**3GPP TSG RAN WG1 #102-e R1-200xxxx**

**e-Meeting, August 17th – August 28th, 2020**

**Agenda Item: 8.3.1.2**

**Source: Moderator (InterDigital, Inc.)**

**Title: Feature lead summary #4 on CSI feedback enhancements for enhanced URLLC/IIoT**

**Document for: Discussion and Decision**

# Introduction

Per chairman’s guidance, two check points for the e-mail discussions were planned as below:

[102-e-NR-IIOT\_URLLC\_enh-02] Email discussion/approval – Moonil (IDC)

* By 8/21 – high priority
* By 8/27 – medium

The summary of the first round of e-mail discussion is available in R1-2007110

This document is for the second round of e-mail discussion and structured as following:

* Section 2 includes outcome of 1st round e-mail discussion and proposals from 2nd round e-mail discussions
* Section 3 is for the details of each CSI enhancement schemes to be studied further.
* Section 4 is for the baseline assumptions as common evaluation methodology to study and evaluate the performance of the proposed CSI enhancement schemes.
* Sections 5-7 discusses details of proposed CSI enhancement schemes for evaluations
* Annex A include the discussion of priority issue
* Annex B include the summary of inputs for the questions discussed in the first round of e-mail discussion

Here is the color code used in this summary:

* FL’s proposals
* Questions for the inputs from companies
* FL summary of the discussions
* RAN1 agreements

# Proposals based on e-mail discussions

## Outcome from the first round e-mail discussion:

Agreements:

* CSI feedback enhancement for Multi-TRP transmission is not to be discussed further under IIoT/URLLC enhancement WI

Agreements:

* Baseline assumptions are used as the required minimum to be simulated for the evaluation of candidate CSI enhancement schemes
	+ Reuse the assumptions in TR 38.824 and TR 38.901 as a starting point
	+ Companies shall report additional parameters (e.g., CSI measurement settings, CSI reporting schemes) used in their evaluation
	+ FFS details of baseline assumptions
* Companies can bring additional simulation results with other set(s) of assumptions

Agreements:

* Study/evaluate further on following CSI enhancement schemes in terms of technical benefit, specification and implementation impacts.
	+ New triggering methods for A-CSI and/or SRS
	+ New reporting based on one or more of the following:
		- Case 1: channel/interference measurement for new CSI reporting, considering aspects such as one or more of the following:
			* Reporting more accurate interference characteristics
			* Reduced CSI feedback overhead (e.g., reporting interference measurement only)
			* Enhanced CSI reporting such as WB/SB CQI
		- Case 2: other measurement (other than channel/interference) for additional information
			* E.g., PDCCH/PDSCH decoding, recommended HARQ RV sequence, etc.
		- It targets to help gNB scheduler for better link adaptation of (re)transmission
	+ [Reduced CSI computation time/complexity]
	+ [CSI feedback for PDCCH]
	+ Other CSI enhancement schemes that enable accurate MCS selection are not precluded
* Detailed assumptions of the proposed CSI enhancement schemes should be provided by the proponent, such as
	+ Reporting values
	+ Triggering conditions for the reporting
	+ Associated measurement resource
	+ Uplink resource to be used for the reporting
	+ How to use the reported information at the gNB scheduler
	+ CSI-RS overhead and CSI reporting frequency
	+ CSI reporting latency/timeline
	+ Etc.

## Proposals from the second round e-mail discussion:

**Priority of the CSI enhancement schemes**

Two CSI enhancement schemes (i.e., reduced CSI computation time and CSI for PDCCH) are still not decided yet whether it will be studied in this WI. The following table shows the latest status of the company position for the two CSI enhancement schemes.

|  |  |  |  |
| --- | --- | --- | --- |
|  | High(study with same priority as others) | Med(study with lower priority than others) | Low(no study in this WI) |
| Reduced CSI computation time/complexity | Vivo, Lenovo, Sharp, HW (4) | DCM, Pana, CMCC, NEC, CATT (5) | Sony, SS, QC, Intel, ZTE, Apple, Nokia, IDC (8) |
| CSI for PDCCH | Sony, SS, QC (3) |  | DCM, Nokia, vivo, CATT, LG, ZTE, Sharp, Intel, Lenovo, IDC, FW (11) |

Note: others here mean new triggering method and new reporting based on Case-1 and Case-2 agreed in Tuesday session

Considering that many companies are still objecting those two schemes and we have a really broad scope already with new triggering method and new reporting based on Case-1 and Case-2 which is also mentioned by several companies, I recommend not to study the above two enhancement schemes further in Rel-17. We may consider those enhancement in the future release.

FL’s proposal #1:

* Reduced CSI computation time/complexity and CSI feedback for PDCCH are NOT to be studied further in Rel-17 URLLC/IIoT enhancement

**Baseline assumptions**

For the baseline assumptions, 9 companies shared their view. Based on the inputs from companies, we observed the following:

* Regarding whether a separate set of baseline assumptions is needed for each CSI enhancement category or not, no clear majority is observed
* As a performance metric, all companies supported option 1 in TR 38.824
* A simple performance metric (e.g., MCS prediction error, CDF of latency samples from all UEs) as an alternative of the option 1 and 2 is proposed by several companies. Also, additional metrics (e.g., DL/UL signaling overhead, BLER of 1st Tx, resource utilization, spectral efficient) are proposed
* For the use case, factory automation and Rel-15 enabled use case are proposed as baseline
* If factory automation is used, 4 companies proposed to use new indoor factor (InF) channel model instead
* Most of companies think baseline assumption for LLS and transmission scheme is not needed

Additional e-mail discussion (Phase-2) related to detailed parameter was conducted. As an outcome, the following baseline assumptions are proposed for agreement.

FL’s proposal #2:

* Consider Table 1 as baseline assumption for system level simulation for evaluating CSI enhancement schemes
	+ The uses cases in Table 1 is for simulation purposes and it does not preclude a CSI enhancement scheme which is beneficial for the other URLLC use cases
* No baseline assumption is used for link level simulation
	+ Companies are encouraged to use one of LLS assumption tables in Section A.3 in TR38.824

Table 1. Baseline SLS assumption for CSI enhancement schemes in URLLC/IIoT

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Performance metric | Option-1 (section 5.1 of TR 38.824)Additional metrics (it is up to company to bring results with additional metric):* MCS prediction error (e.g., difference of a scheduled MCS and an ideal MCS)
* DL/UL signaling overhead
* CCDF of latency samples from all UEs
* BLER of 1st transmission
* Resource utilization
* Spectral efficiency
 |
| Use cases | Following two use cases can be considered for new triggering method and new reporting. It is recommend to evaluate both use cases:* Rel-15 enabled use case (e.g. AR/VR) in TR 38.824
	+ Reliability: 99.999
	+ Latency: 4ms (200bytes)
	+ Traffic mode: FTP model 3 (100p/s)
* Factory automation in TR 38.824
	+ Reliability: 99.9999
	+ Latency: 1ms (32bytes)
	+ Traffic mode: Periodic deterministic traffic model with arrival interval 2ms

Note: companies can bring additional results with the eMBB and URLLC UEs sharing the same carrier (as in A2.5 of TR38.824) |
| Simulation assumptions | Following simulation assumption is used based on the use case selected:* Rel-15 enabled use case with UMa (Table A.2.4-1 in TR 38.824)
* Factory automation at 4GHz (Table A.2.2-1 in TR38.824) with following update:
	+ Channel model is replaced with InF (InF-DH) in TR 38.901
		- Companies can bring results with other InF scenarios additionally
	+ Layout is replaced with BS deployment in Table 7.8-7 in TR 38.901
 |
| Transmission scheme | Multiple antenna ports Tx scheme* Companies report the details of Tx scheme used
 |

# Details of the proposed CSI enhancement schemes

Companies report following assumptions used for the simulation (both w/wo CSI enhancement):

* CQI table used
* Periodicity of P-CSI reporting and measurement resource (if P-CSI reporting is used)
* Frequency reporting granularity for PMI and/or CQI
* Whether OLLA is used or not. If used, the details of OLLA implementation

Following Table 2 is a summary of each CSI enhancements and some questions for missing details.

