**3GPP TSG-RAN WG4 Meeting # 111 R4-2410567**

**Fukuoka, Japan, 20th May 2024 - 24th May 2024**

**Agenda item:** 10.13.4

**Source:** Moderator (CMCC)

**Title:** WF on co-existence evaluation for ambient IoT

**Document for:** Information

# Introduction

This way forward captures the agreements for co-existence evaluation for Rel-19 ambient IOT study item.

The summary in RAN4#111 is R4-2408945. The way forward agreed in RAN4#110bis is in R4-2406714.

# Deployment scenarios and spectrum usage

## Topic 2-1: Deployment scenario

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

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| **Agreement in RAN4#110bis:****Issue 2-1-1: deployment scenarios for D1T1**Option 1-1: Legacy NR gNB are outdoor macro gNB while AIoT reader/CW/devices are all indoors. Legacy NR UE is only allowed outdoors.Option 1-2: Legacy NR gNB are outdoor macro gNB while AIoT reader/CW/devices are all indoors. Legacy NR UE is indoor accessing to outdoor NR marco gNBOption 2-1: Legacy NR gNB are co-located with AIoT reader and CW. All of NR and AIoT BS/UE/Reader/Device/CW are indoors. AIoT reader /CW and Legacy gNB share same hardwareOption 2-2: Legacy NR gNB are co-located with AIoT reader and CW. All of NR and AIoT BS/UE/Reader/Device/CW are indoors. AIoT reader /CW and Legacy NR 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 2-3-2: Priorities of spectrum deployment mode for co-existence evaluation****Agreement:*** Prioritize the following spectrum deployment mode for RAN4 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
 |

**Agreement in RAN4#111:**

* Consider only adjacent RB/channel co-existence evaluation for in-band deployment scenario for NR and AIOT
* Encourage companies to provide the simulation results for option 1-1 and 1-2
	+ FFS on co-site scenario (option 2-1 and 2-2)



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

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| **Agreement in RAN4#110bis:**Option 1-1: Legacy NR gNB are outdoor macro gNB, AIoT intermediate UE/CW/devices are all indoors. Legacy NR UE is only allowed outdoor.Option 1-2: Legacy NR gNB are outdoor macro gNB, AIoT intermediate UE/CW/devices are all indoors. Legacy NR UE is indoor.**Agreement:*** For D2T2 co-existence evaluation, Legacy NR gNB are outdoor macro gNB, AIoT intermediate UE/CW/devices are all indoors.
	+ Consider option 1-1 and option 1-2 as the starting point
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## Topic 2-2: Spectrum usage

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

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| **Agreement in RAN4#110bis:*** FFS on whether to prioritize FDD DL spectrum for R2D for D1T1 for co-existence evaluation.
 |

**Agreement in RAN4#111:**

* Use FDD DL as starting point for co-existence evaluation for R2D in D1T1
	+ FFS on FDD UL spectrum.

**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**

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| **Agreement in RAN4#110bis:**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.
 |

**Agreement in RAN4#111:**

* Use inside topology as starting point for co-existence evaluation (case 1-1, case 1-2) for calibration.
* Further discuss the difference of outside topology (case 1-4) from co-existence study perspective.

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

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| **Agreement in RAN4#110bis:*** 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**

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| **Agreement in RAN4#110bis:**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
 |

**Agreement:**

* Use case 2-2 as starting point for co-existence evaluation for calibration.
* FFS on case 2-3
* Further discuss the difference of outside topology (case2-4) from co-existence study perspective.

# Evaluation methodology and cases

## Topic 3-1: Evaluation methodology

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

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| **Agreement in RAN4#110bis:** * 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
 |

**Agreement in RAN4#111:**

* Use the Monte-Carlo method as baseline for co-existence evaluation, i.e. Section 5.3 in TR38.803
* FFS on whether RAN4 needs to perform link level simulation

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

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| **Agreement in RAN4#110bis:*** 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
 |

**Agreement in RAN4#111:**

* Use SINR for calibration purpose
* FFS on performance metric for co-existence evaluation and requirements definition.

**Issue 2-4-2: SINR definition for D2R**

**Agreement in RAN4#111:**

Do not consider CW interference for calibration purpose for D1T1-A2 and D2T2-A2

FFS on how to consider CW cancellation capability in formal simulation

**Issue 2-4-2: SINR definition for R2D**

**Agreement in RAN4#111:**

SINR for R2D for calibration purposes

* signal power of device to the noise and interference within 10MHz
	+ Assume interference NR BW is 10MHz
* FFS on BB LPF

## Topic 3-2: Evaluation cases

**Issue 3-2-1: device type**

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| --- |
| **Agreement in RAN4#110bis:*** Prioritize device 1 and 2a without a frequency shifter for coexistence evaluation.
 |

