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Views on LP-WUS/WUR for Rel-19

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Motivations for Rel-19 LP-WUS/WUR

- UE energy saving is one of key aspects for battery-powered devices even in 5G network
  - Rel-18 LP-WUS/WUR study item is ongoing to study ultra-low power mechanism that can support low latency, e.g., lower than existing DRX operation

The study item includes the following objectives [1]

- Identify evaluation methodology (including the use cases) & KPIs [RAN1]
  - Primarily target low-power 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
- Study and evaluate low-power wake-up receiver architectures [RAN1, RAN4]
- Study and evaluate wake-up signal designs to support wake-up receivers [RAN1, RAN4]
- Study and evaluate L1 procedures and higher layer protocol changes needed to support the wake-up signals [RAN2, RAN1]
- Study potential UE power saving gains compared to the existing Rel-15/16/17 UE power saving mechanisms, the coverage availability, as well as latency impact of low-power WUR/WUS. System impact, such as network power consumption, coexistence with non-low-power-WUR UEs, network coverage/capacity/resource overhead should be included in the study [RAN1]
  - Note: The need for RAN2 evaluation will be triggered by RAN1 when necessary.

[1] RP-222644, “Revised SID: Study on low-power Wake-up Signal and Receiver for NR”, Vivo, RAN#97e, Sept. 12-16, 2022

Overview of Rel-18 SI

- Based on the SI outcome [1], following can be observed
  - LP-WUS design and waveform
    - » RAN1 studied coverage performance, spectral efficiency, etc. for different waveform candidates (i.e., OOK-1~OOK4, FSK-1/FSK-2, and OFDMA) , and each of the candidates has pros and cons
      - – OOK-based solution seems to have lowest power consumption compared to FSK/OFDM waveform
  - L1 procedures
    - » For IDLE/INACTIVE UEs, LP-WUS/WUR to trigger MR paging monitoring can provide significant UE power saving gain (up to more than 90%)
    - » For CONNECTED UEs, moderate UE power saving gain (up to more than 10%) can be observed across different types of scenarios by using LP-WUS to trigger MR PDCCH monitoring
  - RRM measurements
    - » At least for LP-WUR that cannot receive existing PSS/SSS, periodic LP-SS signal is beneficial both for RRM measurements and coarse time synchronization by LP-WUR

[1] R1-2308729, 3GPP TR 38.840, “Study on low-power wake up signal and receiver for NR (Release 18)”, V0.4.0 (2023-08).

Discussion for prioritization

- Based on research findings from the LP-WUS/WUR SI outcome, it is highly desired to specify further UE power saving enhancements in Rel-19
  - Only essential area should be specified for reasonable standardization workload

- Proposals for potential scope of Rel-19 WI
  - Unified design and mechanisms of LP-WUS/WUR for all RRC states
    - » Significant power saving gain can be achieved for RRC IDLE/INACTIVE mode rather than RRC CONNECTED mode
      - – LP-WUS/WUR for IDLE/INACTIVE modes should be prioritized
    - » Fundamental features of LP-WUS, i.e., indication to wake-up PDCCH monitoring, can be unified among all the RRC states
      - – LP-WUS/WUR for RRC CONNECTED mode brings power/latency saving benefits for smart phones and XR/smart glasses, i.e., major devices on the market today
  - OOK-based LP-WUS waveform
    - » If LP-WUS/WUR is motivated to achieve ultra-low power mechanisms rather than multifunctionally enhancements, OOK-based solution would be the best starting point for LP-WUS waveform
  - RRM measurements offloaded to LP-WUR
    - » Significant power saving gain can be achieved by RRM measurement performed by LP-WUR based on LP-WUS/LP-SS
      - – RRM measurement offloading for serving cell measurement should be prioritized

Proposed WI scope

- **Justification**
  - Rel-18 LP-WUS/WUR SI showed that substantial UE power saving gain can be achieved for different use cases, while keeping latency low
  - LP-WUS/WUR can further expand the application area of NR devices, e.g., for wearables, XR/smart glasses, and smart phones.

- **Objectives**
  - Specify LP-WUS physical design, including:
    - » LP-WUS waveform, channel coding, preamble generation, and payload contents [RAN1, RAN4]
      - – OOK-based waveform seems to be enough for LP-WUS waveform
    - » Periodic low-power synchronization signal (LP-SS), if needed [RAN1, RAN4]

  - Specify L1/L2 procedures for LP-WUS/WUR both for IDLE/INACTIVE mode and CONNECTED mode
    - » Synchronization procedure for LP-WUR [RAN1, RAN4]
    - » UE behavior and procedure for LP-WUS monitoring [RAN1, RAN2]
    - » UE behavior after LP-WUS detection [RAN1, RAN2]
    - » RRM measurement by LP-WUR [RAN4, RAN1]
    - » Activation/deactivation mechanism of LP-WUS monitoring [RAN1, RAN2, RAN4]

  - Specify RAN4 requirements related to LP-WUS/WUR