**3GPP TSG-RAN WG2 Meeting #123bis R2-230xxxx**

**Xiamen, China, 9th – 13th Oct. 2023**

Source: vivo

Title: Summary of discussions on open issues for LP-WUS

Agenda Item: 7.22.1

Document for: Discussion and Decision

# Introduction

This document aims to facilitate the discussion on open issues for LP-WUS, as per the following e-mail discussion:

* [Post123bis][563][LP-WUS] R2 Text Proposal (vivo)

 Scope: Take agreements into account, propose/converge on how to capture in the TR. identify related open issues. Can also include some limited scope for Idle mode not explicitly agreed at current meeting, e.g. describe the general dependency LP-WUS information carrying capability -> R2 related functionality, for confirmation/agreement next meeting. Ambition level limited.

 Intended outcome: Text Proposal to TR, possible complemented by proposals relating to open issues, alternatives etc

 Deadline: Long

In this document, companies are requested to provide their input for some of the open issues, mainly related to SI completion.

1. Contact information

Please provide your contact information in the below table:

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| --- | --- |
| **Company** | **Name and email address** |
| vivo | Chenli (chenli5g@vivo.com) |
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# Discussion

* 1. Idle/Inactive mode issues

**Issue 1 How to progress network awareness of LP-WUS monitoring in idle/inactive mode?**

Regarding whether there is need for the network to be aware of whether the UE is monitoring LP-WUS or not in idle/inactive mode, there are some RAN2 impacts:

* On one hand, if the network is aware of UE monitoring of LP-WUS or not, it is beneficial for the network on resource efficiency. For example, the network needs not send LP-WUS signaling if the network knows the concerned UE is not monitoring LP-WUS. The radio resource for sending LP-WUS can be saved.
* On the other hand, to make the network know whether the UE is monitoring LP-WUS or not, UE needs to report its power state when entering/exiting condition is fulfilled. Besides, the reporting should be performed only after security has been established between UE and the network to avoid potential attacks from wicked UEs. Hence, the reporting of monitoring LP-WUS will cause heavy signaling overhead and extra power consumption.

**Rapporteur thinks there are several way forwards on this issue:**

* WF 1: Capture the corresponding pros/cons in the TR for the network to be aware of whether the UE is monitoring LP-WUS or not, and continue to discuss the details in WI, if it is included. Please specify other impacts, if identified.
* WF 2: Capture nothing in the TR, and discuss it in WI (Rapporteur assumes it is an essential issue).
* WF 3: Determine one of the options in study item phase. Please specify whether the network to be aware of whether the UE is monitoring LP-WUS or not.
* WF 4: Others, please specify.
1. **Companies are invited to provide your views on how to progress progress network awareness of LP-WUS monitoring in idle/inactive mode.**

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| **Company’s name** | **WF(s)** | **Comments, if any** |
| Nokia, Nokia Shanghai Bell | WF 1 | If the UE reports LP-WUS monitoring entering/exiting condition fulfilment then frequent reporting should be avoided.  |
| Lenovo | WF 1 | Agree with Nokia |
| ZTE | WF 1 | We are not so crystal clear on Nokia’s comment. If UE is allowed to report LP-WUS monitoring entering/exiting condition fulfilment, we assume such report may be frequent as UE needs to report at each time when entering or exiting condition is fulfilled? |
| Sony | WF 1 |  |
| LGE | WF1 | It seems premature to exclude a certain option at this stage. We prefer to continue to discuss the details of each option or compromise in WI phase. |
| Huawei, HiSilicon | WF 1 or WF 3 | It would be good to capture something in the TR since this is discussed during SI, WF 1 is ok for us.If we go for WF 3, UE reporting consumes more power for IDLE state, but the reporting may be simpler for INACTIVE state due to SDT-like method. Thus, we think for IDLE state, it can be the baseline that network is not aware of LP-WUS monitoring by UE, for INACTIVE state, it can be further studied in WI whether/how the network knows LP-WUS monitoring by UE. |
| Xiaomi | WF1 |  |
| Ericsson | WF1 |  |
| vivo | WF1 |  |

