**3GPP TSG-RAN WG4 Meeting #113 R4-2418154**

**Orlando, US, 18th – 22nd November, 2024**

**Agenda item: 7.21.4**

**Source:** Moderator (CMCC)

**Title:** Topic summary for [113][132] FS\_Ambient\_IoT\_solutions\_part1

**Document for:** Information

# Introduction

This summary focuses on the R19 ambient IOT study item under agenda 7.21, 7.21.2.1, 7.21.2.2. The summary in previous meetings are in R4-2405289, R4-2408945, R4-2412833 and R4-2415233. The way forward agreed in previous RAN4 meetings are R4-2406714, R4-2410567, R4-2414304 and R4-2417196.

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| --- | --- | --- |
| **TDoc** | **Title** | **Source** |
| [**R4-2418723**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418723.zip) | Draft TP to TR38.769 on conclusion for A-IOT | CMCC |
| [**R4-2418801**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418801.zip) | A-IoT general aspects (move to 133) | Huawei, HiSilicon  |
| **[R4-2419477](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419477.zip)** | TP to TR 38.769: A-IoT general overview (move to 133) | Ericsson  |
| **[R4-2418180](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418180.zip)** | TP to TR 38.769 on the impact from AIoT CW to NR | vivo |
| [**R4-2418724**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418724.zip) | Evaluation methodology for ambient IOT co-existence | CMCC |
| [**R4-2418802**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418802.zip) | A-IoT co-existence evaluation cases | Huawei, HiSilicon |
| **[R4-2419481](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419481.zip)** | Co-existence evaluation methodology and cases | Ericsson |
| [**R4-2419553**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419553.zip) | TP to 38.769 on co-existence evaluation methodology | Qualcomm Incorporated |
| R4-2417831 | Further co-existence evaluation results for Ambient IoT in NR | CATT |
| [**R4-2417979**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2417979.zip) | Simulation analysis for Ambient IoT co-existence | Huawei, HiSilicon |
| [**R4-2417980**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2417980.zip) | TP to TR38.769: Co-existence simulation | Huawei, HiSilicon |
| R4-2417981 | Collection of simulation results for Ambient-IoT co-existence study | Huawei, HiSilicon |
| [**R4-2418034**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418034.zip) | Coexistence evaluation on D1T1 deployment scenario | Sony |
| [**R4-2418181**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418181.zip) | TP to TR 38.769 on D2T2 co-existence evaluation and analysis | vivo |
| [**R4-2418182**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418182.zip) | Further evaluation on D2T2 co-existence | vivo |
| [**R4-2418403**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418403.zip) | Discussion on co-existence evaluation results for Ambient IoT and NR | Spreadtrum Communications |
| [**R4-2418725**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418725.zip) | Discussion on A-IoT co-existence evaluation | CMCC |
| [**R4-2418852**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418852.zip) | Discussion on Ambient IoT Coexistence Evaluations | Qualcomm Incorporated |
| [**R4-2419199**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419199.zip) | Discussion on Co-existence evaluations | ZTE Corporation, Sanechips |
| [**R4-2419366**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419366.zip) | on co-existence evaluations | OPPO |
| [**R4-2419476**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419476.zip) | Coexisting study simulation assumptions and initial results | Ericsson |
| [**R4-2419554**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419554.zip) | TP to 38.769 on co-existence simulation assumptions | Qualcomm Incorporated |
| [**R4-2419649**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419649.zip) | On considerations of frequency shifter | Samsung |

# TP

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| --- | --- | --- | --- |
| **TDoc** | **Title** | **Source** | **Recommendation** |
| [**R4-2418723**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418723.zip) | Draft TP to TR38.769 on conclusion for A-IOT | CMCC | To be revised |
| [**R4-2419553**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419553.zip) | TP to 38.769 on co-existence evaluation methodology | Qualcomm Incorporated | Updates on section 6.6.4, to be merged if agreed |
| [**R4-2417980**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2417980.zip) | TP to TR38.769: Co-existence simulation | Huawei, HiSilicon | Co-existence summary , to be revised |
| [**R4-2418181**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418181.zip) | TP to TR 38.769 on D2T2 co-existence evaluation and analysis | vivo | Co-existence summary, to be merged to Huawei TP if agreed |
| [**R4-2418180**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418180.zip) | TP to TR 38.769 on the impact from AIoT CW to NR | vivo | Updates on section 6.6.4, to be merged if agreed |
| [**R4-2418725**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418725.zip) | Discussion on A-IoT co-existence evaluation | CMCC | Co-existence summary, to be merged to Huawei TP if agreed |
| [**R4-2419554**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419554.zip) | TP to 38.769 on co-existence simulation assumptions | Qualcomm Incorporated | Updates on 6.6.3, to be merged if agreed |

