3GPP TSG-RAN WG4 Meeting #112 R4-2414304

Maastricht, Netherlands,19 – 23 Aug, 2024

**Agenda item:** 8.20.4

**Source:** CMCC

**Title:** WF on Co-existence study for ambient IoT

**Document for:** Approval

# Introduction

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

The summary in RAN4#112 is R4-2412833. The way forward agreed in previous RAN4 meetings are R4-2406714 and R4-2410567.

# 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)

瀑布图  低可信度描述已自动生成 |

**Agreement in RAN4#112:**

* Feasibility of option 2-1/2-2 for device 1 and 2a should be evaluated with LLS simulation. Parameters for LLS are based on company report.
	+ Encourage companies to provide the co-existence simulation results.

## 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.
 |

**Agreement in RAN4#112:**

* Use FDD DL as baseline for co-existence evaluation for R2D in D1T1, FDD UL can be considered as optional

**Issue 2-2-2: CW spectrum for D2T2**

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| 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 in RAN4#111:*** 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.
 |

**Agreement in RAN4#112:**

* For D2T2, CW transmitted in UL is baseline for co-existence evaluation, CW transmitted in DL (i.e. case 2-3) can be considered once RAN4 agreed on the CW distribution for outside topology.

# Evaluation methodology and cases

## Topic 3-1: Evaluation methodology

**Issue 3-1-1: LLS to derive guard RBs**

**Agreement:**

* perform the study within the scope of the feasibility study in issue 2-1-1.

**Issue 3-1-2: SINR vs BLER**

**Agreement:**

* RAN4 does not perform LLS to derive SINR values for R2D and D2R in this SI.
* RAN4 can take RAN1 LLS as the reference to derive SINR values for R2D and D2R in this SI.

**Issue 3-1-3: Assumption of R2D transmission and CW transmission for evaluation**

**Agreement:**

* Assume transmission timeline for R2D and CW signal among different A-IoT BS/CW node transmission are aligned for co-existence evaluation.



**Issue 3-1-4: Assumption of R2D and NR UL for D2T2**

**Agreement:**

* Assume intermediate UE in D2T2 transmitted R2D and transmitted NR UL in TDM manner for co-existence evaluation.

**Issue 3-1-5: whether to study interference mitigation scheme for scenario option 1-2**

**Agreement:**

* RAN4 focus on the co-existence evaluation in this study item.

## Topic 3-2: Performance metric and SINR definition

**Issue 3-2-1: 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.
 |

**Agreement in RAN4#112:**

For inter-system interference (between AIOT and NR):

* If SINR degradation is smaller than and equal to [1]dB, it can be considered that inter-system interference is negligible.
* If SINR degradation is lager than [1]dB, consider following criteria:
	+ Outage percentage consider SINR level with [10%] BLER
	+ FFS on the outage percentage-tile
* Note: For SINR degradation, SINR refers to the 5% and 50% CDF SINR

For intra-system interference (between AIOT and AIOT), consider following criteria:

* + Outage percentage consider SINR level with [10%] BLER
	+ FFS on the outage percentage-tile

**Issue 3-2-2: SINR definition for D2R**

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| **Agreement in RAN4#111:**Do not consider CW interference for calibration purpose for D1T1-A2 and D2T2-A2FFS on how to consider CW cancellation capability in formal simulation |

**Agreement in RAN4#112:**

* SINR includes CW interference is used as the baseline reference for co-existence evaluation for CW reader.
* SINR is calculated as total power ratio:

**Issue 3-2-3: SINR definition for R2D**

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| --- |
| **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
 |

**Agreement in RAN4#112:**

* signal power of device to the noise and interference within 10MHz is baseline assumption
* Consider [180KHz] noise and interference bandwidth as optional

## Topic 3-3: CW considerations

**Issue 3-3-1: Layout of CW for outside topology**

* Option 1 (Huawei): assume that CW node is co-located with the neighbouring A-IoT Reader.
* Option 2 (vivo):



* Option 3 (Ericsson): Model a dedicated CWT node layer with a grid shift to the network layer.

