, [Nokia], NEC, ETRI, LGE, [ZTE], [Apple], [Sharp]
  + Option 1-2-2
    - HW/HiSi, Vivo, Apple, CMCC, OPPO, [ZTE], [Nokia]
* Option 1-3
  + SPRD, CMCC, ETRI, [QC]
  + Need progress in RAN2: Samsung

Also, some companies provided their view on the combinations of these options (in addition to the combination of Option 1-1 and Option 1-2-1, which is already captured in the above agreement)

* Option 1-1 and Option 1-2-2
  + Apple (unified design)
* Option 1-1 and Option 1-3
  + ETRI, [Sharp]
* Option 1-2-2 and Option 1-3
  + HW/HiSi, DCM

In general, it can be said that,

* Option 1-1: small power saving gain, no latency reduction, small spec impact, **majority companies support w/o different interpretations of the previous agreement**
* Option 1-2: tradeoff between large power saving gain and large latency reduction, large spec impact
  + **Companies have different understanding** which options 1-2-1 or 1-2-2 have larger spec impact, especially on the relationship between LP-WUS monitoring and C-DRX related timers
* Option 1-3: small power saving gain, useful for traffic with jitter, small/medium spec impact
  + **Companies may have different understanding** on the relationship between LP-WUS monitoring and C-DRX related timers

For Option 1-1, it should be common understanding that legacy RRC parameters for C-DRX configuration can be reused

* drx-OnDurationTimer, drx-LongCycleStartOffset, drx-SlotOffset, shortDRX gives the understanding of legacy C-DRX active time
* drx-OnDurationTimer, drx-InactivityTimer, drx-RetransmissionTimerDL, drx-RetransmissionTimerUL, drx-HARQ-RTT-TimerDL, drx-HARQ-RTT-TimerUL, etc, enables PDCCH monitoring window extension as in the legacy C-DRX configuration



**Option 1-1**

For Option 1-2-1 (+ Option 1-1), it is unclear whether following is common understanding

* Legacy C-DRX active time as Option 1-1
* New PDCCH monitoring window is defined similar to Legacy C-DRX active time
  + FFS: whether to reuse legacy RRC parameters for C-DRX configuration (while starting point is different from legacy C-DRX active time) or introduce new RRC parameters separately from legacy C-DRX configuration



**Option 1-2-1 + Option 1-1**

For Option 1-2-2, similar to Option 1-2-1, it is unclear whether following is common understanding

* Legacy C-DRX active time as Option 1-1
* New PDCCH monitoring window is defined similar to Legacy C-DRX active time
  + FFS: whether to reuse legacy RRC parameters for C-DRX configuration (while starting point is different from legacy C-DRX active time) or introduce new RRC parameters separately from legacy C-DRX configuration



**Option 1-2-2**

For Option 1-3, it is unclear whether following is common understanding

* Legacy C-DRX active time as Option 1-1
* FFS: once triggered by LP-WUS, whether the PDCCH monitoring lasts until the end of legacy C-DRX active time or other timer(s) are introduced separately from legacy C-DRX configuration



**Option 1-3**

Therefore, moderator suggests that at least Option 1-1 is supported and other options are further discussed for better mutual understanding among companies.

#### **Proposal 3.1-1:**

* **For RRC CONNECTED mode, PDCCH monitoring is triggered by LP-WUS with C-DRX configuration**
  + **Support At least Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.**
    - **Legacy RRC parameters for C-DRX configuration is reused for the PDCCH monitoring**

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| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| Xiaomi |  | We support 1-1, but at least some other enhancement should also be supported otherwise the power saving gain it too small |
| Spreadtrum |  | For Option 1-1, the power saving gain of LP-WUS may not be promising compared to R16 DCP, because power consumption of R16 DCP is not dominant in total power consumption. |
| ZTE, Sanechips | N | We can accept this only when this option has obvious latency reduction gain. There is no reason to ignore the latency gain especially in connected mode. |

#### **Question 3.1-2:**

* **For Option 1-2-1 (+ Option 1-1), do you agree with the following understanding? If no, please clarify your understanding**
  + **Legacy C-DRX active time as Option 1-1, i.e.,**
    - **drx-OnDurationTimer, drx-LongCycleStartOffset, drx-SlotOffset, shortDRX gives the understanding of legacy C-DRX active time**
    - **drx-OnDurationTimer, drx-InactivityTimer, drx-RetransmissionTimerDL, drx-RetransmissionTimerUL, drx-HARQ-RTT-TimerDL, drx-HARQ-RTT-TimerUL, etc, enables PDCCH monitoring window extension as in the legacy C-DRX configuration**
  + **New PDCCH monitoring window is defined similar to Legacy C-DRX active time**
    - **FFS: whether to reuse legacy RRC parameters for C-DRX configuration (while starting point is different from legacy C-DRX active time) or introduce new RRC parameters separately from legacy C-DRX configuration**

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| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| Xiaomi | Y |  |
| Spreadtrum | Y | If Option 1-2-1 is configured together with Option 1-1, it means we need to design two types of LP-WUS functions, one to trigger new PDCCH monitoring window and the other to indicate whether drx-onDurationTimer is started. There are more specification impacts. |
| ZTE, Sanechips | Y |  |

#### **Question 3.1-3:**

* **For Option 1-2-2, do you agree with the following understanding? If no, please clarify your understanding**
  + **Legacy C-DRX active time as Option 1-1, i.e.,**
    - **drx-OnDurationTimer, drx-LongCycleStartOffset, drx-SlotOffset, shortDRX gives the understanding of legacy C-DRX active time**
    - **drx-OnDurationTimer, drx-InactivityTimer, drx-RetransmissionTimerDL, drx-RetransmissionTimerUL, drx-HARQ-RTT-TimerDL, drx-HARQ-RTT-TimerUL, etc, enables PDCCH monitoring window extension as in the legacy C-DRX configuration**
  + **New PDCCH monitoring window is defined similar to Legacy C-DRX active time**
    - **FFS: whether to reuse legacy RRC parameters for C-DRX configuration (while starting point is different from legacy C-DRX active time) or introduce new RRC parameters separately from legacy C-DRX configuration**

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| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | We agree the UE should still be configured with *drx-OnDurationTimer*, *drx-LongCycleStartOffset*, *drx-SlotOffset*, and *shortDRX*. However, the UE does not monitor PDCCH based on these parameters, when the UE monitors LP-WUS to trigger PDCCH monitoring in Option 1-2-2.  With this, we suggest following update:   * + **Legacy C-DRX configurations provided ~~active time~~ as Option 1-1, i.e.,**     - **drx-OnDurationTimer, drx-LongCycleStartOffset, drx-SlotOffset, shortDRX gives the understanding of legacy C-DRX active time**     - **drx-OnDurationTimer, drx-InactivityTimer, drx-RetransmissionTimerDL, drx-RetransmissionTimerUL, drx-HARQ-RTT-TimerDL, drx-HARQ-RTT-TimerUL, etc, enables PDCCH monitoring window extension as in the legacy C-DRX configuration** |
| Xiaomi |  | We suggest the following modification since PDCCH is not triggered by drx-OnDurationTimer.   * + **Legacy C-DRX active time as Option 1-1, i.e.,**     - **drx-OnDurationTimer, drx-LongCycleStartOffset, drx-SlotOffset, shortDRX gives the understanding of legacy C-DRX active time**     - **~~drx-OnDurationTimer,~~ drx-InactivityTimer, drx-RetransmissionTimerDL, drx-RetransmissionTimerUL, drx-HARQ-RTT-TimerDL, drx-HARQ-RTT-TimerUL, etc, enables PDCCH monitoring window extension as in the legacy C-DRX configuration** |
| Spreadtrum |  | Similar views as Qualcomm. |
| ZTE, Sanechips |  | From our understanding, the key difference between option 1-2-1 and option 1-2-2 is regarding the UE behavior in C-DRX active time. There are three interpretations for option 1-2-2   * Interpretation 1: PDCCH monitoring could be triggered by new timers and drx-onDurationTimer can be activated with adjusting the starting time. * Interpretation 2: PDCCH monitoring is triggered by new timers and legacy drx-onDurationTimer are not activated.(No PDCCH monitoring, No measurement based on legacy C-DRX timers) * Interpretation 3: PDCCH monitoring is triggered by new timers and legacy drx-onDurationTimer are activated periodically only for measurement, not for PDCCH monitoring.   For interpretation1, both measurement and PDCH monitoring are performed with adjusting the starting time for legacy C-DRX duration-on timer. For interpretation 2, there is no PDCCH monitoring and No measurement based on legacy C-DRX timers. For interpretation 3, measurement is performed based on the legacy C-DRX active time and No PDCCH monitoring.  Therefore, currently, we hope above three interpretations could be further considered. |

#### **Question 3.1-4:**

* **For Option 1-3, do you agree with the following understanding? If no, please clarify your understanding**
  + **Legacy C-DRX active time as Option 1-1, i.e.,**
    - **drx-OnDurationTimer, drx-LongCycleStartOffset, drx-SlotOffset, shortDRX gives the understanding of legacy C-DRX active time**
    - **drx-OnDurationTimer, drx-InactivityTimer, drx-RetransmissionTimerDL, drx-RetransmissionTimerUL, drx-HARQ-RTT-TimerDL, drx-HARQ-RTT-TimerUL, etc, enables PDCCH monitoring window extension as in the legacy C-DRX configuration**
  + **FFS: once triggered by LP-WUS, whether the PDCCH monitoring lasts until the end of legacy C-DRX active time or other timer(s) are introduced separately from legacy C-DRX configuration**

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| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| Xiaomi | Y |  |
| Spreadtrum | Y |  |
| ZTE, Sanechips |  | I guess the following steps are assumed for option3.  Step1: when the legacy C-DRX duration-on timer is starting, UE does not need to monitor PDCCH, instead, the UE should monitor LP-WUS  Step 2: if UE receive LP-WUS, the LP-WUS could be used to trigger PDCCH monitoring  Step 3: UE starts to monitor PDCCH and LP-WUS monitoring is not deactivated  Additionally, the following question is expected to be discussed.   * During legacy C-DRX active time, whether the LP-WUS could be received multiple times? For example, after the PDCCH monitoring triggered by LP-WUS, whether the UE would switch to WUR and monitor LP-WUS again? * In a PDCCH monitoring slot/occasion, whether LP-WUS also should be monitored? * How much PSG or latency reduction gain can be obtained based on option 1-3? |

### 3.2 Timeline between LP-WUS reception/detection and PDCCH monitoring

Regarding the timeline LP-WUS reception/detection and PDCCH monitoring, following agreements were made in previous RAN1 meetings

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| **Agreement**  For RRC CONNECTED mode, minimum time gap between LP-WUS reception and MR to start PDCCH monitoring is introduced considering at least following   * LP-WUS processing time * MR transition time for ramp up * Time/frequency synchronization of MR * FFS whether UE can report supported minimum time gap from candidate values   FFS: Whether the minimum time gap values can be more than one  **Agreement**  For RRC CONNECTED mode, support UE capability report for determination of minimum time gap between LP-WUS reception and MR to start PDCCH monitoring.   * FFS: exact value(s) of the minimum time gap * FFS: support of multiple minimum time gaps * FFS whether the reported value includes the duration for time/frequency synchronization of MR |

A number of companies provided their view on the FFSs in the agreements:

* FFS: exact value(s) of the minimum time gap
  + can be discussed after LP-WUS design becomes clear: QC
  + several ms plus the time offset from the LP-WUS to [1~3] SSB burst before PDCCH MO: Pana
  + At least 2 set of values for OOK-based receiver and OFDM-based receiver: Pana, ZTE
* FFS: support of multiple minimum time gaps (*Moderator note: This FFS intends to discuss whether a UE reports multiple minimum time gaps. This does not intend to discuss whether spec supports multiple minimum time gaps, which is clear from previous agreement that UE reports its capability on the minimum time gap.*)
  + Support: HW/HiSi, CMCC, vivo, Xiaomi, Nokia, SONY, IDC, Lenovo, MTK
  + Not support: OPPO, CATT, ZTE, Samsung, ETRI, TCL
  + FFS: Apple (different timeline for Option 1-1/1-2 and Option 1-3)
* FFS whether the reported value includes the duration for time/frequency synchronization of MR
  + No: HW/HiSi, CMCC, vivo, Xiaomi
    - i.e., minimum time gap Xmin between LP-WUS reception and MR to start PDCCH monitoring is T1 + T2
      * T1 is the reported UE capability which includes LP-WUS processing time and MR transition time for ramp up
      * T2 includes the duration for time/frequency synchronization of MR
  + Yes: Nokia, Samsung, ETRI
    - i.e., minimum time gap Xmin between LP-WUS reception and MR to start PDCCH monitoring is T3
      * T3 is the reported UE capability which includes LP-WUS processing time, MR transition time for ramp up, and the duration for time/frequency synchronization of MR

Regarding the exact value(s) of the minimum time gap, this can be discussed after LP-WUS design becomes clear.

Regarding the support of multiple minimum time gaps, as mentioned above, this intends to discuss whether a UE reports multiple minimum time gaps. According to companies input, the main motivation seems that a UE reports different minimum time gaps for different sleep states, as captured in TR 38.869 below.

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| The MR sleep states considered for LP-WUS/WUR evaluation in RRC\_CONNECTED are the same as for baseline: deep sleep state with a 20 ms transition time, light sleep state with a 6 ms transition time, or micro sleep without any transition time, as described TR 38.840. Ultra-deep sleep state is not considered for LP-WUS/WUR in RRC\_CONNECTED state as a 400 ms transition time is too long to allow the MR to be ready for PDCCH monitoring from the ultra-deep sleep state considering the traffic requirements for NR. |

Some companies pointed out that it may depend on the LP-WUS monitoring options in Section 3.1, e.g.,

* For Option 1-1, gNB can configure the time gap between LP-WUS MO and PDCCH MO based on the UE capability report. If UE reports multiple minimum time gaps (e.g., one for deep sleep state with a 20 ms transition time, another for light sleep state with a 6 ms transition time), gNB can chose one of them based on its NW operation policy (e.g., UE power saving vs NW resource efficiency) and configure appropriate time gap. UE will go to the corresponding sleep state based on the configured time gap.
* While Option 1-3 requires fast wake-up (short gap between LP-WUS MO and PDCCH MO) to monitor PDCCH within legacy C-DRX active time, and hence, one of sleep states, such as micro sleep without any transition time, would be enough.

Assuming that at least Option 1-1 is supported, here we can discuss whether a UE reports multiple minimum time gaps for Option 1-1. The time gaps for other options can be discussed after progress is made for these options.