Table 2. Details of proposed CSI enhancement schemes for evaluation

|  |  |  |
| --- | --- | --- |
| Category | Schemes | Details |
| New triggering method for A-CSI | A-CSI on PUCCH triggered by DL DCI[2][4][5][10][11][15][17][18][20][21][22] | Additional triggering condition:* A-CSI field [2?][4?][5][10?][11?] [17?][18?][21][22]
* PDSCH is NACK [2][5]
* Priority index 1 [15]
* MAC CE activation [15]

Associated measurement resources:* Same as baseline?
* Additional CSI-RS/CSI-IM in symbols following DCI [4]?
* PDSCH [5]?

Delay between DCI and CSI report* X symbols?
 |
| A-CSI on PUCCH triggered by GC-PDCCH [8][12] | When does network transmit GC-PDCCH (which UE)? |
| A-CSI on PUCCH triggered by PDSCH NACK [5] | Additional triggering condition? |
| SRS triggered by NACK [24] | Additional triggering condition? |
| New reporting based on Case-1 | Statistical CSI based on additional report configuration for interference-to-noise ratio (INR) [3] | Additional CSI report configuration: CSI for “INR”* Channel: additional NZP CSI-RS (periodic 4 ms?) corresponding to dominant interferer (based on RSRP?)
* Interference: additional CSI-IM (periodic 4 ms?)
* RI/PMI reported?
* CQI: StdDev?, maximum?, minimum?, 95% percentile?
* Triggering: periodic 4 ms?

Scheduling aspect:* How to combine “CSI for INR” and baseline CSI to obtain MCS and RB allocation?
* How to take into account “age” of report?
 |
| Statistical CSI based on partial CSI report [4][6][7?][12?] | Additional CQI reporting based on RI/PMI of latest “baseline” CSI report* Interference: additional CSI-IM (periodic 1 ms?)
* Statistical CQI: Mean CQI [4][6] and StdDev CQI [6]
	+ What are the “samples” for statistical CQI? E.g. latest X CSI-IM instances, Y sub-bands?
* Statistical SINR [7], mean and StdDev
	+ Which resource? Granularity?
* Filtering [12]
	+ What type of filtering and number of samples

Triggering condition:* Statistical CQI:
	+ triggered by DCI [4], initial PDSCH of burst?
	+ periodic [6], every 1 ms?
* Statistical SINR: periodic every 2 ms?
* Filtering
	+ CQI change by min margin [12], which margin?

Scheduling aspect:* Select MCS as Mean CQI – StdDev CQI?
 |
| Worst-M CQI [7] | Reporting value:* Wideband CQI+CQI of worst-M sub-bands
* Value of M?

Scheduling aspect:* Random RB allocation

MCS selection: how to interpolate wideband CQI and worst-M subband? |
| Enhanced CSI reporting (WB/SB CQI) [2][9] | Reporting value:* Sub-band CQI without differential operation [2]

3-bit Reversed differential CQI mapping [9] |
| … |  |
| New reporting based on Case-2 | Decoding margin [3] | Report “low margin” or “high margin” from PDSCH in case of ACK* How to determine low vs high margin from actual SINR in simulation?

Scheduling aspect:How to adjust MCS bias as a function of low margin/high margin/NACK? |
| Error probability [7] | Report round(-log10(EP)) from PDSCH, quantized to 3 bits* Range for quantization?
* How to derive EP from received PDSCH?

Scheduling aspect:* Adjust MCS bias up/down if EP><BLERtarget
* What is the step size for up and down?
 |
| Compressed report with HARQ-ACK [14][27] | Report CQI along with HARQ-ACK [14][27]* As Delta-MCS from MCS used for PDSCH [14]
	+ Reporting granularity (e.g., number of bits)?
	+ Resource used for the measurement? CSI-RS or DM-RS?
* Instantaneous CQI from PDSCH [27]
	+ Granularity?

Triggering condition:* For every HARQ-ACK, or only when NACK?

Scheduling aspect:* Set MCS of retransmission or next transmission to the reported MCS?
 |
| PDSCH decoding failure [24] | Report reason from PDSCH decoding failure* Beam blocking
* Other cell interference
* Frequency selective fading
* Coverage hole
* How does UE determine the reason?

Scheduling aspect:* What does scheduler do for coverage hole, beam blocking, other cell interference?
 |
| UE request for CSI measurement [24] | Triggering condition?Uplink resource for the request?Scheduling aspect?Other details? |
| Recommended RV sequence [25] | Report recommended RV sequence along with NACK from PDSCH decoding attempt* How does UE determine this?

Scheduling aspect:* Use recommended RV sequence for retransmission
 |
| … |  |

Q: Please provide your inputs for the following details

* The missing details which may be required for other companies to simulate the proposed scheme
* Any question you might have for evaluating a CSI enhancement scheme proposed by other companies
* Any missing enhancement scheme (which has been agreed to study)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Moderator | Example)

|  |  |
| --- | --- |
| A-CSI on PUCCH triggered by PDSCH NACK [5] | Additional triggering condition?1. When HARQ-ACK priority is 1
 |

 |
|  |  |
|  |  |

# Baseline assumption for performance evaluation

The baseline evaluation assumption can be considered as the required minimum to be simulated for fair comparison of candidate enhancement schemes and this does not preclude companies from providing additional simulation results with other set of assumptions.

The baseline assumption discussion will have two phases:

* Phase-1: to down-select scenarios and assumptions in TR38.824 as baseline assumptions and required update in high level for the selected baseline assumptions
* Phase-2: to determine detailed assumptions (e.g., parameters) of the determined baseline assumptions if any

## General

The following categories have been identified for the proposed CSI enhancement schemes. Each category seems provides different types of gain and multiple CSI enhancement schemes in same or different categories can be used jointly for better performance.

* Cat-1: faster CSI feedback
	+ A-CSI on PUCCH
	+ CSI computation time reduction
	+ Priority indication for P/SP-CSI and/or A-CSI on PUCCH
* Cat-2: more accurate CSI reporting
	+ New CSI reporting types
	+ Subband delta CQI enhancement
* Cat-3: additional information to help gNB scheduler
	+ Additional information reported together with HARQ feedback
	+ Event-triggered UE reporting (e.g., preferred subband, carrier, beam)
* Cat-4: enhancement for PDCCH link adaptation
	+ CSI feedback for PDCCH

**Q1: do we need a different set of baseline assumptions for each CSI enhancement categories?**

* **If yes, any set of categories can share the same baseline assumption?**

Summary:

No clear majority is observed from the inputs provided by the companies. A couple of companies proposed to use a different target use case for each CSI enhancement category agreed in Tuesday session.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| LG | Yes | We are generally fine with the categorization. However, between Cat-2 and 3, it would be hard to differentiate “New CSI reporting types’ and “Additional information reported together with HARQ feedback” especially when A-CSI on PUCCH with HARQ-ACK. Is it correct understanding that “CSI” in Cat-2 is confined to traditional CSI in Rel-15/16? Given that all enhancement are additional and considered to help gNB decision, it is a bit ambiguous.  |
| Sony | Yes | A-CSI on PUCCH and Priority for P/SP-CSI do not seemed to fall under fast CSI category. Cat-2 and Cat-3 look like they should be under the same category.  |
| HW/HiSi |  | We cannot answer with “yes” or “no” at the moment, but would firstly like to discuss about the proposed categories to get a better understanding about the purpose and also about the included sub-bullets.For cat 1, we think some re-organization would be helpful.* We do not think that A-CSI on PUCCH only serves to achieve faster CSI. It is also useful to reduce the control overhead.
* The priority indication help to ensure that a CSI report is not dropped. It does not help to reduce the baseline CSI computation time. It can only help in the case of intra-UE multiplexing that the CSI processing time is not extended additionally.
* What is meant with CSI computation time reduction in this context? Is it referred to a new CSI type that does has a reduced computation complexity, or is it aiming to achieve faster processing for the exiting CSI reports?

