3GPP RAN 5G-ACIA Evaluations Week 3

February 22nd – 26th 2021

Source: Moderator (Ericsson)

Title: Review of provided simulation results and needed updates

Document for: Discussion, Decision

# 1 Introduction

AT RAN#89, the following was agreed in [RP-202069](https://protect2.fireeye.com/v1/url?k=41a5db26-1f051960-41a59bbd-86fc6812c361-73f443258ff773bf&q=1&e=bc078f84-983d-45f3-ab31-19e60d911036&u=https%3A%2F%2Fwww.3gpp.org%2Fftp%2Ftsg_ran%2FTSG_RAN%2FTSGR_89e%2FDocs%2FRP-202069.zip) on providing evaluations for 5G-ACIA:

* Start an offline email-based activity to provide evaluation results for 5G-ACIA
* One company volunteers as moderator
  + Proposes a work plan to follow
  + Ericsson is willing do this
* Discussions are on the RAN1\_NR reflector
  + Email activity only during short periods (< week) distributed across the time allocated to the activity
  + No email activity in weeks before/during/after RAN1 meetings or RAN defined inactive periods
  + All companies should strive to limit email activity as much as possible
  + Outcome of the offline discussion will directly go to RAN without need for discussion in RAN1 nor need for LS from RAN1 to RAN
* Target completion by RAN#91
* At RAN#91, RAN will decide on a response LS to 5G-ACIA

The moderator made the following proposal on a timeline:

1. 12-16 October 2020
   * Discussion on which URLLC features to include in the evaluations and simulation assumptions
2. 14-18 December 2020
   * First round of simulation results
3. 22-26 February 2021
   * Second round of simulation results
4. 8-12 March 2021
   * Finalization of the report to RAN#91

During week 1, the simulation assumptions were agreed as captures in the document below:

[https://www.3gpp.org/ftp/tsg\_ran/TSG\_RAN/TSGR\_90e/Inbox/Drafts/5G-ACIA October/Agreements/Agreements week 1 5G-ACIA.docx](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/Agreements/Agreements%20week%201%205G-ACIA.docx)

For week 2, companies provided the first round of simulation results. The summary is provided here:

[https://www.3gpp.org/ftp/tsg\_ran/TSG\_RAN/TSGR\_91e/Inbox/Drafts/5G-ACIA%20December/Final Summary/5G-ACIA Week 2 - Final summary.docx](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20December/Final%20Summary/5G-ACIA%20Week%202%20-%20Final%20summary.docx)

For the third week, companies provided the second round of simulation results:

[https://www.3gpp.org/ftp/tsg\_ran/TSG\_RAN/TSGR\_91e/Inbox/Drafts/5G-ACIA February/Company Inputs/](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20December/Company%20Inputs)

The input contributions are also listed in the reference section.

In this contribution, review comments from other companies are collected for each input document.