# Evaluation methodology and cases

## Topic 2-1: Performance metric and target SINR

|  |
| --- |
| **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 or 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
* Note: For SINR degradation, SINR refers to the 5% and 50% CDF SINR

For intra-system interference (between AIOT and AIOT):* + Outage percentage consider SINR level with [10%] BLER
	+ FFS on the outage percentage

**Agreement in RAN4#112bis:*** Consider 3 SINR values for D2R and R2D respectively and derive the outage percentage value/range.
* The 3 values can be selected according to following steps:
1. Select one set SNR/CNR values @ 10% BLER from companies based on RAN1 LLS (refer to latest RAN1 LLS summary)
2. Set the SNR/CNR range by removing the highest and lowest value from the set in step 1
3. Pick 3 values from the range in step 2, e.g. highest, lowest, middle

Note: R2D CNR needs to be transformed to SINR |

**Issue 2-1-1: SINR values @10% BLER for D2R**

**Proposal in RAN4#113:**

|  |  |  |
| --- | --- | --- |
| 　 | **D1T1 D2R（coherent）** | **D2T2 D2R****（coherent）** |
| **min** | **-7.8** | **-7.6** |
| **max** | **0.23** | **-5** |
| **average** | **-4.3** | **-6** |

|  |  |  |
| --- | --- | --- |
| 　 | **D1T1 D2R****（non-coherent）** | **D2T2 D2R****（non-coherent）** |
| **min** | **-3** | **-9** |
| **max** | **13** | **2.1** |
| **average** | **5.5** | **-3.2** |

**Recommended WF:**

Following last meeting agreement, moderator provides the target SINR values for D2R.

More discussion is needed on whether to use all the values above to derive the outage percentage for D2R

**Agreement:**

* Use all the values below to derive the outage percentage for D2R

|  |  |  |
| --- | --- | --- |
| 　 | **D1T1 D2R（coherent）** | **D2T2 D2R****（coherent）** |
| **min** | **-7.8** | **-7.6** |
| **max** | **0.23** | **-5** |
| **average** | **-4.3** | **-6** |

|  |  |  |
| --- | --- | --- |
| 　 | **D1T1 D2R****（non-coherent）** | **D2T2 D2R****（non-coherent）** |
| **min** | **-3** | **-9** |
| **max** | **13** | **2.1** |
| **average** | **5.5** | **-3.2** |

**Issue 2-1-2: SINR values @10% BLER for R2D**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 　 | **TDL-A device 1CNR** | **R2D SNR for device 1** | **TDL-A device 2aCNR** | **R2D SNR for device 2a** |
| **min** | **2.6** | **-14.8**  | **3.37** | **-14.1**  |
| **max** | **26.7** | **9.3**  | **22.5** | **5.1**  |
| **average** | **10.9** | **-6.5**  | **10.1** | **-7.3**  |

**Recommended WF:**

Following last meeting agreement, moderator provides the target CNR and transferred SINR values for R2D.

Further discuss whether the CNR to SNR conversion with a scaling factor

Option 1: no scaling factor

Option 2: Required SNR/CNR] - lin2dB([ED channel bandwidth] / [transmission bandwidth])

Option 3: others

Recommend confirming above CNR values @ 10% BLER to derive outage percentage, and discuss transferred SINR values under issue 2-2-1 seperately.

**Ericsson: RAN1 is not aligned with RAN4. It is optional for RAN1.**

* **Moderator: we do not need consider transferring SINR.**

**Ericsson: There are discrepancy in the link level simulation and co-existence evaluation. From the simulation, the noise is far below the signal level. From the network perspective, we do not think it is correct way.**

**ZTE: We have offline discussion on how to transfer SINR. There are different understanding. We can just follow recommended way forward.**

**Qualcomm: It is difficult to discuss how to transfer CNR to SINR. How can we conclude co-existence?**

**Huawei: This issue is only related to case D ,which is NR DL impact IoT device. We have conclusion for this case when the degradation of SINR is less than 1dB. We only need this SINR value to report the outage of intra system. We assume two readers simultaneously. It causes inter-system interference. It may not impact on the co-existence study. We can report the observation from Ericsson and other companies.**

**Moderator: Ideally we would like to draw conclusion from the inter-system. On the other hand, if the baseline SINR is very low, it may tolerate the 1dB degradation. From RAN4, we only conclude from the inter-system perspective.**

