**3GPP TSG-RAN WG4 Meeting # 112 R4-24xxxxx**

**Maastricht, Netherlands, 19th – 23rd August, 2024**

**Agenda item:** 8.22.5

**Source:** Moderator (vivo)

**Title:** draft Minutes for LP-WUR ad hoc discussion

**Document for:** Approval

Based on the latest approved WI in [RP-240135], the objectives of the WI are duplicated as below:

The objectives of the work item are the following:

* To specify an LP-WUS design commonly applicable to both IDLE/INACTIVE and CONNECTED modes (RAN1, RAN4)
  + Specify OOK (OOK-1 and/or OOK-4) based LP-WUS with overlaid OFDM sequence(s) over OOK symbol
    - The LP-WUS design shall ensure that for IDLE/INACTIVE operation, the same information is delivered irrespective of LP-WUR type. The OFDM sequence can carry information.
  + At least duty-cycled monitoring of LP-WUS is supported
* For IDLE/INACTIVE modes
  + Specify procedure and configuration of LP-WUS indicating paging monitoring triggered by LP-WUS, including at least configuration, sub-grouping and entry/exit condition for LP-WUS monitoring (RAN2, RAN1, RAN3, RAN4)
  + Specify LP-SS with periodicity with Yms for LP-WUR, for synchronization and/or RRM for serving cell. (RAN1, RAN4)
    - LP-SS is based on OOK-1 and/or OOK-4 waveform with or without overlaid OFDM sequences. Further down selection between with and without overlaid OFDM sequences is to be done within WI.
    - Note: For LP-WUR that can receive existing PSS/SSS, existing PSS/SSS can be used for synchronization and RRM instead of LP-SS.
    - Y will be decided within WI. 320ms is the start point.
  + Specify further RRM relaxation of UE MR for both serving and neighbor cell measurements, and UE serving cell RRM measurement offloaded from MR to LP-WUR, including the necessary conditions (RAN4, RAN2)
* For CONNECTED mode, specify procedures to allow UE MR PDCCH monitoring triggered by LP-WUS including activation and deactivation procedure of LP-WUS monitoring (RAN2, RAN1)
  + Check in RAN#105 for potential TU adjustment in RAN2
  + Note: In CONNECTED mode, UE MR ultra-deep sleep is not considered, and UE RRM/RLM/BFD/CSI measurements are performed by MR
* Note: The target coverage of LP-WUS and LP-SS shall be the coverage of PUSCH for message3.
* Note: The optimization of LP-WUS signal design for idle/inactive mode is prioritized over the optimization for connected mode.
* Specify the necessary RAN4 core requirement(s) to support the feature (RAN4).
  + Specifying UE low-power wake-up receiver requirements, at least REFSENS, ACS and ASCS requirements with consideration of possible new methodology
    - Define guard RBs for ACS and ASCS cases
    - Study testability of above requirements
    - Consider impacts of different architecture and impairments
  + Study and specify, if necessary, any BS requirements, e.g., increase upper limit for LP-WUS/LP-SS beyond current dynamic range
  + Specify necessary RRM requirements

**Issue 2-1-1-1: SNR setting for serving and interference cell derivation from SINR setting**

* Proposals
  + P1: Use two cells for RAN4 simulation. To derive SNR for serving cell and interference cell from serving cell Ês/Iot, a relationship for the SNR or transmission power between serving cell and interference cell need be pre-defined. Suggest to consider the SNR/transmission power of the interference cell is 9 dB or 6 dB lower compared with that of the serving cell. (vivo, Ericsson)
  + P2: Discuss what is the meaning of Cell 1 and Cell 2 in the simulated scenario as the LP-WUR only supports serving cell measurements. (Nokia)

*Recommendations:*

Agreement:

To derive SNR for serving cell and interference cell from serving cell Ês/Iot, a relationship for the SNR or transmission power between serving cell and interference cell need be pre-defined.

Consider the SNR/transmission power of the interference cell is 9 dB or 6 dB lower compared with that of the serving cell. Other value can be considered.

**Issue 2-1-3: Time/frequency error**

* Proposals
  + P1: Suggest that 5 ppm is used for SSB based LP-WUR receivers and [5 10 20]ppm is used for OOK based receivers. Suggest the timing error are: OFDM type receiver: Residual timing error + 5\*320ms; OOK type receiver: Residual timing error + [5 10 20] \*320ms. (vivo)
  + P2: Discuss Time/frequency error in simulation assumption based on RAN1’s and RF’s agreement (Apple)
  + P3: Use 20ppm Residual Frequency error as the simulation baseline, 0ppm and 10ppm can also be involved if companies interested. Further update is not precluded. (CMCC)
  + P4: 20 ppm frequency error can be considered for OOK based on LR for initial RAN4 evaluation work. (Samsung)
  + P5: Frequency error: 5ppm; Time error: up to companies to report (Huawei)
  + P5: Frequency error: 5ppm for SSB based and [5, 10]ppm for OOK based (Ericsson)