For cat 2,* Could new CSI reporting types could also be included in faster CSI reporting

For cat 3, Additional information to help the gNB scheduler* Not sure if this categories is needed as an independent category? In general and could it be associated with other categories? For example,
	+ With accurate CSI reports, which can help the gNB scheduled to select a more suitable MCS
	+ With faster CSI reports, could help the gNB scheduler to schedule more efficient retransmissions?
	+ With A-CSI on PUCCH, if it can help the gNB scheduler to reduce the control overhead.

For Cat-4, we are concerned that if CSI for PDCCH is included in the WI, then the scope will become too large. Here, we should at least list more details about the envisioned methods and characteristics for CSI. |
| Intel | No | Prefer a single generic set of assumptions. In that case cross-category comparisons are also possible. Furthermore, we would like to avoid discussion on category components, which seems more controversial than the overall intention to define the assumptions |
| FUTUREWEI |  | In our opinion, the current scope of study is too broad if all the schemes listed under the four proposed categories are treated with the same priority. The priority inputs from many companies collected in Round 1 should be used to assign priority to each of the schemes.Regarding the categorization, we think the new FL proposal (merged proposals #3 and #4) is fine and should be used to update the categorization. For example, the description of the new CSI reporting type(s) in the categorization above should use the one listed in the new merged proposal #3 and #4 from FL’s email: * + New CSI reporting type(s) based on channel/interference measurement considering aspects such as
		- Reporting more accurate interference characteristics
		- Reduced CSI computation time
		- Reduced CSI feedback overhead (e.g., reporting interference measurement only)
		- Enhanced WB/SB CQI enhancement
 |
| InterDigital | Yes | The agreement made on Tuesday session has one bullet on new triggering and a second bullet on new reporting types. It makes sense to evaluate a CSI enhancement scheme for the use case in which it is expected to bring most benefits. Such use case may be different between “new triggering” and “new reporting type” schemes, e.g. * New triggering enhancement schemes may be most useful in use cases where a data burst occurs at random time and cannot be transmitted in a single TB, i.e. larger packet sizes with random inter-arrival times
* New reporting type enhancement schemes may be most useful in use cases that result in short bursts of interference, i.e. small packet sizes (32 bytes) and/or use cases with very high reliability requirements for which simple A/N-based OLLA fails (e.g. 99.9999%)

Thus, we propose correspondingly to define two sets of assumptions. |
| DOCOMO | Yes | We agree to evaluate each CSI enhancement categories with different set of baseline assumptions because each categories will bring gains on different suitable assumptions. However, the study scope is too broad to proceed. We prefer to make prioritization for each enhancement based on the 1st round input and the outcome from Tuesday online session. |
| Nokia/NSB | No | This discussion should be updated based on the latest Ran1 agreement.  |
| ZTE |  | According to today’s GTW discussion, only one comment on Cat-4:For Cat-4, firstly, some key points need to be clarified by the proponent:* What quantities need to be fed back to the gNB
* How to determine the link adaption through the feedback quantities by the gNB
* Which resource can be used for the feedback, PUSCH or PUCCH
* How to convert the performance improvement of PDCCH into URLLC evaluation metric

After the answers determined, then we can decide whether Cat-4 is needed. |
| Samsung | Yes | The schemes under consideration have different attributes:1. Schemes that introduce new CSI reporting types
2. Schemes that consider different triggering than in Rel-16
3. Schemes that bundle information or are based on events

Different schemes require different aspects/measurements/metrics/feedback for realization. Impact of measurement accuracy and quantization is rather common but the metrics are different. Realization of feedback accuracy may be a non-issue for some (e.g. new CSI reporting schemes) but needs to be addressed for others (e.g. some of the new triggering schemes)  |

## Performance metric

**From TR 38.824 [25]:**

**Option 1**: Percentage of users satisfying reliability and latency requirements

- Intend for the case with fixed number of UEs and fixed traffic model per UE

**Option 2**: URLLC capacity and URLLC/eMBB multiplexing capacity

- Definition: URLLC system capacity is calculated as follows:

- C(L, R) is the maximum offered cell load under which Y% of URLLC Ues in a cell operate with target link reliability R under L latency bound

- X= (100 – Y) % is the percentage of Ues in outage

- A UE in outage is defined as the UE cannot meet both latency L and link reliability R bound

- Companies report their assumption on X (either ~5% or 0%)

- Companies report their assumption on the number of eMBB Ues deployed together with the URLLC Ues

- Intend for the case that the number of Ues and/or the data arrival rate is adjustable

- Adjusting the number of Ues should be applied to periodic deterministic traffic model

**Q2: which option should be used as a baseline assumption?**

* **Please share your view per CSI enhancement category if needed (e.g., if you answered yes for Q1)**

Summary:

* Majority of companies support to use the option 1 as baseline assumption

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2** | **Comments** |
| LG | Option 1 | Option 1 is easier to compare results of evaluations with fixed number of UE. |
| HW/HiSi | Option 1 | We are not sure if we have to decide at this stage, but if required then Option 1 is our preference.  |
| Intel | Option 1 | See our comments below |
| FUTUREWEI | Option 1 | Our preference is Option 1. |
| InterDigital | Option 1 | This is simpler and could be supplemented by additional metrics. |
| DOCOMO | Option 1 | Option 1 is preferred for simplicity. |
| Nokia/NSB | Option 1/2 | Depends on scenario/ traffic model. Down-selection can be done after agreeing on the scenarios in Q4.As described in TR 38.824, the suitability of Option 1 or Option 2 depends on the scenario and/or traffic model: e.g. Option 1 is more suitable where the number of UEs and arrival rate per UE is fixed, whereas Option 2 is more appropriate when number of UEs and/or the data arrival rate is adjustable. |
| ZTE | Option 1 | We prefer Option 1. |
| Samsung | Option 1 | Generally agree with previous comments |

**Q3: any new option or any modification is needed for the option selected?**

Summary:

* Following additional metrics proposed
	+ MCS prediction error (i.e., difference of a scheduled MCS and an ideal MCS)
	+ DL/UL signaling overhead (especially for new triggering method)
	+ CDF of latency samples from all UEs
	+ BLER of 1st transmission
	+ Resource utilization
	+ Spectral efficiency

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| Intel | Yes | The above alternatives are final metrics which require substantial simulation time and complexity to collect.We prefer at least one simpler metrics which directly show MCS setting accuracy, such as:* MCS prediction error, calculated as a difference of a scheduled MCS and an ideal MCS
 |
| InterDigital | Yes | Option 1 results should be always be shown and additional metrics should be provided:* DL/UL signaling overhead is important since one could make baseline scheme as good as desired by reducing P-CSI and/or CSI/RS periodicity to a sufficiently small value (e.g. down to every slot). It should be shown as part of results (unless they are the same between schemes).
* MCS prediction error is an additional metric that is relevant given objective of WI.
 |
| Nokia, NSB | Yes | Since the timeline for generating simulation results is short, it is convenient to consider a third option consisting of reporting a single latency CCDF containing latency samples from all UEs. The performance of a certain enhancement can be measured by looking at e.g. 99.999% or 99.9999% (depending on scenario/use case) of the global distribution. This requires much shorter simulations compared to estimating the e.g. 99.999%-ile for each UE.Besides, these other metrics are also useful:* + - Block error rate of 1st transmission.
		- PRB utilization