#### **Proposal 3.2-1:**

* **For RRC CONNECTED mode, for LP-WUS procedure Option 1-1 in previous agreement, a UE can report the support of multiple minimum time gaps between LP-WUS reception and MR to start PDCCH monitoring.**
  + **Different minimum time gaps correspond to different sleep states**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | We still think it is good to wait a bit more progress on the framework of LP-WUS procedure in connected mode, before making the decision.  For example, if we allow a UE to support both OOK WUR and OFDM WUR for LP-WUS on the same frequency band, we may want to allow different minimum time gaps for different WUR types for the UE on the frequency band. Or, if we allow a UE to support LP-WUS on a frequency band triggering PDCCH monitoring on the same or other frequency band with the same or different SCSs, we may want to allow different minimum time gaps for these cases. For the time being, it would be difficult to say reporting a single value is sufficient or reporting multiple values are necessary for these cases.  Regarding multiple minimum time gaps corresponding to different sleep states, firstly it would be good to avoid saying “corresponding to different sleep states” as sleep states will not be defined in the spec. Given that sleep states are not defined in the spec, it is not clear how much valuable the multiple minimum time gaps offer to the network. |
| Xiaomi | Y |  |
| ZTE, Sanechips |  | Minimum time gap based on sleep state is not necessary. For the UE, it is better just to report one value which reflect the actual capability and how to configure the offset is up to the NW. The NW would balance the PSG and latency based on the UE’s capability, and the UE may follow the NW’s configuration.  Minimum time gap based on WUR type could be possible, since the sync time, the ramp-up capability is different. But also, for one WUR type, the UE report one value. |

Regarding whether the reported value includes the duration for time/frequency synchronization of MR, companies have divergent views. The main motivation not to include the duration for time/frequency synchronization of MR would be that, time/frequency synchronization of MR is not related to the UE capability but the duration where sufficient number of sync sources, such as SSB and TRS, can be received after MR wake up. In this case, minimum time gap Xmin between LP-WUS reception and MR to start PDCCH monitoring can be expressed as T1 + T2, where

* T1 is the reported UE capability which includes LP-WUS processing time and MR transition time for ramp up
* T2 is the duration for time/frequency synchronization of MR

#### **Proposal 3.2-2:**

* **For RRC CONNECTED mode, the minimum time gap between LP-WUS reception and MR to start PDCCH monitoring is defined as T1 + T2, where**
  + **T1 is the reported UE capability which includes LP-WUS processing time and MR transition time for ramp up**
  + **T2 includes the duration for time/frequency synchronization of MR**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | If measurement offloading from MR to WUR is specified for connected state, SSB/TRS based T/F sync would be necessary for MR before it starts PDCCH monitoring. However, given the current situation that any measurements are supposed to be done by MR, our understanding is that the time gap between LP-WUS and start of PDCCH monitoring does not need to include for MR to perform T/F sync using SSB/TRS before PDCCH monitoring. |
| Xiaomi | N | Our opinion is that the synchronization delay is not included in the wake up delay, and it is up to UE implementation to acquire and maintain synchronization by SSB. For a RRC connected UE, even in micro/light/deep sleep state, it is also possible for UE to decide to monitor SSB whenever needed, and should not be restricted to only re-sync just after LP WUS indication. An example is in R16 power saving study, the wake up delay listed in [3] for micro/light/deep sleep state does not include synchronization time. Considering the typical SSB periodicity is 20ms, the synchronization delay would be larger than 10ms in average, and if UE need to monitor multiple SSBs, the synchronization delay would be even larger and this wake up delay is not acceptable for RRC connected UE. |
| Spreadtrum |  | The minimum time gap between LP-WUS reception and MR to start PDCCH monitoring only includes LP-WUS processing time and MR transition time for ramp up. |
| ZTE, Sanechips |  | There is no need to define two separate parameter T1 and T2. It is understandable that the minimum time gap could be based on sync time, ramp-up time, LP-WUS processing time or something others, but it is difficult to define these values for each factor one by one. We can just simply to focus on a whole value for the total minimum time gap. |

### 3.3 LP-WUS monitoring occasions

As captured in TR38.869, both duty-cycled and continuous monitoring have been discussed for RRC CONNECTED mode in Rel-18 SI. Also, WID states that at least duty-cycled monitoring is suppoeted.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 7.3.2.2-1: Pros and Cons of 'duty-cycled' and 'continuous' mode for LP-WUS in RRC\_CONNECTED mode   |  |  |  | | --- | --- | --- | |  | 'Duty-cycled' mode for LP-WUS | 'Continuous' mode for LP-WUS | | Pros | More UE power saving gain than continuous mode LP-WUS. | Potentially shorter DL latency than 'Duty-cycled' mode.  LP-WUR does not need to keep track of slot or radio frame numbering (i.e., DRX timing). | | Cons | LP-WUR must keep track of slot and/or radio frame numbering (i.e., DRX timing).  Potentially longer DL latency. | Higher power consumption than duty-cycled LP-WUS. |   Two examples for UE operations for 'duty-cycled' mode and 'continuous' mode are shown in the below two Figures.  A screen shot of a computer  Description automatically generated  Figure 7.3.2.2-1: Example for 'Duty-cycled WUR' operation  A screen shot of a computer  Description automatically generated  Figure 7.3.2.2-2: Example for 'Continuous WUR' operation |

For LP-WUS monitoring in connected mode, following agreements were made in previous RAN1 meetings:

|  |
| --- |
| **Agreement**  LP-WUS monitoring occasions (MOs) are configured by RRC, where UE can monitor for LP-WUS transmission in RRC CONNECTED mode.   * FFS whether to define a time window for MOs * It is at least supported that a UE can monitor MOs with a periodicity.   + FFS details of the periodicity, e.g. derived from DRX cycle, separately configured |

* FFS whether to define a time window for MOs
  + Yes: Pana, vivo, E///, Xiaomi (including repetition), Lenovo, LGE, Apple (Option 1-1), TCL
  + No: CATT, Nokia?
  + FFS: CMCC (depend on the LP-WUS procedure options)
* FFS details of the periodicity, e.g. derived from DRX cycle, separately configured
  + derived from DRX cycle: ETRI, E///, Samsung, ETRI
  + separately configured: HW/HiSi, CATT?

Also, some companies pointed out that the required LP-WUS MO configuration would depend on the LP-WUS procedure option. Assuming that at least Option 1-1 is supported, here we can discuss LP-WUS MO configuration for Option 1-1. The LP-WUS MO configuration for other options can be discussed after progress is made for these options.

Regarding whether to define a time window for MOs, most companies are OK to define it for Option 1-1 so as to include multiple LP-WUS MOs before drx-onDurationTimer.

Regarding the details of the MO periodicity, companies assume MO can be located before drx-onDurationTimer, which comes periodically, and hence, MO periodicity should be related to C-DRX cycle

#### **Proposal 3.3-1:**

* **Define LP-WUS monitoring window which include one or multiple LP-WUS MOs before drx-onDurationTimer for LP-WUS procedure Option 1-1 in RRC CONNECTED mode.**
  + **Time offset between LP-WUS monitoring window and drx-onDurationTimer is configured by RRC**
  + **The periodicity of LP-WUS monitoring window is same as [or integer multiple of] C-DRX cycle**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | We assume the intention is to follow the legacy R16 DCP procedure. |
| Xiaomi | Y |  |
| ZTE, Sanechips |  | Before option 1-1 is adopted and clearly clarified, it should be pending, or, we can remove ‘option 1-1’ and make the proposal to include both option 1-1 and option 1-2. |

Regarding the QCL/TCI state for LP-WUS in CONNECTED mode, following agreements were made in previous RAN1 meetings:

|  |
| --- |
| **Agreement**  For LP-WUS monitoring in RRC CONNECTED mode, a LP-WUS is QCLed with existing NR signal/channel/CORESET for the TCI state   * FFS which existing NR signal/channel/CORESET is the QCL source of LP-WUS * FFS exact definition of QCL relationship between LP-WUS and existing NR signal/channel/CORESET |

Following views are provide in the contributions:

* FFS which existing NR signal/channel/CORESET is the QCL source of LP-WUS
  + SSB: QC, CMCC (Type D), vivo, Xiaomi (Type C), Nokia (Type D)
  + CSI-RS: QC, vivo, Nokia (Type D)
  + Same as PDCCH: E///
  + LP-SS: Xiaomi (Type A)
  + Need to clarify how QCL information can be used for LPWUR in FR1 with 1 RX: MTK
* How to define/configure/indicate TCI-state of LP-WUS
  + Re-use TCI-state framework of CORESET: QC, DCM
  + Re-use TCI-state framework w/ or w/o unified framework: vivo
  + Same TCI state as the CORESET: OPPO
  + Same TCI state as the CORESET to receive the PDCCH activating LP-WUS monitoring: HW/HiSi,
  + Same TCI state as the CORESET to receive the last PDCCH before timer expires (if LP-WUS monitoring is activated by timer): HW/HiSi,
  + Same TCI state as the CORESET used for PDCCH monitoring triggered by LP-WUS: CATT, Nokia
  + Latest TCI state for PDSCH or PDCCH: ETRI
  + Default TCI state can be also pre-configured: ETRI
* FFS exact definition of QCL relationship between LP-WUS and existing NR signal/channel/CORESET
  + LP-WUS MO is associated with CORESET: OPPO

Regarding which existing NR signal/channel/CORESET is the QCL source of LP-WUS, majority companies assumes SSB and/or CSI-RS is the QCL source, and hence, it can be discussed as starting point

#### **Proposal 3.3-2:**

* **For LP-WUS monitoring in RRC CONNECTED mode, SSB and CSI-RS can be the QCL source of LP-WUS**
  + **FFS applicable QCL type(s)**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | In a cell where multiple SSBs or CSI-RSs are transmitted by gNB and the UE monitors some of them with different QCL assumptions or TCI-states, the UE wants to know which RS(s) is QCLed with the LP-WUS. Based on the RS measurements and the knowledge of QCLs, the UE can judge whether the channel quality is good or not for LP-WUS monitoring/reception.  All the legacy DL signals or channels are QCLed with SSB or CSI-RS. Therefore, we agree with the proposal that LP-WUS is QCLed with SSB or CSI-RS. We are open to discuss how to configure TCI state for LP-WUS further. |
| Xiaomi | Y |  |
| Spreadtrum | Y |  |
| ZTE, Sanechips |  | May need to Clarify   1. SSB refers to CD-SSB or NCD-SSB? Whether NCD-SSB is considered? 2. If LP-SS is configured in idle mode, whether it could be used in connected mode for QCL resource 3. Any other signals should be considered? |

Regarding how to define/configure/indicate TCI-state of LP-WUS, companies view can be categorized as

* Re-use existing TCI-state framework to indicate TCI-state of LP-WUS
* Define TCI-state association between LP-WUS and CORESET/PDSCH
* Configure default TCI-state

#### **Proposal 3.3-3:**

* **For LP-WUS monitoring in RRC CONNECTED mode, consider following options on how to define/configure/indicate TCI-state of LP-WUS for down selection**
  + **Opt1: Re-use existing TCI-state framework to indicate TCI-state of LP-WUS**
  + **Opt2: Define TCI-state association between LP-WUS and CORESET/PDSCH**
  + **Opt3: Configure default TCI-state**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| Spreadtrum | Y | We prefer Opt1. |
| ZTE, Sanechips |  | Based on option1-1, why the LP-WUS TCI state should be associated with CORESET or PDSCH? From our understanding, before the UE detects the PDCCH, the UE would receive LP-WUS and the TCI state of LP-WUS should be known by UE in connected mode.  For opt1, reusing the existing TCI-state framework is also not clear to us. How to reuse the framework may need further clarification. For example, the current TCI state could be configured for a CORESET. But for LP-WUS, it may not configured in a CORESET. Therefore, more details should be clarified.  Option3 is clear and also, if DCI for LP-WUS activation is supported, the DCI indicated TI state for LP-WUS also could be possible. |

# 4 Activation/deactivation of LP-WUS monitoring

### 4.1 Activation/deactivation mechanism

As captured in TR38.869, following options of activation/deactivation of LP-WUS monitoring have been discussed in Rel-18 SI.

|  |
| --- |
| - In RRC CONNECTED mode, LP-WUS monitoring can be activated/deactivated by at least one or more of  - by gNB RRC signaling, with or without UE assistance.  - by gNB L1/L2 LP-WUS activation/deactivation signaling, with or without UE assistance.  - based on pre-configured condition(s), such as timer.  - LP-WUS monitoring by UE is known to gNB, study whether it could be transparent to gNB.  - other options are not precluded. |

This issue has been discussed in previous RAN1 meetings and following agreements were made:

|  |
| --- |
| **Agreement**  For RRC CONNECTED mode, from RAN1 perspective,   * PDCCH monitoring triggered by LP-WUS is enabled/disabled by gNB RRC signaling   + FFS whether to support UE assistance. * LP-WUS monitoring by UE is known to gNB.   + FFS whether implicit/explicit indication from UE is necessary * In case LP-WUS monitoring is enabled, following options are further studied   + Option 1: No additional indication/condition are introduced for activation/deactivation of LP-WUS monitoring   + Option 2: Activation/deactivation of LP-WUS monitoring by gNB L1/L2 signaling with or without UE assistance.   + Option 3: Activation/deactivation of LP-WUS monitoring based on condition(s), such as timer.   + Option 4: Activation/deactivation of LP-WUS monitoring based on implicit indication/condition, e.g. UL transmission. |

Many companies provided their view on these options for each of the options/cases in Section 3.1

* Option 1-1 in Section 3.1
  + Option 1: Apple, CATT, Xiaomi, Sony, QC, E///, ZTE, Nokia
  + Option 2: Samsung, ZTE (deactivation), Sharp, LGE, Nokia
  + Option 3: Samsung, TCL (deactivation), Lenovo, Nokia
  + Option 4: TCL (deactivation)
* Option 1-2 in Section 3.1
  + Option 1: Apple,
  + Option 2: QC
* Option 1-2-1 in Section 3.1
  + Option 1: ZTE, Nokia
  + Option 2: ZTE (deactivation), Xiaomi (activation), Nokia, LGE
  + Option 3: IDC, Xiaomi (activation), Nokia
* Option 1-2-2 in Section 3.1
  + Option 1: ZTE
  + Option 2: HW/HiSi, ZTE (deactivation)
  + Option 3: HW/HiSi, OPPO
  + Option 4: HW/HiSi
* Option 1-3 in Section 3.1
  + Option 1: Xiaomi, QC
  + Option 2: SPRD, Apple
  + Option 3: Apple (Activation)
  + Option 4: Apple (deactivation)

Also, some companies provide views on the FFS in the last agreement:

* FFS whether to support UE assistance.
  + Yes: IDC, Nokia, OPPO (LP-SS measurement report), QC (Option 1-1/1-3)
  + No: CATT
* FFS whether implicit/explicit indication from UE is necessary
  + Explicit UE feedback to indicate loss of LP-WUS: Nokia
  + L1/L2 dynamic report of UE status: QC (Option 1-2)
  + implicit indication (HARQ-ACK, scheduled UL): ETRI
  + Not support: vivo

Some companies also propose autonomous fallback to PDCCH monitoring when UE monitors LP-WUS

* autonomous fallback to PDCCH monitoring when UE monitors LP-WUS
  + When UE does not received LP-WUS for a long time: Nokia
  + when the channel/beam quality is not satisfactory for successful LP-WUS reception: QC (in addition to recovery from RLF/BFR during LP-WUS monitoring), Lenovo, ETRI
  + Not support: vivo

Beside, companies provide some fundamental assumptions on LP-WUS/PDCCH monitoring

* HW/HiSi
  + PDCCH monitoring of a UE is suspended if LP-WUS monitoring of the UE is activated, and vice versa.
  + PDCCH monitoring of a UE is resumed if LP-WUS monitoring of the UE is deactivated.
  + When a UE is in the state of deactivated LP-WUS monitoring, the UE may or may not monitor LP-WUS.
* Vivo
  + if the LP-WUS is not detected on a WUS monitoring occasion (MO) by the UE, UE does not wake up the MR for PDCCH monitoring
* Nokia
  + If some (legacy) procedures require UE to monitor PDCCH, UE shall follow the legacy behaviour.
  + If UE is not able to monitor a LP-WUS monitoring occasion(s), UE shall resume PDCCH monitoring as it would be triggered by LP-WUS
* LGE
  + Consider the case where LP-WUS monitoring is in active state even during PDCCH monitoring is activated
* DCM
  + For RRC CONNECTED mode, when UE is configured with LP-WUS by gNB RRC signaling, UE is expected to monitor LP-WUS according to the LP-WUS monitoring configuration
  + For RRC CONNECTED mode, when UE detects a LP-WUS indicating the UE to wake-up, UE monitors PDCCH, and UE is not required to monitor LP-WUS during the PDCCH monitoring
  + From RAN1 perspective, when LP-WUS monitoring is enabled for RRC CONNECTED mode, PDCCH monitoring is resumed when LP-WUS monitoring is deactivated by additional indication/condition (if supported)
* Pana
  + For RRC CONNECTED mode, when UE is configured with LP-WUS by gNB RRC signaling, UE is expected to monitor LP-WUS according to the LP-WUS monitoring configuration

Assuming that at least LP-WUS procedure Option 1-1 is supported, here we can discuss activation/deactivation of LP-WUS monitoring for Option 1-1. The activation/deactivation of LP-WUS monitoring for other options can be discussed after progress is made for these options.