**Summary:**

(to be added after the discussion)

**Issue 2: How to progress the extent UE maintains valid SI in case UE’s MR is in ultra-deep sleep state?**

In RAN2#123bis meeting, it is *FFS to what extent UE maintains valid SI in case UE’s MR is in ultra-deep sleep state*. In case UE’s MR enters into ultra-deep-sleep state, it should be studied whether the UE needs to maintain valid SI during ultra-deep sleep, including the scenarios of SI change or cell selection/reselection. The following options could be considered:

* Option 1: UE maintains valid SI during ultra-deep sleep.
* Option 2: UE doesn’t maintain valid SI during ultra-deep sleep.

Option 1 could achieve less paging latency with some power consumption since the MR may need to wake up to receive the updated SI, while option 2 has more power saving gain while the latency may be longer since the UE needs to receive SI after waking up before paging reception or initiating the RRC connection setup. Moreover, Option 2 is not consistent with the legacy and more specification changes are foreseen.

**Rapporteur thinks there are several way forwards on this issue:**

* WF 1: Capture the corresponding impacts in the TR for both solutions, and continue to discuss the details in WI. Please specify other impacts, if identified.
* WF 2: Capture nothing in the TR, and discuss it in WI (Rapporteur assumes it is an essential issue).
* WF 3: Determine one of the options in study item phase. Please specify whether maintains valid SI during ultra-deep sleep.
* WF 4: Others, please specify.
1. **Companies are invited to provide your views on how to progress the extent UE maintains valid SI in case UE’s MR is in ultra-deep sleep state.**

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| **Company’s name** | **WF(s)** | **Comments, if any** |
| Nokia, Nokia Shanghai Bell | WF 3 | We think that the should UE maintain valid SI during ultra-deep sleep. NW can wake-up the UE using LP-WUS and then UE reads paging where SI change is indicated. With this impact is minimal.  |
| Lenovo | WF 1 |  |
| ZTE | WF 3 | Agree with Nokia’s suggestion. |
| Sony | WF 1 | Depends on use case. |
| LGE | WF3 | The paging monitoring can be delayed for up to maximum repetition periodicity of SIB1, 160ms. Since SI is not updated frequenty, additional power saving in option 2 would be marginal and it cannot justify such severe delay. |
| Huawei, HiSilicon | WF 4 | For Option 1, If the UE is required to maintain valid system information, it leads to more frequent switch to MR which consumes more power, and not all the changed system information is useful if the UE stays on LR. However, for Option 2, if there is LP-WUS related SI, the UE should maintain the latest information, otherwise the UE would use the out-of-date LP-WUS related configuration and consequently cannot detect the LP-WUS correctly. Thus, we prefer Option 3:* Option 3: The LP-WUS related system information should be maintained when UE is monitoring LP-WUS by LR. Whether/which/how other SI needs to be maintained to reduce the power consumption and access latency can be further studied during SI.

Considering we may not have enough time to downselect during SI, maybe we can capture all the options in the TR. |
| Xiaomi | WF1 | We see some benefit in option2. Both can be considered in the TR. |
| Ericsson | WF3 or WF1 | We think that the UE should maintain up to date information. Note that a similar mechanism to what we have introduce for eDRX do not work since there is means in such scenario if it turns out that the information to be updated is “critical”, e.g., paging configuration related.Then whether/how much it would be beneficial depends on whether system information update notification is to be carried as part of LP-WUS payload. But even if it is not so, it should be possible for the network to page UEs prior to an update if there is a need to notify UEs. |
| vivo | WF1 |  |

**Summary:**

(to be added after the discussion)

**Issue 3: How to progress whether include SI change notification and/or ETWS/CMAS in LP-WUS?**

In order to achieve the reachability for SI change notification/ETWS/CMAS for UE in ultra-deep sleep, there could be two alternatives to notify the SI change or ETWS/CMAS for the UEs in ultra-deep sleep:

* Alt 1: based on legacy indication in short message/paging, i.e. waking UE up by LP-WUS (e.g., waking up all the subgroups in LP-WUS), and receiving the notification of SI change or ETWS/CMAS as in legacy.
* Alt 2: introduce direct notification indicator(s) in LP-WUS signal, i.e. waking the UE up to receive updated SI, or ETWS/CMAS directly.