# 2 Company Inputs

## 2.1 Ericsson

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/Ericsson%205G-ACIA%20Simulation%20Results%20Round2.zip).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| ZTE | 1. Whether cell coordination is assumed in your evaluation? 2. Regarding ‘ Since packet arrival is known by gNB, allocation in time and periodicity is optimized so that the alignment delay is minimized.’ in section 2.1, do you main the packet arrival is assumed in a predefined manner, e.g., data arrival is try to be aligned with the beginning of a transmission occasion? If so, it seems not aligned with your assumptions in appendix, where it is ‘DL traffic arrival with option-1’ (i.e., the packet arrival is assumed as uniformly random distributed in a transfer interval). 3. For Figure 3, why the delay of DL and UL are the same considering the DL and UL scheduling may be different due to different channel conditions and transmitting power etc. 4. Is a correct understanding that the target PER is assumed as 10^-3? |
| Nokia, NSB | For FR1, performance seems worse than e.g. ours and vivo’s. Any reasoning behind this performance difference? For example, could it be due to the assumed SPS/CG scheme (instead of the random PRB allocation assumed in our study)?  Besides, also for FR1, the PER statistics in Figure 4 doesn’t seem to match the CSA statistics in Figure 1. In the PER statistics, 99% of the UEs have a PER of 0%, but the CSA says that only 84.05% of the UEs reach the CSA target. Could this be clarified?  For FR2, have you assumed some limitations related to the beamforming operation? |
| vivo | Q1: Do you use cell coordination transmission or not?  Q2: For ‘One UE per mini-slot is scheduled both in UL and DL due to analog beamforming selected implementation’, do you mean only one UE can be scheduled for an analog beam? How many PRBs are allocated for the UE?  Q3: Why the delay distributions are same for DL and UL? |
| HW(HiSi | Same question as ZTE, is PER = 10^-3 assumed? Could it be clarified how many samples have been generated per UE in the simulations? If PER = 10^-3 has been assumed is the reason for that that a CSA criteria of two consecutive errors it is assumed and that packet errors are uncorrelated?  A general comment that not only applies to this paper and which maybe is in line with Nokia also in pointing out above is that there are quite some differences in companies’ results. For the purpose of calibration across different companies’ simulations, we might need to define even more details as we already have done? For example the access mode (e.g. CG/SPS, dynamic), TTI length, overhead, scheduling, geometry? What is the view from other companies on that? |
| QC | How is it explained that CSA performance is better in UL than in DL?  How is radio link adaptation done? i.e. is there any MCS or PRB change for new packet transmission?  In UL is CG adapted, or is the MCS and PRB allocation constant throughout the simulation?  How is UL OL PC done?  Is the minimum packet delay of ~380 μsec in FR1 a DL or UL packet delay value? What is the UE and gNB processing delay?  Why PER performance is better in UL than in DL at 4GHz?  Why is it the opposite at 30 GHz (DL slightly better than UL)?  Is there the same comparison for 10-5 PER?  Is the minimum packet delay of ~270 μsec in FR2 a DL or UL packet delay value? What is the UE and gNB processing delay? |

## 2.2 Huawei/HiSilicon

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/HwHiSi%20-%20Simulation%20results%20for%205G-ACIA%20in%20the%20second%20round.docx).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| ZTE | Why the CDF in Figure 4 is a step function? Take Figure 4(a) reliability of DL as an example, is it correct understanding that the PER of all packets of all UEs can only be one the following values: ~4\*10E-6, ~4\*10E-5, 2\*10E-4 or 1\*10E-1?  [HW/HiSi]: This understanding is partially correct, but not entirely correct. In the simulations, most UEs PER is 0. For those UEs that do not have reliability of 1, the simulation resulted into a set of PERs that were the same for multiple of the remaining UEs. |
| Nokia, NSB | In our view, scheme (1) with orthogonal frequency reuse actually falls better in the category of ‘with cell coordination’, since this assumes a static cell coordination.  [HW/HiSi]: We do not think that this is or should be classified as cell cooperation. It can be predefined in the beginning how many UEs a gNB can admit and also which PRBs should be used. This is similar or even part of other cell configurations that also have to be done in the beginning. It does not require any interaction (=cooperation) between the cells during operation.  For scheme (2), the extremely conservative allocation scheme seems to be generating large amount inter-cell interference and is not providing a clear picture of what can be achieved in a realistic uncoordinated scheme. It would be good to see the performance with more traditional link adaptation scheme.  [HW/HiSi]: We agree that some more simulations could be done and more scheduling strategies could be evaluated. What we think is important at the moment is that companies maybe could agree on one common scheduling approach that could be used for further calibration. |
| vivo | Q1: For SU transmission with cell coordination, have you tried to transmit data with more than 1 layer to increase the supported UE number?  [HW/HiSi]: No.  Q2: For ‘Extremely conservative resource allocation’, do you mean the whole bandwidth are occupied in each slot? The interference will be very large with this kind of resource allocation scheme and some UEs, especially the UEs with high SINR, do not need additional resources.  [HW/HiSi]: Yes, we wanted to increase the redundancy as much as possible and we evaluated the impact of the interference. This is the opposite to the first scheme we used, where we completely avoided interference. Please note that the redundancy is added in proportion to the initially allocated resources, e.g. the UEs that experience a worse channel get more extra resources assigned. |
| QC | What is the reliability requirement in Table 4 (10-6)?  Is PDCCH modeled? If yes, how? i.e. how many symbols? E.g. how is 20% overhead due to DCI can be justified in a 6D2G6U slot format?  How is the difference in DL-UL performance in terms of PER and CSA in 4GHz explained (better UL, Table 5)?  What is the number of UEs in the factory in Figure 5?  The only difference between (Tables 4 and 6)   * The orthogonal frequency allocation and * SU transmission   With coordination is the resource allocation scheme?  What is the reliability requirement in Table 6 (10-6)?  With regards to Fig. 6, is there an equivalent number for PER 10-5?  What is the lowest SNR achieved by a UE? 1RB may not be sufficient for a UE to achieve 10^-6 error  Why is the loading among gNBs evenly distributed (FR 1)? In our simulations unbalanced loading among gNBs is observed. |