**Ericsson: Our view is that the co-existence must have CNR degradation and SNR threshold. If SNR degradation is more than 1dB, but it is still greater than the threshold. In such case, the co-exsitence can be ensured. If the SNR is less than 1dB, but SINR is below the threshold, the co-existence cannot be guaranteed.**

**Moderator: To draw the conclusion from the simulation, we can use SNR degradation. We can say that the performance is also impacted by threshold. Even in RAN1 the results are diverse. This is SI.**

**Ericsson: we need recognize that we have discussed the necessity of threshold. For performance metric, we need both.**

**Issue 2-1-3: Outage percentage of AIOT system**

**Proposal in RAN4#113:**

Proposal 1 (Ericsson, R4-2415453): Baseline outage percentile is 20% and needs improvement of coexisting simulation assumption to reduce the outage percentile.

Proposal 2 (CMCC, R4-2418725): If outage percentage is smaller than [5%], consider no outage or no performance impact for ambient IOT reader/device.

**Recommended WF:**

If outage percentage is smaller than [5%], consider no outage or no performance impact for ambient IOT reader/device.

Qualcomm: do we need check SINR degradation and outage?

Moderator: If SINR degradation is less than 1dB, the impact on the system is negligible. Both SINR degradation and outage are performance metric.

Ericsson: We are not sure how to derive this scenario. It is related to RAN1 design. We are not sure how RAN1 design impact this outage.

Qualcomm: we should keep 5% open.

Agreement:

* For D2R and R2D, the SINR degradation will be used as the performance metric
	+ The outage percentage impact will be considered in WI phase.

## Topic 2-2: SINR definition

**Issue 2-2-1: R2D SINR 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:*** Alt-1: Assume no frequency selectivity
* Alt-2:

|  |  |
| --- | --- |
| **SINR** | **R2D with LPF** |
| Interference from NR | Frequency selectivity: [7.5 dB] |
| Noise bandwidth | [180kHz] |
| $$SINR\_{R2D\\_with\\_LPF}=\frac{Wanted\\_S\_{R2D\\_180kHz}}{NoiseFloor\_{ 180kHz}+(Interference\_{NR\_{10MHz}}/LPF\\_Selectivity\_{linear})}$$ |

* Alt-3:

|  |
| --- |
| **For R2D receiver with LPF** |
| **RF BW** | 10MHz |
| **BB BW** | [180kHz] |
| **SINRi** (linear, not dB) | Input SINR at the antenna connector with noise/interferencde BW=RF BW |
| **SINRo** (linear, not dB) | Output SINR after BB LPF assuming downconverted noise/interference BW=BB BW |
| $$SINR\_{o}=\frac{SINR\_{i}^{2}}{\left(8\*SINR\_{i}+4\right)}\*\frac{BW\_{RF}}{BW\_{BB}}$$ |

* Alt-4: other LLS assumptions are not excluded

**Agreement in RAN4#113:*** For R2D, SINR at antenna connector is used as the starting point, i.e interference and noise bandwidth is 10MHz.
 |

**Proposal 1 (Ericsson, R4-2419481):** To factor in the noise increase in the SINR calculation based on the LLS results, the noise increase is listed in Table 1 for different PSD difference between A-IoT RB and NR RB. Such noise raise value can be added in the SINR calculated using the 180kHz noise bandwidth. With this, we suggest the procedure below for R2D SINR calculation:

Step 1: Calculate the SINR within the A-IoT transmission bandwidth (1 RB)

Step 2: Calculate the A-IoT signal power in linear scale and calculate the A-IoT signal PSD level within one RB (should be the same with A-IoT signal power as only one RB is transmitted in this case).

Step 3: Calculate the NR interference power P\_NR in linear scale within the 10 MHz

Step 4: Calculate the PSD of NR signal within 1 RB:  P\_NR /51

Step 5: Compare the PSD level difference in dB between PSD of NR signal in Step 4 and A-IoT signal power in Step 2.

Step 6: Look up for the noise raise value in dB in Table 1 referencing to the PSD difference in step 5

Step 7:  Calculate the new SINR value by subtracting the noise raise value in dB (Step 6) into the SINR in step 2

Step 8: Compare the SINR in step 7 to SNR threshold without the NR interference, if lower than SNR threshold, mark the device as outage.

