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?   [Ericsson] No   1. 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).   [Ericsson] As packet arrival is periodic, network knows this periodicity and predict the time of next arrival. This prediction is used by the scheduler to allocate resources.   1. 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.   [Ericsson] The delay data for UL and DL has been plot on the same CDF.   1. Is a correct understanding that the target PER is assumed as 10^-3?   [Ericsson] This reported PER is an output from the simulations (i.e., actual error rate experienced). The target PER set in link adaptation was 1e-5 to be very conservative. |
| 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?  [Ericsson] PER statistics refer to the percentage of packets which were decoded incorrectly at the receiver. The packet errors are not the only source of reduction of CSA. Delayed (and thus, dropped) packets, e.g. due to congestion and packets lost consecutively add to the reduction of CSA even when they don’t increase the packet error rate.  For FR2, have you assumed some limitations related to the beamforming operation?  [Ericsson] As stated in the contribution, “One UE per mini-slot is scheduled both in UL and DL due to analog beamforming selected implementation.” |
| vivo | Q1: Do you use cell coordination transmission or not?  [Ericsson] No  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?  [Ericsson] Yes, all PRB are potentially used.  Q3: Why the delay distributions are same for DL and UL?  [Ericsson] The delay data for UL and DL has been plot on the same CDF. |
| 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?  [Ericsson] This reported PER is an output from the simulations (i.e., actual error rate experienced). The target PER set in link adaptation was 1e-5 to be very conservative.  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?  [Ericsson] We agree that companies simulation results do not converge at the moment. Many factors impact the performance results. One factor in E/// simulation is, we assumed UE antenna configuration of 1 Tx/2 Rx antenna ports, which are lower than those in 38.824. The reason was, we observed that most of UEs currently deployed have 1TX/2RX. |
| QC | How is it explained that CSA performance is better in UL than in DL?  [Ericsson] We think it is caused by non-optimal link adaptation backoff for DL. Also re-activation of SPS is not performed, i.e., not adapt to channel variation once the SPS is activated.  How is radio link adaptation done? i.e. is there any MCS or PRB change for new packet transmission?  [Ericsson] Link adaptation with static SINR backoff is used. For mid-band, PRB & MCS are selected for SPS & CG after a warming up time, SPS & CG are not re-activated after that. For mmWave, MCS in DL is adaptive.  In UL is CG adapted, or is the MCS and PRB allocation constant throughout the simulation?  [Ericsson] UL CG is not adapted after activation. See response above.  How is UL OL PC done?  [Ericsson] Check the SINR target parameter. This is a target value converted to P0 setting in power control.  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?  [Ericsson] Processing times are taken according to TS 37.910. So, it is half of processing times Capability 2 (N2/2)  Why PER performance is better in UL than in DL at 4GHz?  [Ericsson] We think it is caused by non-optimal link adaptation backoff for DL. Also re-activation of SPS is not performed, i.e., not adapt to channel variation once the SPS is activated.  Why is it the opposite at 30 GHz (DL slightly better than UL)?  [Ericsson] Different DL scheduling is used in 4GHz vs 30 GHz. For 4 GHz, DL SPS is used for DL transmission. For 30 GHz, dynamically scheduling is used instead.  Is there the same comparison for 10-5 PER?  [Ericsson] This reported PER is an output from the simulations (i.e., actual error rate experienced). The target PER set in link adaptation was 1e-5 to be very conservative. In the discussion, we emphasize PER=1e-3 because it corresponds to CSA=1-1e-5. We don’t see the need to discuss PER=1e-5.  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?  [Ericsson] Processing times are taken according to TS 37.910. So, it is half of processing times Capability 2 (N2/2) |
| Intel | Up to Rank 2 scheduling in DL – do you apply MU-MIMO or SU-MIMO?  [Ericsson] SU-MIMO  Which resource allocation type is used for DL and UL?  [Ericsson] Resource allocation type, DL: type 0, UL: type 1  For showing PER, may be better to use log scale for X axis.  [Ericsson] Yes, we realized after submission |
| ITRI | Do you use any cell coordination or resource scheduling strategy to avoid interference in your evaluation?  [Ericsson] No special scheduling strategy to avoid inter-cell interference. |