These two metrics allow to measure the “spectral efficiency” of a certain CSI enhancement. For instance, even though two CSI different enhancements may perform similarly in terms of reliability/BLER/latency, one of them could be superior in terms of MCS selection accuracy which translates into improved spectral efficiency/lower PRB utilization. |
| ZTE | Yes | Spectral efficiency and/or Resource utilization can also reflect whether the better link adaption is achieved, the two metrics could be as the supplement. |
| Samsung | Yes | Generally agree with Intel. In order to have a common metric that may enable some direct comparisons, a first level should be some simple metrics like the MCS prediction error. A second level can be throughput evaluation (although not very meaningful for URLLC), and robustness and latency analysis/evaluation. |

## Use case/requirement

**From TR 38.824 [25]:**

Table A.2-1: Representative use cases for Rel-16 NR URLLC evaluation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Use case | Reliability (%) | Latency  | Data packet size and traffic model | Description |
| Power distribution | 99.9999 | 5 ms (end to end latency)Note: 2-3 ms air interface latency  | DL & UL:100 bytes ftp model 3 with arrival interval 100 ms | Power distribution grid fault and outage management (TR 22.804:5.6.4) |
| 99.999  | 15 ms (end to end latency)Note: 6-7 ms air interface latency | DL & UL:250 bytes Periodic and deterministic with arrival interval 0.833 msRandom offset between UEs  | Differential protection(TR 22.804:5.6.6) |
| Factory automation | 99.9999 | 2 ms (end to end latency)Note: 1 ms air interface latency  | DL & UL:32 bytesPeriodic deterministic traffic model with data arrival interval 2 ms | Motion control |
| Rel-15 enabled use case (e.g. AR/VR)  | 99.999  | 1 ms (air interface delay) for 32 bytes1 ms and 4 ms (air interface delay) for 200 bytes  | DL & UL:32 and 200 bytes FTP model 3 or periodic with different arrival rates |  |
| 99.9 | 7 ms (air interface delay) | DL & UL:4096 and 10 K bytesFTP model 3 or periodic with different arrival rates |  |
| Transport Industry | 99.999 | 5 ms (end to end latency)Note: 3 ms air interface latency  | UL: 2.5 Mpbs; Packet size 5220 bytesDL: 1Mbps; Packet size 2083 bytesNote: Data arrival rate 60 packets per second for periodic traffic model | Remote driving (TS 22.186: 5.5) |
| 99.999 | 10 ms (end to end latency)Note: 7ms air interface latency | UL&DL: 1.1 Mbps; Packet size 1370 bytes Note: Data arrival rate 100 packets per second for periodic traffic model | Intelligent transport system (ITS)(TS 23.501, TS 22.261) |

**Q4: which use case should be used as a baseline assumption?**

* **Case-1: Power distribution**
* **Case-2: Factory automation**
* **Case-3: Rel-15 enabled use case**
* **Case-4: Transport industry**

**Please share your view per CSI enhancement category if needed (e.g., if you answered yes for Q1)**

Summary:

* 2 companies (LG, ZTE) proposed not to use power distribution use case
* 2 companies (HW, FW) proposed not to select use case and leave it as company’s choice
* 2 companies (Sony, Intel) think factory automiation should be prioritized
* 1 company (Nokia) think Rel-15 enabled use case should be used
* 2 companies (NTT, IDC) proposed to use Rel-15 enabled use case for new triggering method and factory automation for new reporting

|  |  |  |
| --- | --- | --- |
| **Company** | **Case 1/2/3/4** | **Comments** |
| LG | Except for Case 1 | Case 1 has lower traffic arrival rate and smaller packet size. Though it is representative case of URLLC, CSI won’t be helpful in this case.  |
| Sony | Case 2 | Although all cases are appropriate, Case 2 seems to be the target for some of the objectives in the WID. |
| HW/HiSI | Al cases should be included | We should not down-select between the use cases at this stage. All use cases are representative for URLLC. Instead we prefer that companies report which use case they selected in their evaluation. |
| Intel | Case 2 | Industrial IOT and factory automation use cases can be studied with higher priority |
| FUTUREWEI | All cases could be considered | Our view is that all cases could be considered in the evaluation and companies need to report the case(s) they selected in their evaluation. |
| InterDigital | New triggering: Case 3New reporting type: Case 2 | “New triggering” schemes may be most useful in use cases where a data burst occurs at random time and cannot always be transmitted in a single TB. This may fit “Rel-15 enabled use case” (Case 3) with 200 bytes packet size“New reporting type” schemes may be most useful in use cases that result in short bursts of interference, i.e. small packet sizes (32 bytes) and/or use cases with very high reliability requirements for which simple A/N-based OLLA fails (e.g. 99.9999%). This may fit “Factory automation” use case. |
| DOCOMO | New triggering: Case 3Others: Case 2 | New triggering methods for A-CSI is useful in use cases where data occurs aperiodically. Thus, case 3 would be appropriate. Besides, factory automation use cases should be prioritized to study considering IIoT scenario although all the use cases are important. |
| Nokia, NSB | Case 3 | Our preference is Case 3: Rel-15 enabled use case with 99.999% reliability, 1 ms air interface delay and FTP3 traffic. Further down-selection between the urban macro or indoor deployment can be discussed later if needed.Reasoning: Use cases with sporadic/random traffic and small payloads (case 1, 3, 4) are preferred over those with periodic traffic (e.g. case 2). The reason is that the latter generally results in repetitive and predictable interference conditions which is not a very realistic assumption. |
| ZTE | Except for Case 1 with 99.9999% reliability | For the case of Power distribution with 99.9999% reliability, which has lower traffic arrival rate the smaller packet size, the CSI enhancement is not very urgent as the requirement could easily be satisfied.  |
| Samsung | Case 2 only | All other cases are not part of the WID. Need to minimize scenarios.Only factory automation for IIoT needs to be considered. |

**Q5: for the Case you selected as baseline use case, any update in the corresponding simulation assumption table in TR38.824 (e.g., channel model for factory automation)?**

* **If yes, which assumption should be updated?**

Summary:

* 4 companies (HW, Intel, IDC, Nokia) think the channel mode and/or deployment layout has be changed based on the outcome of InF channel model if factory automation use case is used
* 1 company (SS) think the channel model in factory automation simulation assumption should be used
* 1 company (ZTE) proposed to use unified values for traffic arrival rates when Rel-15 enabled used case is used

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| LG | No |  |
| HW/HiSi | Yes | If motion control is selected, the new indoor channel model for factory automation should be used. |
| Intel | Yes | Both deployment layout and channel model require updates to align with the outcome of InF channel model study |
| InterDigital | Yes | Agree with Intel |
| Nokia, NSB | No | If Factory automation is selected, then we agree with other companies to adopt the new InF channel model. |
| ZTE | Yes | For the case of AR/VR with 99.999% reliability, the traffic arrival rates should use some unified values. After check in 38.824, we try to give some example values: For the case of 32 bytes DL packet size, the traffic arrival rates can be: 300 p/s, 500 p/s, 700 p/s or 1000 p/s. For the case of 4096 bytes DL packet size, the traffic arrival rates can be: 185 p/s, or larger values. |
| Samsung | No | Use channel model for factory automation |

## Multiplexing of eMBB and URLLC UEs sharing the same carrier

**Q6: do we need to update any assumption for multiplexing of eMBB UEs and URLLC UEs in the same carrier if Option-2 is used as performance metric?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| Nokia, NSB | No | We are fine with the assumptions described in Section A.2.5 of TR 38.824 |
| Samsung | No |  |
|  |  |  |

## Link level simulation (LLS)

**Q7: do we need baseline assumptions for link-level simulation?**

* **If yes,**
	+ **which CSI enhancement category needs LLS and why?**
	+ **which LLS assumption should be used as baseline?**

Summary:

All companies responded think baseline assumption for LLS is not needed

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| LG | No | If necessary, we may be able to re-use LLS assumption in 38.824. |
| HW/HiSi | No | Currently we assume that no LLS are needed. |
| Intel | No | We assume MCS accuracy may be limited by interference prediction, which is hard to model by link level. Thus, SLS evaluations would be more representative and should be used as a baseline. |
| FUTUREWEI | No | If LLS is needed, we could re-use LLS assumptions in 38.824. |
| InterDigital | No | If needed, companies can bring results based on their own assumptions. |
| DOCOMO | No | Share the same view as LG. |
| Nokia/NSB | No |  |
| ZTE | No | If LLS is needed, we could re-use LLS assumptions in 38.824. |
| Samsung | No | However, some aspects related to link level operation, such as measurement reliability/latency of feedback reliability/latency, and how it can be achieved for the various schemes, need to be considered. |

## Transmission scheme

**Q8: do we need a baseline assumption for transmission scheme, or it is up to each company and the company reports the transmission scheme used?**

* **If yes, which transmission scheme should be used as baseline?**

Summary:

* All companies responded except for SS think baseline assumption for Tx scheme is not needed
* 1 company (SS) think rank-1 TxD has to be used as baseline assumption

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| LG | No | At least for the discussion, it would be enough to report the transmission scheme used by the company.  |
| HW/HiSI | No | Transmission scheme can be reported by the company.  |
| Intel |  | We are not sure if the assumption should be fixed, but expect different techniques may be beneficial in different assumptions |
| FUTUREWEI | No | Each company can report the transmission scheme that it uses. |
| InterDigital | No | To be reported by the company. Alternatively, SU-MIMO could be selected as baseline. |
| DOCOMO | No | Transmission scheme can be reported by the company. |
| Nokia/NSB | No |  |
| ZTE | No | Transmission scheme can be reported by the company.  |
| Samsung | Yes | Transmission diversity – rank 1.URLLC needs to be robust and reliable – TBs are small and low MCS values are typically used.  |

## Others

**Q9: any other assumptions we should consider as a baseline assumption?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comments** |
| Nokia/NSB | No |  |
|  |  |  |
|  |  |  |

# Enhancements for faster CSI reporting

In this section, we provide summary of contributions related to the enhancements for faster CSI reporting.

## A-CSI on PUCCH

### Issue #1-1

**Issue #1-1: Support aperiodic CSI report on PUCCH**

* Yes: Huawei [2], Futurewei [3], NTT DCM [23], vivo [4], ZTE [5], CATT [10], NEC [11], CMCC [17], Spreadtrum [18], Panasonic [20], InterDigital [15], Intel [12]
	+ Trigger reporting based on traffic needs,
	+ Less overhead than A-CSI on PUSCH in DL-dominant traffic
	+ Report useful for retransmissions and subsequent TBs
* No: Samsung [16], Sony [8]
	+ Small throughput gains as it does not benefit initial transmission
	+ Latency too high for URLLC
	+ Not useful in case of bursty interference
	+ Retransmissions are rare
	+ Specification impact, e.g. may require new field(s) in DCI
* Further study: Apple [21], Sharp [22], Lenovo [13]

The A-CSI on PUCCH has been discussed in the previous releases and it is observed that majority companies support the A-CSI on PUCCH. However, a few companies still have concerns on the benefits of the A-CSI on PUCCH for the URLLC scenario.

### Issue #1-2

**Issue #1-2: Triggering method of aperiodic CSI report on PUCCH**

* Option-1: A-CSI is triggered by DL scheduling DCI
	+ Yes: Huawei [2], NTT DCM [23], vivo [4], ZTE [5], CATT [10], NEC [11], CMCC [17], Spreadtrum [18], Panasonic [20], InterDigital [15]
		- Less overhead than UL-DCI in DL-dominant traffic
	+ No: Samsung [16], Intel [12], Sony [8]
		- Specification impact, e.g. may require new field(s) in DCI
	+ Further study: Apple [21], Sharp [22], Lenovo [13]
* Option-2: A-CSI is triggered by group-common DCI
	+ Yes: Intel [12]
		- Less DL signaling overhead
	+ No: Huawei [2], ZTE [5], NTT DCM [23], CATT [10]
		- Packet arrival time varies between UEs
		- Increase of blind decoding
	+ Further study: Sony [8]
		- Consider overhead cost
* Option-3: A-CSI is triggered by NACK (without DCI)
	+ Yes: ZTE [5]
		- May be useful for SPS PDSCH and sporadic traffic
	+ No: Sony [8]
		- Not much benefit over soft combining (different RV’s)

The most of companies supporting A-CSI on PUCCH seems to also support DL DCI based triggering as it can avoid unnecessary PDCCH overhead in DL-dominant traffic cases.

### Issue #1-3 and #1-4

**Issue #1-3: Additional conditions for A-CSI reporting on PUCCH triggered by DL DCI**

* Option-1: New field in DCI
	+ NTT DCM [23]
* Option-2: PDSCH is NACK
	+ Huawei [2], ZTE [5]
* Option-3: DL DCI with high priority index
	+ InterDigital [15], ZTE [5]
* Option-4: Activation by MAC CE
	+ InterDigital [15]

Note: one or more of abovementioned options can be used together

Several contributions discussed details on how to trigger A-CSI on PUCCH actually, which include explicit indication in DL DCI and implicit trigger based on PDSCH decoding status or priority indicator in the associated DL DCI in order to reduce the DL and/or UL signaling overhead.

**Issue #1-4: PUCCH resource determination for A-CSI on PUCCH**

* Option-1 : RRC
	+ Panasonic [20]
* Option-2 : MAC CE
	+ InterDigital [15]
* Option-3: Same as HARQ-ACK
	+ OPPO [14], Spreadtrum [18] (under conditions), Panasonic [20], NTT DCM [23]
* Option-4: DCI field (e.g. PRI)
	+ NTT DCM [23], Panasonic [20], ZTE [5]
* Option-5: CSI request field
	+ Panasonic [20]

Note: gray highlight here means that a company mentioned the proposal in the tdoc but not clearly indicate whether the company supports it or not

Several contributions discussed the options related to the PUCCH resource determination when A-CSI on PUCCH is supported. Similar to the Issue #1-3, this issue is also the next level of details which can be discussed after the support of A-CSI on PUCCH is agreed.

## Reduction of CSI computation time

**Background**

The minimum CSI computation time is larger than PDSCH processing time (e.g., PDSCH processing capability 2) in current specification. Therefore, even if A-CSI reporting is triggered in the symbol where a PDSCH is scheduled, a UE may report A-CSI later than the associated HARQ feedback (or HARQ feedback is delayed to be reported together with A-CSI) which may result in delayed retransmission scheduling.

### Issue #1-5

**Issue #1-5: Reduction of CSI computation time**

* Yes: FutureWei [3], Ericsson [6], vivo [4], CATT [10], Lenovo [13], OPPO [14], CMCC [17], propose to study how to support reduction of CSI computation time
	+ To improve accuracy/timeliness of CSI report for URLLC
	+ To allow reporting of CSI at the same time as earliest possible transmission of HARQ-ACK or PUSCH based on PDSCH processing capability 2 (N1/N2)
	+ Proposals to ease CSI computation:
		- Simplified CSI report: CATT [10], Lenovo [13]
		- Partial report: Ericsson [6], Vivo [4], OPPO [14], Lenovo [13]
		- Simplified measurement from data reception status: OPPO [14]
		- Only report sub-band CQI: CMCC [17]
		- More capable UE: Ericsson [6], Futurewei [3]
		- Reporting CQI’s for more than one table in a report: Intel [12]

**Observations**

The minimum required CSI computation time has been specified in section 5.4 of 38.214. Several companies observed that for a UE with PDSCH (PUSCH) processing capability 2, timeline requirement allows for reporting of HARQ-ACK (or transmission of PUSCH) earlier than for reporting A-CSI triggered from same DCI.