**Issue 3-2-4: Evaluation cases for D1T1 for device 1 and 2a between NR and AIOT**

**Agreement in RAN4#111:**

Use the following cases for calibration purposes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Deployment scenario and topology** | **spectrum**  | **aggressor** | **victim** | **Note** |
| 图示  描述已自动生成· Case 1-1: CW is transmitted from inside the topology, transmitted in DL spectrumCase 1-2: CW is transmitted from inside the topology, transmitted in UL spectrum | R2D: DLCW2D and D2R: UL | device | NR UL | D2R |
| NR UL | reader | D2R |
| reader | NR DL | R2D |
| NR DL | device | R2D |
| R2D: DLCW2D and D2R: DL | device | NR DL | D2R |
| NR DL | reader | D2R |

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

**Agreement in RAN4#111:**

Use the following cases for calibration purposes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Deployment scenario and topology** | **spectrum**  | **aggressor** | **victim** | **Note** |
| 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: ULCW2D and D2R: UL | device | NR UL | D2R |
| NR UL | reader | D2R |
| reader | NR UL | R2D |
| NR UL | device | R2D |

**Issue 3-2-7: Multi-operator scenario**

**Agreement in RAN4#111:**

FFS on co-existence between AIOT system and adjacent operator NR system



# Evaluation parameters

## Topic 4-1: Adjacent RB Tx and Rx charateristics

**Issue 4-1-1: A-IOT reader**

**Agreement in RAN4#111:**

For calibration purpose, use 0RB guard band between AIOT and NR for in-band spectrum deployment mode

|  |  |  |
| --- | --- | --- |
|  |  | In-band |
|  | Tx | Rx |
| NR UE/A-IOT Intermediate UE | For calibration purpose | Legacy UE IBE | ACS |
| NR BS | For calibration purpose | ACLR of legacy gNB | ACS of legacy gNB |
| A-IOT BS | For calibration purpose | ACLR of legacy gNB (i.e. 45) | ACS of legacy gNB |

**Issue 4-1-2: Tx for device 1 and 2a**

**Agreement in RAN4#111:**

For device 1 and 2a, 25dBc is used for calibration purposes.

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**Issue 4-1-3: Rx for device 1 and 2a**

**Agreement in RAN4#111:**

Assume no frequency selectivity for co-existence evaluation for calibration purposes for device 1 and 2a.

## Topic 4-2: General paramters and layout

**Issue 4-2-1: General parameters**

**Agreement in RAN4#111:**

Use following parameters for calibration purposes.

|  |  |
| --- | --- |
| **General Parameter** | **D1T1&D2T2****Values for calibration purposes** |
| Carrier frequency | 900MHz |
| BW for NR | 10MHz with 15KHz SCS |
| BW for AIOT system | 180KHz |
| Waveform (CW) | CW: Unmodulated single tone |
| Waveform (R2D) | OOK waveform generated by OFDM modulator |
| A-IoT DL power control | No |
| A-IoT UL power control | No |
| Traffic model | Full buffer |
| Frequency reuse | 1 |

**Issue 4-2-2: Layout for D1T1**

**Agreement in RAN4#111:**

Use following parameters for calibration purposes, i.e. scenario 1-1 and 1-2.

For Indoor NR, parameters are FFS, i.e. scenario 2-1 and 2-2.

|  |  |
| --- | --- |
| **Parameter** | **Assumptions for D1T1** |
| Scenario | InF-DH |
| Hall size | 120x60 m |
| Room height | 10 m |
| Sectorization | None |
| Pathloss model | NLOS and LOS in TR38.901 |
| BS deployment / Intermediate UE dropping | For D1T1-A2: 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

For D1T1-A1: * FFS on layout: one node as transmission and CW, the neighbour node as reception
 |
| Device distribution  | Device Height= 1.5 mAIoT devices drop uniformly distributed over the horizontal area Number of A-IoTs = Total area × activated density (1.5 A-IOT devices/m²)1 active AIOT device under one reader at one dropMCL between device and reader is 45dB for calibration. |
| NR BS deployment (outdoor), i.e. scenario 1-1 and 1-2 | Hexagonal grid, 19 macro sites, 3 sectors per site with wrap around, 1 AIOT indoor scenario per sectorthe minimum 2D distance between macro BS and indoor factory centre is set as 100m.图示  描述已自动生成  |
| NR BS Inter-site distance | 750 |
| Minimum NR BS – NR UE distance (2D) | 35 m |
| NR UE (D1T1) dropping | For scenario option 1-1, uniformly distributed outdoor.For scenario option 1-2, uniformly distributed, 80% indoor, 20% outdoorUE number:DL active: 1 UE per cell UL active UE: 3UE per cell |
| O2I penetration loss | High penetration loss as in TR 38.901 for calibration |

**Issue 4-2-3: Layout for D2T2**

**Agreement in RAN4#111:**

Use InH-office as baseline for D2T2 co-existence evaluation.

