3GPP TSG RAN WG1 #102-e R1-2009546

e-Meeting, August 17th – 28th, 2020

Source: Moderator (OPPO)

Title: Summary#1 of email thread [103-e-NR-IIOT\_URLLC\_enh-04]

Agenda Item: 8.3.3

Document for: Discussion and Decision

# Introduction

This is the summary for the following email discussion:

[103-e-NR-IIoT-URLLC-04] Email discussion/approval for intra-UE multiplexing/prioritization– Jia (OPPO)

* 1st check point: 11/5
* 2nd check point: 11/10
* 3rd check point: 11/12

# Multiplexing UCIs of different priorities in a PUCCH

## Agreements in previous meetings

Agreements:

*Support multiplexing for following scenarios in R17:*

* *Multiplexing a high-priority HARQ-ACK and a low-priority HARQ-ACK into a PUCCH in R17.*
* *Multiplexing a low-priority HARQ-ACK and a high-priority SR into a PUCCH for some HARQ-ACK/SR PF combinations (FFS applicable combinations).*
* *Multiplexing a low-priority HARQ-ACK, a high-priority HARQ-ACK and a high-priority SR into a PUCCH.*

*For the above multiplexing scenarios,*

* *FFS conditions, if needed, for the multiplexing, e.g*
	+ *Whether to support multiplexing between different resources not confined within a sub-slot.*
	+ *Whether to support multiplexing in case a PUCCH overlaps with more than one PUCCH.*
	+ *Timeline requirements.*
* *FFS: details, if needed, of the multiplexing scheme, e.g.*
	+ *How to minimize impact on the latency for high-priority HARQ-ACK.*
	+ *How to determine the PUCCH resource used for multiplexing (e.g. HP or LP PUCCH resource, or a dedicated PUCCH resource for the multiplexing).*
	+ *How to multiplex the HARQ-ACK bits (e.g. multiplexing, bundling).*
	+ *How to encode the UCIs with different priorities (e.g. separate coding vs. joint coding)*
	+ *How to guarantee the target code rate (e.g. payload control, multiplexing priority, LP HARQ-ACK compression/compaction).*
	+ *Explicit indication for enabling multiplexing.*

*Multiplexing rule and order (e.g. HP/LP multiplexing is after resolving collision within the same priority).*

## Conditions for multiplexing

## Whether to support multiplexing between different resources not confined within a sub-slot

* Option 1: Support if the latency requirement is met
	+ HW, vivo, Samsung, Spreadtrum, Xiaomi, CMCC, Sharp, DCM, ZTE, ETRI, Pana, Ericsson
	+ Arguments:
		- For the case of the HP HARQ-ACK overlapping with the LP HARQ-ACK, the LP HARQ-ACK is often scheduled earlier than the HP HARQ-ACK, and would occupy more than one sub-slot (or slot-based). If the multiplexing case is not allowed, the spectrum efficiency of eMBB services would be greatly degraded due to the frequently dropping of LP HARQ-ACK.
* Option 2: Multiplexing of low priority HARQ-ACK and high priority HARQ-ACK/SR only if the PUCCH resource for the low priority HARQ-ACK is confined within the sub-slot configured for the high priority HARQ-ACK.
	+ CATT, Nokia, LG
* Option 3: Multiplexing is allowed only if the resulted PUCCH is confined within the sub-slot of the HP-PUCCH sub-slot.
	+ MTK, NEC
	+ Arguments:
		- Multiplexing between PUCCHs spanning different sub-slot/slot durations, raises a lot of concern and some HP-PUCCHs could be dropped or delayed in multiple scenarios.
		- Multiplexing between PUCCHs on different sub-slot/slot lengths is not supported, then this functionality will be rarely used in practice and if the gNB wants to use it then it needs to configure sub-slot with the same duration for eMBB which will limit the PUCCH durations used for eMBB.
* Option 4: Multiplexing of low-priority PUCCH and high-priority PUCCH, when feasible, is allowed only if this multiplexing is done on a high-priority PUCCH resource. In addition:
	+ UE does not expect an overlap between the resulting PUCCH resource to be used for multiplexing and another high-priority PUCCH;
	+ and if the resulting PUCCH resource overlaps with a low-priority PUCCH, the low-priority PUCCH is then dropped.
	+ Nokia

