

3GPP TSG RAN Meeting #102

RP-232871

Edinburgh, Scotland, December 11-15, 2023

Agenda item: 9.1.1.6 Low-Power Wake-up Signal (LP-WUS)/Wake-up Receiver (WUR)

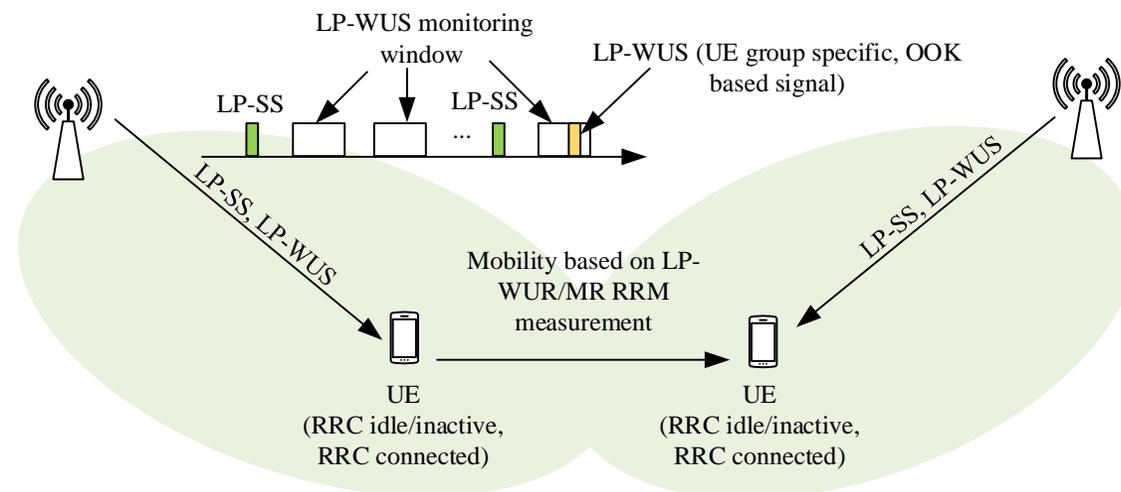
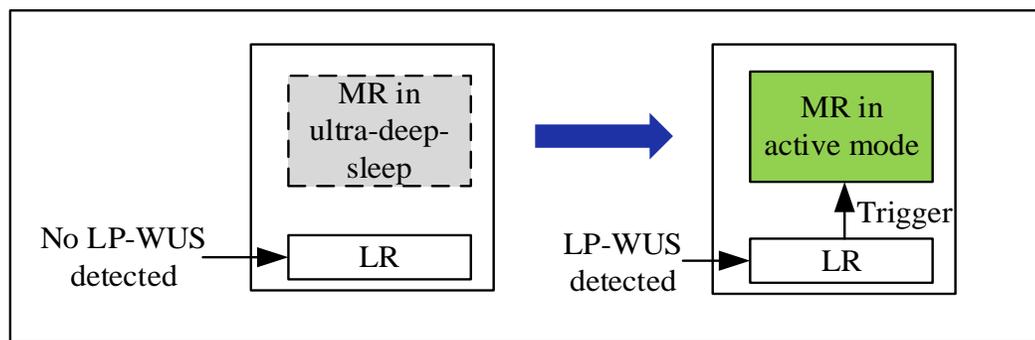
Low-power Wake-up Signal and Receiver for NR

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Motivation for LP-WUS/WUR

- ◆ In the Study Item of LP-WUS/WUR in Rel-18, the evaluation methodology & KPIs, receiver architectures of LP-WUR, L1 signal design, PHY and higher layer procedures have been studied.
- ◆ The primary target is supporting LP-WUS/WUR for power-sensitive, small form-factor devices including IoT use cases (such as industrial sensors, controllers and wearables). Other use cases are not precluded, e.g. XR/smart glasses, smart phones.
- ◆ As the outcome of RAN#101, the WI on LP-WUS/WUR has been listed as agreeable RAN1-led project in Chair summary (RP-232745). However, detailed objectives need to be discussed for waveform selection, LP-SS support, RRM measurement offloading and LP-WUS support.

MR power state transition triggered by LP-WUS/WUR



Waveform down-selection and LP-SS support

- ◆ In RP-232745, it is proposed to further down select waveform from Alt 1 and Alt 2:
 - Alt 1: Waveform-option-1 + waveform-option-3
 - Alt 2: Waveform-point-3 only
 - Waveform-option-1: OOK-1 and/or OOK-4, as described in section 7.2.1.1 (A)(D) in TR38.869.
 - Waveform-option-3: Harmonized design that accommodates OOK-1/OOK-4 and OFDM waveform, i.e., specified overlaid OFDM sequences over OOK symbol
- ◆ In RP-232745, it is also proposed to support LP-SS for RRC IDLE/INACTIVE, in addition to existing PSS/SSS, for LP-WUR that cannot receive existing PSS/SSS.
- ◆ Observation 1: in TR 38.869, three types of receiver architectures for OOK have been considered: RF envelope detection, heterodyne architecture with IF envelope detection, and homodyne/zero-IF architecture with baseband envelope detection, wherein detection of OFDM waveform may not be supported by some of the receiver types, e.g., receiver with RF envelope detection. Therefore, UE with these types of receiver may not be able to support waveform Alt2 and the PSS/SSS.
- ◆ **Proposal 1: for waveform down-selection, support waveform-option-1 + waveform-option-3, and waveform-option-3 is an optional feature that depends on UE capability.**
- ◆ **Proposal 2: support LP-SS for LP-WUR that cannot receive existing PSS/SSS.**