## 2.3 Intel

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/INTEL%20-%205G-ACIA%20LS%20-%20Phase%203%20inputs%20v0.docx).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| ZTE | Whether cell coordination is assumed in your evaluation? |
| Nokia, NSB | We observe that the performance is generally poorer than other companies’ results. We wonder if the reason is the relatively high 1E-3 BLER target which may not be sufficient to achieve CSA of 6-nines? The low PRB utilization (<30%) suggests that it is possible to operate at lower BLER target. |
| vivo | Q1: What’s the user plane latency assumption? |
| HW/HiSi | Is cell coordination used in the evaluation or do you have otherwise assume a certain scheduling strategy, e.g. to avoid interference? |

## 2.4 Nokia

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/NOKIA%20-%205G-ACIA%20Final%20round%20of%20simulation%20results.docx).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| ZTE | 1. Whether cell coordination is assumed in your evaluation?   Nokia: No. A fully uncoordinated-scheme is considered where each BS independently allocates the RBs to its UEs.   1. Whether MU-MIMO is enabled in your evaluation?   Nokia: No. Each BS schedules at most 1 UE per RB. So only ‘inter-cell’ interference is experienced in the case the same RBs are scheduled for transmission/reception at neighboring BSs. |
| Vivo | Q1: For the CDF of per-packet latency, why some UE’s per-packet latency can be larger than 1ms? In our point of view, packets with E2E latency larger than 1ms should be discarded.  Q2: For FR2, how does gNB transmit/receive on 2 beams simultaneously per interval/mini-slot with one panel based on the simulation assumption?  Q3: For the Figure 8, does it mean that the CSA performance for 50 with 2 beams are better than 40 with 2 beams? |
| QC | It seems that minimum packet delay for both DL and UL is 0.5 ms. What are the assumptions for gNB and UE decoding delays?  Are there simulation results with lower UE numbers & higher reliability (close to 100%)? |

## 2.5 Qualcomm

Contribution links for [FR1](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/QUALCOMM-5G-ACIA_URLLC_simulation_results_2nd_round_FR1.docx) and [FR2](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/Qualcomm5G-ACIA_URLLCsimulationResultsRound1_FR2_version1.docx).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| ZTE | For FR1 with HARQ re-transmission, it seems you assumed cell coordination among BSs, right? If so, gNB can coordinate each other to avoid any interference if the number of UEs per cell is not too much, e.g., up to 20 UEs in your evaluation. Thus, no matter the BLER is set to 10-2 or 10-4 or 10-6, the packet could be highly likely to be successfully transmitted even with the highest MCS index (no re-transmission is needed) for FR1. Thus, setting the initial or retransmission BLER lower than the 10-6 seems not able to save resources in most cases. Instead, it seems the reserved half of resources always for re-transmission would be wasted. |
| Nokia, NSB | For FR1, it seems that no UE/gNB processing times are assumed since the minimum latency is the same as the mini-slot duration. |
| vivo | Q1: For ‘Half of the available frequency band is dedicated to retransmissions during the PDSCH and PUSCH symbols’, do you mean half of the resource can only be used to retransmissions? |
| HW/HiSi | Agree with the comment from ZTE (*gNB can coordinate each other to avoid any interference if the number of UEs per cell is not too much, e.g., up to 20 UEs in your evaluation*).  We are also wondering as ZTE and vivo above, if 50% of the available resources are precluded for initial transmission? |