Table 1: noise increase due to NR signal interferer for a noise bandwidth of 180kHz RF ED receiver

|  |  |  |  |
| --- | --- | --- | --- |
| Case#1 | PSD difference | SNR threshold | Noise raise factor (dB) |
| 1 | -22 | 17,8 | 0 |
| 2 | -21 | 18 | 0,2 |
| 3 | -20 | 18,15 | 0,35 |
| 4 | -19 | 18,3 | 0,5 |
| 5 | -18 | 18,5 | 0,7 |
| 6 | -17 | 18,8 | 1 |
| 7 | -16 | 19,2 | 1,4 |
| 8 | -15 | 19,5 | 1,7 |
| 9 | -14 | 20,1 | 2,3 |
| 10 | -13 | 21,2 | 3,4 |
| 11 | -12 | 22,8 | 5 |
| 12 | -11 | 26,7 | 8,9 |

Proposal 2 (Sony, R4-2418034): to obtain the SINR in R2D link correctly, the RF-ED receiver needs to be correctly modelled with consideration of the self-mixing effect.

**Recommended WF:**

More discussion is needed.

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

|  |
| --- |
| **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.

$$baseline SINR=\frac{received wanted signal power}{\left(noise + intra\\_system interference\right)\_{within total receiver bandwidth}+\left(residual CW interference after cancellation\right)\_{in linear scale}}$$* SINR is calculated as total power ratio:

$$SINR=\frac{received wanted signal power}{\left(noise + intra\\_system interference + inter\\_system interference\right)\_{within total receiver bandwidth}+\left(residual CW interference after cancellation\right)\_{in linear scale}}$$**Agreement in RAN4#112bis:*** For -B and -A1, consider following baseline SINR:
	+ Option 1 (last meeting agreement):

$$baseline SINR for CW outside=\frac{received wanted signal power}{\left(noise + intra\_{systeminterference}\right)\_{within total receiver bandwidth}+\left(residual CW interference after cancellation\right)\_{in linear scale}}$$* + Option 2 (new proposal):

$$baseline SINR for CW outside=\frac{received wanted signal power}{\left(noise + intra\_{systeminterference}+phase noise\right)\_{within total receiver bandwidth}+\left(residual CW interference after cancellation\right)\_{in linear scale}}$$Note: If option2 is used, companies needs to report phase noise modelling. |

**Proposal in RAN4#113：**

Proposal 1 (Qualcomm, R4-2418852):

* Phase noise has non-negligible impact to the D2R SINR.
* RAN4 should specify phase noise requirements for the component which provides the phase noise to the system.

**Recommended WF:**

Recommend discussing in thread 133 on the potential phase noise requirements.

Qualcomm: We want to clarify that we need study and specify it in the WI phase. Option 2 needs more discussion on how to capture it in the TR.

# Evaluation parameters and results

## Topic 3-1: Adjacent RB Tx and Rx characteristics

**Issue 3-1-1: A-IOT reader and NR BS**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Agreement in RAN4#112bis:**

|  |  |
| --- | --- |
|  | In-band |
| Tx | Rx |
| NR UE/A-IOT Intermediate UE | For NR UE:* Baseline: Legacy UE IBE

For intermediate UE:* Baseline: legacy UE IBE
* Optional: NB-IOT ACLR
 | In-band A-IOT signal interference to NR is not considered when calculating SINR. Companies to check the interference caused by non-orthogonal A-IOT signal |
| NR BS | Option 1: 30dBcOption 2: 17dBcOption 3: 12dBc with 1 blank RB | In-band A-IOT signal interference to NR is not considered when calculating SINR. Companies to check the interference caused by non-orthogonal A-IOT signal |
| A-IOT BS | ACLR of legacy NB -IOT gNB (i.e. ACLR1:40dBc，ACLR2:50dBc) | ACS of legacy gNB |

 |

**Proposals in RAN4#113:**

Proposal-1 (Ericsson, R4-2419476): The inband leakage from iFFT modulation should be 12 dB considering averaging all leakage within the blanked RB.

Proposal 2 (Huawei, R4-2418802):

* the NR BS in-band ACLR range from 19 to 33dB with 0 to 2 guard RBs.
* Different NR BS in band ACLR values can be used for evaluate the number of guard RBs required to ensure coexistence performance.

**Recommended WF:**

Three options for NR BS Tx had already been captured as the simulation assumption. No further discussion is needed.

**Issue 4-1-2: CW unwanted emissions**

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| --- |
| **Agreement in RAN4#112:**Discuss whether and how to model the CW unwanted emission. |

**Agreement:**

The impact of CW node to adjacent NR carrier can be analysed and captured in TR.Note: no impact to co-existence simulation

**Proposals in RAN4#113:**

Proposal-1 (Ericsson, R4-2419476): CW unwanted emission can be modeled with 37 dBc for ACLR1 and 47 dBc for ACLR2

Moderator: we do not need re-evaluate the simulation.