Regarding additional indication/condition for activation/deactivation of LP-WUS monitoring, even for LP-WUS procedure Option 1-1, companies have different preference, and need further discussion here.

#### **Question 4.1-1:**

* **For LP-WUS procedure Option 1-1, which option(s) do you support** **in case LP-WUS monitoring is enabled? Please elaborate the details on how to activate/deactivate LP-WUS monitoring as well.**
  + **Option 1: No additional indication/condition are introduced for activation/deactivation of LP-WUS monitoring**
  + **Option 2: Activation/deactivation of LP-WUS monitoring by gNB L1/L2 signaling with or without UE assistance.**
  + **Option 3: Activation/deactivation of LP-WUS monitoring based on condition(s), such as timer.**
  + **Option 4: Activation/deactivation of LP-WUS monitoring based on implicit indication/condition, e.g. UL transmission.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option(s)** | **Comments** |
| Qualcomm | Option 1 |  |
| Xiaomi |  | We think how to do activation/deactivation is a case by case study. |
| ZTE, Sanechips | Option1 as baseline | We think RRC configuration should be the baseline for both option 1-1 and 1-2. for example, for option 1-2, after the UE receives the RRC configuration, the UE starts to monitor LP-WUS. If the UE does not want to continue monitoring LP-WUS, the gNB could reconfigure the parameter to disable this function. Disabling it may be not so convenient but also workable as a simple way.  Additionally, if the UE does not receive a LP-WUS for a long time, the UE may be out of the LP-WUS coverage and it is better to exit the LP-WUS monitoring. In this case, if the NW has sent a LP-WUS before, and receives no ACK/NACK response for the following scheduling, the NW also be aware that the UE can not receive the LP-WUS. If the NW doe not send any LP-WUS during the long time, then the NW also knows the UE would exit the LP-WUS monitoring. Therefore, the deactivation based on a timer in option3 could be considered.  Last, L1/L2 signalling for activating LP-WUS is not so necessary based on above. If time permits, we are also open to consider it to adapt the LP-WUS configuration based on the channel condition. |

#### **Question 4.1-2:**

* **For LP-WUS procedure Option 1-1, do you support UE assitance for enabling/disabling PDCCH monitoring triggered by LP-WUS? If yes, please elaborate the details of UE assitance**

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| --- | --- | --- |
| **Company** | **Option(s)** | **Comments** |
| Qualcomm |  | We consider the UE assistance information can be in RRC IE *UEAssistanceInformation*. |
| Xiaomi |  | Currently see no need, but open to discuss. |
| ZTE, Sanechips |  | Open to this. |

#### **Question 4.1-3:**

* **For LP-WUS procedure Option 1-1, regarding “LP-WUS monitoring by UE is known to gNB”, do you think implicit/explicit indication from UE is necessary? If yes, please elaborate the details of implicit/explicit indication from UE**

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| --- | --- | --- |
| **Company** | **Option(s)** | **Comments** |
| Qualcomm |  | We think it is useful for gNB to know whether the UE is in the situation where it can monitors LP-WUS or not based on higher-layer signalling, such as UE assistance information in RRC IE *UEAssistanceInformation*.  However, we think (new L1/L2) dynamic signalling from UE is not necessary for Option 1-1, as gNB will anyway transmit PDCCH in C-DRX active time when there is a traffic for the UE. Without dynamic report, a UE should be allowed to fallback to legacy C-DRX operation whenever it thinks necessary. This is not harmful for network operation of Option 1-1. |
| Xiaomi |  | Open to discuss |
| ZTE, Sanechips |  | We did not see the necessity. Hope it could be clarified further. |

In addition, following views are provided related to activation/deactivation of LP-WUS monitoring, which can be discussed after high-level design of activation/deactivation of LP-WUS monitoring is decided.

* IDC
  + Support a mechanism to report UE decision of LP-WUS monitoring deactivation potentially with reason for the decision.
* OPPO
  + The LP-WUS LR and MR switching behavior is not specified in the operation for LP-WUS RRC CONNECTED mode.

### 4.2 Miss/False-detection of LP-WUS activation/deactivation and fallback mechanism of LP-WUS monitoring

Following companies mentioned Miss/False-detection of LP-WUS activation/deactivation.

* HW/HiSi
  + The impact due to miss-detection/falsely-detection of LP-WUS activation/deactivation signaling should be minimized/avoided for CONNECTED mode UE.
* Samsung
  + For activation/deactivation of LP-WUS monitoring, prioritize Option 2 and Option 3, and support explicit confirmation message(s) from the UE to the gNB for handshake in Option 2.

This issue has been discussed in previous RAN1 meetings but as commented by some companies, this proposal can be low priority and discussed after high-level LP-WUS activation/deactivation procedure in connected mode becomes clear.

# 5 LP-WUS payload

As captured in TR38.869, following candidates of LP-WUS contents have been discussed in Rel-18 SI.

|  |
| --- |
| - For CONNECTED mode, study at least following candidates for content of LP-WUS  - information on which user(s) is/are targeted by the LP-WUS  - e.g UE-group, -subgroup or -ID  - indication to wake-up to PDCCH monitoring. |

This issue has been discussed in RAN1#116 and RAN1#116bis, and following agreements were made:

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| --- |
| **Agreement**  For RRC CONNECTED mode, maximum number of LP-WUS information bits is up to X bits   * FFS value X, which is no more than [8 or 16]   **Agreement**  Regarding the LP-WUS information to trigger PDCCH monitoring of RRC connected UEs, at least consider the following:   * Option 1: A bitmap with each bit corresponding to [one or more] UEs * Option 2: A codepoint value corresponding to one or part of UE identity, e.g., C-RNTI * Option 3: A codepoint value corresponding to [one or more] UEs * Option 4: Multiple codepoint values with each corresponding to [one or more] UE(s) * Option 5: Multiple bit blocks with each corresponding to [one or more] UE(s) * Combination of above options are not precluded. * FFS how to carry LP-WUS information, e.g, by encoded bits (with/without CRC) and/or by OOK sequence selection for ‘ON-OFF’ pattern for OOK symbols of LP-WUS. * FFS how to carry LP-WUS information by overlaid OFDM sequences.   + It doesn’t preclude considering the configuration where a single candidate overlaid OFDM sequence is used * FFS details of LP-WUS information to trigger PDCCH monitoring (e.g. whether above is applicable to one or more serving cells) |

* Value X (to be further discussed in AI 9.6.1)
  + 8: Sony, QC (as WA), Nokia, E/// (FFS how to support LP-WUS operation with up to 8 bits)
  + 16: HW/HiSi, vivo, Lenovo,
  + 24: ZTE
* Bitmap vs codepoint (to be discussed in AI 9.6.1)
  + Option 1: OPPO, DCM
  + Option 2:
  + Option 3: QC
    - Maximum number of sequence(s) that the UE can monitor for a LP-WUS is per UE capability: QC
  + Option 4: DCM
  + Option 5: ZTE, DCM (merged with Option 4)
  + Combination of Options 1 and 3: vivo
* Other contents
  + Scell dormancy: IDC, CATT
    - No: vivo, OPPO, ZTE
    - FFS: Sharp
  + SSSG switching: Xiaomi
  + BWP switching: Xiaomi
  + Cell information: TCL

Regarding the value X, since the above agreement was made in RAN1#116 meeting as a great compromise among companies, moderator assumes we don’t need to further down select the value in this agenda, but it can be further discussed in AI 9.6.1 considering performance, system overhead, etc.

Regarding Bitmap vs codepoint, this is highly related to LP-WUS structure and hence, those can be further discussed in AI 9.6.1.

Regarding the other contents than wake-up indication (PDCCH triggering), this may depend on the overall LP-WUS procedure to trigger PDCCH discussed in Section 3.1. For example, for Option 1-1 (replace Rel-16 DCP) in Section 3.1, Rel-16 DCP supports group common PDCCH monitoring and UE specific wake-up indication (up to 140 bits) as specified in TS38.212, and hence, same mechanism can be considered while payload size is much smaller.

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| --- |
| 7.3.1.3.7 Format 2\_6  DCI format 2\_6 is used for notifying the power saving information outside DRX Active Time for one or more UEs.  The following information is transmitted by means of the DCI format 2\_6 with CRC scrambled by PS-RNTI:  - block number 1, block number 2,…, block number *N*  where the starting position of a block is determined by the parameter *ps-PositionDCI-2-6* provided by higher layers for the UE configured with the block.  If the UE is configured with higher layer parameter *ps-RNTI* and *dci-Format2-6*, one block is configured for the UE by higher layers, with the following fields defined for the block:  - Wake-up indication - 1 bit  - SCell dormancy indication – 0 bit if higher layer parameter *dormancyGroupOutsideActiveTime* is not configured; otherwise 1, 2, 3, 4 or 5 bits bitmap determined according to the number of different *DormancyGroupID(s)* provided by higher layer parameter *dormancyGroupOutsideActiveTime,* where each bit corresponds to one of the SCell group(s) configured by higher layers parameter *dormancyGroupOutsideActiveTime,* with MSB to LSB of the bitmap corresponding to the first to last configured SCell group in ascending order of *DormancyGroupID*.  The size of DCI format 2\_6 is indicated by the higher layer parameter *sizeDCI-2-6*, according to Clause 10.3 of [5, TS 38.213]. |

Assuming that at least LP-WUS procedure Option 1-1 is supported, here we can discuss other contents in LP-WUS for Option 1-1. Other contents in LP-WUS for other options can be discussed after progress is made for these options.

#### **[TBD]Proposal 4.2-1:**

* **TBD**

|  |  |  |
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| **Company** | **Y/N** | **Comments** |
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### **Question 5-1:**

* **For the LP-WUS information in LP-WUS procedure Option 1-1 in RRC connected UEs, in addition to the wake-up indication to trigger PDCCH monitoring, do you think other information is necessary to be transmitted? If yes, please elaborate the details of the other information**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | We think we can prioritize wake-up indication. If time allows and if necessity is clear, we can discuss if any other indication is necessary. |
| Xiaomi |  | Wake up indication mapping to each serving cell may worth discussion |
| ZTE, Sanechips |  | 1. Hope both option 1-1 and 1-2 could be discussed, instead of only option 1-1. 2. Regarding other information, it my depends on the further discussion. Currently. At least, wake-up indication is included. |

Regarding whether wake-up indication is applicable to one or more serving cells, following agreement was made in previous RAN1 meetings

|  |
| --- |
| **Agreement**   * Study whether/how LP-WUS works when UE is configured with CA in RRC CONNECTED mode   + FFS: The cell(s) where PDCCH monitoring triggered by a LP-WUS is applicable     - Option 1: one or more serving cells based on gNB indication/configuration     - Option 2: all activated serving cells     - Note: other options are not precluded |

* whether LP-WUS works when UE is configured with CA in RRC CONNECTED mode
  + Yes: QC, HW/HiSi, SPRD, CMCC, vivo, OPPO, Xiaomi, CATT, ZTE, Nokia, IDC, LGE, ETRI, MTK, Apple, Sharp, DCM
  + Deprioritize: SONY
* FFS: The cell(s) where PDCCH monitoring triggered by a LP-WUS is applicable
  + Option 1: OPPO (same carrier), Xiaomi, LGE, Sharp, TCL
  + Option 2: QC, vivo, CATT, Pana, Nokia, IDC, ETRI, MTK, Apple, DCM
* The cell(s) where LP-WUS is monitored
  + CA
    - on a serving cell: QC, vivo, Xiaomi?, Nokia?
    - on Pcell: CMCC, CATT, ZTE
  + DC
    - on a serving cell per cell-group: QC
* Special handling
  + QC
    - For a UE configured with CA with dual-DRX groups, support LP-WUS monitoring on a serving cell per DRX group
      * Opt.1: LP-WUS is configured to be monitored per DRX group
        + For dual DRX groups, LP-WUS monitoring is configured per DRX group
        + LP-WUS monitored on a cell within a DRX group triggers PDCCH monitoring on the cell of the DRX group
      * Opt.2: LP-WUS carries an indication for which DRX group(s) it triggers PDCCH monitoring
  + HW/HiSi
    - For LP-WUS in FR1-FR2 CA, the trigger of PDCCH monitoring of FR2 cells can be separate from that of FR1 cells.
      * If PDCCH monitoring of an SCell is triggered, then PDCCH monitoring of PCell is also triggered, regardless their frequency range.
  + DCM
    - LP-WUS indication is applicable to all activated serving cells in the same DRX group(s), if configured
    - For dual DRX groups, further consider following options
      * Option 1: LP-WUS monitoring/indication is applied per DRX group
      * Option 2: LP-WUS monitoring on one of DRX group, LP-WUS indication to either or both DRX group(s)

Clear majority companies assume LP-WUS works when MR is configured with CA, while companies have divergent views on the details how it works. Following can be considered as the starting point

### **Proposal 5-2:**

* **LP-WUS works when UE is configured with CA[/DC] in RRC CONNECTED mode**
  + **LP-WUS wake-up indication is applicable to all activated serving cells in CA, if dual-DRX groups are not configured**
    - **FFS the case when dual-DRX groups are configured**
  + **FFS: The cell(s) where LP-WUS is monitored**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| Spreadtrum |  | We think this issue depends on the trigger procedure of LP-WUS. We prefer PDCCH monitoring triggered by a LP-WUS is applied for one or more serving cells based on gNB indication/configuration. |
| ZTE, Sanechips | N | If the wake-up indication is applied for all serving cells, there is no any PSG, but power consumption increasing, which is not reasonable |

In addition, following views are provided related to how to inform LP-WUS information in addition to the LP-WUS payload, which can be discussed after high-level design of LP-WUS payload is decided in AI 9.6.1.

* IDC
  + A portion of LP-WUS information can be informed to UE implicitly using LP-WUS monitoring resource association (e.g., LO and MO) and structure of LP-WUS.
* LGE
  + To overcome limited maximum number of LP-WUS information bits, consider the combination of time/frequency resources and LP-WUS payload for UE identification.