## 2.6 vivo

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/vivo%20-%205G-ACIA%202nd%20round%20URLLC%20evaluation%20results.zip).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| ZTE | For the results without cell coordination, it seems the performance is also very good even when the number of UEs are very large. In our understanding, the interference cannot be avoided without cell coordination, and the severe interference in factory scenario would be very likely to cause packet error. Conservative resource allocation may not be helpful since it could also increase the interference. Could you clarify a bit more on the scheduling or other aspects about the performance without cell coordination? |
| Nokia, NSB | For FR2, have you assumed some limitations related to the beamforming operation? Would it be possible to clarify the following sentence: *For coordination transmission in FR2, since multi-beam transmission is adopted in FR2, and all UEs are uniformly distributed within per service area without considering uniformly distributed in each beam, some UEs may not be fully FDMed within a beam with the increasing of UEs per service area.* |
| Hw/HiSi | For your scheduling strategy, could you please explain if it is correctly understood that the given scheme is intended to improve the CSA (for survival time = 1ms), i.e. in case of a failure the next packets. The scheduling strategy is not aiming to improve the reliability (PER), right?  Could you please also clarify how the resources for the original resource allocation and the MCS are selected? |
| QC | Supporting 30 UEs without cell coordination and with most of the UEs having BLER < 1e-5 does not seem to be in alignment with results from other companies, especially considering the delay budget in your tables. Could you please share the geometry curve or SINR curves for your setup? How is interference among the UEs mitigated? |

## 2.7 ZTE

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/ZTE-5G-ACIA%20evaluations%20-%202nd%20round%20of%20simulation%20results.docx).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| Nokia, NSB | The case of ‘no coordination’ seems a bit misleading. Actually, this seems like a ‘static’ coordination scheme where orthogonal PRBs are statically assigned to each BS.  Can you clarify the following in Observation 2: “*If the number of UEs per service area is 40, the CSA is 100% for both DL and UL, while the percentage of UEs satisfying the requirements is 68.75% and 78.33% for DL and UL respectively”*? In our understanding the requirement is that each UE should have a CSA of 99.9999%, so it’s unclear which requirement is referred to when reporting the “Percentage of UEs satisfying requirements”. |
| Vivo | Q1: For the figures of per-packet latency, why some UE’s per-packet latency can be larger than 1ms? In our point of view, packets with E2E latency larger than 1ms should be discarded.  Q2: For Table 4, why DL RU is bigger than UL RU with same UE number? Since there is no inter-cell interference when UEs are fully FDMed, and the assumptions of overhead are same for DL and UL in the simulation assumption, the required resource are same for DL and UL.  Q3: What does the mean of target BLER 1E-6, does it mean more conservative MCS selection, why the performance of target BLER 1E-6 is worse than target BLER 1E-3 with the same RU?  Q4: Why the performance of cell coordination of FR2 is worse than FR1, since there are more RBs in 1ms can be FDMed allocated in FR2? |
| HW/HiSi | For the case of SU with cell coordination (e.g. for BLER target = 10^-3), when there are 50 UEs in the cell, it can be seen that about 27% of UEs do not meet the requirements in DL. Is it correctly understood that the reason is due to inter-cell interference, since not all UEs can be scheduled on different PRBs? |
| QC | What is the rationale behind 5 symbols PDSCH?  In the Table A-2 for simulation assumptions for 30 GHz, the carrier frequency is 4 GHz and the SCS is 30 kHZ. It seems that these are the parameters for FR1. |