Ericsson: Our simulation also shows that such values impact NR system. We are fine to discuss this in the RF requirements offline.

Ericsson: This is CW model. What we model is the phase noise only. We do not have PA model.

Huawei: Is it agreed 900MHz band? We can further discuss it in RF requirement.

CATT: ACLR concept for CW signal may need more discussion. We can discuss how to define the requirements.

## Topic 3-2: Evaluation Conclusion

**Moderator note:**

Following table summarizes the observation of evaluation from companies’ contributions. Updates are needed according to agreements during RAN4#113 and more simulation input from companies.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **deployment scenario and topology** | **spectrum** | **Evaluation case No.** | **(Aggressor -> Victim)** | **Tentative Co-existence conclusion in RAN4#112bis** | **Proposals in RAN4#113** | **Recommended WF in RAN4#113** |
| **1-1** | **D1T1-A2- legacy UE only outdoor** | R2D: DLCW2D and D2R: DL | a | Device->NR DL | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed |  | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed |
| b | NR DL->reader | TBA | **Proposal 1 (Huawei):** SINR degradation is less than 1dB. Inter-system interference is negligible. Outage percentage for intra-system interference is 0.64%.**Proposal 2 (Sony):** the SINR degradation on both 50% and 5% in case b of deployment scenario 1-1 is negligible. **Proposal 3 (Spreadtrum):** There is no SINR degradation for inter-system. For intra-system, outage percentage is large than 5%.**Proposal 4 (CMCC):** SINR degradation is less than 1dB. Inter-system interference is negligible.No outage percentage is observed for min, max and average SNR.**Proposal 5 (Ericsson):** SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is less than 1dB. Inter-system interference is negligible.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| c | Reader->NR DL | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed |  | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed |
| d | NR DL->device | SINR degradation is less than 1dB. Inter-system interference is negligible.TBD on the outage percentage | **P****roposal 1 (Huawei)**: Outage percentage for intra-system interference is 0.2%**Proposal 2 (spreadtrum)**: For intra-system, outage percentage is 0% when use min and average SINR. Outage percentage is 49% when use max SINR.**Proposal 3 (CMCC):** No outage percentage is observed for min, max and average SNR. | SINR degradation is less than 1dB. Inter-system interference is negligible.[Outage percentage is TBA (depending on topic 2 conclusion)] |
| **t1-2** | **D1T1-A2-legacy UE indoor** | R2D: DLCW2D and D2R: DL | a | Device->NR DL | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed |  | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed |
| b | NR DL->reader | TBA | **Proposal 1 (Huawei):** SINR degradation is less than 1dB. Inter-system interference is negligible. Outage percentage for intra-system interference is 0.7%**Proposal 2 (Sony):** The SINR loss for NR DL as aggressor and reader as victim is less than 1 dB.**Proposal 2 (Spreadtrum)**: there is no SINR degradation for inter-system. For intra-system, outage percentage is larger than 5%.**Proposal 3 (CMCC):** SINR degradation is less than 1dB. Inter-system interference is negligible. No outage percentage is observed for min, max and average SNR.**Proposal 4 (Ericsson):** SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is less than 1dB. Inter-system interference is negligible.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| c | Reader->NR DL | FFS: NR DL throughput degradation for both average throughput and cell edge throughput is observed. *Note: TBD on the throughput degradation range**FFS on the UE blocking issue.**Interference coordination/mitigation solution can be considered.* | **Proposal 1 (Huawei)**: NR DL throughput degradation for cell edge throughput is observed, and NR DL throughput degradation for average throughput is less than 5%. Interference coordination/mitigation solution can be considered.**Proposal 2 (Sony):** the SINR degradation on NR DL due to the AIoT system are significant when the NR UE percentage is 100% indoor.**Proposal 3 (Spreadtrum):** * When 10% indoor UE, SINR degradation is less than 1dB. Throughput degradation is 2.65% for cell edge and 2% for average throughput.
* When 100% indoor UE, SINR degradation is larger than 1dB.Throughput degradation is 82.9%.