## 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:

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| --- | --- |
| 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)?  [HW/HiSi]: the reliability requirement is 1e-3  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?  [HW/HiSi]: The PDCCH is not modeled, the DCI overhead is calculated. Originally, we assumed that a compact DCI of 40 bits (including CRC) and a packet size of 400 bits (48 bytes + 16 CRC) are used. Hence the DCI overhead is 10% for one transmission assuming the spectrum efficiency for DCI transmission and data transmission are the same. Then the total DCI overhead becomes 20% for both DL and UL DCI.  How is the difference in DL-UL performance in terms of PER and CSA in 4GHz explained (better UL, Table 5)?  [HW/HiSi]: Due to the UL power control, the UL capacity is increased.  What is the number of UEs in the factory in Figure 5?  [HW/HiSi]: 100 UEs for the left figure (DL) and 125 for the right figure (UL)  The only difference between (Tables 4 and 6)   * The orthogonal frequency allocation and * SU transmission   With coordination is the resource allocation scheme?  [HW/HiSi]: In both schemes the resources are allocated based on CSI. But in the former, PRBs are pre-allocated to the TRPs. In the latter, all PRBs would be available to all TRPs, but the TRPs are treated as one cell, so interference can be avoided during scheduling.  What is the reliability requirement in Table 6 (10-6)?  [HW/HiSi]: 1e-6 (Percentage of UEs satisfying 1ms E2E latency and 99.9999% reliability/CSA requirement in the DL transmission).  With regards to Fig. 6, is there an equivalent number for PER 10-5?  [HW/HiSi]: Could you elaborate what you mean?  What is the lowest SNR achieved by a UE? 1RB may not be sufficient for a UE to achieve 10^-6 error  [HW/HiSi]: The smallest PRB allocation per UE is 2 PRBs. In different cases the values of the lowest SNR are different and for the case of orthogonal frequency re-using and the case of SU with cell coordination, the lowest SNR is very large, always larger than 29 dB, i.e. the limit of the EVM.  Why is the loading among gNBs evenly distributed (FR 1)? In our simulations unbalanced loading among gNBs is observed.  [HW/HiSi]: The UE administration is controlled by the network. The gNB is preconfigure to admit a certain number of UEs, additional UEs would connect to another TRP. |
| Ericsson | For section “4.2.1 (1) Orthogonal frequency reusing among TRPs” and “4.2.2 Simulation results for single-layer SU transmission with cell coordination”:  What’s the difference between them? These two ways are very similar, and both use static orthogonal resource allocation between cells?  [HW/HiSi]: In orthogonal frequency re-use, a pre-defined number of PRBs is allocated to each gNB, different gNBs have different PRBs. In the SU MIMO will cell cooperation, the PRB allocation is dynamic and all TRP are treated as one cell.  Is the resource allocation strategy is the same for UL and DL?  [HW/HiSi]: yes.  Although it is fine to include as a reference point, it is clear that these scheduling strategy are limited by the number of PRBs relative to the resources needed for one UE. For 4GHz, it maxed out at ~22 UE/SA (264 or 272 UEs total). It can’t handle up to 50 UE/SA, for example. |
| Intel | Is it correct understanding, that at any time the interference from another BS is wideband since you add redundant PRBs to every UE?  [HW/HiSi]: This depends on the cases we are studying. For orthogonal frequency re-use and SU MIMO, there is no interference. Only for the extremely conservative RA, there is wideband interference. For MU MIMO, there is inter-layer interference.  If yes, does it mean you model a full-buffer system in terms of interference?  [HW/HiSi]: For the extremely conservative RA, it is similar to full buffer interference.  Do you model fast-fading for interference links?  [HW/HiSi]: Yes, but only for the interfering gNBs that are close to the victim UE, gNBs further away are not modeled with fast-fading. |
| ITRI | For SU transmission with cell coordination, it is most serve up to 272 UEs. Have you considered other methods, other than MU-MIMO, to achieve more UEs, such as 40, 50 UEs per service area while the performance is still maintained?  [HW/HiSi]: We are planning to do more simulations, with different schemes in case of both non-cell cooperation and cell cooperation. For example, in case of cell-cooperation we want to split the 12 cells into 2 clusters to improve to spectrum re-use and in each cluster 6 TRPs will operate in D-MIMO mode  Based on the information in Table 3, 4, and 5, the avoidance of inter-cell interference is necessary to meet the needs of CSA. Is it correct? Furthermore, which messages is used or required for the cell coordination among TRPs?  [HW/HiSi]: The avoidance of inter-cell interference may not be necessary, but it is important to achieve a high spectrum efficiency. In case of cell-cooperation, the TRPs are operated as one large cell, so there is no specific message needed, all TRP are served by the same scheduler that has full control.  One question for cell coordination, is it semi-persistent configured or dynamic configured with frequent message exchange in your assumption?  [HW/HiSi]: For the cell-coordination will cell-cooperation (SU-MIMO, MU-MIMO simulations), it is dynamic and under control of the same scheduler. |