*Recommendations:*

*Residual frequency error:*

Agreement:

OFDM based receiver [5] ppm

OOK based receiver [ 10 20] ppm

Timing error

Timing error = Residual timing error (up to company report) + residual frequency error\* reference signal periodicity (320ms);

**Issue 2-1-5: Measurement interval**

* Proposals
  + P1: LP-SS measurement requirement in IDLE/Inactive mode shall be defined based on LP-SS periodicity (Apple, Ericsson)
  + P2: Define the LR measurement requirements based on measurement interval of 320ms for both LP-SS and SSB based measurement. (vivo Huawei)
  + P3: SSB burst periodicity: 20ms (CMCC, Ericsson)
  + P4: SSB periodicity 160ms (CATT)

*Recommendations:*

Agreement:

Use 320ms for SSB based LP-WUR firstly.

**Issue 2-1-4: Accuracy baseline for simulation**

* Proposals
  + P1: The accuracy requirement defined for Redcap with 1Rx for RSRP or RSRQ in 10.1A can be used as the base when defining requirements for LP-WUR serving cell measurement. (vivo)
  + P2: RAN4 to use the legacy measurement accuracy for CONNECTED mode in Clause 10.1.2 TS 38.133 as baseline. (CATT CMCC)
  + P3: Use the accuracy requirement defined for CA/DC Idle Mode Measurements, i.e., ±6dB RSRP measurement accuracy and ±4dB RSRQ measurement accuracy, as the starting point when determining the measurement accuracy in RRC\_IDLE/INACTIVE state for LP-WUR serving cell measurement. RAN4 to consider the same target accuracy when defining LP-SS based and PSS/SSS based RRM delay requirements for LP-WUR (xiaomi)
  + P4: RAN4 not to define baseline for accuracy requirements for LR measurement. (Huawei)

*Recommendations:*

**Issue 2-2-2: Simulation parameters (include all other parameters not discussed in above issues)**

Agreement:

|  |  |
| --- | --- |
| LP-SS block BW | 132 subcarriers for SCS=30kHz for LP-SS initially |

Table 1: General parameters

|  |  |
| --- | --- |
| **Simulation parameters** | **Comments/values** |
| Carrier frequency for Cell 1 and Cell 2 | Option 1: FR1: 2.6 GHz and 700MHz (vivo Ericsson Nokia)  O2: FR1: 2.6 GHz (CATT Apple MTK) |
| System bandwidth | O1: 20 and 100 MHz; (vivo CATT)  O2: 20MHz (Apple Ericsson MTK)  O3: 20MHz for 700MHz carrier frequency/100 MHz for 2.6GHz carrier frequency (Huawei) |
| Prior knowledge of Cell 1 / Cell 2 by the UE | Interfering cell (Cell 2) is not known to UE |
| DRX | No applicable for LP-WUR |
| BS transmit antennas for LP-SS blocks | 1 Tx |
| UE receive antennas | 1 Rx |
| Data and control channel subcarrier spacing | Data, SSB and LP-SS have the same SCS [for cell 1 and cell 2] |
| Subcarrier spacing | 30KHz  [15 KHz for 700 MHz] (Huawei) |
| Measurement period (in number of measurement samples) | LP-SS for OOK based LP-WUR: [4, 5, other number could be studied upon a need]  SSB for OFDM based LP-WUR: [4, 5] (other number could be studied upon a need) |
| LP-SS/SSB burst periodicity | LP-SS: 320 ms  SSB: 320 ms |
| LP-SS block BW | 132 subcarriers for SCS=30kHz for LP-SS initially |
| SSS block | 20PRBs for 15kHz and 30kHz for SSS (CATT) |
| Actual LP-SS transmissions | always transmitted |
| Guard band | 1 RB on each side of LP-SS/LP-WUS signal |