Alt 1 could save the overhead for the payload of WUS signal, but there may be the issue of missing short message in the worst case. Alt 2 could reduce the latency for reception, especially for ETWS/CMAS, and also save some power due to no need to receive short message. But it needs more payload in LP-WUS, which depends on the LP-WUS signaling design.

**Rapporteur thinks there are several way forwards on this issue:**

* WF 1: Capture the corresponding impacts in the TR for both solutions, and continue to discuss the details in WI. Please specify other impacts, if identified.
* WF 2: Capture nothing in the TR, and discuss it in WI based on companies’ contribution.
* WF 3: Exclude Alt 2 in study item phase. (Rapporteur assumes Alt 1 should be supported by default)
* WF 4: Others, please specify.
1. **Companies are invited to provide your views on how to progress whether include SI change notification and/or ETWS/CMAS in LP-WUS.**

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| **Company’s name** | **WF(s)** | **Comments, if any** |
| Nokia, Nokia Shanghai Bell | WF 4 | Alt 1 only should be specified where based on legacy indication in short message/paging, i.e. waking UE up by LP-WUS (e.g., waking up all the subgroups in LP-WUS), and receiving the notification of SI change or ETWS/CMAS as in legacy. We don’t see any issues with this. |
| Lenovo | WF 1 |  |
| ZTE | WF 4 | We don’t understand why Alt 2 should be supported by default since it relys on whether LP-WUS sequence allows such overhead?We support to only capture Alt1 in the TR for this aspect (as we assume Alt 1 should be supported by default). |
| Sony | WF4 | Agree with Nokia, btu think the not necessarily all subgroup needs to be woken up. Depends on use case whether device is dependent on PWS information or not. |
| LGE | WF4: exclude Alt 2. | Using legacy signal should be considered as a default. We cannot see any clear benefit of alt2.  |
| Huawei, HiSilicon | WF 1 | It would be good to capture something in the TR since this is discussed during SI. Alt 2 is better for performance but needs more payload in LP-WUS, but the payload is not determined yet, so this issue can be further discussed in WI after the payload is determined. |
| Xiaomi | WF4: exclude Alt 2. | Agree with LGE. |
| Ericsson | WF1 but | We agree that Alt1 should be considered as default. |
| vivo | WF1 |  |

**Summary:**

(to be added after the discussion)

* 1. Connected mode issues

According to the discussion in RAN2#123bis meeting on the connected mode [1], there are still some open issues need further discussion.

**Issue 4: How to progress LP-WUS configured/used together with Rel-16 DCP?**

Regarding the coexistence of LP-WUS and Rel-16 DCP, some solutions are discussed in [1]:

* Solution 1: Both LP-WUS and DCP can be configured for a UE. However, UE may use only one of them at any time, e.g. depend on network configuration or link quality, etc.
* Solution 2: LP-WUS is used in conjunction with DCP, e.g. LP-WUS first wakes up MR, which then monitors DCP.

Rapporteur thinks there are several way forwards on this issue:

* WF 1: Capture some (or all) solution(s) in the TR, and continue to discuss the details in WI, if it is included. Please specify which solution(s).
* WF 2: Capture nothing in the TR, and discuss it in WI, if it is included or based on companies contribution during WI.
* WF 3: Exclude this scenario during study item phase.
* WF 4: Others, please specify.
1. **Companies are invited to provide your views on how to progress LP-WUS configured/used together with Rel-16 DCP**