## 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).

[Updated contribution link (add 20 UE/area for UL)](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%20v1.docx).

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

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| --- | --- |
| Company | Questions and comments |
| ZTE | Whether cell coordination is assumed in your evaluation?  [Intel] no coordination |
| 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.  [Intel] That was an unfortunate discovery after very long simulations. We suppose the change in link adaptation target contributed the most, as you highlight. Currently in process of obtaining other results. |
| vivo | Q1: What’s the user plane latency assumption?  [Intel] The latency components are accounted. |
| HW/HiSi | Is cell coordination used in the evaluation or do you have otherwise assume a certain scheduling strategy, e.g. to avoid interference?  [Intel] no coordination, but randomization of collisions from allocation to allocation. |
| Ericsson | For DL results in section 2.1 Fig 2, the packet error rate CDF shows that about 45% and 20% UEs have packet error rate higher than 1e-3 for 20 UE/SA and 30 UE/SA, respectively. Does this mean: about 45% and 20% UEs do not satisfy CSA requirement of (1-1e-6) for 20 UE/SA and 30 UE/SA, respectively? It’s hard to tell from the CSA CDF plot.  [Intel] As we commented to Nokia, the results do not seem to be optimized in terms of link adaptation assumption which we changed from the first phase. We also think PER better not to be used to re-calculate CSA due to potential consecutive error probabilities. |
| ITRI | Is any scheduling strategy used to avoid interference in your evaluation? Do you compare the performance difference whether or not any interference avoidance strategy is applied? |

