**3GPP TSG-RAN WG4 Meeting #110bis R4-2406618**

**Changsha, China, 15th – 19th April, 2024**

**Agenda item:** 9.13.3

**Source:** CMCC

**Title:** WF on Ambient IoT in NR

**Document for:** Approval

# Introduction

This way forward captures agreements on ambient IOT co-existence evaluation aspects in RAN4#110bis meeting.

The summary for ambient IOT is in R4-2405289 for information.

# Way forward for co-existence evaluation

## Topic 2-1: Deployment scenario

**Issue 2-1-1: deployment scenarios for D1T1**

Option 1-1: existing NR gNB are outdoor macro gNB while reader/CW/devices are all indoors. existing NR UE is only allowed outdoors.

Option 1-2: existing NR gNB are outdoor macro gNB while reader/CW/devices are all indoors. existing NR UE is indoor accessing to outdoor marco gNB

Option 2-1: existing NR gNB are co-located with gNB like reader and CW. All are indoors. Reader /CW and existing gNB share same hardware

Option 2-2: existing NR gNB are co-located with gNB like reader and CW. All are indoors. Reader /CW and existing gNB do not share same hardware. (less limitation on the power boosting)

**Agreement:**

* RAN4 to first evaluate co-existence for deployment scenario of option 1-1 and 1-2, and further study option 2-1 and 2-2.

**Issue 2-1-2: deployment scenarios for D2T2**

Option 1-1: existing NR gNB are outdoor macro gNB, intermediate UE/CW/devices are all indoors. existing NR UE is only allowed outdoor.

Option 1-2: existing NR gNB are outdoor macro gNB, intermediate UE/CW/devices are all indoors. existing NR UE is indoor.

**Agreement:**

* For D2T2 co-existence evaluation, existing NR gNB are outdoor macro gNB, intermediate UE/CW/devices are all indoors.
  + Consider option 1-1 and option 1-2 as the starting point

## Topic 2-2: Spectrum usage

**Issue 2-2-1: Spectrum usage for R2D in D1T1**

Option 1: FDD DL spectrum for R2D

Option 2: FDD UL spectrum for R2D

**Agreement:**

* FFS on whether to prioritize FDD DL spectrum for R2D for D1T1 for co-existence evaluation.

**Issue 2-2-2: Spectrum usage for CW transmission in D1T1 for the case that D2R backscattering is transmitted in the same carrier as CW for D2R backscattering**

For the case that D2R backscattering is transmitted in the same carrier as CW for D2R backscattering, and for topology 1, the following cases for CW transmission are studied.

· Case 1-1: CW is transmitted from inside the topology, transmitted in DL spectrum

· Case 1-2: CW is transmitted from inside the topology, transmitted in UL spectrum

· Case 1-4: CW is transmitted from outside the topology, transmitted in UL spectrum

**Agreement:**

* For the case that D2R backscattering is transmitted in the same carrier as CW for D2R backscattering, consider the following for co-existence evaluation
  + CW transmits in either UL or DL spectrum
  + FFS on inside topology and outside topology.

**Issue 2-2-4: Spectrum usage for R2D in D2T2**

**Agreement:**

* Use FDD UL spectrum for R2D in D2T2.

**Issue 2-2-5: Spectrum usage for CW transmission in D2T2 for the case that D2R backscattering is transmitted in the same carrier as CW for D2R backscattering**

For the case that D2R backscattering is transmitted in the same carrier as CW for D2R backscattering, and for topology 2, the following cases for CW transmission are studied.

· Case 2-2: CW is transmitted from inside the topology (i.e., intermediate UE), transmitted in UL spectrum

· Case 2-3: CW is transmitted from outside the topology, transmitted in DL spectrum

· Case 2-4: CW is transmitted from outside the topology, transmitted in UL spectrum

**Agreement:**

* For the case that D2R backscattering is transmitted in the same carrier as CW for D2R backscattering
  + Use UL spectrum as the starting point for co-existence evaluation.
    - It won’t preclude the use of DL for backscattering transmission.
    - FFS on the minimum distance between the intermediate UE and A-IoT device

## Topic 2-3: Spectrum deployment mode

**Issue 2-3-2: Priorities of spectrum deployment mode for co-existence evaluation**

**Agreement:**

* Prioritize the following spectrum deployment mode for co-existence evaluation
  + A-IoT is located within a NR transmission bandwidth configuration
  + A-IoT which is operating indoor shares in-band spectrum with outdoor macro BS