## Priority of P/SP-CSI/[A-CSI] on PUCCH

**Background**

The P/SP-CSI on PUCCH has been considered as a lowest priority as compared with other CSI reporting types and no priority index associated with the CSI reporting configuration. Therefore, even if it is targeted for URLLC traffic link adaptation, it may be dropped if it collides with a higher priority CSI reporting (e.g., A-CSI reporting, SP-CSI on PUSCH) irrespective of whether the higher priority CSI reporting is targeted for eMBB or URLLC.

### Issue #1-6

**Issue #1-6: Priority applicable to P/SP-CSI on PUCCH and (if supported) A-CSI on PUCCH**

* Mediatek [9], Samsung [16], Intel [12], propose that P/SP-CSI on PUCCH can have priority index 1 in some cases
	+ Proposals for assignment of priority:
		- BLER target of the configured CQI table: Mediatek [9]
		- Semi-static configuration or activation: Intel [12]
* NTT DCM [23] and Panasonic [20] propose that A-CSI on PUCCH (if supported) can have priority index configurable, e.g. indicated from DCI
* NTT DCM [23] also proposes that priority used in clause 5.2.5 in 38.214 for A-CSI PUCCH is higher than for A-CSI on PUSCH
* FutureWei [3] proposes CSI reporting procedures with less CSI report dropping due to collision

**Observations**

Several companies propose to introduce an additional means to support priority configuration or determination of P/SP-CSI on PUCCH as well as A-CSI on PUCCH (if supported) so that dropping of those CSI reporting due to collision with a high priority CSI reporting targeting eMBB.

# Enhancements for more accurate CSI reporting

## Enhancements for bursty interference conditions

**Background**

Several companies identified the following issues on the existing CSI report types for URLLC scheduling especially under bursty interference environment

* Channel/interference measurement resource configuration is not flexible enough
* Channel and interference should be measured at the same time always although only interference part is changed dynamically
* Wideband CQI is not accurate when a small number of RBs are scheduled
* Channel prediction is not accurate at the scheduler with existing CSI

### Issue #2-1

**Issue #2-1: introduce new CSI report type(s)**

* Yes: Futurewei [3], Ericsson [6], Nokia [7], Intel [12] propose enhancements to provide additional or more relevant information to help scheduler select MCS for reliable transmission when interference is bursty
	+ Proposals
		- Separate CSI reporting of signal information and interference information: Futurewei [3]
		- Report interference statistics (e.g. minimum, maximum, stddev): Futurewei [3]
		- Report CQI or SINR statistics (e.g. variance): Ericsson [6], Nokia [7]
		- Explicit interference averaging: Intel [12]
		- Filtered CSI reporting (e.g. report only when CQI changes): Intel [12]
		- Report the CQI associated with the worst-M sub-bands: Nokia [7]

**Observation**

The necessity of a new CSI report type for better capturing interference characteristics is seen by several companies but the proposals are diverging at this point and more details are needed.

## More accurate sub-band CQI feedback

**Background**

A few companies raised concern on the accuracy of the current subband CQI as 2-bit delta CQI used with quantization and the quantization error is relatively large, resulting in inaccurate subband CQI.

### Issue #2-2

**Issue #2-2: Need for enhancing accuracy of sub-band differential CQI feedback**

* Yes: Huawei [2], Mediatek [9], CMCC [17] propose enhancements to improve accuracy of sub-band differential CQI feedback
	+ Proposals
		- Sub-band CQI with no differential CQI (Huawei [2])
		- New differential CQI tables (Mediatek [9])

# Other enhancements

## Enhancements to support OLLA with low BLER target

**Background**

An ACK/NACK based outer loop link adaptation has been used and it worked fine with eMBB use case since it has higher target BLER ($10^{-1}$). However, for URLLC, the ACK/NACK based OLLA performs poorly since NACK occurs very rarely as it targets much lower BLER ($10^{-5}$) and it cannot track the channel/interference variation dynamically.

Also, the latency bound can be small with URLLC, the gNB and UE do not have the time to conduct multiple rounds of HARQ retransmission. Providing additional information to the gNB would allow it to allow enough resources for the UE to decode the transmitted packet within the latency bound.

### Issue #3-1

**Issue #3-1: Need for additional information bundled to HARQ-ACK**

* Yes: Ericsson [6], Oppo [14], ZTE [5], Nokia [7], Apple [26], Qualcomm [27] propose to bundle additional information to the HARQ-ACK report
	+ Proposals
		- Decoding margin: Ericsson [6], ZTE [5]
		- Compressed CSI report: Oppo [14], ZTE [5]
		- Estimated error probability, e.g. LLR: Nokia [7], Oppo [14]
		- Recommended RV sequence: Apple [26]
		- PDSCH decoding failure reason: Qualcomm [24][27]
		- Per-TRP decoding result: Qualcomm [27]
		- Preferred beam, subband, and/or component carrier info: Qualcomm [27]
		- New Tx-Rx beam pair request: Qualcomm [24][27]
		- Instantaneous MCS/CQI feedback: Qualcomm [27]

Note: Apple [26], Qualcomm [27] contributions submitted under AI 8.3.1.1

**Observation**

OLLA performance issue is seen by several companies and those companies see the benefit of additional information bundled with HARQ feedback for better OLLA performance.

**Q: if you are a proponent of proposal listed above and there is any missing detailed assumption (e.g., not provided in the contribution), please provide the detailed assumption for other companies to evaluate the proposal.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | For the scheme of decoding margin, some information reflecting the offset between the effective value obtained by UE decoding the PDSCH/PDCCH and the target value can be determined, and then the information can be quantized into 2 or 3 bits overhead, which is reported to the gNB. After receiving such quantized offset, gNB can do more precise/fast OLLA and ILLA especially for the very low target BLER requirement, e.g. 10-5.  |
|  |  |
|  |  |

## Enhancements for URLLC in multi-TRP scenarios

**Background**

From Rel-16, the multi-TPR transmission (NCJT) has been supported but there is no CSI feedback design optimized for the multi-TRP transmission

### Issue #3-2

**Issue #3-2: Enhanced CSI reporting for multi-TRP scenarios**

* Yes: Futurewei [3], Ericsson [6], proposed CSI enhancements optimized for multi-TRP transmission schemes with high reliability
	+ Proposals
		- Joint CSI report for multi-TRP URLLC scenario: Ericsson [6]
		- UE selecting whether a RS resource is for CM, IM, or muting: Futurewei [3]

The support of tailored CSI feedback design for multi-TRP transmission is proposed by two companies. Considering that multi-TRP enhancement is currently under Rel-17 FeMIMO WI, it is unclear whether this issue should be studied in the URLLC/IIoT WI.

### Issue #3-3

## Enhancements for PDCCH link adaptation

**Issue #3-3: CSI feedback for PDCCH link adaptation**

* Yes: Qualcomm [24], Sony, Samsung, FutureWei, InterDigital, CMCC proposed to study CSI feedback for PDCCH link adaptation