**Proposal 4 (CMCC):** when 10% NR UE indoor,about 10% throughput degradation for average throughput is observed, about 70% throughput degradation for cell edge throughput is observed | [Under the assumption of 10% NR UE indoor, NR DL throughput degradation is TBA][Under the assumption of 100% NR UE indoor, significant NR DL throughput degradation is observed.]*Interference coordination/mitigation solution can be considered.* |
| d | NR DL->device | SINR degradation is less than 1dB. Inter-system interference is negligible.TBD on the outage percentage. | Proposal 1 (Huawei): Outage percentage for intra-system interference is 0.2%Proposal 2 (Spreadtrum): For intra-system interference, outage percentage is 0% when SINR is min value. Outage percentage is 0% when SINR is average value. Outage percentage is 48% when SINR is max value.Proposal 3 (CMCC): No outage percentage is observed for min, max and average SINR. | SINR degradation is less than 1dB. Inter-system interference is negligible.[Outage percentage is TBA (depending on topic 2 conclusion)] |
| **2-1** | **D1T1-B-legacy UE only outdoor** | R2D: DLCW2D and D2R: UL | e | Device->NR UL | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed.  |  | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed.  |
| f | NR UL->reader | TBA | **Proposal 1 (Huawei)**: SINR degradation is less than 1dB. Inter-system interference is negligible. Outage percentage for intra-system interference is 0.26%**Proposal 2 (Spreadtrum)**: For intra-system interference, outage percentage is larger than 39%.**Proposal 3 (CMCC):** SINR degradation is less than 1dB. Inter-system interference is negligible.No outage percentage is observed for min, max and average SNR.**Proposal 4 (Ericsson)**: SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is less than 1dB. Inter-system interference is negligible.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| c | Reader->NR DL | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed.  |  | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed.  |
| d | NR DL->device | SINR degradation is less than 1dB. Inter-system interference is negligible.TBD on the outage percentage. | **Proposal 1(Huawei)**: Outage percentage for intra-system interference is 0.2%**Proposal 2 (Spreadtrum)**: Outage percentage is larger than 49% when max SNR.**Proposal 3 (CMCC)**: No outage percentage is observed for min, max and average SNR. | SINR degradation is less than 1dB. Inter-system interference is negligible.[Outage percentage is TBA (depending on topic 2 conclusion)] |
| **2-2** | **D1T1-B-legacy UE indoor** | R2D: DLCW2D and D2R: UL | e | Device->NR UL | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed.  |  | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed.  |
| f | NR UL->reader | TBA | **Proposal 1(Huawei)**: SINR degradation is more than 1dB. Inter-system interference is Observed. Outage percentage for inter-system interference is 14.1%**Proposal 2 (Sony):** The SINR degradation on the AIoT system due to NR UL are significant when the NR UE percentage is 100% indoor.**Proposal 2 (Spreadtrum):** SINR degradation is larger than 1dB for inter-system.When 10% indoor UE, outage percentage is large than 62%; when 100% indoor UE, outage percentage is larger than 95%.**Proposal 3 (CMCC)**: SINR degradation is 17dB for cell edge and 4dB for cell average. Outage percentage is:* 17% @ 0.23dB
* 13% @-4.3dB
* 10% @ -7.8dB