## Topic 2-4: Evaluation methodology

**Issue 2-4-1: Evaluation methodology**

**Agreement:**

* Use the Monte-Carlo method as baseline for co-existence evaluation, i.e. Section 5.3 in TR38.803
* Depending on the discussion on deployment scenarios, for some cases, calculation for the worst interference link may be enough.
* FFS on whether RAN4 needs to perform link level simulation

**Issue 2-4-2: Performance metric for AIOT**

**Agreement:**

* For NR system, use 5% throughput loss as performance metric as legacy.
* For AIOT system, including reader, device, intermediate UE, further discuss the performance metric:
  + Option 1: [10%] BLER, [Rx power]
  + Option 2: SINR degradation
  + Other options are precluded

## Topic 2-5: Evaluation cases

**Issue 2-5-1: device type**

**Agreement:**

* Prioritize device 1 and 2a without a frequency shifter for coexistence evaluation.

**Issue 2-5-2: Evaluation cases for D1T1 for device 1 and 2a between NR and AIOT**

**Agreement:**

* Corresponding evaluation cases are listed for further down selection. Note that some duplicated cases are omitted in the table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Deployment scenario and topology** | **spectrum** | **aggressor** | **victim** |
| 图示  描述已自动生成  · Case 1-1: CW is transmitted from inside the topology, transmitted in DL spectrum  · Case 1-2: CW is transmitted from inside the topology, transmitted in UL spectrum | R2D: DL CW2D and D2R: UL | CW and/or device | NR UL |
| NR UL | device and/or reader |
| reader | NR DL |
| NR DL | device |
| R2D: DL CW2D and D2R: DL | CW and/or device | NR DL |
| NR DL | device and/or reader |
| R2D: UL CW2D and D2R: UL | Reader | NR UL |
| NR UL | reader |
| 图示  描述已自动生成  Self interference cancelation is needed for reader  · Case 1-1: CW is transmitted from inside the topology, transmitted in DL spectrum  · Case 1-2: CW is transmitted from inside the topology, transmitted in UL spectrum | R2D: DL CW2D and D2R: UL | CW and/or device | NR UL |
| NR UL | device and/or reader |
| reader | NR DL |
| NR DL | device |
| R2D: DL CW2D and D2R: DL | CW and/or device | NR DL |
| NR DL | device and/or reader |
| R2D: UL CW2D and D2R: UL | reader | NR UL |
| NR UL | reader |
| 图示  描述已自动生成  Self interference cancellation is needed for reader  · Case 1-4: CW is transmitted from outside the topology, transmitted in UL spectrum | R2D: DL CW2D and D2R: UL | CW and/or device | NR UL |
| NR UL | device and/or reader |
| reader | NR DL |
| NR DL | device |
| R2D: UL CW2D and D2R: UL | reader | NR UL |
| NR UL | reader |

**Issue 2-5-3: Evaluation cases for D2T2 for device 1 and 2a between NR and AIOT**

**Agreement:**

* Corresponding evaluation cases are listed for further down selection. Note that some duplicated cases are omitted in the table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Deployment scenario and topology** | **spectrum** | **aggressor** | **victim** |
| 图示  描述已自动生成  Case 2-2: CW is transmitted from inside the topology (i.e., intermediate UE), transmitted in UL spectrum | R2D: UL CW2D and D2R: UL | CW and/or device | NR UL |
| NR UL | Device and/or reader |
| reader | NR UL |
| NR UL | device |
| 图示  描述已自动生成\  Case 2-2: CW is transmitted from inside the topology (i.e., intermediate UE), transmitted in UL spectrum  Self interference cancelation is needed for reader | R2D: UL CW2D and D2R: UL | CW and/or device | NR UL |
| NR UL | Device and/or reader |
| reader | NR UL |
| NR UL | device |
| 图示  描述已自动生成  Case 2-3: CW is transmitted from outside the topology, transmitted in DL spectrum  Case 2-4: CW is transmitted from outside the topology, transmitted in UL spectrum  Self interference cancelation is needed for reader | R2D: UL CW2D and D2R: UL | CW and/or device | NR UL |
| NR UL | Device and/or reader |
| reader | NR UL |
| NR UL | device |
| R2D: UL CW2D and D2R: DL | CW and/or device | NR DL |
| NR DL | device and/or reader |