# References

1. RP-201310, Revised WID: Enhanced IIoT and URLLC support for NR, Nokia, Nokia Shanghai Bell.
2. R1-2005244 CSI feedback enhancements Huawei, HiSilicon
3. R1-2005281 CSI feedback enhancements for URLLC FUTUREWEI
4. R1-2005375 CSI feedback enhancements for Rel-17 URLLC vivo
5. R1-2005432 Discussion on CSI feedback enhancements for eURLLC ZTE
6. R1-2005514 CSI Feedback Enhancements for IIoT/URLLC Ericsson
7. R1-2005552 CSI feedback enhancements for URLLC/IIoT use cases Nokia, Nokia Shanghai Bell
8. R1-2005570 Considerations on CSI feedback enhancements Sony
9. R1-2005634 CSI feedback enhancements for URLLC MediaTek Inc.
10. R1-2005702 CSI feedback enhancements CATT
11. R1-2005776 CSI feedback enhancement NEC
12. R1-2005870 CSI feedback enhancements in Release 17 URLLC/IIoT Intel Corporation
13. R1-2005930 CSI feedback enhancements Lenovo, Motorola Mobility
14. R1-2006059 Enhancement for CSI feedback OPPO
15. R1-2006071 CSI feedback enhancements for enhanced URLLC/IIoT InterDigital, Inc.
16. R1-2006140 CSI feedback enhancements for URLLC Samsung
17. R1-2006208 Discussion on CSI feedback enhancements CMCC
18. R1-2006276 Discussion on CSI feedback enhancements Spreadtrum Communications
19. R1-2006315 Discussion on CSI feedback enhancements for URLLC LG Electronics
20. R1-2006343 Discussion on CSI feedback enhancements Panasonic Corporation
21. R1-2006515 CSI feedback enhancements for URLLC Apple
22. R1-2006573 CSI feedback enhancements for eURLLC Sharp, NICT
23. R1-2006729 Discussion on CSI feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.
24. R1-2006800 CSI enhancement for IOT and URLLC Qualcomm Incorporated
25. 3GPP TR38.824, “Study on physical layer enhancements for NR URLLC”, v16.0.0.
26. R1-2006514 UE feedback enhancements for HARQ-ACK Apple
27. R1-2006799 HARQ-ACK enhancement for IOT and URLLC Qualcomm
28. R1-2007064 Feature lead summary #1 on CSI feedback enhancement for enhanced URLLC/IIoT
29. R1-2007110 Feature lead summary #1 on CSI feedback enhancement for enhanced URLLC/IIoT

# Annex A: Priority of the issues

**List of the issues identified:**

**Issue #1-1: Support aperiodic CSI report on PUCCH**

**Issue #1-2: Triggering method of aperiodic CSI report on PUCCH**

**Issue #1-3: Additional conditions for A-CSI reporting on PUCCH triggered by DL DCI**

**Issue #1-4: PUCCH resource determination for A-CSI on PUCCH**

**Issue #1-5: Reduction of CSI computation time**

**Issue #1-6: Priority applicable to P/SP-CSI on PUCCH and (if supported) A-CSI on PUCCH**

**Issue #2-1: introduce new CSI report type(s)**

**Issue #2-2: Need for enhancing accuracy of sub-band differential CQI feedback**

**Issue #3-1: Need for additional information bundled to HARQ-ACK**

**Issue #3-2: Enhanced CSI reporting for multi-TRP scenarios**

**Issue #3-3: CSI feedback for PDCCH enhancement**

**Summary:**

The number in the table is the number of companies supporting the issue for the given priority

|  |  |  |  |
| --- | --- | --- | --- |
|  | **High** | **Medium** | **Low** |
| **Issue #1-1** | **8** | **2** | **5** |
| **Issue #1-2** | **6** | **1** | **7** |
| **Issue #1-3** | **0** | **5** | **10** |
| **Issue #1-4** | **3** | **4** | **8** |
| **Issue #1-5** | **2** | **7** | **7** |
| **Issue #1-6** | **2** | **6** | **8** |
| **Issue #2-1** | **7** | **6** | **3** |
| **Issue #2-2** | **1** | **5** | **8** |
| **Issue #3-1** | **5** | **4** | **8** |
| **Issue #3-2** | **0** | **1** | **12** |
| **Issue #3-3** | **5** | **1** | **10** |

**FL suggestion for the issue priority for discussion**

Issue priority:

* High: 1-1, 1-2, 2-1
* Medium: 1-5, 1-6, 3-1
* Low: 1-3, 1-4, 2-2, 3-3

Note:

* High priority issue was determined if High > 5
* Medium priority issue was determined if High+Medium >7
* Low priority issue was determined otherwise
* Issues #1-3 and #1-4 can be discussed after the Issue #1-1 is resolved as those issues are next level of details if Issue #1-1 is agreed
* Issue #3-2 doesn’t need to be discussed further in this WI to avoid duplicated discussion in multiple WIs as it is under discussion in FeMIMO WI already
* Issue #3-3 is added as a reasonable number of companies supported (see Question #11)

**Please provide the company’s view on the priority of the issues listed above:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Priority of the issues** | **Comments** |
| Sony | High: 1-1, 2-1, Medium: 2-2, 3-1Low: 1-2, 1-3, 1-4, 1-5, 1-6, 3-2 | Consider feedback for PDCCH. |
| Samsung | High: 1-6Medium: 2-1Low: Everything else above  |  |
| FUTUREWEI | High: 2-1Medium: 1-1, 3-2, 2-2Low: 1-2, 1-3, 1-4, 1-5, 1-6, 3-1 | Support new CSI report type(s) such as report of channel/interference statistics to allow for more accurate MCS selection. |
| InterDigital | High: 1-1, 1-2, 2-1, 3-1Medium: 1-3, 1-5, 2-2 Low: 1-4, 1-6, 3-2 | Feedback for PDCCH (Medium) |
| Qualcomm  | High: 3-1, feedback for PDCCHMedium: 1-6, Low: 1-1, 1-2,1-3,1-4,1-5, 2-1, 2-2, 3-2 | We support to study channel state information feedback for PDCCH.  |
| DOCOMO | High: 1-1, 1-2Medium: 1-3, 1-4, 1-5, 2-1Low: 1-6, 3-1 | Low: Feedback for PDCCH |
| HW/HiSi | High: 1-1, 1-2, 2-2Medium: 1-3, 1-4, 2-1,1-5Low: 1-6, 3-1, 3-2 | For 1-3 and 1-4, we think they are very important, but during this phase not as important as 1-1 and 1-2. We would appreciate an exchange of views on 1-3 and 1-4 and maybe a list of candidate methods, however.  |
| Panasonic | High: 1-1, 1-2, 1-4, 1-6Medium: 1-3, 1-5, 2-1, 2-2, 3-1Low: 3-2 |  |
| Intel | High: 2-1Medium: 1-6Low: 1-5 | It seems details of A-CSI on PUCCH got many lines in the issue list. We first need to decide general support of A-CSI on PUCCH in order to go to the details.In our view w/o analyzing and introducing new CSI measurements/reporting, other discussed mechanisms could not combat bursty interference dominated in URLLC scenarios, |
| vivo | High: 1-5, evaluation methodology/assumptionsMedium: 1-1, 1-2, 1-4, 1-6, 2-1Low: 1-3, 2-2, 3-1, 3-2 | Currently, the timeline required for CSI computation is longer than the PDSCH processing. Whether and how to reduce the CSI computation time needs to be discussed with high priority.The potential gains by CSI enhancements need to be further clarified. So, we suggest to discuss how to evaluate the performance and identify the benefits for the enhancements. |
| CMCC | High：1-1,1-2,1-4 Medium：1-5,1-6,2-1,3-1 Low:1-3,2-2,3-2  |  |
| NEC | High:1-1, 1-2,2-1Medium:1-3, 1-4, 1-5,1-6, 2-2Low:3-1 | 3-2 should be left for handling in Rel-17 FeMIMO WI |
| CATT | High: 1-1, 1-2, 1-4Medium: 1-5, 2-1Low: 1-3, 1-6, 2-2, 3-1, 3-2 |  |
| Lenovo, Motorola Mobility | High: 1-5Medium: 1-6 Low: the rest | 1-5: In our view, CSI computation time reduction is the most straight-forward way of getting fresh MCS. We are open to discuss different ways of achieving CSI computation reduction (e.g., more capable UE, simplified CSI report, etc.)1-1 to 1-4: * A-CSI trigger by DL-DCI may be beneficial for reducing PDCCH blocking (especially in DL heavy traffic scenario), however, it is not clear to us if it leads to more accurate MCS selection compared to using existing A-CSI triggering via UL-DCI.
* CSI computation delay requirements should be first decided before considering whether to introduce A-CSI trigger by a DL-DCI.