# 6 Coexistence with existing UE power saving features

In addition to C-DRX discussed in Section 3, many companies provided their view on the coexistence with existing UE power saving features, roughly categorized as follows:

|  |
| --- |
| **Agreement**  For RRC CONNECTED mode, LP-WUS can be configured without following existing features.   * + Rel-16 DCP   + Rel-17 PDCCH skipping   + Rel-17 SSSG switching   + Rel-18 cell DTX   Further study whether/how LP-WUS works with following existing features (PDCCH skipping, SSSG switching, cell DTX) |

* PDCCH skipping
  + Can coexist
    - HW/HiSi: After LP-WUS monitoring is activated, the UE should stop/suspend the Rel-17 PDCCH adaption mechanism, if configured
    - ZTE: If LP-WUS is monitored outside active time, no spec impacts are foreseen for PDCCH skipping and LP-WUS coexistence.
    - Nokia: Once PDCCH skipping is triggered by DCI UE would start to monitor LP-WUS. If the LP-WUS is detected within PDCCH skipping period, it could trigger the termination of skipping and UE would resume PDCCH monitoring
    - CMCC: LP-WUS procedure Option 1-2-2/Option 1-3 and Rel-17 PDCCH skipping/SSSG switching can be configured or activated to one UE simultaneously. Rel-17/18 PDCCH skipping/SSSG switching is used to indicate UE go to sleep
    - Vivo: if PDCCH skipping indication is used as LP-WUS activation signalling, following enhancements are needed.
      * Enhancement#1 on skipping duration for PDCCH skipping and related UE behavior
      * Ehancement#2 on applying a PDCCH skipping indication to multiple scheduling cells, which is the same scheduling cells as a LP-WUS is applied to
    - OPPO: When PDCCH Skipping is configured, the PDCCH skipping indication can enable the LP-WUS monitoring occasions
    - Pana: If Option 1-1 is adopted for LP-WUS monitoring procedure triggering PDCCH monitoring, LP-WUS should work with PDCCH skipping, SSSG switching, and cell DTX
    - E///: For Option 1-1, since legacy onDurationTimer is triggered by LP-WUS, there is no issue on the coexistence with existing power saving techniques used during Active Time of C-DRX, e.g., PDCCH skipping, SSSG switching. However, if a separate PDCCH monitoring occasion is triggered by LP-WUS, e.g., as in Option 1-2-1 and Option 1-2-2, further study is needed on impact of using existing power saving techniques to the new PDCCH monitoring occasions.
    - QC: PDCCH monitoring in the DRX Active Time, even if it is triggered by LP-WUS, can be skipped/reduced by Rel-17 PDCCH skipping or SSSG switching indication. This will be quite beneficial for power saving, especially if the value(s) of *drx-onDurationTimer* and/or *drx-InactivityTimer* is/are relatively large. Use of Rel-17 PDCCH skipping or SSSG switching does not require additional specification impact.
  + FFS
    - LGE: Co-existence of Rel-17 PDCCH monitoring adaptation and LP-WUS can be revisited after the LP-WUS procedure about PDCCH monitoring are discussed
* SSSG switching
  + Can coexist
    - HW/HiSi: After LP-WUS monitoring is activated, the UE should stop/suspend the Rel-17 PDCCH adaption mechanism, if configured
    - ZTE: No much power saving is observed if LP-WUS is used for SSS switching and no issue is observed when LP-WUS coexist with SSSG switching
    - CMCC: LP-WUS procedure Option 1-2-2/Option 1-3 and Rel-17 PDCCH skipping/SSSG switching can be configured or activated to one UE simultaneously. Rel-17/18 PDCCH skipping/SSSG switching is used to indicate UE go to sleep
    - Vivo: For co-exsistence between LP-WUS and Rel-17 SSSG switching, Rel-17 SSSG switching is performed after successful detection of LP-WUS triggering PDCCH monitoring and Rel-17 SSSG switching is stopped after successful detection of LP-WUS reactivation signalling
    - Pana: If Option 1-1 is adopted for LP-WUS monitoring procedure triggering PDCCH monitoring, LP-WUS should work with PDCCH skipping, SSSG switching, and cell DTX
    - Lenovo: The benefit of support the functionality of Rel.17 PDCCH monitoring adaption may need further study
    - E///: For Option 1-1, since legacy onDurationTimer is triggered by LP-WUS, there is no issue on the coexistence with existing power saving techniques used during Active Time of C-DRX, e.g., PDCCH skipping, SSSG switching. However, if a separate PDCCH monitoring occasion is triggered by LP-WUS, e.g., as in Option 1-2-1 and Option 1-2-2, further study is needed on impact of using existing power saving techniques to the new PDCCH monitoring occasions.
    - QC: PDCCH monitoring in the DRX Active Time, even if it is triggered by LP-WUS, can be skipped/reduced by Rel-17 PDCCH skipping or SSSG switching indication. This will be quite beneficial for power saving, especially if the value(s) of *drx-onDurationTimer* and/or *drx-InactivityTimer* is/are relatively large. Use of Rel-17 PDCCH skipping or SSSG switching does not require additional specification impact.
  + FFS
    - LGE: Co-existence of Rel-17 PDCCH monitoring adaptation and LP-WUS can be revisited after the LP-WUS procedure about PDCCH monitoring are discussed
* Cell DTX
  + Can coexist
    - HW/HiSi, TCL, LGE: The co-existence of LP-WUS and cell DTX should be considered in Rel-19
      * if UE receives an LP-WUS targeted to itself, whether UE monitors PDCCH within a cell DTX time after the minimum wake-up gap
      * whether LP-WUS can be transmitted within DTX inactive time and/or whether the UE should receive/monitor LP-WUS
    - Vivo:
      * A UE does not expect to monitor the LP-WUS during the non-active periods of cell DTX of a serving cell, if cell DTX is activated for the serving cell with the LP-WUS monitoring.
      * UE monitors PDCCH on a cell in case LP-WUS for the cell is detected, irrespective of the cell-DTX active periods or non-active periods of the cell
    - OPPO: LP-WUS is assumed to be disabled during the DTX time
    - Pana: If Option 1-1 is adopted for LP-WUS monitoring procedure triggering PDCCH monitoring, LP-WUS should work with PDCCH skipping, SSSG switching, and cell DTX
    - ZTE: During Cell-DTX off period, UE does not need to monitor LP-WUS

Almost all companies assume LP-WUS works with {PDCCH skipping, SSSG switching, cell DTX}. Assuming that at least LP-WUS procedure Option 1-1 is supported, here we can discuss the coexistence for Option 1-1. Coexistence for other options can be discussed after progress is made for these options.

### **Question 6-1:**

* **For LP-WUS procedure Option 1-1 in RRC CONNECTED mode, do you think any special handling is necessary to work with PDCCH skipping? If yes, please elaborate the details.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N |  |
| Xiaomi | Y | Details are shown in our contribution and coped as below,  The following case is when UE is configured with C-DRX and also configured PDCCH skipping for C-DRX active time. Within the indicated PDCCH skipping duration, UE keeps monitoring LP WUS. And when LP WUS indicating wake up is received, the PDCCH skipping duration will end. In this case, the PDCCH skipping duration can be terminated in advance, and would be beneficial for latency performance. Related figure is shown in Fig.6.    Fig.6 Case 3-3, LP WUS is used within C-DRX active time and within PDCCH skipping duration  The following case is when UE is configured with C-DRX and also configured PDCCH skipping for C-DRX active time. At the end of PDCCH skipping duration, UE will monitor LP WUS instead of PDCCH. gNB need to wake up UE by LP WUS first before transmitting PDCCH. UE will switch to PDCCH monitoring after LP WUS is received. In this case, unnecessary PDCCH monitoring can be reduced after a PDCCH skipping duration. Related figure is shown in Fig.7.    Fig.7 Case 3-4, LP WUS is used within C-DRX active time and outside PDCCH skipping duration |
| ZTE, Sanechips |  | It is not only for option 1-1. for option 1-2, it is the same. |

### **Question 6-2:**

* **For LP-WUS procedure Option 1-1 in RRC CONNECTED mode, do you think any special handling is necessary to work with SSSG switching? If yes, please elaborate the details.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N |  |
| Xiaomi | Y | How the SSSG timer is running when LP WUS monitoring is activated/deactivated should be discussed. |
| ZTE, Sanechips |  | It is not only for option 1-1. for option 1-2, it is the same. |

### **Question 6-3:**

* **For LP-WUS procedure Option 1-1 in RRC CONNECTED mode, do you think any special handling is necessary to work with Cell DTX? If yes, please elaborate the details.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N |  |
| Xiaomi | N |  |
| ZTE, Sanechips |  | During inactive time for cell DTX, LP-WU is not expected to be transmitted. No other handing is considered. |

# 7 Other aspects

The submitted contributions bring up the following other aspects which are not covered in any other sections in this summary.

**L1 measurement/report**

* QC
  + Introduce RRC configuration enabling/disabling skipping of CSI/BM measurement reporting during the time that the UE does not monitor PDCCH
    - At least for periodic CSI, periodic L1-RSRP, and periodic L1-SINR reporting
* Xiaomi
  + Support CSI report enhancement during the MR’s non-active period.
    - CSI report can be skipped or relaxed to a larger periodicity during the MR’s non-active period so that more power saving gain can be expected from MR
* TCL
  + At least support transmitting HARQ-ACK when LP-WUS indicates no PDCCH monitoring. Study whether or not transmitting CSI reporting and SRS when the UE MR is in light/micro sleep state

**Frequency location of LP-WUS**

* QC
  + As baseline, LP-WUS on a serving cell is configured within active DL BWP of the serving cell
    - FFS: outside active DL BWP of the serving cell (as optional UE capability)

**LP-WUS monitoring parameters**

* HW/HiSi:
  + In CONNECTED mode, monitoring parameters of LP-WUS can be adjusted by MR signaling and/or pre-defined rules at least for different coverage requirement.

### **Question 7-1:**

* **Is there a need to treat any of the issues listed above in this meeting?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | We are open to discuss them or prioritize other discussions in this meeting. However we think anyway we need to discuss them before WI completion. |
| ZTE, Sanechips |  | Suggest band operation or LP-WUS frequency location is discussed. |
|  |  |  |

# 8 Conclusions

To be updated

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | **[RP-240801](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_103/Docs/RP-240801.zip)** | Revised WID: Low-power wake-up signal and receiver for NR (LP-WUS/WUR) | vivo, NTT DOCOMO, Ericsson, MediaTek, Samsung, Sony |
| [2] | **[R1-2400640](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116/Docs/R1-2400640.zip)** | Work plan for Low-power wake-up signal and receiver for NR | vivo, NTT DOCOMO |
| [3] | **[R1-2405721](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_117/Docs/R1-2405721.zip)** | FL summary #4 on LP-WUS operation in CONNECTED mode | Moderator (NTT DOCOMO) |
| [4] | **[R1-2405869](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2405869.zip)** | Procedures and functionalities of LP-WUS in CONNECTED mode | Huawei, HiSilicon |
| [5] | **[R1-2405921](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2405921.zip)** | Discussion on LP-WUS operation in CONNECTED modes | Spreadtrum Communications |
| [6] | **[R1-2405998](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2405998.zip)** | Discussion on LP-WUS operation in CONNECTED mode | CMCC |
| [7] | **[R1-2406195](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406195.zip)** | Discussion on LP-WUS operation in CONNECTED modes | vivo |
| [8] | **[R1-2406224](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406224.zip)** | Further consideration on LP-WUS operation in connected mode | OPPO |
| [9] | **[R1-2406297](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406297.zip)** | Discussion on LP-WUS operation in Connected mode | Xiaomi |
| [10] | **[R1-2406381](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406381.zip)** | System design and procedure of LP-WUS operation for UE in CONNECTED Modes | CATT |
| [11] | **[R1-2406390](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406390.zip)** | Discussion on LP-WUS operation in CONNECTED mode | Panasonic |
| [12] | **[R1-2406414](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406414.zip)** | Discussion on LP-WUS operation in CONNECTED mode | ZTE Corporation, Sanechips |
| [13] | **[R1-2406424](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406424.zip)** | LP-WUS operation in CONNECTED mode | Nokia |
| [14] | **[R1-2406482](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406482.zip)** | LP-WUS operation in CONNECTED mode | Sony |
| [15] | **[R1-2406500](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406500.zip)** | Discussion on RRC CONNECTED mode LP-WUS monitoring | InterDigital, Inc. |
| [16] | **[R1-2406510](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406510.zip)** | Discussion on LP-WUS operation in CONNECTED modes | Lenovo |
| [17] | **[R1-2406539](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406539.zip)** | Discussion on LP-WUS operation in RRC CONNECTED mode | NEC |
| [18] | **[R1-2406613](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406613.zip)** | Discussion on LP-WUS operation in CONNECTED modes | LG Electronics |
| [19] | **[R1-2406663](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406663.zip)** | Discussion on LP-WUS operation in CONNECTED modes | Samsung |
| [20] | **[R1-2406736](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406736.zip)** | Discussion on LP-WUS operation in CONNECTED modes | ETRI |
| [21] | **[R1-2406764](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406764.zip)** | LP-WUS operation in CONNECTED modes | MediaTek Inc. |
| [22] | **[R1-2406852](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406852.zip)** | LP-WUS operation in CONNECTED modes | Apple |
| [23] | **[R1-2406883](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406883.zip)** | Discussion on LP-WUS operation in CONNECTED modes | Sharp |
| [24] | **[R1-2406943](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2406943.zip)** | Discussion on LP-WUS operation in CONNECTED mode | NTT DOCOMO, INC. |
| [25] | **[R1-2407042](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2407042.zip)** | LP-WUR operation in connected mode | Qualcomm Incorporated |
| [26] | **[R1-2407061](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118/Docs/R1-2407061.zip)** | LP-WUS operation in CONNECTED mode | Ericsson |
| [27] | R1-2407104 | Discussion on LP-WUS procedures in Connected mode | TCL |