**Issue 2-5-4: Evaluation cases for device 2b between AIOT and NR**

**Agreement:**

* FFS for evaluation cases for device 2b

**Issue 2-5-5: Interference between AIOT systems**

**Agreement:**

* RAN4 to first evaluate interference between AIOT and NR.
* FFS on interference between AIOT and AIOT

## Topic 2-6: Evaluation parameters

**Issue 2-6-1: General parameters**

Following parameters are for information.

|  |  |
| --- | --- |
| **General Parameter** | **D1T1&D2T2** |
| Carrier frequency | 900 MHz |
| Channel BW for NR | 10MHz or 20MHz with 15KHz SCS |
| Channel BW for AIOT | DL: 180kHz with 15KHz SCS  UL: 15KHz or 180KHz |
| Waveform | DL: OFDM based waveform  UL: single carrier |
| A-IoT DL power control | No |
| A-IoT UL power control | No |
| Traffic model | Full buffer |
| Frequency reuse | 1 |

**Issue 2-6-2 and 2-6-3: Layout for D1T1 and D2T2**

**Agreement:**

Use RAN1 agreements in RAN1#116bis meeting as baseline (copied as below).

* FFS on whether any updates are needed for RAN4 co-existence evaluation.
* FFS on other parameters.

**RAN1 agreements:**

For D1T1,

* InF-DH NLOS model defined in TR38.901 is used for D2R and R2D links as pathloss model in coverage evaluation.

For D2T2,

* InF-DL and InH-Office model defined in TR38.901is used as pathloss model in coverage evaluation,
  + NLOS for D2R and R2D links if InF-DL is used
  + LOS for D2R and R2D links if InH-Office is used

The following layout is used for evaluation purpose,

* FFS: CW distribution for D1T1-B and D2T2-B

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Assumptions for D1T1** | **Assumptions for D2T2** | |
| Scenario | InF-DH | InH-office | InF-DL |
| Hall size | 120x60 m | 120 x50 m | 300x150 m |
| Room height | 10 m | 3m | 10 m |
| Sectorization | None | | |
| BS deployment / Intermediate UE dropping | 18 BSs on a square lattice with spacing D, located D/2 from the walls.   * L=120m x W=60m; D=20m * BS height = 8 m | * L=120m x W=50m; * Intermediate UE height = 1.5 m   FFS: Intermediate UE dropping | * L=300m x W=150m; * Intermediate UE height = 1.5 m   FFS: Intermediate UE dropping |
| Device distribution | Device Height= 1.5 m  AIoT devices drop uniformly distributed over the horizontal area | Device Height= 1.5 m  AIoT devices drop uniformly distributed over the horizontal area  FFS: which devices are involved in the evaluations | Device Height= 1.5m  AIoT devices drop uniformly distributed over the horizontal area  FFS: which devices are involved in the evaluations |
| Device mobility (horizontal plane only) | 3 kph | 3 kph | 3 kph |

**Issue 2-6-4: AIOT micro-BS parameters for D1T1**

Following parameters are for information.

|  |  |  |
| --- | --- | --- |
| **A-IoT micro BS parameters** | **Recommended value** | **Note** |
| A-IoT micro-BS total Tx power | 33dBm baseline  38 dBm (optional) |  |
| A-IoT micro-BS receiver Noise Figure（dB） | 10 |  |
| A-IoT micro-BS antenna gain (dBi) | 5 or 8 |  |
| A-IoT micro-BS ACLR (dB) | [ACLR1:40dB，ACLR2:50dB] | Reference to TS 36.104 NB-IoT standalone |
| Antenna configuration | 2 or 4 antenna elements, with (M,N,P,Mg,Ng) = (1,1,2,1,1) or (M,N,P,Mg,Ng) = (2,1,2,1,1) |  |

**Issue 2-6-4: Intermediate UE parameters for D2T2**

Following parameters are for information.

|  |  |
| --- | --- |
| **intermediate UE parameters** | **Recommended value** |
| intermediate UE total Tx power（dBm） | 23dBm baseline  26dBm |
| gain of antenna intermediate UE including feeder loss (dBi) | 0 |
| intermediate UE receiver Noise Figure（dB） | 7 |
| Antenna configuration | Omni direction antenna |

**Issue 2-6-4: CW parameters**

Following parameters are for information.