Table 2: Cell-specific parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Unit | Cell 1 | Cell 2 |
| RF Channel number | - | Channel 1 | Channel 1 |
| NR-PSS, NR-SSS (OFDM based LP-WUR) | - | To be indicated by companies  Same as in R4-1708698 (Apple) | To be indicated by companies  Same as in R4-1708698 (Apple) |
| LP-SS (OOK based LP-WUR receiver) |  | OOK-1; or  OOK-4 with M = 2,4,[8]  Note: 8 is up to company’s preference  To be indicated by companies, including number of OFDM symbols, M value for OOK-4, binary sequence and overlaid sequence (Huawei) | when Cell 1 uses OOK-1; OOK-1 or NR signal is used for Cell 2  when Cell 1 uses OOK-4,  OOK-4 with same M value as cell 1 or NR signal is used for Cell 2  Same as Cell 1 but with different sequences (Huawei) |
| LP-SS pattern |  | [M sequence]  [Golden sequence]  [Computer search sequence]  Note: Company can simulate one or all of them | [M sequence]  [Golden sequence]  [Computer search sequence]  Note: Company can simulate one or all of them |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |
| Data and control PSD relative to NR-PSS,NR-SSS and LP-SS | dB | 0 | 0 |
| RB Utilization | % | 100 | 100 |
| Data Modulation | - | QPSK | QPSK |
| Slot length | - | 14 symbols | 14 symbols |
| CP Length | - | Normal | Normal |
| Frequency offset relative to UE frequency reference | Hz | OFDM based receiver [5] ppm  OOK based receiver [ 10 20] ppm | N/A |
| Timing error |  | Residual timing error  + timing drift (frequency offset\* 320ms (reference signal periodicity)  Residual timing error: company report |  |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | CP/2 |
| 2) Relative Delay of 1st Path (asynchronous): Fixed delay | ms | 0 | 3 ms |
| SNR | dB | When Ês/Iot = -3 dB   * When SNR of cell 2 is 9 dB lower compared with cell 2;   SNR = [-2.7]   * When SNR of cell 2 is 6 dB lower compared with cell 2   SNR = [-2.4] | When Ês/Iot = -3 dB   * When SNR of cell 2 is 9 dB lower compared with cell 2;   SNR = [-11.7]   * When SNR of cell 2 is 6 dB lower compared with cell 2;   SNR = [-8.4] |
| When Ês/Iot = -0.5 dB  Determine the SNR based on the method used for when Ês/Iot = -3 dB | When Ês/Iot = -0.5 dB  Determine the SNR based on the method used for when Ês/Iot = -3 dB |
| When Ês/Iot = 2 dB  Determine the SNR based on the method used for when Ês/Iot = -3 dB | When Ês/Iot = 2 dB  Determine the SNR based on the method used for when Ês/Iot = -3 dB |
| Ês/Iot | dB | -3; -0.5dB; 2dB | N/A |
| Propagation conditions | - | FR1:  AWGN  TDL-C 300ns | |
| UE speed |  | 3 km/h  30km/h (MTK) | |
|  | | | |

Table 3: UE-specific parameters

|  |  |
| --- | --- |
| [Receiver Filter] | [3th/5th Order Butterworth with 3.96MHz bandwidth] |
| [Receiver ADC bit width] | [4 or 8-bitADC] |
| [Receiver Sampling Rate for LP-SS only] | [3.84 or 7.68MHz] |

**Issue 1-1-8: On jointly consideration on issue 1-1-5, 1-1-6 and 1-1-7**

* Proposals
  + P1: It is suggested to define the same entry/exit conditions for LP-WUR serving cell measurement and LP-WUS monitoring (Xiaomi LG)
  + P2: Same criteria and same/different entry/exit conditions can be used for LP-WUS monitoring and case 1, or case 2 or 3 if case 2 or 3 are supported (vivo).
  + P3: In order to guarantee the power saving gain, the serving cell quality threshold in entry/exit condition for LP-WUS monitoring and the serving cell quality threshold entry/exit condition for LP-WUR measurement should be considered jointly. (CMCC)
  + P4: RAN4 needs to consider overall entry/exit condition for LP-WUR measurement, MR measurement relaxation, and LP-WUS monitoring jointly based on RAN2 agreements of entry/exit condition for LP-WUS monitoring. And if there are other conditions that should be considered, RAN4 needs to provide input to RAN2 (LG)
  + P5: RAN4 shall be involved on criterion and scenario (entry/exit condition) design for LP-WUR measurement and MR RRM measurement relaxation together with RAN1 and RAN2. (Samsung)
    - RAN4 shall further discuss the applicable side condition /scenario with corresponding assumption on MR serving cell measurement, MR neighbouring cell measurement and LP-WUR measurement as a package
  + P6: assumption of thresholds for RAN4 discussion can be (Apple):
    - the threshold for MR fully offloading to LR can be same as the threshold for neighbor cell measurement triggering (highest one between SIntraSearchP/SIntraSearchQ and SnonIntraSearchP/SnonIntraSearchQ), or at least offloading threshold can be not lower than threshold for neighbor cell measurement triggering.
    - the threshold to turn on LR or to involve LR for measurement can be equivalent to the threshold of entry condition for LP-WUS monitoring.

*Recommendations:*

*Suggest to check whether the following top level description:*

*LP-WUR monitoring is triggered not early than MR RRM relaxation or MR serving cell offloading (case 1)*