## 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.  Nokia: In our simulations, we do not discard packets that pass through PDCP layer. Note that it’s only very little fraction of packets (<0.01%) that arrive after 1 ms, so we don’t expect the performance to be much different if we had assumed the discarding at lower layers also. Note that latency > 1 ms is counted as an error in both CSA and PER statistics.  Q2: For FR2, how does gNB transmit/receive on 2 beams simultaneously per interval/mini-slot with one panel based on the simulation assumption?  Nokia: We have set of static analog beams, from which 1 or 2 may be used simultaneously. In order to avoid inter-beam interference only one beam per RB is utilized.  Q3: For the Figure 8, does it mean that the CSA performance for 50 with 2 beams are better than 40 with 2 beams?  Nokia: For UL, yes. For DL, when Tx power was put only to a single beam, we did not have survival time violations with 50 UEs during simulated steps. Note that for FR2 we only simulate 100.000 samples per UE which could impact the accuracy of the obtained results. |
| 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?  Nokia: Thanks for pointing this out. There are two things that are not correctly shown in our contribution. First, the processing time for FR1 is not 5 symbols in total (as shown in Table 4) but 6 symbols, where the extra symbol is due to the assumption of front-loaded DMRS. Second, for the plotting of the latency CCDF, by mistake the minimum latency was rounded to 0.5 ms, but it should have been 0.428571 ms (corresponding to 6 symbols TTI + 6 symbols processing).  Are there simulation results with lower UE numbers & higher reliability (close to 100%)?  Nokia: For FR1 and for cases with 40 UEs (or less), we observed that 100% of the UEs fulfilled the CSA requirement; therefore, we didn’t put explicitly such results in the contribution. |
| Ericsson | * + The overhead of dynamic scheduling of both DL and UL is quite high. It would be useful to consider DL SPS and UL CG to reduce overhead and eliminate PDCCH error issue.   Nokia: We see that our approach is still quite close to frequency hopping SPS/CG with occasional allocation reconfiguration. In DL, this can be achieved by using multiple SPS configurations.  In general, there is a tradeoff between scheduling flexibility and control overhead (SPS may allow to reduce PDCCH overhead, but PRB allocation is semi-statically the same which may not be good for avoiding consecutive errors). Note that we have not considered PDCCH errors in our simulations.   * + For FR2 UE with 2 panel: what’s the panel selection method?   Nokia: UE uses the panel that provides the best RSRP towards connected gNB. |
| Intel | Does CSA account for packets with latency > 1ms?  Nokia: Yes, latency > 1 ms is counted as an error in both CSA and PER statistics. |
| ITRI | Is any scheduling strategy used to avoid interference in your evaluation? Do you compare the performance difference whether or not any interference avoidance strategy is applied?  Nokia: A fully uncoordinated-scheme is considered where each BS independently allocates the RBs to its UEs. Some level of interference avoidance is achieved by randomising the allocated RBs.  For the packet latency, why is some UE’s per-packet latency larger than 1ms? In our understanding, packet transmission cannot be performed after the latency deadline. Please clarify.  Nokia: Latency > 1 ms is counted as an error in both CSA and PER statistics, even if the packet is eventually transmitted. |

## 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:

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| --- | --- |
| 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.  QC: It is true that with full coordination among cells, orthogonal SPS transmissions are sufficient and no retransmission are needed. However, when the backhaul capacity limits the possibility of full coordination among cells, we show that reuse-0 retransmission strategy is a low-complexity solution which significantly outperforms 1-shot strategy. Note that each UE remains connected to the same base station in the RSRP sense, and the base stations do not need to share the packet or channel state information among them. The base stations only need to share among themselves how many RBs are needed for retransmissions. Therefore, the backhaul complexity requirement is low compared to full cooperation among the gNBs. |
| 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.  QC: The latency figure is updated in the revised version. |
| 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?  QC: Yes. Since retransmissions target at a higher reliability, it is not a bad choice to make the two resources equal. Further optimization of resources partitioning may slightly improve the capacity. |
| 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?  QC: Please refer to the above answers and our revised version. |
| Ericsson | * + For FR1, it seems that ‘capacity’ is defined as 100% of the UEs satisfy the requirements? It’s better to clarify such definition. For example, other companies may assume a different ‘capacity’ criteria. In fact, QC study of FR2 assumes capacity to be at least 90% (i.e., not 100%) UE satisfy the requirements.   + For FR2: what’s the UE antenna configuration?   QC: You are right. We have clarified the definition of capacity in the revised version. |
| Intel | For the case of non-zero survival time, how CSA is calculated – based on actual consecutive drops of packets or based on the formula assuming e.g. independent errors?  QC: It is based on actual consecutive drops of packets. No independence assumption is made. |