**Proposal 4 (Ericsson):** SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is larger than 1dB.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| c | Reader->NR DL | FFS: NR DL throughput degradation for both average throughput and cell edge throughput is observed. Note: TBD on the throughput degradation range levelFFS on the UE blocking issue.Interference coordination/mitigation solution can be considered. | **Proposal 1 (Huawei):** NR DL throughput degradation for cell edge throughput is observed, and NR DL throughput degradation for average throughput is less than 5%. Interference coordination/mitigation solution can be considered.**Proposal 2 (Spreadtrum):** when 10% indoor UE, SINR and throughput degradation can be negligible. When 100% indoor UE, SINR degradation is larger than 1dB and throughput degradation is 80.78%**Proposal 3 (CMCC):** about 30% throughput degradation for average throughput is observed, about 70% throughput degradation for cell edge throughput is observed | [Under the assumption of 10% NR UE indoor, NR DL throughput degradation is TBA][Under the assumption of 100% NR UE indoor, significant NR DL throughput degradation is observed.]Interference coordination/mitigation solution can be considered. |
| d | NR DL->device | SINR degradation is less than 1dB. Inter-system interference is negligible.TBD on the outage percentage. | **Proposal 1(Huawei)**: Outage percentage for intra-system interference is 0.2%**Proposal 2 (Spreadtrum)**: outage percentage is 48% when use max SINR**Proposal 3 (CMCC):** No outage percentage is observed for min, max and average SINR. | SINR degradation is less than 1dB. Inter-system interference is negligible.[Outage percentage is TBA (depending on topic 2 conclusion)] |
| **3 (O)** | **D1T1-A2-legacy UE indoor** | R2D: ULCW2D and D2R: DL | a | Device->NR DL | TBA | Proposal 1 (Qualcomm): Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observedProposal 2 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | Negligible NR DL throughput degradation for both average throughput and cell edge throughput is observed |
| b | NR DL->reader | TBA | Proposal 1 (Qualcomm): SINR degradation @5-ile is 2dB, 50-ile is 0.8dB with 140dB CW cancellation capabilityProposal 2 (Ericsson): SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is larger than 1dB.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| g | Reader->NR UL | TBA | Proposal 1 (Qualcomm): 8.73% mean T-put loss, cell edge T-put is N/A due to outageProposal 2 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | [NR UL throughput degradation is TBA] |
| h | NR UL->device | TBA | Proposal 1 (Qualcomm): 1.78dB for 5-ile SINR degradation, 1.22dB for 50-ile SINR degradationProposal 2 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | [SINR degradation is TBA.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| **4 (O)** | **D1T1-B-legacy UE indoor** | R2D: ULCW2D and D2R: UL | e | Device->NR UL | TBA | Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | TBA |
| f | NR UL->reader | TBA | Proposal 1 (Ericsson): SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions.. | TBA |
| g | Reader->NR UL | TBA | Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | TBA |
| h | NR UL->device | TBA | Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | TBA |
| **5-1** | **D2T2-A2-legacy UE only outdoor** | R2D: ULCW2D and D2R: UL | e | Device->NR UL | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed |  | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed |
| f | NR UL->reader | SINR degradation is less than 1dB. Inter-system interference is negligible.TBD on the outage percentage. | Proposal 1 (vivo, R4-2418182): The maximum outage percentage is 0%Proposal 2 (CMCC): No outage percentage is observed for min, max and average SINRProposal 3 (OPPO): For average SNR for D2R both outage percentage is only 0.1% for coherent and non-coherent.Proposal 4 (Ericsson): SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is less than 1dB. Inter-system interference is negligible.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| g | Reader->NR UL | TBA | Proposal 1 (CMCC): about 6% throughput degradation is observed for average throughput, about 13% NR BS throughput degradation is observed for cell edge throughput.Proposal 2 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | [NR UL throughput degradation is TBA] |
| h | NR UL->device | SINR degradation is less than 1dB. Inter-system interference is negligible.TBD on the outage percentage. | Proposal 1 (vivo): The maximum outage percentage is less than 5%Proposal 2 (CMCC): For device 1, 4% outage percentage @ 9.3dB SNR (max), no outage percentage for average and min SNR.No outage percentage for device 2aProposal 3 (OPPO): For average SNR for R2D the outage percentage is 0.Proposal 4 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | SINR degradation is less than 1dB. Inter-system interference is negligible.[Outage percentage is TBA (depending on topic 2 conclusion)] |
| **5-2** | **D2T2-A2-legacy UE indoor** | R2D: ULCW2D and D2R: UL | e | Device->NR UL | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed |  | Negligible NR UL throughput degradation for both average throughput and cell edge throughput is observed |
| f | NR UL->reader | TBA | Proposal 1 (vivo): when 10% indoor UE, SINR degradation is larger than 1dB. The maximum outage percentage is less than 5%Proposal 2 (CMCC): SINR degradation is 20dB for cell edge and 4.8dB for averageOutage percentage is:• 12% @ -5dB SNR, • 11% @-6dB• 10% @ -7.6dB SNRProposal 3 (Ericsson): SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is larger than 1dB.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| g | Reader->NR UL | FFS: NR UL throughput degradation for both average throughput and cell edge throughput is observed. *Note: TBD on the throughput degradation range**Interference coordination/mitigation solution can be considered.* | Proposal 1 (CMCC): about 6% throughput degradation is observed for average throughput, about 12% NR BS throughput degradation is observed for cell edge throughput.Proposal 2 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | [NR UL throughput degradation is TBA] |
| h | NR UL->device | TBA | Proposal 1 (vivo): when 10% indoor UE, SINR degradation is larger than 1dB. The maximum outage percentage is less than 10%Proposal 2 (CMCC): SINR degradation is 3dB for cell edge and 5dB for average.For device 1:* 11% @ 9.3dB SNR (max)
* No outage percentage for min and average SNR

For device 2a:* 5% @ 5.1 dB SNR (max)