**Agreement in RAN4#112:**

* ~~Simulate CW outside topology case~~
* ~~For the CW outside topology layout:~~
	+ ~~For every reader, the outside topology CW node is always located at a different nearest neighboring reader location.~~
	+ ~~The nearest CW to reader is activated.~~
	+ ~~If the CW node is co-located with other readers, CW node and reader are not transmitted simultaneously.~~
	+ ~~Note: This proposal is based on some further offline discussion. Companies please further check~~

-           For the CW outside topology layout for co-existence study:

* + The CW layout is the same as AIoT reader
	+ For each device, the nearest CW node will be activated during the simulation
	+ For each grid point, CW node and AIoT reader will not be activated simultaneously

**Issue 3-3-2: CW cancellation capability**

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| **Agreement in RAN4#111:**Do not consider CW interference for calibration purpose for D1T1-A2 and D2T2-A2FFS on how to consider CW cancellation capability in formal simulation |

**Agreement in RAN4#112:**

* Companies to report the CW cancellation capability used for co-existence evaluation, CW cancellation capability for inside topology and outside topology can be different.
	+ total interference cancellation capability = spatial isolation + RF cancellation + digital cancellation
	+ CW transmission impact on the received SINR, e.g. degradation

**Issue 3-3-3: CW unwanted emissions**

**Agreement:**

* FFS on how to model CW unwanted emissions.

## Topic 3-4: Evaluation cases

**Issue 3-4-1: Evaluation cases for co-existence evaluation**

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| **No.** | **deployment scenario and topology** | **spectrum** | **(Aggressor -> Victim)** | **note** |
| **1-1** | **D1T1-A2- legacy UE only outdoor** | R2D: DLCW2D and D2R: DL | Device->NR DL | D2R |
| NR DL->reader | D2R |
| Reader->NR DL | R2D |
| NR DL->device | R2D |
| **1-2** | **D1T1-A2-legacy UE indoor** | R2D: DLCW2D and D2R: DL | Device->NR DL | D2R |
| NR DL->reader | D2R |
| Reader->NR DL | R2D |
| NR DL->device | R2D |
| **2-1** | **D1T1-B-legacy UE only outdoor** | R2D: DLCW2D and D2R: UL | Device->NR UL | D2R |
| NR UL->reader | D2R |
| Reader->NR DL | R2D |
| NR DL->device | R2D |
| **2-2** | **D1T1-B-legacy UE indoor** | R2D: DLCW2D and D2R: UL | Device->NR UL | D2R |
| NR UL->reader | D2R |
| Reader->NR DL | R2D |
| NR DL->device | R2D |
| **3 (O)** | **D1T1-B-legacy UE indoor** | R2D: ULCW2D and D2R: UL | Device->NR UL | D2R |
| NR UL->reader | D2R |
| Reader->NR UL | R2D |
| NR UL->device | R2D |
| **4-1** | **D2T2-A2-legacy UE only outdoor** | R2D: ULCW2D and D2R: UL | Device->NR UL | D2R |
| NR UL->reader | D2R |
| Reader->NR UL | R2D |
| NR UL->device | R2D |
| **4-2** | **D2T2-A2-legacy UE indoor** | R2D: ULCW2D and D2R: UL | Device->NR UL | D2R |
| NR UL->reader | D2R |
| Reader->NR UL | R2D |
| NR UL->device | R2D |
| **5-1 (O)** | **D2T2-B-legacy UE only outdoor** | R2D: ULCW2D and D2R: DL | Device->NR DL | D2R |
| NR DL->reader | D2R |
| Reader->NR UL | R2D |
| NR UL->device | R2D |
| **5-2 (O)** | **D2T2-B-legacy UE indoor** | R2D: ULCW2D and D2R: DL | Device->NR DL | D2R |
| NR DL->reader | D2R |
| Reader->NR UL | R2D |
| NR UL->device | R2D |

*Moderator note: Following cases are agreed offline for evaluation. The note will be removed in the final Tdoc of WF*

*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, D1T1-A2 only*

*~~· 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, D1T1-B*

*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, D2T2-A2*

*· Case 2-3: CW is transmitted from outside the topology, transmitted in DL spectrum , D2T2-B*

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

**Issue 3-4-3: Device type**

**Agreement:**

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

**Issue 3-4-4: Multi-operator scenario**

**Agreement:**

* Focus on the co-existence study between A-IoT and NR in this study item.
* The scenario of multiple A-IOT operators in the same band can be considered in the WI phase or in the study of the future release.