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| **Company’s name** | **WF(s)** | **Comments, if any** |
| Nokia, Nokia Shanghai Bell | WF 1  | We think that LP-WUS should work with or without DCP depending on the network configuration. If only LP-WUS is configured then LP-WUS wakes up MR, which then monitors PDCCH. In addition, if both LP-WUS and DCP are configured, there may be a case that the UE cannot receive LP-WUS (out of LP-WUS coverage), and the UE needs to switch back to DCP operation. When both are configured, it sould also be possible that LP-WUS first wakes up MR, which then monitors DCP.  |
| Lenovo | WF1 |  |
| ZTE | WF1 | But we are not fan for Solution 1 and think it’s not so reasonable. In our assumption, either UE can only use LP-WUS (that means DCP can be replaced by LP-WUS), or LP-WUS is just to wake up UE and then UE uses DCP as legacy. |
| Sony | WF1 | We think LP-WUS should work as an alternative to DCP not as an additional step for wake-up. |
| LGE | WF1 | This is SI phase. We can capture all options in the TR. |
| Huawei, HiSilicon | WF 1 | It depends on the basic procedure for LP-WUS, if the LP-WUS is not combined with C-DRX or transparent to MAC, then we don’t need to discuss this issue. So capturing solutions in the TR is enough. |
| Xiaomi | WF1 | Same view with ZTE.  |
| Ericsson | WF1 | LP-WUS and DCP should be considered as independent features. |
| vivo | WF1 |  |

**Summary:**

(to be added after the discussion)

**Issue 5: How to progress option 3 for the use of LP-WUS, i.e. the LP-WUS monitoring occasion is located after drx-onDurationTimer is started?**

This option was proposed by some companies in RAN2 and has been evaluated in RAN1 with some power saving gain for some scenario, e.g. in XR use case.

Rapporteur thinks there are several way forwards on this issue:

* WF 1: Capture this solution in the TR as one of the alternative to make the use of LP-WUS complete in connected mode, whether to continue to discuss it depends on study conclusion or WI scope.
* WF 2: Capture nothing in the TR, and discuss it in WI, if it is included.
* WF 3: Exclude this scenario during study item phase.
* WF 4: Others, please specify.
1. **Companies are invited to provide your views on how to progress option 3 for the use of LP-WUS, i.e. the LP-WUS monitoring occasion is located after drx-onDurationTimer is started?**

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| **Company’s name** | **WF(s)** | **Comments, if any** |
| Nokia, Nokia Shanghai Bell | WF 1 | We are fine with capturing this because it has clear use case, e.g., XR traffic. |
| Lenovo | WF 2 | We think that monitoring for LP-WUS before the DRX onDuration Time is the most straightforward way to use LP-WUS in RRC\_CONNECTED. Also, the specification complexity for this option may be high. Hence, it is best to exclude this from SI phase and discuss it later in WI if included.  |
| ZTE | WF 2 or WF 3 | From RAN2 perspective, we hardly see the point of Option 3 “***LP-WUS monitoring occasion is located after drx-onDurationTimer is started***”, we assume it may be covered by Direction 3 and can be later discussed during WI, if needed. |
| Sony | TBD | Not clear which is option 3? Since not fully clear in ref [1]. |
| LGE | WF1 | This is SI phase. We can capture all options in the TR. |
| Huawei, HiSilicon | No strong view for WF 1-3 |  |
| Xiaomi | WF 3 | We do not see the benefit for XR jitter handling for this solution since R17 SSG switching can handle this. |
| Ericsson | WF2/3 | Not clear how WF2 and WF3 differ in practice considering that RAN2 cannot decide the scope of a potential follow up WI in Rel-19.  |
| vivo | WF1 | RAN1 has testified the option 3 has substantial power saving gain, hence we think it is worth to be discussed in WI. |

**Summary:**

(to be added after the discussion)

**Issue 6: How to progress the impact on SPS and CG for LP-WUS?**

This issue was proposed by some companies in RAN2#123bis in [1]. Some companies think the impact on SPS and CG for LP-WUS should be studied and captured in the TR.