Use following parameters for calibration purposes, i.e. scenario 1-1 and 1-2.

|  |  |
| --- | --- |
| **Parameter** | **Assumptions for D2T2** |
| Scenario | InH-office |
| Hall size | 120 x50 m |
| Room height | 3m |
| Sectorization | None |
| Pathloss model | LOS and NLOS in TR38.901 |
| BS deployment / Intermediate UE dropping | * L=120m x W=50m;
* Intermediate UE height = 1.5 m

For D2T2-A2: The intermediate UEs selected from the fixed positions.Number of intermediate UE for calibration: * Option 1: 2 UE at one drop
* Option 2: 12 UE at one drop

For D2T2-A1: FFS on layout |
| Device distribution  | Device Height= 1.5 mAIoT devices drop uniformly distributed over the horizontal area Number of A-IoTs = Total area × activated density (1.5 A-IOT devices/m²)1 active AIOT device under one reader at one dropMinimum distance between reader and device is 1m  |
| NR BS deployment | Hexagonal grid, 19 macro sites, 3 sectors per site with wrap around, 1 AIOT indoor scenario per sectorthe minimum 2D distance between macro BS and indoor factory centre is set as 100m.图示  描述已自动生成 |
| NR UE dropping | For scenario option 1-1, uniformly distributed outdoor.For scenario option 1-2, uniformly distributed, 80% indoor, 20% outdoorUE number:* DL active UE: 1 UE per cell
* UL active UE: 3 UE per cell
 |
| O2I penetration loss | High penetration loss as in TR 38.901 |

## Topic 4-3: Paramters for AIOT BS/intermedaite UE and device

**Issue 4-3-1: AIOT micro-BS parameters for D1T1**

**Agreement in RAN4#111:**

Use following parameters for calibration purposes.

|  |  |
| --- | --- |
| **A-IoT micro BS parameters** | **Values for calibration purposes** |
| A-IoT micro-BS total Tx power | 33dBm |
| A-IoT micro-BS receiver Noise Figure（dB） | 10 |
| A-IoT micro-BS antenna gain (dBi) |  6 dBi |
| Antenna pattern | Refer to TR25.942 |

**Issue 4-3-2: Intermediate UE parameters for D2T2**

**Agreement in RAN4#111:**

Use following parameters for calibration purposes.

|  |  |
| --- | --- |
| **intermediate UE parameters** | **Values for calibration purposes** |
| intermediate UE total Tx power（dBm） | 23dBm |
| gain of antenna intermediate UE (dBi) | 0 |
| intermediate UE receiver Noise Figure（dB） | 9 |
| Antenna configuration | Omni direction antenna |

**Issue 4-3-3: CW parameters**

**Agreement in RAN4#111:**

Do not use CW2D for calibration purposes.

FFS on:

* CW interference to NR BS/UE/AIOT
* CW remaining interference after CW cancellation.
	+ [CW IBE]

**Issue 4-3-4: AIOT device parameters**

**Agreement in RAN4#111:**

Use Device 1 with following parameters for calibration purposes.

|  |  |
| --- | --- |
| **A-IoT device parameters** | **Device 1****Values for calibration purposes** |
| A-IoT device effective antenna gain per Tx or Rx branch (dBi) | 0  |
| A-IoT device reflection （backscatter）loss (dB)Note: due to, e.g., impedance mismatch | OOK: -6 dB |
| A-IoT device power gain of reflection amplifier (dB) | N/A |
| A-IoT Device receiver sensitivity (dBm)Use this value to determine whether device can camp on the cell. | -36 |
| A-IoT device noise figure (dB) | 24 |
| Guard band | 0PRB |

## Topic 4-4: Paramters for legacy NR

**Issue 4-4-1: NR macro BS parameters**

**Agreement in RAN4#111:**

Use following parameters for calibration purposes.

|  |  |
| --- | --- |
| **NR macro-BS Parameter** | **Values for calibration purposes** |
| Macro-BS Tx power (dBm) | 46 |
| BS antenna gain (dBi) | Refer to TR36.942 |
| Height of macro NR BS (m) | 25 |
| NR Macro-BS Noise Figure(dB) | 5 |
| Network location | outdoor |

**Issue 4-4-2: NR UE parameters**

**Agreement in RAN4#111:**

Use following parameters for calibration purposes.

|  |  |
| --- | --- |
| **NR UE Parameter** | **Values for calibration purposes** |
| UE TX power in dBm | -40 to 23 |
| NR UE Antenna gain (dBi) | 0 |
| Height of UE antenna (m) | 1.5  |
| NR UE ACLR（dB） | 30 |
| NR UE Noise Figure（dB） | 9 |
| Antenna configuration | Omni direction antenna |