

3GPP TSG RAN Rel-19 workshop  
Taipei, June 15 - 16, 2023

Source: ZTE, Sanechips

Agenda: 5

RWS-230301

ZTE

Tomorrow never waits

## Views on LP-WUS in Rel-19



# Background

- In RAN #94 meeting, new study item on low-power Wake-up Signal and Receiver for NR was approved in RP-213645 and the latest revision was updated in RP-222644.
- **Objectives in SI**

The study item includes the following objectives:

- 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.

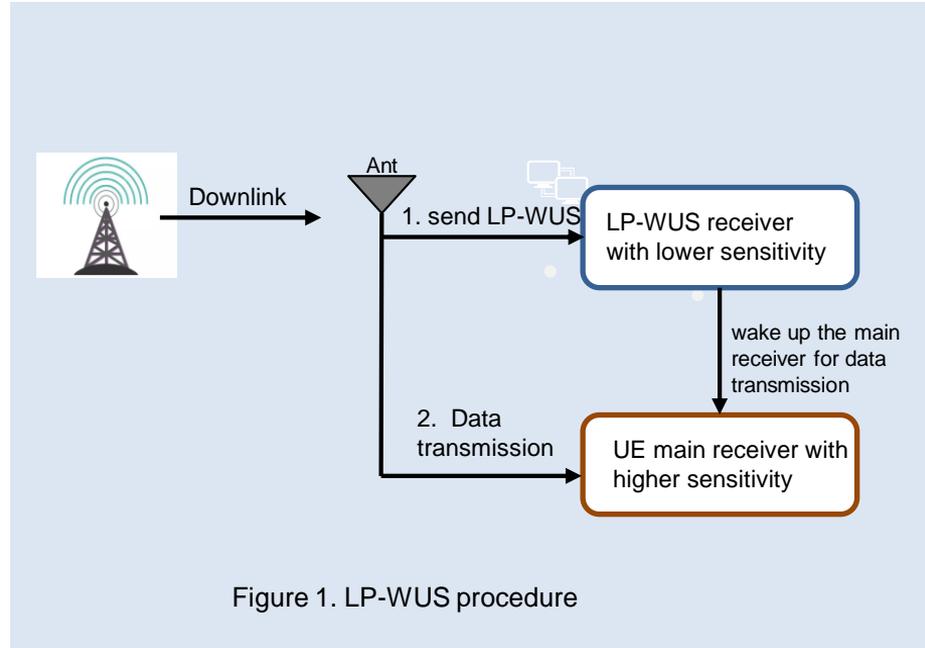


Figure 1. LP-WUS procedure

# Design target

## Use cases:

- IoT use cases (such as industrial sensors, controllers) and wearables are primarily targeted.
- eMBB UE/smart phones can be included.

## Power saving gain

- Substantial gains compared to the existing Rel-15/16/17 UE power saving mechanisms

## Latency requirement

- Reduce the latency brought by eDRX or DRX
  - In fire detection and extinguishment use case, fire shutters shall be closed and fire sprinklers shall be turned on by the actuators within 1 to 2 seconds from the time the fire is detected by sensors

## Coverage

- Satisfying the minimum coverage requirement to match the network deployment
- Larger coverage benefits more UEs from power saving

## System impacts

- Controlable/configurable by network
- Minimize the impacts on existing NW implementation

# Power consumption evaluation for idle/inactive mode

- The power consumption of the following four cases are evaluated and provided in Figure 2.
  - LP-WUS based paging procedure: always-on monitoring of LP WUS.
    - The relative power of LP WUS is 0.1 or 0.5
  - LP-WUS based paging procedure: duty-cycled monitoring of LP WUS
    - The relative power of LP WUS is 0.1 or 0.5
  - DRX with paging early indication (PEI)
  - eDRX with PEI