|  |  |
| --- | --- |
| Company | Comments |
| LG | We prefer Option 2 (as added in the above). We are wondering how latency requirement could be met between LP HARQ-ACK PUCCH and multiple sub-slot HP HARQ-ACK PUCCHs overlapped with the LP HARQ-ACK PUCCH. |
| Sony | Option 1 |
| CMCC | Option 1  |
| Sharp | Option 1. A HP PUCCH resource can be selected within the same subslot of the original HP PUCCH for multiplexing of HP and LP UCI, the latency is not an issue. Thus, the multiplexing should be supported if the LP PUCCH can be fully dropped by the HP PUCCH with current dropping timeline.  |
| Samsung | Support Option1 If gNB would like to only support multiplexing between different PUCCH resources not confined within a sub-slot, gNB can simply configure a same sub slot length for the 2 PUCCH-Config. If this case is not supported, the scheduling flexibility and LP traffic performance will be degraded. Option 2 is not realistic (e.g. PUCCH resource for eMBB is not confined in 2/7 symbols). Option 3 is functionally equivalentOption 3 and Option 4 are detailed solutions under Option 1. Option 3 is practically equivalent to Option 4. We prefer Option 4 as it is simpler for a UE. |
| DOCOMO | Option 1 |
| InterDigital | Yes, multiplexing between different resources not confined within a sub-slot should be supported. Support Option 1 assuming it means latency requirement of the HP PUCCH.Option 2 seems too restrictive. In a typical case where LP PUCCH is over 1 slot and HP PUCCH is over 1 sub-slot, LP PUCCH would always be dropped.Option 3 makes sense as it ensures that HP UCI is not delayedOption 4 main bullet and first sub-bullet also makes sense. However, the second sub-bullet is unclear. What low-priority PUCCH is this talking about? |
| NEC | Option 3. |
| Intel | Support Option 1. Option 3 and 4 (main bullet) are special cases of Option 1 |
| TCL | Option 1 |
| ZTE | Option 1. Option 3 is not good for us. If the multiplexing between different resources confines within a sub-slot only, the low priority channel are more likely to be dropped, which is not consistent with the original intention of R17. By the way, it seems to that option 4 is not relevant to this issue. Maybe it can be moved to issue 2.3.3.  |
| Xiaomi | Support Option 1, can also support Option 3, since the two are not exclusive to each other. |
| OPPO | Option 4, Option 4 is a simpler solution to meet latency requirement and has small spec impact. Option 4 is special case of option 1 |
| WILUS | Option 1 |
| ETRI | Option 1 |
| Panasonic | Support Option 1. Option 4 can also be considered. |
| CATT | Option 2.For the following case, HP SR is expected to be multiplexed in a LP HARQ-ACK resource which goes across sub-slot boundary and then collides with another HP UCI in time. In this case, at least some of the HP UCI would be dropped. |
| Huawei, HiSilicon | We support option 1.Option 2 is too restrictive especially considering that the low priority HARQ-ACK is very likely to be transmitted on PUCCH not confined in a certain sub-slot.Option 3 and option 4, share similar view as Samsung it is kind of details of option 1 and we can discuss the details later once the option 1 is agreed. BTW, we think the motivation of both option 3 and option 4 is to ensure no impact of the latency for high priority HARQ-ACK, however there is some other way that can achieve the target with more flexibility also, e.g. the multiplexing is allowed only when the PUCCH carrying the multiplexed UCI ends no later than the PUCCH carrying HP UCI. In addition, instead of using HP PUCCH resource to carry the multiplexed UCI, gNB can multiplex on a third PUCCH resource configured dedicated for multiplexing (i.e. not HP resource or LP resource), to address the ambiguity that gNB is not able to identify if the multiplexing is done or not between low priority UCI and high priority UCI.  |
| Ericsson | We support Option 1Option 2 is too restrictive. * The gNB can dynamically enable/disable multiplexing. If delay becomes issue, LP is dropped. This approach is preferred that enforcing a general restriction or complicate the procedures.

IOption 3 and Option 4 are the details of procedures corresponding to Option 1:* When mux between LP and HP, the resulting PUCCH is from the PUCCH resource set associated to sub-slot. In case of slot and sub-slot, HP would be sub-slot.
 |
| Nokia, NSB | As indicated above, we prefer to down select between Options 2 and 4. |

#### 1st round proposal and discussion

Potential proposal 2.2.1:

For multiplexing UCIs of different priorities in a PUCCH in R17,

* Support of multiplexing between different resources not confined within a sub-slot ~~if the latency requirement is met~~.
	+ FFS: Details and/or conditions
* Nokia/NSB, Intel, Lenovo/Moto, Spreadtrum, ZTE, HW/HiSi, CATT, TCL, vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, QC, NEC, WILUS, OPPO