# Summary of observations/proposals in contributions

### **R1-2405869 Huawei, HiSilicon**

|  |
| --- |
| 1. ***For LP-WUS in CONNECTED mode, if a UE receives LP-WUS targeting to itself, the UE is not required to start monitoring PDCCH before t0+A+B, where:***  * ***t0 is the time point corresponding to the end of LP-WUS*** * ***A is the time duration for ramp-up based on UE capability reporting***   + ***More than one minimum time gaps are supported and can be reported by UE capability*** * ***B is the time duration for time/frequency synchronization of MR***  1. ***In CONNECTED mode, maximum number of LP-WUS information bits is up to 16 bits.*** 2. ***The impact due to miss-detection/falsely-detection of LP-WUS activation/deactivation signaling should be minimized/avoided for CONNECTED mode UE.*** 3. ***In CONNECTED mode, if LP-WUS monitoring is enabled, at least the following options are supported which can be jointly used***    * ***Option 2: Activation/deactivation of LP-WUS monitoring by gNB L1/L2 signaling with or without UE assistance.***    * ***Option 3: Activation/deactivation of LP-WUS monitoring based on condition(s), such as timer.***    * ***Option 4: Activation/deactivation of LP-WUS monitoring based on implicit indication/condition, e.g. UL transmission.***    * ***Note: PDCCH monitoring of a UE is suspended if LP-WUS monitoring of the UE is activated, and vice versa. PDCCH monitoring of a UE is resumed if LP-WUS monitoring of the UE is deactivated. When a UE is in the state of deactivated LP-WUS monitoring, the UE may or may not monitor LP-WUS.*** 4. ***In CONNECTED mode, the periodicity of LP-WUS monitoring is configured, and continuous monitoring is supported by configuring proper value of MO number and monitoring periodicity.*** 5. ***For CONNECTED mode, at least Option 1-2-2 is supported, i.e., LP-WUS can be monitored by LP-WUR at any configured monitoring occasion according to the LP-WUS monitoring configuration, and following two alternatives are further studied:***    * ***Alt 1: legacy C-DRX related timers keep running when UE is monitoring LP-WUS to control UE behavior on measurement,***      + ***The PDCCH monitoring is only controlled by LP-WUS monitoring, i.e. when UE is monitoring LP-WUS UE is allowed not to monitor PDCCH even if legacy Active Time related timers are running;***      + ***Option 1-3 should also be supported and work together with Option 1-2-2;***    * ***Alt 2: legacy C-DRX related timers are terminated/suspended when UE is monitoring LP-WUS,***       + ***Option 1-3 may or may not be supported;*** 6. ***For Option 1-2-2 of LP-WUS procedures to trigger PDCCH monitoring, enhancement is supported to enable that UE can start PDCCH monitoring irrespective of drx-onDurationTimer after receiving LP-WUS targeted to itself.*** 7. ***If DCP is configured, after LP-WUS monitoring is activated, the UE should not monitor DCP in MR.*** 8. ***After LP-WUS monitoring is activated, the UE should stop/suspend the Rel-17 PDCCH adaption mechanism, if configured.*** 9. ***The co-existence of LP-WUS and cell DTX should be considered in Rel-19.*** 10. ***For LP-WUS in FR1-FR2 CA, the trigger of PDCCH monitoring of FR2 cells can be separate from that of FR1 cells.***  * ***If PDCCH monitoring of an SCell is triggered, then PDCCH monitoring of PCell is also triggered, regardless their frequency range.***  1. ***The QCL source determination can be discussed after the progress achieved on LP-WUS monitoring activation/deactivation***    * ***If LP-WUS monitoring is activated by PDCCH, UE can assume the same TCI state as the CORESET to receive the PDCCH activating LP-WUS monitoring***    * ***If LP-WUS monitoring is activated by timer, the TCI state can be the same as the CORESET to receive the last PDCCH before the timer expires.*** 2. ***In CONNECTED mode, monitoring parameters of LP-WUS can be adjusted by MR signaling and/or pre-defined rules at least for different coverage requirement.*** |

### **R1-2405921 Spreadtrum Communications**

|  |
| --- |
| LP-WUS mechanisms  ***Proposal 1: In C-DRX scenarios, UE MR PDCCH monitoring triggered by LP-WUS during on-duration timer/inactive timer can be supported.***  LP-WUS monitoring  ***Observation 1: The configuration of LP-WUS monitoring occasions needs based on LP-WUS procedures to trigger PDCCH monitoring.***  Activation and deactivation  ***Proposal 2: Activation/deactivation of LP-WUS monitoring by gNB L1 signaling, e.g., DCI can be considered.***  LP-WUS mechanisms in CA case  ***Proposal 3: Whether wake-up indication by LP-WUS is applied for all the serving cells or for a group of SCells for triggering PDCCH monitoring need to be considered for Option 1-2 and Option 1-3.*** |

### **R1-2405998 CMCC**

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| For concept on wake-up mechanism,  **Proposal 1. Support LP-WUS procedure Option 1-1, Option 1-2-2 and Option 1-3, gNB can configure UE which procedure is used.**  **Proposal 2. The time duration of PDCCH monitoring triggered by LP-WUS in Option 1-2-2 and Option 1-3 can be pre-defined or configured.**  **Proposal 3. LP-WUS procedure Option 1-1 and Rel-16 DCP cannot be configured or activated to one UE simultaneously.**  **Proposal 4. LP-WUS procedure Option 1-2-2/Option 1-3 and Rel-17 PDCCH skipping/SSSG switching can be configured or activated to one UE simultaneously.**  **Proposal 5: For go-to sleep mechanism after UE being wake-up, further study the following option,**   * **Option 1: Rel-17/18 PDCCH skipping/SSSG switching is used to indicate UE go to sleep.** * **Option 2: Use LP-WUS to indicate UE go to sleep.**   For design on LP-WUS monitoring occasion,  **Proposal 6. Support UE report more than one minimum time gaps from multiple candidates, gNB configures the gap value.**  **Proposal 7. Support the minimum time gap does not include the duration for time/frequency sync of MR.**  **Proposal 8. Support LP-WUS QCLed with SSB in QCL-Type D.**  **Proposal 9. Whether a time window or periodicity is introduced for LP-WUS should base on the function of LP-WUS. RAN1 suspend this discussion until the function of LP-WUS is down-selected or defined.**  **Proposal 10. Support UE monitoring LP-WUS only on PCell in CA scenario.**  For relationship between operating bands on MR and LR,  **Proposal 11. Support LR and MR work on both the same and different operating bands (or carriers).** |

### **R1-2406195 vivo**

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| ***Observations***  **Observation 1: For Option 1-1 that LP-WUS is used to trigger the starting of the drx-onDurationTimer, , if the short C-DRX cycle is configured, UE power concumption cannot be reduced since short DRX cycle would increase the MR power consumption for RLM/BM/BFD/RRM etc.measurements.**  **Observation 2: From latency reduction perspective, Option 1-2-1 combined with Option 1-1 and Option 1-2-2 are comparable. From power saving perspective, Option 1-2-1 combined with Option 1-1 still result in more power consumption, given that PDCCH monitoring is still needed based on legacy C-DRX cycle and drx-onDurationTimer if LP-WUS is successfully detected.**  **Observation 3: Option 1-3 can achieve power saving benefit within C-DRX active time with limited impact on the capcacity. While Option 1-3 cannot reduce the traffic latency in case the traffic arrives outside the C-DRX active time.**  **Observation 4: After LP-WUS monitoring is enabled by RRC signalling, the activation/deactivation of LP-WUS monitoring by Option 2 of gNB L1/L2 signaling and/or Option 3 of condition(s), such as timer are options for switching between LP-WUS monitoring and PDCCH monitoring.**  ***Proposals***  **Proposal 1: LP-WUS does not support SCell dormancy indication.**  **Proposal 2: From RAN1 perspective, LP-WUS CONNECTED operation Option 1-2-2 (i.e. PDCCH monitoring triggered by LP-WUS but not by legacy C-DRX cycle and drx-onDurationTimer) that provides the best performance for both UE power saving and UPT/latency perspectives should be prioritized.**  **Proposal 3: UE monitors LP-WUS only on one serving cell per MAC entity when UE is configured with CA in RRC CONNECTED mode.**   * **The serving cell where to monitor LP-WUS is configured by the network.**   **Proposal 4: When UE is configured with CA in RRC CONNECTED mode, the LP-WUS information is applied to all activated serving/scheduling cells.**  **Proposal 5: Support following:**   * **UE can report one or more than one minimum time gap value(s) between LP-WUS reception and MR to start PDCCH monitoring.**    + **The different minimum time gap values can be associated with different MR sleep states.** * **Network configures one time gap between LP-WUS reception and MR starting PDCCH monitoring.**   **Proposal 6: For RRC CONNECTED mode, the reported value(s) of minimum time gap between LP-WUS reception and MR to start PDCCH monitoring does not include the duration for time/frequency synchronization of MR.**  **Proposal 7: In RRC\_CONNECTED mode, the indication from UE to indicate whether it monitors LP-WUS is not needed.**  **Proposal 8: In RRC\_CONNECTED mode, if the LP-WUS is not detected on a WUS monitoring occasion (MO) by the UE, UE does not wake up the MR for PDCCH monitoring.**  **Proposal 9: After LP-WUS monitoring is enabled by RRC signalling, the conditions used for LP-WUS deactivation due to poor channel condition for LP-WUS monitoring is not needed.**  **Proposal 10: For UE in RRC\_CONNECTED mode, UL transmissions such as SR, PRACH and CG PUSCH should not be impacted by the introduction of LP-WUS.**  **Proposal 11: For UE in RRC\_CONNECTED mode, in case LP-WUS monitoring is enabled by RRC signalling, switching from PDCCH monitoring to LP-WUS monitoring is supported by gNB L1/L2 signaling.**  **Proposal 12: if PDCCH skipping indication is used as LP-WUS activation signalling, following enhancements are needed.**   * **Enhancement#1 on skipping duration for PDCCH skipping and related UE behavior** * **Ehancement#2 on applying a PDCCH skipping indication to multiple scheduling cells, which is the same scheduling cells as a LP-WUS is applied to**   **Proposal 13: For co-exsistence between LP-WUS and Rel-17 SSSG switching, Rel-17 SSSG switching is performed after successful detection of LP-WUS triggering PDCCH monitoring and Rel-17 SSSG switching is stopped after successful detection of LP-WUS reactivation signalling.**  **Proposal 14: A UE does not expect to monitor the LP-WUS during the non-active periods of cell DTX of a serving cell, if cell DTX is activated for the serving cell with the LP-WUS monitoring.**  **Proposal 15: UE monitors PDCCH on a cell in case LP-WUS for the cell is detected, irrespective of the cell-DTX active periods or non-active periods of the cell.**  **Proposal 16: LP-WUS monitoring occasion(s) (MOs) is determined by a Periodicity, Offset, and Multiple LP-WUS MOs within the period which are configured by the network.**  **Proposal 17: To support the TCI state configuration/indication for a LP-WUS resource,**   * **The QCL source of LP-WUS should be SSB and/or CSI-RS.** * **Existing TCI state with or without unified framework should be the baseline.**   **Proposal 18: Support a flexible frame work for bitmap and codepoint for RRC connected state. A LP-WUS can include X bits for codepoint plus Y bits for bitmap, where X and Y is configurable.**   * **If X=0, LP-WUS information is indicated by a UE specific or UE-group specific bitmap.** * **If Y=0, LP-WUS information is indicated by a UE specific or UE-group specific codepoint.** * **If X ≠0 and Y≠0, , e.g., LP-WUS information is indicated by sub-group codepoint and bitmap for UEs within the subgroup.**   **Proposal 19: For RRC\_CONNECTED mode, maximum number of LP-WUS information bits is up to 16 bits.** |

### **R1-2406224 OPPO**

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| **Proposal 1: All RRC modes are sharing the same WUS signal in coding, payload and modulation.**  **A UE is assigned with single bit in the LP-WUS for indication of a duration of PDCCH monitoring in** **CONNECTED mode.**  **Proposal 2: RAN1 support the option 1-2-2 LP-WUS wake-up in CONNECTED mode. The LP-WUS is monitored and triggering the PDCCH monitoring during** **C-DRX active time.**  **Proposal 3: The LP-WUS should be configured with following legacy schemes in CONNECTED mode:**  **Rel-16 Cross-slot scheduling can be configured together with LP-WUS in CONNECTED mode without specification impact.**  **When PDCCH Skipping/SSSG switching is configured, the PDCCH skipping indication can enable the LP-WUS monitoring occasions.**  **For the Cell DTX, LP-WUS is assumed to be disabled during the DTX time.**  **Proposal 4: When the LP-WUS is configured with CA in CONNECTED mode:**  **One serving cell should be only indicated by the LP-WUS in the same carrier.**  **Only wake-up bits are carried by LP-WUS, e.g., no Scell dormancy indication.**  **Proposal 5: For the LP-WUS activation and deactivation by pre-configured condition(s), timer-based monitoring of LP-WUS is the baseline.**  **Proposal 6: LP-WUS Monitoring Occasions can be associated with CORESETs for the TCI states determination. The activated TCI state of the CORESET is applied for the associated LP-WUS Monitoring Occasion.**  **Proposal 7: RAN1 can assume that MR measurements are one of the UE assistant information for the LP-WUS activation and deactivation.**  **RAN1 discuss the introduction LP-SS measurement in CONNECTED mode as another UE assistant information.**  **Proposal 8: In RRC CONNECTED mode, support UE capability report one value among candidate values for minimum time gap between LP-WUS reception and MR to start PDCCH monitoring.**  **Proposal 9: RAN1 may specify that the monitoring occasion of LP-WUS and associated monitoring occasion of PDCCH should meet the reported minimum gap.** |

### **R1-2406297 Xiaomi**

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| ***Proposal 1: The following LP WUS application cases can be considered and down-selected,***  ***Case 1: LP WUS replaces DCI 2-6;***  ***Case 2-1:*** ***LP WUS outside C-DRX active time with legacy on-duration;***  ***Case 3-1:*** ***LP WUS within C-DRX on duration***  ***Case 3-2: LP WUS is used within C-DRX re-transmission timer running duration;***  ***Case 3-3: LP WUS is used within C-DRX active time and within PDCCH skipping duration;***  ***Case 3-4: LP WUS is used within C-DRX active time and outside PDCCH skipping duration;***  ***Proposal 2: If LP WUS replaces DCI 2-6 is supported, at least one of the other application cases should also be supported to guarantee enough power saving gain compared to existing techniques.***  ***Proposal 3: Not support LP WUS outside C-DRX active time without legacy on-duration (Case 2-2), since its impact on measurement for RRM/RLM/LR procedures.***  ***Proposal 4: Suggest the activation/deactivation of LP-WUS monitoring summarized in Table 1.***  Table 1 Activation/deactivation of LP-WUS monitoring   |  |  |  | | --- | --- | --- | |  | **Activation** | **Deactivation** | | **Case 1** | No explicit indication | No explicit indication | | **Case 2-1** | No explicit indication/by timer/by explicit indication | By LP-WUS | | **Case 3-1/3-2/3-3/3-4** | No explicit indication | By LP-WUS |   ***Proposal 5: Support multiple repetitions of a LP WUS occasion.***  ***Proposal 6: LP WUS can be configured in the same or different carrier/band from where MR operates.***  ***Proposal 7: UE is only required to monitor LP WUS on one carrier.***  ***Proposal 8: Required monitoring occasions at UE side depends on the application cases.***  ***Proposal 9: LP WUS at least includes bits indicating whether to monitor PDCCH. SSSG switching, BWP switching indication can also be considered.***  ***Proposal 10: LP WUS indication can be per cell or per cell group when UE is configured with multiple serving cells.***  ***Proposal 11: Multiple wake up delays of LP WUS should be defined.***  ***Proposal 12: Synchronization is up to UE implementation and synchronization delay should not be included in wake up delay.***  ***Proposal 13: Support CSI report enhancement during the MR’s non-active period.***  ***Proposal 14: LP WUS in connected state can be QCLed with LP -SS by QCL type A, and can be QCLed with SSB by QCL type C.*** |

### **R1-2406381 CATT**

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| **Proposal 1: For RRC\_CONNECTED mode, the LP-WUS could be configured for one or more UEs for the control signaling to indicate the UE wake up in the subsequent DRX ON.**  **Proposal 2: UE can only report one minimum time gap and the value of minimum gap depends on the functionality of LP-WUS whether the LP-WUS indication includes the SCell dormancy indication.**  **Proposal 3: The periodicity of LP-WUS MOs can be configured deterministically.**  **Proposal 4: One LP-WUS is configured to be QCLed with the RS associated with each of the TCI states of the CORESETs in order to trigger the PDCCH monitoring at the associated CORESET when LP-WUS is detected.**  **Proposal 5: For RRC CONNECTED mode, support Option 1-1 as the baseline.**  **Proposal 6: NOT support UE assistance for PDCCH monitoring triggered by LP-WUS is enabled/disabled by gNB RRC signaling.**  **Proposal 7: Support Option 1: No additional indication/condition is introduced for activation/deactivation of LP-WUS monitoring.**  **Proposal 8：The indication of PDCCH monitoring for both PCell and SCells by LP-WUS at the PCell is supported for CA in RRC\_CONNECTED mode.**  **Proposal 9: PDCCH monitoring triggered by a LP-WUS is applicable for all serving cells with SCell dormancy indication in LP-WUS. The number of SCells supported for SCell dormancy indication by LP-WUS outside Active Time needs to consider the capability of LP-WUS for indication.** |