# Evaluation parameters for formal simulation

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

**Issue 4-1-1: A-IOT reader and NR BS**

**Agreement:**

|  |  |
| --- | --- |
|  | In-band |
| Tx | Rx |
| NR UE/A-IOT Intermediate UE | Legacy UE IBE | ACS |
| NR BS | ~~Option 1: ACLR of legacy gNB (45dB)~~Option 1: 30dB (baseline)Option 2: 17dB (optional) | ACS of legacy gNB |
| A-IOT BS | ACLR of legacy NB -IOT gNB (i.e. ACLR1:40dB，ACLR2:50dB) | ACS of legacy gNB |

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

|  |
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| **Agreement in RAN4#111:**For device 1 and 2a, 25dBc is used for calibration purposes **图表, 直方图  描述已自动生成** |

**Agreement in RAN4#112:**

* + 25dBc with 15KHz bandwidth as baseline
	+ 16dBc with 90KHz bandwidth as optional

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

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| **Agreement in RAN4#111:**Assume no frequency selectivity for co-existence evaluation for calibration purposes for device 1 and 2a. |

**Agreement in RAN4#112:**

* + Use R2D without LPF as baseline for co-existence evaluation
	+ R2D with LPF as optional.

|  |  |
| --- | --- |
| **SINR** | **R2D with LPF** |
| Interference from NR | Frequency selectivity: [4.3 dB] |
| Noise bandwidth | [180kHz] |

**Issue 4-1-4: Scaling factor**

**Agreement:**

* when A-IoT reader as victim, the scaling factor is suggested as below to compensate different aggressor and victim bandwidth when calculating inter-system interference.
* Scaling factor =

## Topic 4-2: General parameters and layout

**Issue 4-2-1: Active rate of reader for D1T1 and D2T2**

**Agreement:**

* Minimum distance between active readers: 60m as baseline, other values can be reported by other companies.

- 2 readers are activated in one drop

**Issue 4-2-2: Indoor UE percentage for scenario option 1-2**

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| **Agreements in RAN4#111:**For scenario option 1-2, uniformly distributed, 80% indoor, 20% outdoo |

**Agreements in RAN4#112:**

* Option 1: 10%
* Option 2: 100%

**Issue 4-2-3: Minimum NR BS-NR UE distance (2D)**

|  |
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| **Agreements in RAN4#111:**Minimum NR BS – NR UE distance (2D): 35 m |

**Agreements in RAN4#112:**

* Use MCL of 70 dB for Minimum NR BS – NR UE distance

**Issue 4-2-4: Minimum distance between device and reader for D1T1 and D2T2**

|  |
| --- |
| **Agreements in RAN4#111:**For D1T1: MCL between device and reader is 45dB for calibration.For D2T2: Minimum distance between reader and device is 1m |

**Agreements in RAN4#112:**

* Minimum distance between reader and device is 1m.

**Issue 4-2-5: NR RB allocation**

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| **Agreements in RAN4#111:**NR UE number:- DL active UE: 1 UE per cell - UL active UE: 3UE per cell |

**Agreements in RAN4#112**

* For RB allocation, each UE is scheduled with 17PRB and A-IoT using 1PRB is located between the most two UEs. Detailed illustration is listed as below:



**Issue 4-2-6: Penetration loss for O2I**

**Agreement:**

* Use the equation of 7.4-2 in 38.901
* PLin = 0.5 \* d2D-in where d2D-in is the distance to nearest factory/office boundary on the line between Tx and Rx point.
* Check whether to set maximum value of d2D-in as [25m]



**Issue 4-2-7: Pathloss**

**Agreement:**

|  |  |  |
| --- | --- | --- |
|  | **D1T1** | **D2T2** |
| Indoor legacy UE <-> indoor device | Indoor office |
|  |  |
| Indoor legacy UE <-> indoor reader | Indoor factory DH | Indoor office |
| Outdoor macro gNB <-> indoor device/indoor reader | PLb: Uma |
| Outdoor UE <-> indoor device/ D2T2 UE, i.e. UE<->UE | PLb: Umi |
| Outdoor UE <-> indoor D1T1 reader, i.e. UE<-> reader | PLb: UMi |
| Note: For other indoor factory related parameters that are not listed, it’s suggested to refer to 7.8.4 of TR 38.901. |

 **Issue 4-2-8: Other general parameters**

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| --- | --- |
| **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 |

## Topic 4-3: Parameters for AIOT BS/intermediate UE and device

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

**Agreement:**

|  |  |
| --- | --- |
| **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 | Antenna Array Geometry：* 1\*1\*1 antenna element
* equals to omni-directional antenna pattern in GCG in horizontal