## 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?  vivo: In our scheduling strategy, to avoid continuous errors, the scheduling priority of the UE will be increased when packet error occurs. After a period of time for system warm-up, each UE can transmit in a relatively stable environment with few packet errors. When packet error occurs, gNB will re-configure the resource allocation with highest priority and select a more conservative MCS for the UE, then UE can continue to transmit in a relatively stable environment. |
| 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.*  vivo: For FR2, both gNB and UE can only transmit/receive one analog beam in one slot. Since the number of users per beam may be different due to UE random dropping, for some beams, the frequency resource may not be enough for the UEs to be fully FDMed scheduled. |
| 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?  vivo: Yes, our scheme is intended to improve the CSA.  Could you please also clarify how the resources for the original resource allocation and the MCS are selected?  vivo: We allocate frequency resource and choose MCS for UEs according to their CSI feedback. And we apply an offset (e.g. 2dB) to the reported DL CQI or the measured UL SINR to choose a more conservative MCS for the UE. After a period of time for system warm-up, each UE can transmit in a relatively stable environment with few packet errors. When packet error occurs, gNB will re-configure the resource allocation with highest priority and select a more conservative MCS for the UE, then UE can continue to transmit in a relatively stable environment. |
| 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?  vivo: For BLER < 1e-5, our AMC target BLER is 1e-5 and we also apply an offset (e.g. 2dB) to the reported DL CQI or the measured UL SINR to choose a more conservative MCS for the UE with NACK packets, just like the MCS selection strategy of Nokia and we also have similar PER results for 50 UEs. For geometry curve, we have already provided it in our contribution. For interference mitigation, we do not use special interference mitigation methods. |
| Ericsson | Q1. The larger number of UEs supported does not seem possible. Consider coordinated transmission. The study seems to assume that one UE only need to occupy 1 PRB \* 6 os (Section 3: max 546 UE for FR1, max 856 UE for FR2). But this is not possible as shown below.  TBS >= (48bytes + TB\_CRC) = (384 bits + TB\_CRC) = 400 bits  Highest MCS level in the low SE 64-QAM table is: {R = 772/1024, 64-QAM}  REs needed for transmission of one TB: ceil( 400/(772/1024 \* 6) ) = 89 (RE) > #RE in one PRB (=12\*6 RE)  In addition, it’s necessary to take into account overhead such as DMRS.  Thus, even if SINR is very high, 2 PRBs are needed to transmit one TB assuming time domain duration is 6 os.  vivo: We use rank 2 for coordinated transmission due to the high SINR, so only 1 PRB is needed for each UE.  Q2. For FR2 results, is digital or analog beamforming used?  vivo: Analog beamforming is used. |
| Intel | For the largest UE density, is still full FDM orthogonalization achieved? If not, how the scheduler chooses to overlap transmissions in different cells?  vivo: For FR1, 40 UEs per service area can be fully FDMed scheduled. For FR2, when UEs per service area are more than 50, the frequency resource may not be enough for all UEs to be FDMed scheduled for some beams due to UE random dropping. In that case, two UEs could reuse same resources, but the serving cell of the two UEs should be as far as possible to mitigate inter-cell interference. |
| ITRI | For the case of cell coordination, have you tried to transmit data with more than 1 layer? If 1 layer is applied, one packet may not be completely transmitted in one PRB. Or, do you have another assumptions? Please clarify.  vivo: We use rank 2 for coordinated transmission due to the high SINR. |