Rapporteur thinks there are several way forwards on this issue:

* WF 1: Capture the impacts on SPS and CG for LP-WUS in the TR, and continue to discuss the details in WI, if it is included. Please specify what impact(s).
* WF 2: Capture nothing in the TR, and discuss it in WI, if it is included or based on companies contribution during WI.
* WF 3: Exclude this scenario during study item phase.
* WF 4: Others, please specify.
1. **Companies are invited to provide your views on how to progress the impacts on SPS and CG for LP-WUS?**

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| **Company’s name** | **WF(s)** | **Comments, if any** |
| NokiaNokia, Nokia Shanghai Bell | WF 1 | Given that LP-WUS wakes up the MR for the coming scheduling and latency matters, RAN2 need to consider both dynamic scheduling and CG/SPS based scheduling.  |
| Lenovo | WF 2 | We do think that this issue is relevant to be studied, but as there is less time left for the SI phase, we think this may be postponed to WI based on companies’ contribution.  |
| ZTE | WF 2 or WF 3 | In last meeting, RAN2 has already agreed LP-WUS indication in connected is to trigger MR PDCCH monitoring (not wake up MR).Moreover, we understand RAN1 has agreement that for RRC connected mode, Ultra-deep sleep state is not allowed for MR. So we don’t think UE needs to use LP-WUS to wake up UE’MR to transmit CG or receive SPS. For this aspect, UE can rely on legacy process (e.g., rely on UE’s implementation). |
| LGE | WF 3 | CG and SPS are mainly used for transmission of the periodic traffic. Considering that, we do not see an association between the LP-WUS and CG/SPS. In addition, considering the TU limitation in the SI phase, we may not have enough time to discuss the CG and SPS for LP-WUS. Thus, we do not need to capture it in the TR. |
| Huawei, HiSilicon | WF 4 | It is unclear what impact is since the whole procedure for LP-WUS is not clear. Maybe it is enough to just capture: The impact on SPS and CG for LP-WUS (if any) can be studied in WI. |
| Xiaomi | WF1 | The intention is to discuss that when the MR goes to micro deep sleep and no PDCCH monitoring is required unless triggered by LP-WUS, whether SPS and CG should be kept as activated or deactivated.We think that needs to be discussed. |
| Ericsson | WF2/3 | Not clear how WF2 and WF3 differ in practice considering that RAN2 cannot decide the scope of a potential follow up WI in Rel-19. |
| vivo | WF1 or WF 2  | We could discuss it in WI, and no need to capture it in TR. |

**Summary:**

(to be added after the discussion)

* 1. Others

If companies have any other issues to discuss/solve for LP-WUS, companies are requested to raise them here.

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| **Company’s name** | **Comments, if any** |
| Nokia, Nokia Shanghai Bell | When LP-WUS is deployed it can be assumed that not all the cells will support LP-WUS. In some NW implementations LP-WUS support can be introduced in some specific cells or frequency(s). For the UE supporting LP-WUS it would be more saving friendly to camp on the cell which is supporting LP-WUS. It can be assumed that from system perspective it would be beneficial if the UE always camps and starts the access on the best cell of the frequency to avoid interference. Different cell (re)selection enhancements could be studied for enabling that the UE camps on the cell supporting LP-WUS more often. |
| Lenovo | We think it might be beneficial to consider wake-up behaviour options for MR to ensure prolonged sleep of MR if the wake-up may not be urgent (e.g if MR needs to wake-up for UL transmission).  |
| ZTE | 1. For UE in idle or inactive mode, whether and how to cooperate R16/R17 relaxed neighbor cell measurement based on SSB with (relaxed) serving cell measurement based on LP-SS (if this is supported/configured).
2. In connected mode, gNB could activate LP-WUS per UE based on UE’s traffic and the power saving preferences. Moreover, gNB needs to transmit the LP-WUS for UE only if the UE is activated to use LP-WUS. Hence, it is essential or beneficial for gNB to acquire kind of assistance information about LP-WUS from UE, for example, whether UE desires a LP-WUS. Different from the case of UE in idle or inactive mode, it’s feasible or easy for UE in connected mode to report some assistance information to NW.
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# Conclusion

This contribution is the report of email discussion: xxxx with the following proposals:

# References

1. R2-2311336, Summary of [AT123bis][510][LP-WUS] connected mode (vivo), vivo