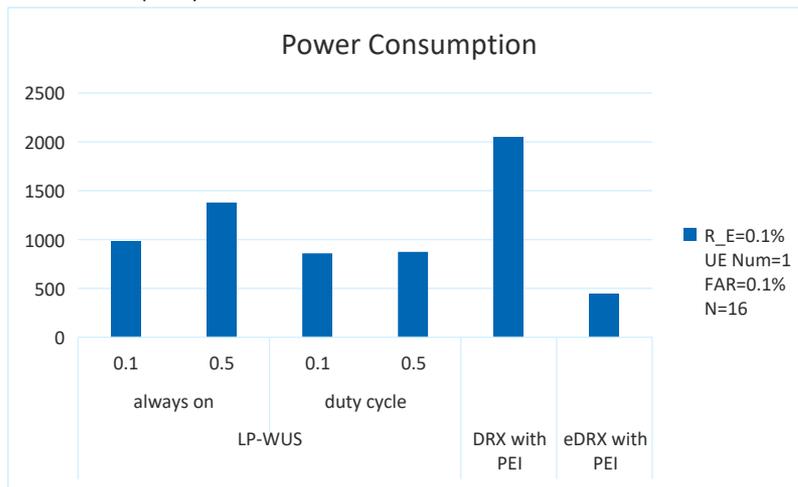
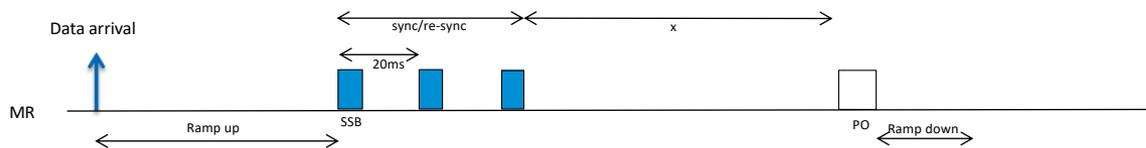


Figure 2: Power consumption evaluation results

**Observation 1:** For paging procedure in idle/inactive mode, LP-WUS based schemes have power saving gain compared with existing NR power saving mechanism(i.e., DRX with PEI).

# Latency evaluation for idle/inactive mode

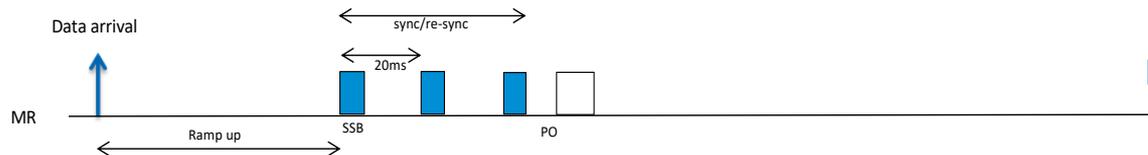
- For latency evaluation, the following two cases are evaluated:
  - Case 1: After main radio ramps up and performs sync/re-sync, UE monitors the legacy PO for paging as shown in Figure 3.



Latency= Time for main radio ramp-up +  
Time for sync/re-sync  
+ Delay from sync/re-sync to legacy PO

Figure 3: Latency for LP-WUS based on legacy PO mechanism

- Case 2: After main radio ramps up and performs sync/re-sync, UE monitors a dynamic PO for paging as shown in Figure 4.



Latency= Time for main radio ramp-up  
+ Time for sync/re-sync

Figure 4: Latency for LP-WUS based on dynamic PO mechanism

# Latency evaluation for idle/inactive mode

- Latency evaluation results are shown in Table 1

Table 1. Latency evaluation for LP-WUS and legacy DRX

| LP WUS: always-on monitoring |            | LP WUS: duty cycled(D/T=1ms/1.28s) monitoring |            | i-DRX (T=1.28s) | eDRX (T=61.44s) |
|------------------------------|------------|---|------------|-----------------|-----------------|
| Legacy PO                    | Dynamic PO | Legacy PO                                     | Dynamic PO |                 |                 |
| 1.38s                        | 0.45s      | 1.92s   | 1.08s      | 0.64s           | 26.46s          |

**Observation 2:** For UEs in idle/inactive mode, LP-WUS based paging procedure has significant benefits of lower latency compared with legacy paging mechanism.

- With substantial power saving gain, LP-WUS still can achieve latency less than 1s