## 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:

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| --- | --- |
| 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.  ZTE: In our understanding, such predefined resource split should be regarded as no coordination. Because the resource split is done for all cells at very beginning of deployment.  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”.  ZTE: The requirements include latency requirement (i.e., 1ms) and packet reliability requirement (i.e., 1-PER). This is similar as what simulated in Rel-16 URLLC SI. As we mentioned in our paper, our scheduling strategy is to try to avoid consecutive packet errors. For instance, if the first packet fails the following-up packet would have higher priority by allocating sufficient resources to try to guarantee its successful transmission. Thus, it could be possible that the CSA is 100% while there are many non-consecutive packet errors which makes the percentage of UEs satisfying the requirements is lower than 100%. |
| 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.  ZTE: For CDF of latency in our evaluation, we take all generated packets into account including the one doesn’t satisfying the PER requirement or the one doesn’t have a chance to be transmitted. For these packets, the latency is regarded as 1.1ms deliberately, as the following note in our paper.  *Note that, if the user plan latency exceeds 1ms, it would be labeled by 1.1 ms.*  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.  ZTE: First of all, when the number of UEs are large, different UEs cannot be fully FDMed even coordination is enabled. For FR1, there are two transmission occasions within 1ms. For each transmission occasion, it can support up to 273 UEs if one UE only uses one PRB. That is, a maximum of 273\*2 UEs can be fully FDMed. Regarding the RU, the channel condition and transmission power are different between DL and UL. It may cause different allocated number of RBs.  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?  ZTE: The target BLER of a TB is the target packet error rate (PER) since no packet segmentation. It seems straightforward that a higher requirement would cause worse performance. More specifically, for a higher requirement on PER, the SNR may not satisfy the stringent requirement even more conservative MCS selection may be used. In addition, it may require more number of RBs for each UE, which may cause inter-cell interference when the number of users are large.  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?  ZTE: This may come from different channel/interference conditions between FR1 and 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?  ZTE: Yes, inter-cell interference is one main reason causing the unsatisfied requirements for many UEs. |
| QC | What is the rationale behind 5 symbols PDSCH?  ZTE: There are 6 symbols in one slot for DL, and one symbol is regarded as PDCCH overhead. In addition, we find that the 1ms latency cannot be satisfied even using 2OS PDSCH if one retransmission is considered for FR1. Thus, a longer PDSCH duration could reduce the DMRS overhead to some extent.  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.  ZTE: For 30 GHz, the SCS should be 120kHz as agreed. It is a copy-paste typo, and will be corrected in the next version. |
| Ericsson | Q1: For FR2 results, is digital or analog beamforming used?  ZTE: Analog beamforming is used.  Q2: For FR2 BLER 1e-3 results, why UL percentage of 10/SA and 20/SA UEs satisfying CSA is worst for the coordinated case?  ZTE: Thanks for spotting this！We indeed made some mistakes when collecting such extensive results. For 10/SA case, we can clearly find that the PER is 0 and the latency is less than 1ms for all packets of all UEs based on the CDF for 10 users case in Figure 34 and 35. That is, the percentage of UEs satisfying the requirements for 10 uses case for UL with cell coordination should be 100%. For 20/SA case, it can also find that the PER for coordination case (Figure 34) is smaller than the case without coordination (Figure 28). The percentage of UEs satisfying the requirements for 20 uses case for UL with cell coordination should be 98.3%.  Q3: Is it possible to increase resource utilization (RU) to improve the percentage of UEs satisfying the requirement?  ZTE: Increasing the RU may not help since it would also increase the inter-cell interference, which is quite severe in factory scenario.  Q4. For cell coordination, this is very difficult to achieve dynamically: “When the number of UEs is more than the number of RBs, two users can be transmitted in a same RB. In order to reduce the interference, the servicing BSs for these two users should be as far away as possible.”  ZTE: This is an implementation issue for scheduling. Our strategy is to try to reduce the inter-cell interference as much as possible. Note that, there is one PDCCH symbol reserved per slot in our evaluation. It can be used for re-allocating the resources by re-activation DCI if needed. |
| ITRI | For the result of no cell coordination transmission, the performance for 40 UE dropped to 68.75% and 78.33%. In our view, the maximum number of supported resources are 273 PRBs for 100 MHz bandwidth, and there are total 2 slots within 1ms, the maximum number of UEs can be up to 546 if each packet accommodated within 1 PRB. In other words, the performance could be still maintained when a designed resource scheduling is applied. Do you observe any factors, other than interference, to degrade the performance?  ZTE: For the case without cell coordination, the resource allocation is fully independent. This would cause resource allocation collision among different cells. Thus, more number of RBs may be used for more conservative MCS for accommodate the interference. In other words, the number of UEs satisfying the requirements would be reduced due to limited resources if some of UEs use more than one RBs. |