No outage percentage for min and average SNRProposal 3 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | [SINR degradation is TBA.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| **6-1(O)** | **D2T2-B-legacy UE only outdoor** | R2D: ULCW2D and D2R: DL | a | Device->NR DL | TBA | Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | TBA |
| b | NR DL->reader | TBA | Proposal 1 (vivo): SINR degradation is less than 1dB. Inter-system interference is negligible. The maximum outage percentage is 0%Proposal 2 (Ericsson): SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is TBA.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| g | Reader->NR UL | TBA | Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | TBA |
| h | NR UL->device | TBA | Proposal 1 (vivo): SINR degradation is less than 1dB. Inter-system interference is negligible. The maximum outage percentage is less than 5%Proposal 2 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | [SINR degradation is TBA.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| **6-2(O)** | **D2T2-B-legacy UE indoor** | R2D: ULCW2D and D2R: DL | a | Device->NR DL | TBA | Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | TBA |
| b | NR DL->reader | TBA | Proposal 1 (vivo): when 10% indoor UE, SINR degradation is larger than 1dB. The maximum outage percentage is less than 5%Proposal 2 (Ericsson): SNR degradation larger than 1dB. Coexistence not feasible based on current assumptions. | [SINR degradation is larger than 1dB.][Outage percentage is TBA (depending on topic 2 conclusion)] |
| g | Reader->NR UL | TBA | Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | TBA |
| h | NR UL->device | TBA | Proposal 1 (vivo): when 10% indoor UE, SINR degradation is larger than 1dB. The maximum outage percentage is less than 5%Proposal 1 (Ericsson): SINR degradation is less than 1dB. Inter-system interference is negligible. | [SINR degradation is TBA.][Outage percentage is TBA (depending on topic 2 conclusion)] |

Qualcomm: we will provide the new results during this week.

## Topic 3-3: General remarks on coexistence findings

**Proposal 1 (Sony, R4-2418034): RAN4 can conclude that some mechanisms to support a higher percentage of indoor UE need to be studied.**

**Proposal 2 (Sony, R4-2418034): RAN4 can conclude that mechanisms to coordinate multiple readers to be active simultaneously need to be studied and specified.**

Sony: This is the general observation and we provide the guidance for normative work.

Qualcomm: The beneficial to capture something in the TR. We are OK to have the high level agreement in the TR.

Huawei: Some mechanisms may not be work for RAN4. RAN4 should not discuss them.

Ericsson: Sony want to improve the co-existence according to current observation. Maybe we can reword it.

Moderator: From RAN4 TR, we can conclude that we need study. For some mechanism, it belongs to WI scope discussion. We can consider the wording for some case when interference happens, some mechanism can be considered. Work offline on the wording in the TP.

**Proposal 3 (Spreadtrum, R4-2418403): Guard RB(s) between NR and A-IoT needs to be considered for co-existence between A-IoT and NR when 10% legacy UE is indoor for D1T1-B and 100% legacy UE is indoor for D1T1-A2.**

**Proposal 7 (Huawei, R4-2418802): Guard RBs can be used to improve coexistence performance if necessary.**

**Proposal 8 (Ericsson, R4-2419476): The leakage from NR base station should be lowered by adding more guard RB, how to model this FFS.**

Spreadtrum: it is beneficial to have mechanism to consider the guard RB for co-existence.

Moderator: it is quite detailed design. We can say some mechanism needs be considered. Not all the companies simulate the guard RB cases.

**Proposal 4 (CMCC, R4-2418725): Capture the following contents as the general remarks on coexistence findings.**

* **For the deployment scenarios with legacy NR UE indoor (scenario 1-2, 2-2, 5-2, 6-2), which NR throughput degradation is observed, some mechanisms based on gNB implementation can be considered. In existing deployed network to avoid/mitigate the interference from ambient IOT to NR UE. For example, for RRC idle mode, NR UEs can camp on a frequency different from ambient IOT system based on frequency priority configured by network; for RRC connected mode, gNB can handover NR UEs to a different cell (e.g. indoor gNB) based on existing measurement report triggering and event.**

CMCC: even though the degradation is observed, UE can configured on the different frequency.

Qualcomm: this approach is also applicable to D2T2 case.

**Proposal 5 (Qualcomm, R4-2418852): RAN4 consider decreasing the Tx power by power control for reader in D2T2 to solve the coexistence issue for reader interfering NR UL.**

Qualcomm: D2T2 face the cochannel interference as dominant. A-IoT system performance won’t be impacted.

**Proposal 6 (Samsung, R4-2419649): To clarify in the TR that the different types of frequency shifter were not discussed nor concluded from RAN4 perspective.**

Moderator: usually we just capture what we have done in the TR rather than what we did not do.

Samsung: We do not want to have any conclusion on the work in RAN4. We have not finish all the evaluation.

Sony: From RF perspective, we propose it in the previous meeting. For evaluation of co-existence, we use the worst case. We just need to keep it open and discuss it in the WI phase.

**Recommended WF:**

Discuss whether and how to capture the above proposals in TR.