### **R1-2406390 Panasonic**

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| **Proposal 1: Option 1-1 is adopted that LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.**  **Proposal 2: If Option 1-1 is adopted for LP-WUS monitoring procedure triggering PDCCH monitoring, LP-WUS should work with PDCCH skipping, SSSG switching, and cell DTX. It is not required to support joint operation between LP-WUS and Rel.16 DCP.**  **Proposal 3: For LP-WUS monitoring, UE monitoring behavior should be under control and known by gNB in order to avoid the waste of occupied resource by LP-WUS transmission. "Is expected to" is more appropriate.**  **Proposal 4: LP-WUS MOs should be flexibly configured with a periodicity and time window (=duration) to support both the case of coexistence with and independent from existing UE power saving features, e.g., C-DRX cycle.**  **Proposal 5: The minimum time gap between LP-WUS reception and the start of MR PDCCH monitoring should consider several ms plus the time offset from the LP-WUS to [1~3] SSB burst before PDCCH MO.**  **Proposal 6: The minimum time gap should support different receiver type of LP-WUR. At least 2 set of values for OOK-based receiver and OFDM-based receiver can be expected respectively.**  **Proposal 7: CA should be supported as general feature working with LP-WUS in RRC CONNECTED mode.**  **Proposal 8: For the** **cell(s) where PDCCH monitoring triggered by LP-WUS, Option 2 is simpler and can be sufficient to support.** |

### **R1-2406414 ZTE Corporation, Sanechips**

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| **Observations**:  ***Observation 1: Monitoring DCI for LP-WUS activation, compared with RRC activation, causes more power consumption.***  ***Observation 2: Only adjusting the starting time for the C-DRX timers does not change the definition of C-DRX active time.***  ***Observation 3: For option 1-1, PSG can be achieved in connected mode***   * ***No latency reduction if the startoffset for duration-on timer is not adjusted.*** * ***Latency reduction if the startoffset for duration-on timer could be adjusted.*** * ***In one C-DRX cycle, the drx-onDurationTimer configured by DRX-config only could be triggered once.***   ***Observation 4: For option 1-2-1, both PSG and latency reduction could be achieved if combined with option 1-1.***  ***Observation 5: For Interpretation 1 of option 1-2-2, both PSG and latency reduction can be achieved and no need to combine with option 1-1.***  ***Observation 6: For Interpretation 2 of option 1-2-2, both latency reduction and PSG can be achieved, legacy behaviors in legacy C-DRX active time are not performed anymore.***  ***Observation 7: For Interpretation 3 of option 1-2-2, latency reduction can be achieved, and the PSG could be further studied due to the legacy measurement.***  ***Observation 8: The benefits for option 1-3 is not evaluated in SI.***  ***Observation 9: Based on the TR, 24bits as maximum payload size is feasible.***  ***Observation 10: In connected mode, group specific LP-WUS still cause unnecessary power consumption for other UEs, which brings fairness issue due to the different traffic model and UE’s requirement.***  ***Observation 11: LP-WUS carrying more information bits could help improve spectrum efficiency.***  ***Observation 12: Option 1, option2, option3 and option4 could be included in option5 as a special case.***   * ***Option5 is more appropriate to be expanded for SCell wake-up support***   ***Observation 13: Option 5 has maximum flexibility and robustness.***  ***Observation 14: If LP-WUS is monitored outside active time, no spec impact is foreseen for PDCCH skipping and LP-WUS coexistence.***  ***Observation 15: No much power saving is observed if LP-WUS is used for SSS switching and no issue is observed when LP-WUS coexist with SSSG switching.***  **Proposals**:  ***Proposal 1: RRC activation/deactivation is the baseline***   * ***DCI deactivation and fallback mechanism based on that UE does not received LP-WUS for a long time can be considered.*** * ***The motivation for L2 activation/deactivation should be further clarified if L1 deactivation is introduced.*** * ***Option 4 is not considered for activation/deactivation of LP-WUS monitoring.***   ***Proposal 2: For LP-WUS monitoring in CONNECTED mode, UE power consumption reduction and maintaining latency performance should be ensured compared to the existing power saving mechanisms.***  ***Proposal 3: For option 1-1, further clarify the starting time of the drx-onDurationTimer may be adjusted to achieve latency reduction***   * ***Note: the drx-onDurationTimer only could be triggered once in one C-DRX cycle.***   ***Proposal 4: For option 1-2-2, clarify the following interpretations are included***   * ***Interpretation 1: PDCCH monitoring could be triggered by new timers and drx-onDurationTimer can be activated with adjusting the starting time.*** * ***Interpretation 2: PDCCH monitoring is triggered by new timers and legacy drx-onDurationTimer are not activated.*** * ***Interpretation 3: PDCCH monitoring is triggered by new timers and legacy drx-onDurationTimer are activated periodically only for measurement, not for PDCCH monitoring.*** * ***FFS further down selection***   ***Proposal 5: Further study the following alternatives for PSG and latency reduction***   * ***Alt1: Option 1-1 with adjustable starting time for the drx-onDurationTimer*** * ***Alt2: Option 1-2-1 combined with option 1-1*** * ***Alt3: Interpretation 1 of option 1-2-2, i.e., PDCCH monitoring could be triggered by new timers or drx-onDurationTimer with adjustable starting time.***   ***Note: both PSG and latency reduction in connected mode should be ensured.***  ***Proposal 6: The maximum number of LP-WUS information bits is configurable***   * ***Up to 24bits.*** * ***Support UE specific wake-up with high priority***   ***Proposal 7: Based on the framework of option5, further discuss whether LP-WUS target***   * ***One or more UEs in one LP-WUS*** * ***[One or more subgroups in one LP-WUS]*** * ***SCell wake-up/dormancy***   ***Proposal 8: LP-WUS and CA could be enabled simultaneously in connected mode.***  ***Proposal 9: For CA support, discuss whether LP-WUS is applied for all serving cells or for a group of SCells for triggering PDCCH monitoring.***  ***Proposal 10: Deprioritize LP-WUS used for SCell dormancy and prioritize LP-WUS used for SCell wake-up for PDCCH monitoring.***  ***Proposal 11: LP-WUS is only transmitted in PCell.***  ***Proposal 12: the LP-WUS could be located flexibly in the same band where SSB locates.***  ***Proposal 13: During Cell-DTX off period, UE does not need to monitor LP-WUS.***  ***Proposal 14: One minimum time gap is defined/reported based a configuration set.***   * ***The configuration set may contains SCS, WUR type and others if any.***   ***Proposal 15: One preferred time gap from a set of values could be reported based on UE assistance information*** |

### **R1-2406424 Nokia**

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| **Observation 1: The minimum time gap values can vary greatly between different devices and scenarios.**  **Observation 2: When the available time for the MR to enter and wake from a sleep state is reduced (eg by the inactivity timer), the system can use an alternative shorter minimum time gap.**  **Observation 3: Minimising signalling to support the operation of LP-WUS can help reduce power and resource consumption as well as minimise processing delays.**  **Observation 4: The number of UEs that are expected to share the same LP-WUS in connected mode, is likely to be very low**.  **Proposal 1: The start time of the minimum time gap is defined from end of the last symbol used to transmit the LP-WUS.**  **Proposal 2: The potential values of the minimum time gap are defined in ms.**  **Proposal 3: The reported minimum time gap value includes the duration for the time/frequency synchronization of the MR.**  **Proposal 4: Multiple minimum time gaps are supported, to enable the system to exploit the longest possible minimum time gap given the available time for the MR to enter and wake from a sleep state.**  **FFS: If switching between gaps is implicit (eg option 1-1) or explicit.**  **Proposal 5:** **The Network uses the TCI-state of the Coreset used for PDCCH monitoring, to determine the QCL relationship with LP-WUS.**  **Proposal 6: The LP-WUS from the gNB is QCLed with the SSB/CSI-RS via at least Type-D.**  **FFS: If Type-B/C QCL relationships are also applicable**  **Proposal 7: For Option 1-1, an offset parameter, Lpwus-offset, from the start of the drx-onDurationTimer, to the start symbol of the LP-WUS MO.**  **FFS: Whether the LR expects the time window to be used for one format of LP-WUS or multiple formats or multiple attempts of LP-WUS transmission.**  **Proposal 8: The MO configuration for Option 1-1 can be extended to support Option 1-2-1.**  **Proposal 9: RAN1 wait for RAN2 conclusion on the design of Option 1-2-2 before developing an MO scheme for that option.**  **Proposal 10: RAN1 deprioritise further study into option 1-3.**  **Proposal 11: RAN1 study the use of LP-WUS to support early termination of PDCCH skipping.**  **Proposal 12:**  **From a RAN1 perspective, when enabling LP-WUS to trigger PDCCH monitoring in RRC CONNECTED mode, an option for using UE assistance is supported.**  **Proposal 13: From a RAN1 perspective, an option to support explicit UE feedback to indicate loss of LP-WUS in CONNECTED mode is supported.**  **Proposal 14:**  **For the LP-WUS connected mode scheme selected, a mode of operation (option 1) of LP-WUS activation/deactivation is supported that requires no additional indication/condition (option 1).**  **Proposal 15: For the LP-WUS connected mode scheme selected, the gNB supports a mode of operation (option 2) to use a L1/L2 dynamic mechanism to indicate to UEs the temporary deactivation or reactivation of LP-WUS usage.**  **FFS: Exact details of L1/L2 scheme**  **Proposal 16:**  **For the LP-WUS connected mode scheme selected, support mechanisms to deactivate LP-WUS monitoring and fallback to a recovery mode of operation.**  **FFS: If this UE initiated fallback procedure triggers UE feedback to the network.**  **Proposal 17: For the LP-WUS connected mode scheme selected, if some (legacy) procedures require UE to monitor PDCCH, UE shall follow the legacy behaviour. If UE is not able to monitor a LP-WUS monitoring occasion(s), UE shall resume PDCCH monitoring as it would be triggered by LP-WUS.**  **Proposal 18: For RRC CONNECTED mode, the maximum number of LP-WUS information bits is up to 8 bits.**  **Proposal 19:**  **RAN1 determines the maximum amount of information bits and associated encoding before discussing the preferred payload content.**  **Proposal 20: RAN1 deprioritize option 2 (UE specific codepoint) for LP-WUS information to trigger PDCCH monitoring of RRC connected UEs**.  **Proposal 21:** **Baseline operation of LP-WUS with CA assumes only a single LR implementation at the device.**  **Proposal 22:** **For baseline operation of LP-WUS with CA, the LP-WUS triggers PDCCH monitoring in all activated serving cells (Option 2).** |

### **R1-2406482 Sony**

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| Proposal 1: Support LP-WUS monitoring to trigger the starting of the drx-onDurationTimer (known as Option 1-1).  Proposal 2: Support LP-WUS in RRC connected mode with multiple time-gaps  Proposal 3: RAN1 strives for the LP-WUS common design including supporting sequence-based LP-WUS operation in both RRC CONNECTED and RRC idle/inactive mode.  Proposal 4: LP-WUS transmission in RRC Connected mode indicates the target UE and the subsequent action from the UE upon the reception of LP-WUS.  Proposal 5: The maximum number of LP-WUS information bits for RRC connected mode is up to 8 bits  Proposal 6: The UE operating in RRC connected mode and configured to receive LP-WUS is expected to monitor a given LP-WUS resource.  Proposal 7: Support both duty-cycled monitoring mode and continuous monitoring mode for LP-WUS in RRC-connected.  Proposal 8: Enabling/Disabling of LP-WUS monitoring by RRC signalling is sufficient. No additional indication/condition are introduced for activation/deactivation of LP-WUS monitoring (known as Option 1).  Proposal 9: Down-prioritize on supporting LP-WUS for the UE operating Carrier Aggregation (CA). |

### **R1-2406500 InterDigital, Inc.**

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| ***Observation 1:*** *C-DRX introduces scheduling latency for DL data transmission and reduces scheduling flexibility of gNB.*  ***Observation 2:*** *Longer C-DRX cycles can help to save more power, however longer C-DRX cycles increase the latency and impact of C-DRX on scheduling flexibility of gNB severe.*  ***Observation 3:*** *Latency due to use of C-DRX can be reduced by using LP-WUS to trigger PDCCH monitoring (e.g., starting a drx-onDurationTimer) outside C-DRX active time.*  ***Observation 4:*** *LP-WUS monitoring configuration should be selected to match the conditions UE is experiencing.*  ***Observation 5:*** *Higher power saving can be achieved by activating LP-WUS monitoring only when UE is in appropriate conditions.*  ***Observation 6:*** *gNB is unable to select all the appropriate LP-WUS monitoring configuration and determine to activate/deactivate LP-WUS monitoring without UE assistance.*  ***Observation 7:*** *CA is an essential feature to support many high-bandwidth demanding use cases.*  ***Observation 8****: A LP-WUS design that can control waking-up of each UE separately can provide higher power saving compared to a LP-WUS design in which multiple UEs share the same wake-up indication.*  ***Observation 9****: Supporting SCell dormancy indication via LP-WUS is important to make LP-WUS monitoring can be used for all the use cases supported by DCP.*  ***Observation 10:*** *Compact LP-WUS payload size is important to support coverage comparable with PUSCH for Msg3.*  ***Observation 11:*** *LP-WUS payload can be reduced by implicitly indicating some of information of LP-WUS.*  ***Observation 12:*** *Use of sleep states achieving higher power saving can cause increased latency while use of sleep states that supports lower latency can reduce power saving gains of LP-WUS monitoring.*  ***Proposal 1:*** *For triggering PDCCH monitoring via LP-WUS ‘Option 1-2-1’ is supported.*   * *Option 1-2-1: PDCCH monitoring may be additionally triggered based on legacy C-DRX cycle and drx-onDurationTimer when monitoring LP-WUS.*   ***Proposal 2:*** *Introduce a mechanism to conditionally support Option 1-1 together with Option 1-2-1 targeting power saving gains compared to legacy C-DRX.*   * *Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.* * *Conditions for supporting Option 1-1 together with Option 1-2-1, FFS.*   ***Proposal 3:*** *PDCCH monitoring triggered by LP-WUS is enabled/disabled or activated/deactivated with UE assistance.*  ***Proposal 4:*** *For a LP-WUS monitoring enabled UE, support activating/deactivating LP-WUS monitoring based on following preconfigured conditions.*   * *For activating LP-WUS monitoring: level of UE activity (e.g., timer and/or counter associated with UE activity), channel/signal quality, mobility.* * *For deactivating LP-WUS monitoring: level of UE activity (e.g., timer and/or counter associated with UE activity), channel/signal quality, mobility, LP-WUS reception quality.*   ***Proposal 5:****For OFDM based LP-WUR, both NR-SS (existing SSB) and LP-SS can be used to determine activation/deactivation of LP-WUS monitoring.*  ***Proposal 6:*** *Support a mechanism to report UE decision of LP-WUS monitoring deactivation potentially with reason for the decision.*  ***Proposal 7:*** *CA is supported with LP-WUS monitoring in connected mode.*  ***Proposal 8:*** *When UE is configured with CA in RRC connected mode, PDCCH monitoring triggered by a LP-WUS is applicable to all active cells (Option 2).*  ***Proposal 9:*** *Indications supported in DCP, i.e., per UE wake-up indication and SCell dormancy indication, should be supported in LP-WUS.*  ***Proposal 10:*** *A subset of LP-WUS information can be informed to UE implicitly using LP-WUS monitoring resource (e.g., LO and MO) association and structure of LP-WUS.*  ***Proposal 11:*** *For LP-WUS in connected mode, multiple minimum time gaps corresponding to different sleep states are supported.* |

