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Views on scope for NR LP-WUS/WUR in Rel-19

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Outline

- Background
- LP-WUS Techniques
- WI Scope for Rel-19 LP-WUS/WUR

Background

- Rel-18 LP-WUS/WUR SI has been successfully finished in RAN1#104.
- RAN1 has studied LP-WUS/LP-SS in the aspect of waveform, receiver architecture, synchronization, LP-WUS monitoring scheme, RRM relax and offloading, and L1/UL procedures.
- Performance of LP-WUS/WUR and LP-SS have been studied in terms of power consumption, coverage, overhead, and network energy consumption.
- In scoping R19 LP-WUS/WUR WI, followings aspects need to be considered.
  - Waveform
  - LP-WUS monitoring scheme
  - Synchronization method
  - RRM offloading
  - LP-WUS design
  - Idle vs connected mode

LP-WUS Techniques

- **Waveform**
  - RAN1 studied multiple waveforms including OOK1/2/3, FSK1/2, and OFDM.
  - Frequency error tolerance: OOK1/4 provides the best performance (up to 800kHz for OOK4).
  - Timing error tolerance: OOK1/4 shows similar or better performance (3us) than FSK(2us) and OFDM.
  - OFDM in general has higher requirement in time/frequency accuracy, which needs clock with higher power consumption and higher cost.
  - For LP-WUR targeting low power consumption, low accuracy clock w/ lower power consumption is better design choice.
  - → OOK1/4 which is robust to frequency and timing error could be the best design choice.
  - Optional overlaying OFDM sequence on top of OOK symbol
    - This could provide a way to improve detection performance/coverage at an increased receiver complexity/power.
    - The overlayed sequence is better to be used only for detection performance increase. The reason is that if it is used to increase data rate (or carrying additional information), this will potentially result in multiple LP-WUR device types, which fragments eco-system; different UE vendors could have different implementations and gNB should handle those receivers differently.
    - → So, the overlayed sequence should be used only for detection performance increases.
- **LP-WUS Monitoring Scheme**
  - RAN1 studied Duty Cycled Monitoring (DCM) and Continuous Monitoring (CM) scheme.
  - DCM maintain good power consuming even at higher power consumption of LP-WUR (10+) → smaller NF, better coverage
  - CM does not provide power saving gain if power consumption is larger than 1 → higher NF, limited coverage
  - → DCM allows better coverage and relaxed requirement on implementation yet providing reasonable power saving gain.

LP-WUS Techniques

- **Synchronization**
  - RAN1 studied low power sync signal (LP-SS) based synchronization mechanism.
  - LP-SS is a new reference signal having the same waveform as LP-WUS.
  - LP-SS transmission periodicity could be order of hundreds ms and its overhead is less than 0.4%.
  - → LP-SS is used not only for synchronization but also for offloading RRM measurements from main radio to LP-WUR, supporting at least low mobility/nomadic or stationary device use cases.
- **RRM offloading**
  - Power consumption for RRM measurement is bottleneck for power consumption.
  - Offloading RRM measurement from MR to LP-WUR could provide around 80% of power saving gain.
  - → Offloading provides higher power saving gain than just further relaxing RRM measurement.
- **LP-WUS design**
  - The number of information bits carried in LP-WUS should provide at least similar capability as PEI.
  - For small number of bits e.g., < 8-10 bits, sequence based WUS could provide better performance. For longer length, payload based scheme could be considered. The comparison study of these two scheme needs to be done during WI.
  - With OOK waveform, Manchester coding could be also considered, which allow full utilization of energy at tx signal, helping symbol synchronization, easier detection, etc.
  - → Consider sequence-based LP-WUS based on OOK waveform with Manchester coding.
- **Idle mode and Connected mode**
  - LP-WUS usage in Idle mode provides higher / convincing power saving gain than that in Connected mode.
  - Connected mode gain is limited to applications w/ very sparse traffic such as Instant messaging (IM).
  - → Put higher priority for Idle mode design of LP-WUS.

WI Scope for Rel-19 LP-WUS/WUR

- Specify OOK1/4-based Low-power wake-up signal (LP-WUS) for RRC idle/inactive and connected mode [RAN1]
  - RRC idle/inactive mode for IoT use case is prioritized
  - Coverage target is PUSCH Msg3
  - WUS design is based on sequence at least for small number of information bits.
  - Optional OFDM sequence overlayed on top of OOK symbol to improve detection performance.
- Specify OOK1/4-based low power synchronization signal (LP-SS) for synchronization of LP-WUR and RRM measurement by LP-WUR.
- Specify wake-up receiver (LP-WUR) procedures including
  - L1/L2 procedures, duty cycled LP-WUS monitoring procedure, main radio wake-up operation, activation/deactivation of LP-WUS, LP-SS based synchronization [RAN1, RAN2]
  - RRM measurements offloaded to LP-WUR based on LP-SS at least for serving cell and new measurement metrics [RAN1,RAN4]
  - Time/frequency tracking function, and ideally beam management function, should be provided.
- Specify RAN4 core requirements for the above [RAN4]

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