|  |  |  |
| --- | --- | --- |
| **intermediate UE parameters** | **D1T1** | **D2T2** |
| Tx power（dBm） | If UL spectrum is used, UE Tx power is assumed, i.e. 23dBm/26dBm  If DL spectrum is used, AIOT micro-BS Tx power is assumed. | Inter-mediate UE Tx power is assumed. |
| Other parameters | Same as AIOT micro-BS？ | Same as inter-mediate UE |

**Issue 2-6-5: AIOT device parameters**

Following parameters are for information.

|  |  |  |  |
| --- | --- | --- | --- |
| **A-IoT device parameters** | **Device 1** | **Device 2a** | **Device 2b** |
| A-IoT device Tx power (dBm) | <-10 | <-10 | [-10/-20] |
| A-IoT device effective antenna gain per Tx or Rx branch (dBi) | -3 or 0 | -3 or 0 | -3 or 0 |
| A-IoT device reflection （backscatter）loss (dB)  Note: due to, e.g., impedance mismatch | -6 dB and 0 dB for OOK / FSK and BPSK | N/A | N/A |
| A-IoT device power gain of reflection amplifier (dB) | N/A | [10 / 20] | N/A |
| A-IoT Device receiver sensitivity (dBm) | -36 | -46 | [FFS] |
| BB filter type | 3/5 Butterworth filter | 3/5 Butterworth filter | 3/5 Butterworth filter |
| Cutoff frequency | FFS  e.g. 1PRB or related to DL data rate | FFS  e.g. 1PRB or related to DL data rate | FFS  e.g. 1PRB or related to DL data rate |
| Guard band | 1PRB, 2PRB, etc  increasing in steps of 1dB | 1PRB, 2PRB, etc  increasing in steps of 1dB | 1PRB, 2PRB, etc  increasing in steps of 1dB |

**Issue 2-6-6: NR macro BS parameters**

Following parameters are for information.

|  |  |
| --- | --- |
| **NR macro-BS Parameter** | **Recommended value** |
| Macro-BS Tx power (dBm) | 46 |
| Height of macro NR BS (m) | 25 |
| NR Macro-BS Noise Figure(dB) | 5 |
| Network location | outdoor |

**Issue 2-6-7: NR UE parameters**

Following parameters are for information.

|  |  |  |
| --- | --- | --- |
| **NR UE Parameter** | **Recommended value** | **note** |
| UE TX power in dBm | -40 to 23 |  |
| NR UE Antenna gain (dBi) | 0 |  |
|  |  |  |
| NR UE ACLR（dB） | 30 | For power class 3 NR UE |
|  |  |  |
| NR UE Noise Figure（dB） | 9 |  |
| Antenna configuration | Omni direction antenna |  |

**Issue 2-6-8: Adjacent RB/carrier Tx leakage and Rx suppression characteristics**

Proposal:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | In-band | | Guard-band | | standalone | |
| Tx | Rx | Tx | Rx | Tx | Rx |
| Intermediate UE/CW of topology 2 | Legacy UE IBE requirement | ICS=ACS value  According to SBFD analysis, ICS could be equals to ACS | Legacy UE ACLR requirement? | Legacy UE ACS requirement? | Legacy UE ACLR requirement | Legacy UE ACS requirement |
| Existing gNB/reader of topology 1/CW of topology 1 | Based on companies’ input since there is no such requirements in 38.104 | Based on companies’ input since there is no such requirements in 38.104 | Legacy gNB ACLR requirement? | Legacy gNB ACS requirement? | Legacy gNB ACLR requirement | Legacy gNB ACS requirement |
| devices | Based on BB LPF performance | | | | | |

**Agreement:**

FFS on the Adjacent RB/carrier Tx leakage and Rx suppression characteristics.

**Issue 2-6-9: CW-interference cancellation capability when CW inside and outside topology**

Proposal: following CW interference cancellation evaluation methodology is suggested. Besides, RAN4 needs to further discuss whether it is still necessary to evaluate -A2 evaluation case if CW interference cancellation capability is already much high, i.e. remaining CW interference is much lower than noise floor.

* Methodology: residual self-interference= Tx power - self-interference cancellation capability
* self-interference cancellation capability = spatial isolation + RF cancellation + digital cancellation if applicable
* spatial isolation is based on isolation distance assumption

**Agreement:**

* FFS on the CW-interference cancellation assumption for co-existence evaluation.