### **R1-2406510 Lenovo**

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| ***Proposal 1:***  ***For RRC CONNECTED mode, PDCCH monitoring is triggered by LP-WUS with C-DRX configuration, at least the following LP-WUS procedures is supported:***   * ***Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.***   ***Proposal 2: One or more [periodical] LP-WUS occasions are configured in WUS monitoring window before drx-onDurationTimer to trigger the PDCCH monitoring.***  ***Proposal 3: LP-WUS can be designed to indicate whether to start the corresponding one or more drx-onDurationTimer in one or more DRX cycle(s)(e.g. take the place of DCP).***  ***Proposal 4: LP-WUS monitoring outside C-DRX active time and inside C-DRX active time needs further clarification and discussion.***  ***Proposal 5: The benefit of support the functionality of Rel.17 PDCCH monitoring adaption may need further study.***  ***Proposal 6: UE may need to report one or more suitable time gaps used for MR transition and/or WUS processing time similar as eMTC/NBIoT WUS gap reporting.***  ***Proposal 7: For CONNECTED mode, LP-WUS monitoring can be activated/deactivated by timer (especially for switching between LP-WUS monitoring and MR PDCCH monitoring after activation).***  ***Proposal 8: When channel/beam quality is below a certain value for a certain time, UE is expected to trigger PDCCH monitoring when UE monitors LP-WUS.***  ***Proposal 9: gNB configures the cell lists/carrier lists for UE PDCCH monitoring if MR is configured with CA.***  ***Proposal 10: For RRC CONNECTED mode, maximum number of LP-WUS information bits is up to X=16 bits.*** |

### **R1-2406539 NEC**

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| **Proposal 1: support option 1-1 with group based LP-WUS for RRC\_CONNECTED, and the group based LP-WUS can be used in combination with DCP to further reduce power consumption without introducing too much overhead.**  **Proposal 2: for option 1-2, prioritize option 1-2-1 due to less standard impact than option 1-2-2.** |

### **R1-2406613 LG Electronics**

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| **Observation #1: If LP-WUS only triggers the starting of drx-onDurationTimer, it may be implemented at the expense of the functionality of DCP.**  **Proposal #1: Consider DRX Active Time without periodicity for LP-WUS triggering dynamic PDCCH monitoring occasion.**  **Proposal #2: Consider candidate starting points of potential DRX Active Time triggered by LP-WUS.**  **Proposal #3: Specify the following two options for further discussion,**   * **Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.** * **Option 1-2-1: LP-WUS monitoring outside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.**   **Proposal #4: Specify the periodic LP-WUS MOs and the corresponding monitoring window for triggering MR PDCCH monitoring.**  **Proposal #5: Support LP-WUS triggering PDCCH monitoring for the serving cells based on gNB indication/configuration (i.e., option 1).**  **Proposal #6: Study how SCell of the UE is operated when start of drx-onDurationTimer is triggered by LP-WUS replacing DCP.**  **Proposal #7: Co-existence of Rel-17 PDCCH monitoring adaptation and LP-WUS can be revisited after the LP-WUS procedure about PDCCH monitoring are discussed.**  **Proposal #8:** **Further discuss how LP-WUS (and LP-SS) can be handled or interacted with cell DTX configurations.**  **Proposal #9: Specify activation/deactivation of LP-WUS monitoring by gNB L1/L2 signaling with or without UE assistance.**  **Proposal #10: Specify activation/deactivation of LP-WUS monitoring based on DRX timer and/or UL transmission at least considering followings,**   * **LP-WUS monitoring is deactivated when drx-onDurationTimer and drx-InactivityTimer is running.** * **LP-WUS monitoring is activated when drx-RetransmissionTimerDL, drx-RetransmissionTimerUL, drx-RetransmissionTimerSL, ra-ContentionResolutionTimer, or msgB-ResponseWindow is running.**   **Proposal #11: Consider the case where LP-WUS monitoring is in active state even during PDCCH monitoring is activated.**  **Proposal #12: To overcome limited maximum number of LP-WUS information bits, consider the combination of time/frequency resources and LP-WUS payload for UE identification.**  **Proposal #13: For supporting more functionality or information bits, consider the transmission of overlaid OFDM sequence over LP-WUS for CONNECTED modes.**  **Proposal #14: Discuss how to compose the payload and overlaid OFDM sequence of LP-WUS for CONNECTED mode at least as follows,**   * **The essential indication for UE behavior is contained in the payload of LP-WUS.** * **The additional information for UE behavior is contained in the overlaid OFDM sequence of LP-WUS.** |

### **R1-2406663 Samsung**

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| **Proposal 1: LP-WUS operation in RRC\_CONNECTED mode shall take RRC\_IDLE and RRC\_INACTIVE modes as a baseline, and is only optimized over aspects exclusively applicable for RRC\_CONNECTED mode.**  **Proposal 2: For configuration of LP-WUS:**   * **Frequency location of LP-WUS shall be configurable;** * **DRX operation for monitoring LP-WUS is supported.**   **Proposal 3: When C-DRX operation is configured, the cycle for LP-WUS DRX can be at least the same as the C-DRX cycle.**  **Proposal 4: For activation/deactivation of LP-WUS monitoring, prioritize Option 2 and Option 3, and support explicit confirmation message(s) from the UE to the gNB for handshake in Option 2.**  **Proposal 5: For PDCCH monitoring after wake-up indication by LP-WUS, at least support Option 1-1, and the consideration of other options shall be subject to RAN2 progress.**  **Proposal 6: For the minimum time gap between LP-WUS reception and MR to start PDCCH monitoring:**   * **Support two set of minimum gaps per SCS, and the UE can report its capability of one set of minimum gaps.** * **UE’s reported value shall include the duration for time/frequency synchronization of MR.** |

### **R1-2406736 ETRI**

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| **Proposal 1: It should be supported Option 1-1 which has the same function as Rel-16 DCP to indicate whether to start the next *drx-onDurationTimer*.**  **Proposal 2: In case of Option 1-2, it is proposed to support Option 1-2-1 only.**   * **Option 1-1 should be configured together with Option 1-2-1 to achieve the power saving gain.**   **Proposal 3: In case of Option 1-3, it is proposed to support Option 1-3-1 only.**   * **Option 1-1 should be configured together with Option 1-3-1 to achieve the power saving gain.** * **Note:**   + **Option 1-3: LP-WUS monitoring inside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.**     - **Option 1-3-1: PDCCH monitoring may be triggered based on legacy C-DRX cycle and *drx-onDurationTimer* when monitoring LP-WUS**       * **If this is adopted, it should be configured together with Option 1-1 to achieve power saving gain compared to legacy C-DRX**       * **If Option 1-1 is not configured together, this option cannot have any chance to monitor LP-WUS.**     - **Option 1-3-2: PDCCH monitoring is not triggered by legacy C-DRX cycle and *drx-onDurationTimer* when monitoring LP-WUS**   **Proposal 4: The LP-WUS occasions for additional options i.e., Option 1-2-1 or Option 1-3-1 should be configured separately from the configuration for Option 1-1.**  **Proposal 5: It is proposed to focus on the above three options i.e., Option 1-1, the combination of Option 1-1 and Option 1-2-1, the combination of Option 1-1 and Option 1-3-1 for further study, and preclude other options.**  **Proposal 6: It is proposed to focus only duty-cycled monitoring mode for LP-WUS in Rel-19.**  **Proposal 7: For the UE capability report, at least two values for the minimum time gap should be supported similar as Rel-16 DCP.**   * **The minimum time gap should include the duration for time/frequency synchronization of MR.**   **Proposal 8: Regarding periodicity of LP-WUS monitoring occasions, the periodicity should be the same or integer multiple of C-DRX periodicity.**   * **If the periodicity of LP-WUS monitoring occasions is the same as the C-DRX periodicity, no sperate configuration is necessary.**   **Proposal 9: In order for gNB to know that LP-WUS is monitored by a UE correctly, it will be sufficient the implicit indication such as**   * **HARQ-ACK feedback corresponding to scheduled downlink transmission** * **Scheduled uplink transmission** * **Other options are not precluded.**   **Proposal 10: It is proposed to study the options for activation/deactivation of LP-WUS monitoring further after the supporting scenarios and options become clear enough since different options can be supported depending on the scenarios and LP-WUS use options.**  **Proposal 11: Regarding the cell(s) where PDCCH monitoring triggered by a LP-WUS is applicable, Option 2 should be considered for further study.**   * **Option 2: all activated serving cells**   **Proposal 12: For LP-WUS transmission, the latest TCI state for PDSCH or PDCCH can be applied.**   * **FFS: PDSCH or PDCCH** * **Default TCI state can be also pre-configured.**   **Proposal 13: It should be supported fallback mechanisms which the MR switches to legacy operation in case the channel condition of LP-WUS is not good enough.**   * **Details of fallback mechanisms can be discussed further.** |

### **R1-2406764 MediaTek Inc.**

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| **Proposal 1: Support multiple minimum time gaps in case additional sleep patterns in DRX active time are needed for MR.**  **Proposal 2: Clarify how QCL information can be used for LPWUR in FR1 with 1 RX.**  **Proposal 3: Consider LP-CORESET with 11 or 12 PRBs and more than 3 symbols of duration, where UE can monitor LPWUS with a periodicity.**  **Proposal 4: Support Option 2: all activated serving cells for simplicity.** |

### **R1-2406852 Apple**

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| **Observation 1: Option 1-1 and Option 1-2 can achieve similar latency if LP-WUS monitoring periodicity in Option 1-2 is configured as the same as C-DRX cycle in Option 1-1.**  **Observation 2: In terms of PDCCH monitoring timers triggered by LP-WUS, Option 1-1 simpler operations compared with Option 1-2, while Option 1-2 needs to introduce new timers.**   * **For Option 1-1, only drx-onDurationTimer needs to be activated by LP-WUS, no change to other timer behaviors.** * **For Option 1-2 (both 1-2-1 and 1-2-2),  a new timer should be defined based on the LP-WUS triggering for PDCCH monitoring regardless of the drx-onDurationTimer.**   **Observation 3: Option 1-2-1 can be viewed as a combination of Option 1-1 and Option 1-2-2, where one LP-WUS configuration triggers legacy drx-onDurationTimer and the other LP-WUS configuration triggers the new timer.**  **Observation 4: Option 1-1 and Option 1-2 can achieve similar power saving gain if measurement requirement based on C-DRX cycle can be relaxed in Option 1-1.**  **LP-WUS triggering PDCCH monitoring**  **Proposal 1: Consider a unified design for Option 1-1 and 1-2 to achieve the same power saving gain through one of the following alternatives:**   * **Alt 1: Support Option 1-1 with one LP-WUS configuration, further consider measurement requirement relaxation for UE power saving.** * **Alt 2: Support Option 1-2-2 with one LP-WUS configuration, where LP-WUS monitoring periodicity is configured as an integer fraction of the C-DRX cycle, or C-DRX cycle is configured as multiples of LP-WUS monitoring periodicity.**   **Proposal 2: If both Option 1-1 and Option 1-2-2 are supported, further consider the support of Option 1-2-1, achieved by combination of Option 1-1 and Option 1-2-2.**   * **FFS: additional details when both LP-WUS for Option 1-1 and Option 1-2-2 are configured.**   **Proposal 3: If Option 1-2 is supported, the PDCCH monitoring duration triggered by LP-WUS is included in C-DRX Active Time.**  **Proposal 4: Option 1-3 is updated as:**   * **Option 1-3: LP-WUS monitoring inside ~~at least legacy~~ C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.**   **LP-WUS activation/deactivation**  **Proposal 5: For Option 1-1 and 1-2, activation/deactivation of LP-WUS monitoring is based on configuration, i.e. Option 1 (No additional indication/condition are introduced for activation/deactivation of LP-WUS monitoring).**  **Proposal 6: For Option 1-3, L1/L2 signaling based activation (Option 2) or timer-based activation (Option 3) of LP-WUS monitoring should be considered.**   * **FFS: Whether LP-WUS can be monitored when a PDCCH monitoring timer is extended and covers the LP-WUS configured for option 1-1/1-2**   **Proposal 7: For deactivation of LP-WUS monitoring under Option 1-3, which option should be considered depends on the relationship of LP-WUS and PDCCH monitoring:**   * **Case A: UE switches between LP-WUS monitoring and PDCCH monitoring, Option 4 (based on implicit indication/condition) can be considered.** * **Case B: UE can keep monitoring LP-WUS while monitoring PDCCH , Option 2 (L1/L2 signaling) is needed.**   **Minimum time gap**  **Proposal 8: If both Option 1-1/1-2 and 1-3 are supported, UE could report 2 values of minimum gap according to different sleep modes, otherwise, if either Option 1-1/1-2 or Option 1-3 is supported, only single minimum time gap needs to be reported.**  **LP WUS MO**  **Proposal 9: If Option 1-1 is supported, a time window for LP-WUS monitoring can be configured, otherwise no explicit configuration of time window is needed.**  **LP-WUS with CA**  **Proposal 10: Support LP-WUS triggerring all activated serving cells (Option 2), considering impact on UE complexity as well a s NW signaling overhead.** |

### **R1-2406883 Sharp**

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| **Observation 1: DCI format 0\_1/1\_1 can also provide the function of dormancy indication. whether including dormancy indication in LP-WUS needs further study.**  **Proposal 1: Support group cast LP-WUS for UE in connected mode.**  **Proposal 2: LP-WUS procedures Option 1-1 ,which replaces DCP functionality, can be used as a baseline for UE in connected mode.**  **Proposal 3: Further consider the combination of Option 1-1 and Option 1-2-1 and the combination of Option 1-1 and Option 1-3 for UE in connected mode.**  **Proposal 4: Support LP-WUS for UE configured with CA in connected mode.**  **Proposal 5: Support Option 1, i.e. including indication for one or more serving cells in a LP-WUS .**  **Proposal 6: Consider both RRC signaling and L1/L2 command for activation and deactivation of LP-WUS monitoring.** |