RRM measurement offloading

- ◆ In RP-232745, the following potential objectives for RRM measurement are proposed by chair:
 - For IDLE/INACTIVE operation, specify
 - UE serving cell RRM measurement offloaded from MR to LR
 - Further time domain relaxation (at least X times) of UE MR RRM measurement for both serving and neighbor cell measurement
 - X to be determined in the WI phase
 - Note: For CONNECTED mode, UE RRM/RLM/BFD/CSI measurements are performed by MR
- ◆ Observation 2: Offloading RRM measurement from MR to LR can further reduce the active time of MR, therefore the power consumption can be largely reduced in the RRC IDLE/INACTIVE mode. However, besides serving cell measurement, at least intra-frequency neighbor measurement (which has less impact on spec and UE complexity compared to inter-frequency measurement) can also be considered to further enhance the power saving gain.
- ◆ **Proposal 3: support RRM measurement on LP-SS by LP-WUR.**
- ◆ **Proposal 4: support RRM measurement offloaded from MR to LP-WUR for serving cell and intra-frequency neighbor cell.**
- ◆ **Proposal 5: support RRM measurement relaxation for MR.**

Support of RRC IDLE/INACTIVE and RRC CONNECTED modes

- ◆ In RP-232745, the following potential objectives for RRM measurement and L1/L2 procedures are proposed by chair:
 - To specify an LP-WUS design commonly applicable to both IDLE/INACTIVE and CONNECTED modes
 - For IDLE/INACTIVE mode, to specify procedures to allow UE MR paging monitoring triggered by LP-WUS
 - For CONNECTED mode, to specify procedures to allow UE MR PDCCH monitoring triggered by LP-WUS
- ◆ Observation 3: In TR 38.869, considerable power saving gains can be observed for both RRC IDLE/INACTIVE and RRC CONNECTED modes. To better exploit the benefit of LP-WUS, it is beneficial to support LP-WUS/WUR in both RRC IDLE/INACTIVE and RRC CONNECTED modes.
- ◆ **Proposal 6: support LP-WUS for both RRC IDLE/INACTIVE and RRC CONNECTED modes.**

Objectives for LP-WUS

- ◆ Specify signal generation for LP-WUS and LP-SS based on waveform-option 1 and waveform-option 3, including:
 - Signal generation for LP-WUS and LP-SS, including baseband signal generation, encoding, multiplexing with other signal/channels, etc.
- ◆ Specify L1 procedures to support LP-WUS/WUR, including:
 - UE monitoring configuration and monitoring procedure for LP-WUS
 - Synchronization and measurement procedure based on LP-SS
- ◆ Specify higher layer enhancement to support LP-WUS/WUR in RRC_IDLE/INACTIVE and RRC_CONNECTED, including:
 - Enhancement on paging/PEI monitoring behavior to support LP-WUS/WUR in RRC_IDLE/INACTIVE
 - Enhancement on C-DRX (with/without DCP) and PDCCH monitoring behavior to support LP-WUS/WUR in RRC_CONNECTED
 - Support of entry/exist condition of LP-WUS monitoring
 - LP-WUS content and LP-WUS grouping mechanism
 - Support of RRM measurement by LR (at least for serving cell and intra-frequency measurement), and relaxed RRM measurement by MR

Summary

- ◆ As the continuation from the Rel-18 SI, the work on LP-WUS/WUR should be done based on the outcome of the SI.
- ◆ All new functions including new receiver architecture shall be operated in a cell supporting legacy UEs, as confirmed in the SI.
- ◆ **Proposal 1: for waveform down-selection, support waveform-option-1 + waveform-option-3, and waveform-option-3 is an optional feature that depends on UE capability.**
- ◆ **Proposal 2: support LP-SS for LP-WUR that cannot receive existing PSS/SSS.**
- ◆ **Proposal 3: support RRM measurement on LP-SS by LP-WUR.**
- ◆ **Proposal 4: support RRM measurement offloaded from MR to LP-WUR for serving cell and intra-frequency neighbor cell.**
- ◆ **Proposal 5: support RRM measurement relaxation for MR.**
- ◆ **Proposal 6: support LP-WUS for both RRC IDLE/INACTIVE and RRC CONNECTED modes.**
- ◆ **Proposal 7: support the detailed objectives in slide 6.**

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