## 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:

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| 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.  ITRI: We also observe that a fixed configuration may not be appropriate in different cases. Each UE’s SINR should be really taken into account when determining MCS, resource allocation size, resource scheduling, etc. However, the current simulation results could be seen as a baseline. Thanks for these suggestions. We will take these suggestions for future simulations.  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.*  ITRI: The main difference is the configuration of DL SPS and UL CG, especially in the considerartion of the packet arrival pattern. The configuration of DL SPS and UL CG in the time domain allocation for the first round does not depend on the packet arrival time, so that the alignment delay might be too long to make latency less than 1ms. However, in the second round simulation, the configuration of DL SPS and UL CG is adjusted appropriately according to the information of the packet arrival pattern. Therefore, the resource allocation in time domain and the resource periodicity could 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?  ITRI: Yes, the main difference comes from the alignment delay. In Table two, it is assumed that the traffic arrival is known at the gNB. Therefore, the SPS/CG resources are configured accordingly to enable the requirement satisfied.  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?  ITRI: It is only applicable for table 2 and table 3, not for table 1. |
| QC | How is it explained that DL is better than UL (contrary to HW, Ericsson)?  ITRI: We does not have a clear answer yet. But, we guess that the assumption of power control in our simulation may be one of reasons. Based on our quick simulation, we do observe a better performance by adjusting power control parameters. However, a complete evaluation is still under going. |
| Ericsson | Given that the message size is 48 bytes, even 4 PRBs occupation granularity is still pretty coarse. Will the performance improve if finer resource granularity is applied?  ITRI: We agree with this view. We also use a finer resource granularity, such as 1 PRB to simulate in section 3.1.1. It is oberved that the performance is improved. |
| Intel | We also wonder if any insights could be given why CSA is not met for many UEs in DL and UL? Is it because of persistent collisions?  ITRI: In our view, inter cell/UE interference may be the main cause. In the first released version, frequency resource allocation is allocated without a specific design. Interference might be large and cause low SINR. However, in the update simulation results of enhanced resource allocation in section 3.1.1, the performance of CSA almost meets the requirement for the case of many UEs when an enhanced method is designed to avoid interference. |
| ZTE | 1. Even if DL SPS or UL CG is assumed, the resource allocation/MCS could be adjusted by re-activation DCI. Thus it seems always assuming a fixed number of RBs is not optimal.   ITRI: We also observe that a fixed configuration may not be appropriate in different cases. The performance may be improved by re-activation DCI. However, the current simulation results could be seen as a baseline. Thanks for these suggestions. We will take these suggestions for future simulations.   1. If the resource allocation is assumed as fixed in your evaluation, could you clarify what’s your assumption on the number of ranks?   ITRI: We assume fixed rank 1 in our simulations. |

## 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:

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| 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.  [CATT response]: The higher reliability requires the critical SNR condition. In order to obtain the higher reliability performance, the conservative MCS is adopted for the certain SNR. In the simulation, lower MCS would be allocated more resource for transmission while the interference would be increased. |
| 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?  [CATT response]: The higher reliability requires the critical SNR condition. In order to obtain the higher reliability performance, the conservative MCS is adopted for the certain SNR. In the simulation, lower MCS would be allocated more resource for transmission while the interference would be increased. |
| 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?  [CATT response]: The higher reliability requires the critical SNR condition. In order to obtain the higher reliability performance, the conservative MCS is adopted for the certain SNR. In the simulation, lower MCS would be allocated more resource for transmission while the interference would be increased. |
| QC | What is the minimum DL packet delay value?  [CATT response]: According to the simulation results, the minimum DL packet delay value is 0.23ms.  What is the UE processing time?  [CATT response]: The UE processing time for DL is the PDSCH decoding time, which is assumed as the half of T*proc,1* in our contribution.  The DL slot duration?  [CATT response]: Since the sub-carrier space is 30KHz, the DL slot duration is 0.5ms.  How is radio link adaptation done? i.e. if there is one erroneous packet does something change when a new packet is transmitted?  [CATT response]: No. The gNB would consider the MCS according to the measured SNR, and the corresponding conservative MCS could be chosen under that SNR. |
| Ericsson | Both PER and BLER are used in the discussion. Since only one-shot transmission is applied, PER = BLER?  [CATT response]: Yes. The packet size is small without any packet segmentation. |
| ZTE | In simulation assumption part, it is assumed as ‘DUDUD’. But, it seems you used a 2-OS duration for scheduling. It seems there are discrepancies. Could you clarify this?  [CATT response]: The TDD configuration is assumed as “DU”, i.e., DL : UL=1slot:1slot. TTI length for scheduling is 2-OS, which means there is 7 TTIs in same direction in each slot. |

# 3 Conclusions

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