### **R1-2406943 NTT DOCOMO, INC.**

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| **Proposal 1: From RAN1 perspective,**   * **Support at least Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer**   + **This option may replace DCP functionality** * **Further consider unified Option 1-2-2 + 1-3: LP-WUS monitoring irrespective of legacy C-DRX active time**   + **Option 1-2-2: LP-WUS monitoring outside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.**   + **Option 1-3: LP-WUS monitoring inside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.**   **Observation 1: Prior to discuss candidate time gap values** **between LP-WUS reception and PDCCH monitoring, RAN1 needs to down-select LP-WUS procedures to trigger PDCCH monitoring**  **Proposal 2: Consider TCI framework for CORESET as baseline for LP-WUS: RRC configured K TCI states and MAC-CE activates one of them**   * **FFS value range of K** * **FFS timeline to apply the activated TCI state**   **Proposal 3: To cover as many LP-WUS UEs as possible, study the following options:**   * **Option 1: A bitmap with each bit corresponding to [one or more] UEs** * **Option 4: Multiple codepoint values with each corresponding to [one or more] UE(s)** * **Option 5: Multiple bit blocks with each corresponding to [one or more] UE(s)**   **Proposal 4: The following two options can be merged into one option:**   * **Option 4: Multiple codepoint values with each corresponding to [one or more] UE(s)** * **Option 5: Multiple bit blocks with each corresponding to [one or more] UE(s)**   **Proposal 5: LP-WUS works when UE is configured with CA in RRC CONNECTED mode**   * **LP-WUS indication is applicable to all activated serving cells in the same DRX group(s), if configured** * **For dual DRX groups, further consider following options**   + **Option 1: LP-WUS monitoring/indication is applied per DRX group**   + **Option 2: LP-WUS monitoring on one of DRX group, LP-WUS indication to either or both DRX group(s)**   **Proposal 6: For RRC CONNECTED mode, when UE is configured with LP-WUS by gNB RRC signaling, UE is expected to monitor LP-WUS according to the LP-WUS monitoring configuration**  **Proposal 7: For RRC CONNECTED mode, when UE detects a LP-WUS indicating the UE to wake-up, UE monitors PDCCH, and UE is not required to monitor LP-WUS during the PDCCH monitoring**  **Proposal 8: From RAN1 perspective, when LP-WUS monitoring is enabled for RRC CONNECTED mode, PDCCH monitoring is resumed when LP-WUS monitoring is deactivated by additional indication/condition (if supported)**  **Observation 2: Prior to discuss coexistence with existing features (PDCCH skipping, SSSG switching, cell DTX), RAN1 needs to discuss procedures to trigger PDCCH monitoring** |

### **R1-2407042 Qualcomm Incorporated**

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| **Observation 1:**   * **For Option 1-1, legacy RRC parameters for C-DRX configuration can be re-used**   + ***drx-OnDurationTimer, drx-LongCycleStartOffset*, *drx-SlotOffset*, *shortDRX* gives the understanding of legacy C-DRX active time**   + ***drx-OnDurationTimer*, *drx-InactivityTimer*, *drx-RetransmissionTimerDL*, *drx-RetransmissionTimerUL*, *drx-HARQ-RTT-TimerDL*, *drx-HARQ-RTT-TimerUL*, etc, enables PDCCH monitoring window extension same as in the legacy C-DRX configuration** * **LP-WUS monitoring with Option 1-1 in connected mode offers significant power saving gain for FR2**   **Observation 2:**   * **For Option 1-2, MAC timer based PDCCH monitoring window control is preferable**   + **RRC parameters to control the window for PDCCH monitoring for MAC are necessary, similar to *drx-OnDurationTimer*, *drx-InactivityTimer*, *drx-RetransmissionTimerDL*, *drx-RetransmissionTimerUL*, *drx-HARQ-RTT-TimerDL*, *drx-HARQ-RTT-TimerUL*, etc, in the legacy C-DRX configuration**     - **Either re-using legacy C-DRX parameters or introducing new parameters separately is to be considered**   + **The difference between Option 1-1 and Option 1-2 is that Option 1-2 allow more granular start occasions of ON-duration timer compared to Option 1-1 in which ON-duration is restricted by C-DRX cycle/offset determined by *drx-LongCycleStartOffset*, *drx-StartOffset*, and *drx-SlotOffset***   **Observation 3:**   * **For Option 1-3, legacy RRC parameters for C-DRX configuration can be re-used**   + ***drx-OnDurationTimer, drx-LongCycleStartOffset*, *drx-SlotOffset*, *shortDRX* gives the understanding of legacy C-DRX active time**   + ***drx-InactivityTimer*, *drx-RetransmissionTimerDL*, *drx-RetransmissionTimerUL*, *drx-HARQ-RTT-TimerDL*, *drx-HARQ-RTT-TimerUL*, etc, enables PDCCH monitoring window extension same as in the legacy C-DRX configuration**   **Proposal 1:**   * **At least support Option 1-1** * **Further study Option 1-2 and Option 1-3**    + **Check the performance benefits and standardization impacts**   + **Discuss if observation 2 and observation 3 are common understanding**   **Proposal 2:**   * **Minimum time gap between LP-WUS reception and MR to start PDCCH monitoring is further discussed once the other details such as LP-WUS design, PDCCH triggering procedure, etc, are clear**   **Proposal 3:**   * **Confirm that a UE can trigger recovery from beam failure or radio link failure even when the UE monitors LP-WUS and does not monitor PDCCH**   + **Once the UE triggers the recovery, the UE autonomously activate PDCCH monitoring to receive the response to the recovery request** * **Additionally, allow a UE to autonomously fallback from LP-WUS monitoring to PDCCH monitoring when the channel/beam quality is not satisfactory for successful LP-WUS reception**   **Observation 4:**   * **For Option 1-1 and Option 1-3, autonomous fallback from LP-WUS monitoring to PDCCH monitoring in C-DRX active time can be enabled without specific handling**   + **It is beneficial to consider UE assistance information to let network know whether the UE is in LP-WUS coverage or not** * **For Option 1-2, autonomous fallback from LP-WUS monitoring to PDCCH monitoring in C-DRX active time may need specific handling**   + **The handling can be e.g., L1/L2 dynamic report of UE status (e.g., indicating whether the UE monitors LP-WUS or the UE fallback to PDCCH monitoring based on C-DRX configuration)**   **Observation 5:**   * **For Option 1-1 or Option 1-3, additional activation/deactivation signalling or timer may not be much essential. Gain should be clear if additional activation/deactivation is to be introduced.** * **For Option 1-2, if the L1/L2 dynamic report of UE status (e.g., indicating whether the UE monitors LP-WUS or the UE fallback to PDCCH monitoring based on C-DRX configuration) is introduced, network may want to enable activation/deactivation of LP-WUS monitoring based on L1/L2 signalling.**   **Proposal 4:**   * **Introduce RRC configuration enabling/disabling skipping of CSI/BM measurement reporting during the time that the UE does not monitor PDCCH**   + **At least for periodic CSI, periodic L1-RSRP, and periodic L1-SINR reporting**   **Proposal 5:**   * **X = 8 as working assumption**   + **Revisit the value depending on the progress for idle/inactive mode, if necessary** * **If LP-WUS is based on codepoint/sequence (not based on bit-map), for connected mode,**   + **UE is configured to monitor LP-WUS for one or multiple sequences that trigger PDCCH monitoring of the UE**     - **Maximum number of sequence(s) that the UE can monitor for a LP-WUS is per UE capability**   **Proposal 6:**   * **For LP-WUS in CONNECTED mode**   + **Re-use TCI-state framework of CORESET/PDCCH for LP-WUS**   + **QCL source of a LP-WUS is either SSB or CSI-RS**   **Proposal 7:**   * **As baseline, LP-WUS on a serving cell is configured within active DL BWP of the serving cell**    + **FFS: outside active DL BWP of the serving cell (as optional UE capability)**   **Proposal 8:**   * **For a UE configured with DC, support LP-WUS monitoring on a serving cell per cell-group** * **For a UE configured with CA without dual-DRX groups, support LP-WUS monitoring on a serving cell that triggers PDCCH monitoring on all the serving cells** * **For a UE configured with CA with dual-DRX groups, support LP-WUS monitoring on a serving cell per DRX group**   + **Opt.1: LP-WUS is configured to be monitored per DRX group**     - **For dual DRX groups, LP-WUS monitoring is configured per DRX group**     - **LP-WUS monitored on a cell within a DRX group triggers PDCCH monitoring on the cell of the DRX group**   + **Opt.2: LP-WUS carries an indication for which DRX group(s) it triggers PDCCH monitoring** |

### **R1-2407061 Ericsson**

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| Observation 1 Option 1-1 configured with frequent DRX cycle can achieve most of the gains achievable by Option 1-2 without the additional complexity.  Observation 2 There is no issue for Option 1-1 on coexistence with existing power saving techniques like PDCCH skipping and SSSG switching. While for Option 1-2-1 and Option 1-2-2, the specification impact should be studied further.  Proposal 1 Only duty-cycled LP-WUS operation is supported in Rel-19.  Proposal 2 Support Option 1-1: LP-WUS monitoring for connected mode is configured only when C-DRX is configured. LP-WUS detection triggers PDCCH monitoring by starting drx-OnDurationTimer (configuration details can be discussed further RAN2).  Proposal 3 LP-WUS monitoring is activated/deactivated via dedicated RRC signaling.  Proposal 4 Further study how to support LP-WUS operation RRC connected mode with small payload size per LP-WUS transmission (e.g., no more than 8 bits).  Proposal 5 LP-WUS and DCP are independent features which should not be configured simultaneously.  Proposal 6 A time window could be configured which contains multiple LP-WUS monitoring occasions.  Proposal 7 The periodicity of LP-WUS monitoring should be derived from DRX cycle, at least for Option 1-1.  Proposal 8 LP-WUS should share the same QCL source with PDCCH. |

### **R1-2407104 TCL**

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| **Proposal 1: Support multiple values of minimum time gap and one of the values is reported by UE capability.**  **Proposal 2: gNB configures time offset(s) to determine a time window for the UE to monitor LP-WUS before the start of *drx-onDurationTimer*.**  **Proposal 3: The content of LP-WUS for connected states may include:**   * **Cell information and Temporary subgroup ID for UEs in connected mode** * **Indication field to wake up the MRs of UEs for PDCCH monitoring**   **Proposal 4: The following fallback mechanism should be supported:**   * **Deactivation of LP-WUS monitoring and resume PDCCH monitoring by timers.** * **Deactivation of LP-WUS monitoring and resume PDCCH monitoring by UL signaling including SR, BSR, PRACH, CG PUSCH.**   **Proposal 5: LP-WUS can be configured together with Cell DTX.**  **Proposal 6: At least support transmitting HARQ-ACK when LP-WUS indicates no PDCCH monitoring. Study whether or not transmitting CSI reporting and SRS when the UE MR is in light/micro sleep state.** |

# RAN1 agreements

### **RAN1#116**

**Agreement**

* For RRC CONNECTED mode, from RAN1 perspective, further study following LP-WUS procedures to trigger PDCCH monitoring:
  + Case 1: PDCCH monitoring is triggered by LP-WUS with C-DRX configuration
    - Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.
      * This option may replace DCP functionality
    - Option 1-2: LP-WUS monitoring outside C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.
      * PDCCH monitoring possibly irrespective of drx-onDurationTimer
    - Option 1-3: LP-WUS monitoring inside C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.
  + Case 2: PDCCH monitoring is triggered by LP-WUS without C-DRX configuration. LP-WUS can be monitored at any time according to the LP-WUS monitoring configuration
    - FFS duty-cycled and/or continuous LP-WUS monitoring
* Combination of options in Case 1 and combination of options in Case 1 and Case 2 are not precluded.

**Agreement**

For RRC CONNECTED mode, maximum number of LP-WUS information bits is up to X bits

* FFS value X, which is no more than [8 or 16]

**Agreement**

For RRC CONNECTED mode, minimum time gap between LP-WUS reception and MR to start PDCCH monitoring is introduced considering at least following

* LP-WUS processing time
* MR transition time for ramp up
* Time/frequency synchronization of MR
* FFS whether UE can report supported minimum time gap from candidate values

FFS: Whether the minimum time gap values can be more than one

**Agreement**

For RRC CONNECTED mode, from RAN1 perspective,

* PDCCH monitoring triggered by LP-WUS is enabled/disabled by gNB RRC signaling
  + FFS whether to support UE assistance.
* LP-WUS monitoring by UE is known to gNB.
  + FFS whether implicit/explicit indication from UE is necessary
* In case LP-WUS monitoring is enabled, following options are further studied
  + Option 1: No additional indication/condition are introduced for activation/deactivation of LP-WUS monitoring
  + Option 2: Activation/deactivation of LP-WUS monitoring by gNB L1/L2 signaling with or without UE assistance.
  + Option 3: Activation/deactivation of LP-WUS monitoring based on condition(s), such as timer.
  + Option 4: Activation/deactivation of LP-WUS monitoring based on implicit indication/condition, e.g. UL transmission.

### **RAN1#116bis**

**Agreement**

Update the following agreement in RAN1#116 in red:

**Agreement**

* For RRC CONNECTED mode, from RAN1 perspective, further study following LP-WUS procedures to trigger PDCCH monitoring:
  + Case 1: PDCCH monitoring is triggered by LP-WUS with C-DRX configuration
    - Option 1-1: LP-WUS monitoring according to the LP-WUS monitoring configuration before drx-onDurationTimer to trigger the starting of the drx-onDurationTimer.
      * This option may replace DCP functionality
    - Option 1-2: LP-WUS monitoring outside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.
      * PDCCH monitoring possibly irrespective of drx-onDurationTimer
        + Option 1-2-1: PDCCH monitoring may be additionally triggered based on legacy C-DRX cycle and drx-onDurationTimer when monitoring LP-WUS

If this is adopted, it should be configured together with Option 1-1 to achieve power saving gain compared to legacy C-DRX

* + - * + Option 1-2-2: PDCCH monitoring is not triggered by legacy C-DRX cycle and drx-onDurationTimer when monitoring LP-WUS
    - Option 1-3: LP-WUS monitoring inside at least legacy C-DRX active time according to the LP-WUS monitoring configuration to trigger PDCCH monitoring.
  + ~~Case 2: PDCCH monitoring is triggered by LP-WUS without C-DRX configuration. LP-WUS can be monitored at any time according to the LP-WUS monitoring configuration~~
    - ~~FFS duty-cycled and/or continuous LP-WUS monitoring~~
* Combination of options in Case 1 ~~and combination of options in Case 1 and Case 2 are not precluded~~ should be considered.
* RAN1 does not discuss C-DRX related timers other than drx-onDurationTimer, this topic is up to RAN2
* Note: Above does not preclude to support fallback mechanism to trigger PDCCH monitoring, if any

### **RAN1#117**

**Agreement**

For RRC CONNECTED mode, support UE capability report for determination of minimum time gap between LP-WUS reception and MR to start PDCCH monitoring.

* FFS: exact value(s) of the minimum time gap
* FFS: support of multiple minimum time gaps
* FFS whether the reported value includes the duration for time/frequency synchronization of MR

**Agreement**

For LP-WUS monitoring in RRC CONNECTED mode, a LP-WUS is QCLed with existing NR signal/channel/CORESET for the TCI state

* FFS which existing NR signal/channel/CORESET is the QCL source of LP-WUS
* FFS exact definition of QCL relationship between LP-WUS and existing NR signal/channel/CORESET

**Agreement**

LP-WUS monitoring occasions (MOs) are configured by RRC, where UE can monitor for LP-WUS transmission in RRC CONNECTED mode.

* FFS whether to define a time window for MOs
* It is at least supported that a UE can monitor MOs with a periodicity.
  + FFS details of the periodicity, e.g. derived from DRX cycle, separately configured

**Agreement**

* Study whether/how LP-WUS works when UE is configured with CA in RRC CONNECTED mode
  + FFS: The cell(s) where PDCCH monitoring triggered by a LP-WUS is applicable
    - Option 1: one or more serving cells based on gNB indication/configuration
    - Option 2: all activated serving cells
    - Note: other options are not precluded

**Agreement**

For RRC CONNECTED mode, LP-WUS can be configured without following existing features.

* + Rel-16 DCP
  + Rel-17 PDCCH skipping
  + Rel-17 SSSG switching
  + Rel-18 cell DTX

Further study whether/how LP-WUS works with following existing features (PDCCH skipping, SSSG switching, cell DTX)