# Power consumption and UPT for connected mode

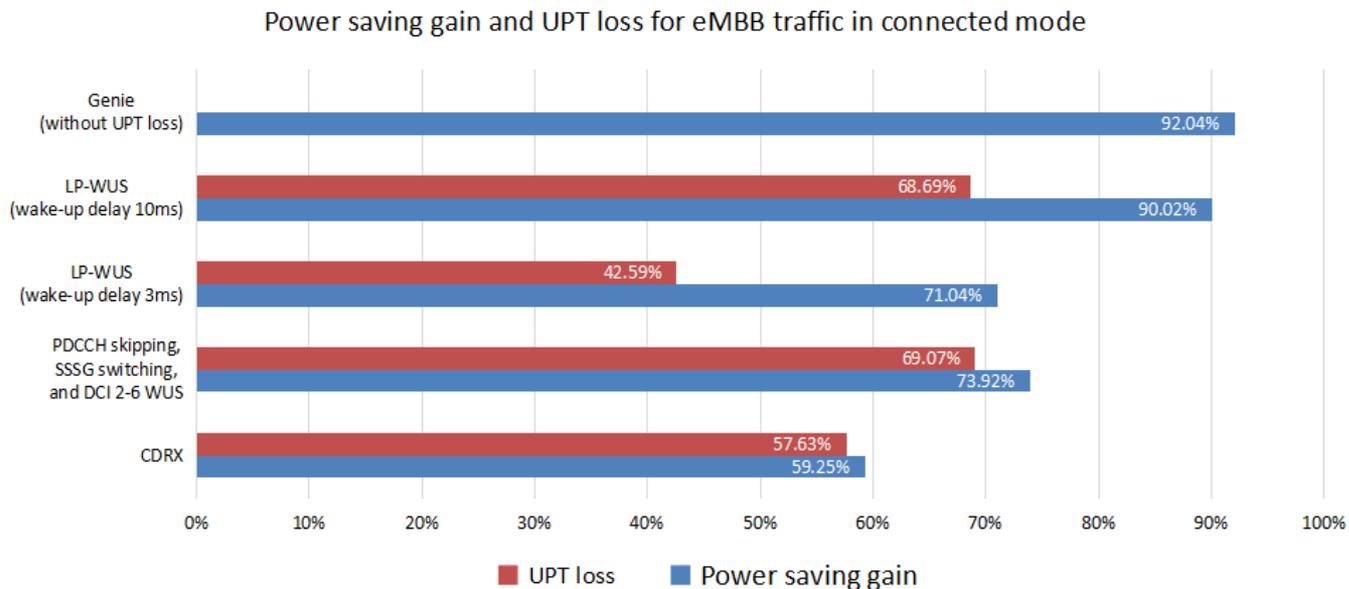


Figure 5: Evaluation results of power saving gain and UPT loss for eMBB traffic in connected mode

Genie: UE power consumption is calculated assuming that UE is in a sleep state (e.g., micro/light/deep sleep as defined in TR38.840) whenever there is neither DL reception nor UL transmission.

**Observation 3:** For UEs in connected mode,

- LP-WUS can achieve more power saving gain and less UPT loss than Rel-16/17 power saving techniques.
- LP-WUS can achieve power saving gain close to genie.

# Coverage

- MC-OOK based signal can be used for DL synchronization and data transmission.
- The following three cases are used for coverage evaluation. The evaluation result is shown in Figure 6.
  - Case 1: NR PUSCH in TR38.875;
  - Case 2: MC-OOK based data with CRC, where the payload size is 24 bits, CRC is 8-bit, Manchester coder with code rate=1/2;
  - Case 3: 32-length MC-OOK based preamble sequence

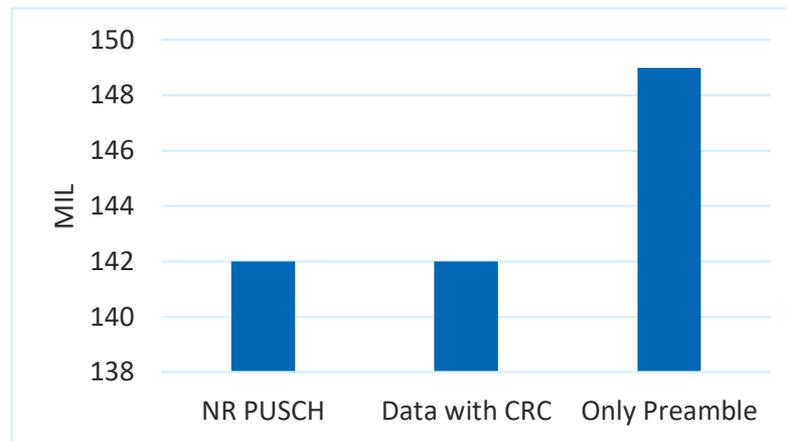


Figure 6. LP-WUS coverage performance with MIL @2.6GHz

**Observation 4:** For the coverage performance of LP-WUS,

- MC-OOK based data transmission with large bit size can achieve similar coverage performance as legacy NR PUSCH.
- MC-OOK based sequence transmission with limited bit size can achieve much better coverage performance than legacy NR PUSCH;

# Potential objectives

- **Overviews**

- Aim to achieve substantial power saving for UE and lower latency for data transmission
- Specify UE categories/capabilities for supporting LP-WUS/WUR
  - At least for (e)RedCap UE,eMBB UE
  - At least for FR1

- **Scope**

- Specify design of LP-WUS [RAN1,RAN2,RAN4]
  - Structure of LP-WUS
  - Waveform, bandwidth, SCS of LP-WUS
  - Information carried by multiple sequences/coding schemes
- Specify related LP-WUS procedures [RAN1,RAN2,RAN3,RAN4]
  - Specify L1/L2 related procedures for LP-WUS
    - Configuration of LP-WUS
    - LP-WUS activation/de-activation
    - LP-WUS monitoring behavior
  - Specify RRM measurement enhancements for LP-WUR
- Note: The impacts on legacy network and UEs should be minimized.

# Thank You!



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