图示, 示意图  描述已自动生成

|  |  |
| --- | --- |
| **Parameter** | **Assumption** |
| Antenna pattern (horizontal) | ,  = 90°, *Am* = 15 dB  |
| Antenna pattern (vertical) | ,  = 90°, *SLAv* = 15 dB |
| Combining method in 3D antenna pattern |  |
| BS antenna gain (dBi) (including feeder loss) | 6 |

 |

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

**Agreement:**

|  |  |
| --- | --- |
| **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: AIOT device parameters**

**Recommended WF:**

|  |  |  |  |
| --- | --- | --- | --- |
| **A-IoT device parameters** | **Device 1****Values used for calibration**  | **Device 2a** | **~~RAN1 assumption~~****~~(R1-2406752)~~** |
| A-IoT device effective antenna gain per Tx or Rx branch (dBi) | 0  | [0] | ~~For A-IoT device, 0dBi~~ |
| A-IoT device reflection （backscatter）loss (dB)~~Note: due to, e.g., impedance mismatch~~ | OOK: -6 dB | OOK: -6 dB | ~~OOK: 6 dB~~~~PSK: 0 dB~~~~FSK: Y dB~~~~It is applicable for device 1 and 2a.~~~~Companies to report and justify their assumptions for Y.~~~~Companies to report in row 3D if they assume any additional related loss.~~ |
| A-IoT device power gain of reflection amplifier (dB) | N/A | 10(M),15(O) | ~~10 dB (M)~~~~15 dB (O)~~~~Note: Only for device 2a~~ |
| A-IoT Device receiver sensitivity (dBm)Use this value to determine whether device can camp on the cell. | -36 | [-45] | ~~For Budget-Alt1~~~~For device 1 (RF-ED), for example:~~~~{‑30 dBm, ‑36 dBm, ‑40 dBm, etc}~~~~For device 2 (RF-ED), for example:~~~~{-40 dBm, -45 dBm, etc}~~~~For Budget-Alt2~~~~Calculated (see note1)~~ |
| A-IoT device noise figure (dB) | 24 | [20] | ~~For RF-ED receiver~~* ~~20dB, Device 2~~
* ~~FFS other values~~
 |
| Guard band | 0PRB | 0PRB |  |

## Topic 4-4: Paramters for legacy NR

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

**Agreement:**

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| --- | --- |
| **NR macro-BS Parameter** | **Values for calibration purposes** |
| Macro-BS Tx power (dBm) | 46 |
| BS antenna gain (dBi) and antenna pattern | Antenna Array Geometry：* 1\*1\*1 antenna element
* BS point at fixed beam direction
	+ vertical: θtilt + 90°
	+ horizontal: 0, 120, 240 °

图示, 示意图  描述已自动生成

|  |  |
| --- | --- |
| **Parameter** | **Assumption** |
| Antenna pattern (horizontal)(For 3-sector cell sites with fixed antenna patterns) |  = 65 degrees, *Am* = 25 dB  |
| Antenna pattern (vertical)(For 3-sector cell sites with fixed antenna patterns) |  = 10 degrees, *SLAv* = 25 dB, = 9 degrees |
| Combining method in 3D antenna pattern |  |
| BS antenna gain (dBi) (including feeder loss) | 15 |

 |
| 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:**

|  |  |
| --- | --- |
| **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 |

## Topic 4-5: Paramters for CW

**Issue 4-5-1: Other CW parameters**

**Agreement:**

|  |  |  |
| --- | --- | --- |
| **CW parameters** | **D1T1** | **D2T2**  |
| Tx power（dBm） | If UL spectrum is used, UE Tx power is assumed, i.e. 23dBIf DL spectrum is used, AIOT micro-BS Tx power is assumed. | Inter-mediate UE Tx power is assumed. |
| Antenna gain | Same as AIOT reader | Same as inter-mediate UE |

## Topic 4-6: Parameters for collocated scenario (option 2-1 and 2-2)

**Issue 4-6-1: Simulation assumptions for collocated scenario**

**Agreement:**

Reuse the evaluation parameters of scenario option1-1 and 1-2, additionally use following parameters.

1) NR BS indoor gNB deployed co-site with A-IoT indoor reader;

2) ISD as 20m;

3) Min BS-UE distance: 0m;

4) NR indoor UE uniformly distributed.