1-6: makes sense to us for collision handlingThe rest:* Although many of these proposals are quite interesting, many of them can be discussed in a more general framework than the URLLC WI.

3-2: can be discussed in the MIMO AI. |
| ZTE | High: 3-1,1-1, 1-2, 1-3, 1-4Medium: 1-6Low:1-5, 2-1, 2-2, 3-2 | For 1-3, we think the triggering mechanism should be first considered, then based on the triggering mechanism, other issues can be considered, so 1-3 is also very important. |
| Sharp | High: 1-5,2-1Medium: 1-1, 1-6, 2-2, 3-1Low: 1-2, 1-3, 1-4, 3-2 |  |
| Apple | High: 3-1Low: the rest |  |
| Nokia/NSB | High: 2-1, 3-1Low: remaining ones |  |

# Annex B: Summary of first round of e-mail discussions

Note:

* The comments from companies for the questions are captured in R1-2007110

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| **Question #1:** considering that the A-CSI on PUCCH issue has been discussed and evaluated in the previous releases, can we make the decision to support the A-CSI on PUCCH based on the majority support?* If no, what would be the suggested next step for this issue?

**Summary of the inputs:*** Ready to make decision to support A-CSI on PUCCH (10):
	+ Sony, FutureWei, InterDigital, DOCOMO, Spreadtrum, HW/HiSi, Panasonic, CMCC, CATT, ZTE
* Further study is needed (9):
	+ Samsung, Nokia/NSB, Qualcomm, Intel, LG, Vivo, NEC, Lonovo, Sharp
		- Several companies mentioned that performance evaluation is needed to identify technical merits based on common assumptions (scenarios, realistic assumption)
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| **Question #2:** based on the majority support, can we at least agree on that DL DCI based triggering is used for A-CSI on PUCCH if the A-CSI on PUCCH is supported?**Summary of the inputs:*** Down-select to support DL DCI based triggering for A-CSI on PUCCH if supported (9):
	+ FutureWei, InterDigital, DOCOMO, Spreadtrum, HW/HiSi, Panasonic, NEC, CATT, ZTE
* No down-selection of the options (10):
	+ Support other options or open to discuss other options:
		- Sony, Intel, CMCC
	+ Technical justification is needed (e.g., wait until Issue #1-1 is resolved):
		- Samsung, Nokia/NSB, Qualcomm, Apple, vivo, LG, Sharp
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| **Question #3:** regarding Issue #1-3 and Issue #1-4, these issues are a next level of details to be discussed if A-CSI on PUCCH is agreed. Do we need to put this issue on hold until the A-CSI on PUCCH is agreed?* In the meantime, please provide any additional options if you have

**Summary of the inputs:*** Issues #1-3 and #1-4 should be discussed if/after RAN1 agrees to support A-CSI on PUCCH (18):
	+ Sony, Samsung, Nokia/NSB, FutureWei, InterDigital, Qualcomm, Apple, DOCOMO, Spreadtrum, Panasonic, Intel, vivo, CMCC, NEC, CATT, LG, ZTE, Sharp
* Issues #1-3 and #1-4 can be discussed in parallel with A-CSI on PUCCH:
	+ HW/HiSi
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| **Question #4:** should CSI computation time reduction be supported for faster CSI reporting in Rel-17?* If yes, any additional restriction is required to reduce the computation time?

**Summary of the inputs:*** Yes (11), reducing CSI processing time would be beneficial or open to discuss:
	+ Futurewei, InterDigital, DOCOMO, Panasonic, vivo, CMCC, NEC, CATT, Lenovo, LG, Sharp
* No (8),
	+ Not beneficial: Sony, Nokia, Apple, Intel
	+ Not feasible: Samsung, Qualcomm, Spreadtrum
	+ Not critical: ZTE
* FFS:
	+ HW/HiSi
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| **Question #5:** Is CSI computation time reduction issue tied with A-CSI on PUCCH?* If yes, should we put this issue on hold until the decision is made for A-CSI on PUCCH?
* If no, in which case the CSI computation time reduction can provide gain?

**Summary of the inputs:*** Yes, it is dependent on the outcome of A-CSI on PUCCH (4)
	+ FutureWei, InterDigital, Panasonic, CATT
* No, it is not dependent on the outcome of A-CSI on PUCCH (12)
	+ Samsung, Nokia, Qualcomm, Apple, DOCOMO, Spreadtrum, HW/HiSi, Vivo, CMCC, NEC, LG, Sharp
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| **Question #6:** Should possibility of configuring priority index 1 at least for P/SP-CSI be supported in R17?* If A-CSI on PUCCH is supported, should it be possible to configure it with priority index 1

**Summary of the inputs:*** Yes (10)
	+ Samsung, InterDigital, DOCOMO, Spreadtrum, Intel, NEC, Lenovo, ZTE (only for A-CSI on PUCCH), Qualcomm, Huawei (at least for A-CSI on PUCCH)
* No (6)
	+ Sony, Nokia, FutureWei, vivo, CATT, LG
* FFS (3)
	+ Sharp, Apple, CMCC
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| **Question #7:** Should new CSI report type(s) be supported to better capture interference characteristics in URLLC scenarios?* If yes, do we need to agree on common scenario, assumptions and metrics for comparing the different schemes?

**Summary of the inputs:*** Yes (9): Sony, Nokia/NSB, FutureWei, InterDigital, DOCOMO, HW/HiSi, Intel, CMCC, Shrap
	+ Interference statistics: Sony, FutureWei, DOCOMO
	+ Not limited to interference statistics: CMCC
* No (5): Samsung, Qualcomm, vivo, LG, ZTE
	+ Not useful: Samsung, LG
	+ Need technical justification: Qualcomm, vivo, ZTE
* FFS (2):
	+ Spreadtrum, Panasonic
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| **Question #8:** Should performance of sub-band CQI reporting be enhanced for R17?* If yes, do we need to agree on common scenario, assumptions and metrics for comparing the different schemes?

**Summary of the inputs:*** Yes (4): Sony, FutureWei, HW/HiSi, CMCC
* No (6): Nokia/NSB, InterDigital, Qualcomm, DOCOMO, LG, ZTE
	+ Consider it as an alternative to new CSI report type(s): Nokia/NSB, DOCOMO
	+ Additional feedback overhead should be taken into account: ZTE
* FFS (8): Samsung, Spreadtrum, Intel, vivo, NEC, CATT, Lenovo, Sharp
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| **Question #9:** Should R17 support reporting of additional information bundled to HARQ-ACK?* If yes, what should the additional information be obtained from (e.g., PDSCH, CSI-RS, etc.)?

**Summary of the inputs:*** Yes (9): Sony, Nokia/NSB, FutureWei, InterDigital, Qualcomm, Apple, DOCOMO, Spreadtrum, ZTE
* No:
* FFS (10): Samsung, Huawei, Panasonic, Intel, vivo, CATT, NEC, Lenovo, LG, Sharp
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| **Question #10:** Should enhancements to CSI reporting for URLLC in multi-TRP scenarios be discussed as part of this WI?**Summary of the inputs:*** 18 companies (Sony, Samsung, Nokia/NSB, FutureWei, InterDigital, Qualcomm, DoCoMo, Spreadtrum, HW/HiSi, Panasonic, Intel, vivo, NEC, CATT, Lenovo, LG, ZTE, Sharp) responded are ok not to handle this topic under this WI
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| **Question #11:** any of above proposals should be considered as a high priority topic? **Summary of the inputs:*** CSI feedback for PDCCH as high priority topic
	+ Yes (6): Sony, Samsung, FutureWei, InterDigital, Qualcomm, CMCC
	+ No (8): DOCOMO, Nokia/NSB, HW/HiSi, vivo, CATT, LG, ZTE, Sharp
	+ FFS (2): Intel, Spreadtrum
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