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Rel-19 LP-WUS/WUR Work Item

Source: vivo, CMCC, China Unicom, China Telecom, Nordic Semiconductor

Document for: Discussion and Decision

Agenda Item: 9.1.1.6

Outlines

- Background (2745 from RAN chair)
- Additional information to WID
  - L1 Signal Design: Waveform, WUS Information Payload Size, LP-SS
  - RRM relaxation and offloading to LP-WUR
  - Procedure: RRC idle/inactive mode UE
  - UE and BS RF related aspects
- Potential Rel-19 WID Scope

Background

RP-232745

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LP-WUS/WUR WI

- References: RWS-230488, RP-231540, RP-232616
- Potential objectives:
  - Waveform & LP-SS support
    - Waveform-option-1 + waveform-point-3, or waveform-point-3 only → Further downselection
      - 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 overlayed OFDM sequences over OOK symbol
    - For RRC IDLE/INACTIVE, in addition to existing PSS/SSS, LP-SS (, i.e., OOK-1 and/or OOK-4 waveform with/without overlayed OFDM sequences with potential further down selection in WI phase) for LP-WUR that cannot receive existing PSS/SSS, is supported for synchronization and/or RRM for serving cell.

- 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
- 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
- At least duty-cycled monitoring for LP-WUS is supported
- Note: LP-WUS shall be able to reach at least the coverage of PUSCH for message3

- **Support potential objectives as listed in RP-232745 as a starting point for LP-WUS/WUR WI.**
- **In addition, we propose to add further details to guide WGs for more efficient discussion, shown in later slides**

SI Output and Conclusion: L1 Signal Design

LP-WUS waveform and payload

Motivation

- LP-WUS waveform option and target payload should be made clear in the WID
  - Common WUS design for both RRC IDLE/INACTIVE and CONNECTED mode is desired for system simplification and less standard effort.
  - Waveform (based on option 3): Both OOK with and without overlaid OFDM sequence can be specified to provide trade-off between power consumption and coverage
  - Payload: at least 8 bits (excluding CRC) would be needed for LP-WUS
    - For RRC IDLE/INACTIVE, to provide similar subgrouping functionality as in R17 PEI, at least 8bits should be provided
    - For RRC CONNECTED mode, adequate number of bits (e.g. more than 10) is desired to allow triggering individual UE's PDCCH monitoring

Proposal

- Specify an LP-WUS design commonly applicable for both IDLE/INACTIVE and CONNECTED mode usage. (RAN1, RAN2, RAN3)
  - Specify OOK (OOK-1 and/or OOK-4) based LP-WUS for envelop detection based LP-WUR
    - Specify OFDM sequence(s) overlaid over OOK symbol for OFDM based LP-WUR for better detection performance
  - Information payload carried by LP-WUS can be [1~X] bits (excluding CRC, if any), with X>=8, upper limit to be decided in WI phase

SI Output and Conclusion: L1 Signal Design

LP-SS

Motivation

- Periodicity of LP-SS should take into account both synchronization and RRM measurement requirement for IDLE/INACTIVE UE and impacts to network overhead and energy consumption
- RAN1 evaluated OOK-based LP-SS with periodicity of at least 320ms in SI [1].
- LP-SS is designed mainly for LP-WUR without OFDM capability, it should be discussed whether overlaid OFDM sequence is needed for LP-SS design

Proposal

Specify an OOK (OOK-1 and/or OOK-4) based periodic LP-SS for synchronization and serving cell measurement performed by LP-WUR, with its coverage performance no worse than LP-WUS and periodicity no less than [320ms] (RAN1, RAN4, RAN2)

- LP-SS is based on OOK-1 and/or OOK-4 waveform [with/without overlaid OFDM sequence with potential further down-selection during WI]
- For OFDM based LP-WUR, existing NR signal, e.g., SSS can be used for synchronization and measurements, instead of LP-SS.

[1]: RP-233068, TR38.869 v2.0.0, section 6.2.1

SI Output and Conclusion: Procedure

RRM relaxation and offloading to LP-WUR

Motivation

- For LP-WUR duty-cycled monitoring, no meaningful power saving gain is observed for MR RRM relaxation < 8 times or no MR RRM relaxation and offloading to LP-WUR [1].