## 2.8 ITRI

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/ITRI_5G-ACIA%20Simulation%20Results_2nd%20round.docx).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| Nokia, NSB | The performance seems slightly lower than what is reported by other companies. One reason seems to be the fact that the resource allocation size (i.e. number of PRBs per TB) is exactly the same for all UEs (16, 8 or 4 PRBs) which is probably suboptimal since the MCS is not adjusted as per each UE’s specific SINR conditions.  Also, it is unclear what are exactly the main differences between the first and second round of simulation results. Could this part be clarified? *However packet arrival is available to gNB in connection setup phase. The configuration of DL SPS and UL CG could be adjusted appropriately for the packet arrival pattern. For example, the resource allocation in time domain and the resource periodicity may be configured to minimize the gap of the DL/UL frame alignment delay.* |
| HW/HiSi | Regarding this sentence in section 3.1:” *However packet arrival is available to gNB in connection setup phase. The configuration of DL SPS and UL CG could be adjusted appropriately for the packet arrival pattern*” - Is it correctly understood that the performance difference between table 1 and table 2 comes from the alignment delay? In table two, it is utilized that the traffic arrival is known at the gNB and the SPS/CG resources are configured accordingly?  If the above is the case, then I have another question in Section 3.2, in that section it is written that “*The alignment delay depends on the packet arrival in our simulation, which is less than 14 symbol time*”. Is this sentence only applicable to the first round simulations in table 1, or also for table 2? |
| QC | How is it explained that DL is better than UL (contrary to HW, Ericsson)? |

## 2.9 CATT

[Contribution link](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/CATT%205G-ACIA%20evaluation%20results%20Round2.docx).

Other companies can provide questions and comments in the table below:

|  |  |
| --- | --- |
| Company | Questions and comments |
| Nokia, NSB | For BLER target 1E-3, it would be good to include results with larger number of UEs (e.g. 30, 40, 50) to see at which load point the CSA gets below 100%.  For BLER target 1E-5, it’s unclear why the achieved CSA is lower than the one achieved with 1E-3. |
| vivo | Q1: It seems the RU performance for different BLER targets were not provided. Why the performance of target BLER 1E-5 is worse than target BLER 1E-3? |
| HW/HiSi | Same question as Nokia “*For BLER target 1E-5, it’s unclear why the achieved CSA is lower than the one achieved with 1E-3*”. Is this because a more conservative MCS is selected for the former? |
| QC | What is the minimum DL packet delay value?  What is the UE processing time?  The DL slot duration?  How is radio link adaptation done? i.e. if there is one erroneous packet does something change when a new packet is transmitted? |

# 3 Conclusions

# References

1. [RP-202069](https://protect2.fireeye.com/v1/url?k=41a5db26-1f051960-41a59bbd-86fc6812c361-73f443258ff773bf&q=1&e=bc078f84-983d-45f3-ab31-19e60d911036&u=https%3A%2F%2Fwww.3gpp.org%2Fftp%2Ftsg_ran%2FTSG_RAN%2FTSGR_89e%2FDocs%2FRP-202069.zip), “Way forward on RAN work for 5G ACIA requested simulations“, Ericsson
2. “[Simulation Results for 5G-ACIA (Second round)](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/Ericsson%205G-ACIA%20Simulation%20Results%20Round2.zip)”, Ericsson
3. “[Simulation results for 5G-ACIA in the second round](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/HwHiSi%20-%20Simulation%20results%20for%205G-ACIA%20in%20the%20second%20round.docx) Huawei, HiSilicon
4. “[5G-ACIA LS – Phase 3 input](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/INTEL%20-%205G-ACIA%20LS%20-%20Phase%203%20inputs%20v0.docx)”, Intel Corporation
5. “[Final round of simulation results for 5G-ACIA evaluation](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/NOKIA%20-%205G-ACIA%20Final%20round%20of%20simulation%20results.docx)”, Nokia, Nokia Shanghai Bell
6. “[Second round of FR1 simulation results for 5G ACIA URLLC LS response](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/QUALCOMM-5G-ACIA_URLLC_simulation_results_2nd_round_FR1.docx)”, Qualcomm CDMA Technologies
7. “[Simulation Assumptions and URLLC Performance Evaluations for 5G-ACIA Performance Evaluation Round 1](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/Qualcomm5G-ACIA_URLLCsimulationResultsRound1_FR2_version1.docx)(FR2)”, Qualcomm CDMA Technologies
8. “[5G-ACIA 2nd round URLLC evaluation results](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/vivo%20-%205G-ACIA%202nd%20round%20URLLC%20evaluation%20results.zip)”, vivo
9. “[5G-ACIA evaluations - 2nd round of simulation results](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Inbox/Drafts/5G-ACIA%20February/Company%20Inputs/ZTE-5G-ACIA%20evaluations%20-%202nd%20round%20of%20simulation%20results.docx)”, ZTE