Proposal

Support further RRM relaxation (X times, X>=8) of UE MR for both serving and neighbor cell measurements, including offloading MR serving cell measurement(s) to LP-WUR in Rel-19 WI

Table 1 LP-WUR duty-cycled monitoring[1]

MR RRM relaxation/ offloading to LP-WUR	Mean power saving gain range	Mean power saving gain average	# of input sources
No MR RRM relaxation and offloading to LP-WUR	**-624%~-5%**	**-211%**	5
MR RRM relaxation < 8 times	**-18%~50%**	**4%**	6
8 times <= MR RRM relaxation < =16 times	**-18%~60%**	**40%**	9
MR RRM relaxation >16 times	**22%~90%**	**60%**	9
No RRM performed by MR, fully offloading to LP-WUR	**76%~94%**	**83%**	10

[1]: RP-233068, TR38.869 v2.0.0, section 8.1.1

SI Output and Conclusion: Procedure

IDLE/INACTIVE UE procedure

RAN2 Conclusion

RAN2 has studied the procedure where network configures LR for LP-WUS monitoring and concluded that LP-WUS to control paging/PEI monitoring with no UE reporting of WUS coverage status or change is feasible. Details are to be decided in WI phase [1].

Proposal

- Specify necessary procedures to allow UE MR (Main receiver) paging monitoring triggered by LP-WUS (RAN1, RAN2, RAN3)
  - Note: It is assumed that network need not be aware of whether UE is monitoring LP-WUS or not

[1]: RP-233068, TR38.869 v2.0.0, section 9.6

SI Output and Conclusion: UE and BS RF related aspects

RAN4 RF aspects

RAN4 conclusion

RAN4 also identified some RF issues which could be further discussed in WI phase, e.g.,

- Specifying at least the REFSENS, ACS and ASCS requirements with consideration of possible new methodology
- Impacts of different architecture on RF requirements, if any
- Specific guard RBs for ACS and ASCS cases
- Study and specify BS power boosting value/range for LP-WUS
- Specific IMT operating band(s) for LP-WUS if necessary
- Possible testability issues. [1]

Proposal

- Specify UE and BS RF related aspects (RAN4)
  - Specify at least the REFSENS, ACS and ASCS requirements with consideration of possible new methodology and impacts of different receiver architectures
  - Study and specify BS power boosting value/range for LP-WUS/LP-SS
  - Specific IMT operating band(s) for LP-WUS if necessary
  - Possible testability issues

[1]: RP-233068, TR38.869 v2.0.0, section 9.5

Potential Rel-19 WID Scope

- Specify an LP-WUS design commonly applicable for both IDLE/INACTIVE and CONNECTED mode usage. (RAN1, RAN2, RAN4)
  - Specify OOK (OOK-1 and/or OOK-4) based LP-WUS for envelop detection based LP-WUR
    - Specify OFDM sequence(s) overlaid over OOK symbol for OFDM based LP-WUR for better detection performance
  - Information payload carried by LP-WUS can be [1~X] bits (excluding CRC, if any), with X>=8, upper limit to be decided in WI
  - Note: LP-WUS shall be able to reach at least the coverage of existing Msg3 PUSCH (single transmission).
- For IDLE/INACTIVE modes,
  - Specify necessary procedures to allow UE MR (Main receiver) paging monitoring triggered by LP-WUS (RAN1, RAN2, RAN3)
    - Note: It is assumed that network need not be aware of whether UE is monitoring LP-WUS or not
  - Specify an OOK based periodic LP-SS for envelop detection based LP-WUR for synchronization and serving cell measurement purpose, with its coverage performance no worse than LP-WUS and periodicity no less than [320ms] (RAN1, RAN4, RAN2)
    - LP-SS is based on OOK-1 and/or OOK-4 waveform [with/without overlaid OFDM sequence with potential further down-selection during WI]
    - For OFDM based LP-WUR, existing NR signal, e.g., SSS can be used for synchronization and measurements, instead of LP-SS.
  - Specify further RRM relaxation (X times, X>=8) of UE MR for both serving and neighbor cell measurements, and offloading MR serving cell measurement(s) to LP-WUR (RAN4, RAN2, RAN1)
- For CONNECTED mode, specify necessary procedure to allow UE MR PDCCH monitoring triggered by LP-WUS (RAN2, RAN1)
  - Note: In CONNECED mode, UE MR ultra-deep sleep is not considered, and UE RRM/RLM/BFD/CSI measurements are performed by MR
- Specify UE and BS RF related aspects (RAN4)
  - Specify at least the REFSENS, ACS and ASCS requirements with consideration of possible new methodology and impacts of different receiver architectures
  - Study and specify BS power boosting value/range for LP-WUS/LP-SS
  - Specific IMT operating band(s) for LP-WUS if necessary
  - Possible testability issues

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THANK YOU.
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