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Do not support the proposal.First, supporting multiplexing on the PUCCH not confined within the sub-slot, there could be more than one PUCCH of a shorter sub-slot configuration be overlapping. And there needs to be specific handling. E.g. see conditions discussed in 2.2.2. Therefore, we cannot support such generic agreement without any related FFS etc. Moreover, it would be good to clarify on how a sub-slot is defined here (HP / LP / PUCCH configuration used for multiplexing of HP/LP HARQ). Moreover, it’s not clear how to define whether the ‘latency requirement is met’.  |
| Intel | Support. We suggest following revision to address Nokia’s concernFor multiplexing UCIs of different priorities in a PUCCH in R17, Support of multiplexing between different resources not confined within a sub-slot FFS: Conditions |
| Lenovo, Motorola Mobility | Support the proposal in principle. Can leave FFS for detailed multiplexing timeline/conditions. |
| Spreadtrum | Support the proposal. Details needs FFS, and it can be discussed together with 2.3.3 and 2.3.4. |
| ZTE | Support the FL’s proposal. |
| Huawei, HiSilcion | Support the FL proposal, reasons as given in the above section. Fine with the suggestion from Intel to address some concern from companies.  |
| CATT | We share the similar view with Nokia and we are fine with option 4. |
| TCL | Support the FL’s proposal. |
| vivo | Support the proposal in principle. We can leave FFS for conditions |
| Sony | Support the proposal |
| Ericsson | We are in principle OK with proposal but agree with Nokia and Intel to be reformulated.With respect to FFs, we don’t think it is conditions. It is up to gNB whether allows or not. Perhaps if an FFs is needed, we can say FFs details.On Nokia’s comment, as we state earlier, Option 3 and Option 4 should be part of the procedures. We are supportive of applying both for the procedure. Updated proposal:For multiplexing UCIs of different priorities in a PUCCH in R17, * Support of multiplexing between different resources not confined within a sub-slot ~~if the latency requirement is met.~~
	+ FFS details.
 |
| Samsung | Support the updated proposal by Ericsson |
| Sharp | Support the proposal |
| Panasonic | We support the FL’s proposal and the update proposal by Ericsson is also fine. |
| InterDigital | Support updated proposal from Ericsson. One could also add “and/or conditions” to the FFS. |
| DOCOMO | Support the proposal. |
| QC | In general, we are fine with the FL proposal. Just a few editorial comments. 1. Besides the latency requirements, we need add if multiplexing timeline requirements are satisfied.
2. We kind of agree with Nokia, maybe other requirements besides the timeline and latency requirements are needed. So add FFS: other conditions is better.

In summary, we suggest following For multiplexing UCIs of different priorities in a PUCCH in R17, * Support of multiplexing between different resources not confined within a sub-slot if the multiplexing timeline and the latency requirement is met.
* FFS: other requirements
 |
| NEC | Support the proposal in principle and agree with Intel’s updated proposal. |
| WILUS | We support the FL’s proposal |
| OPPO | We support the FL’s proposal |

#### Agreements

Potential proposal 2.2.1:

For multiplexing UCIs of different priorities in a PUCCH in R17,

## Whether to support multiplexing in case a PUCCH overlaps with more than one PUCCH

* Option 1: Leave this question open before the UCI multiplexing rule for two overlapping PUCCHs is clear.
	+ HW, Sharp, ZTE
	+ Arguments:
		- The final multiplexing result depends on the specific multiplexing order.
* Option 2: Support if conditions (e.g. multiplexing timeline, latency requirement, specific overlapping scenarios) are met

vivo, Samsung, Nokia, Lenovo/Moto, Intel (consider joint multiplexing instead of two-step approach), Spreadtrum (joint multiplexing method can be considered instead of the two step approach in Rel-16), Xiaomi (only multiplex the slot based PUCCH and the first subslot PUCCH resource), CMCC, LG, DCM, NEC, Pana, Ericsson

Nokia proposal:

*Proposal 3.9: For handling the scenarios with more than two overlapping channels of different priorities, down-select between the following two alternatives:*

* *Alt.1: Allow a single checking/multiplexing step between channels of different priorities, where in case multiplexing is feasible:*
	+ *UE does not expect an overlap between the resulting resource to be used for multiplexing and a high-priority PUCCH;*
	+ *and if the resulting PUCCH resource overlaps with a low-priority PUCCH, the low-priority PUCCH is then dropped.*
* *Alt.2: The UE doesn’t expect to multiplex channels with different priorities, i.e. UE drops the low-priority channel(s).*

|  |  |
| --- | --- |
| Company | Comments |
| LG | Option 2 is preferred (as added in the above). We are understanding this case is differentiated from the above issue 2.2.1, in terms of whether the overlapping PUCCHs are all within a same time unit (all are within a same slot or sub-slot in this case). |
| Sony | Clarify whether this means more than 2 PUCCHs carrying HARQ-ACK or is this 2 PUCCH carrying HARQ-ACK + another one or more PUCCH carrying SR? |
| CMCC | Support multiplexing in case a LP PUCCH overlaps with more than one HP PUCCH with principle of ensuring the performance of each HP PUCCH. |
| Sharp | It is better to discuss this after two channel collision case is concluded. |
| Samsung | Option 2However, this issue can be revisited later. A solution should be simple as this case is not as important as the previous one (e.g. not as likely to have multiple non-overlapping LP PUCCHs in a same slot).  |
| InterDigital | Option 2 |
| NEC | Support option 2 |
| Intel | Option 2According to the agreement, following is already supported which is one example of the issue.* Multiplexing a low-priority HARQ-ACK, a high-priority HARQ-ACK and a high-priority SR into a PUCCH.
 |
| TCL | Option 2 |
| ZTE | We generally support multiplexing between more than two PUCCHs, but the overlapping between the two channels should be resolved first. Therefore, we slightly support option 1. |
| Xiaomi | Support option 2 |
| OPPO | Option 2 |
| WILUS | Option 2. We are also ok to deprioritize this issue after defining clear UE behaviors for collision of two PUCCHs.  |
| Panasonic | Option 2 |
| CATT | As pointed out by Intel, based on previous agreements, it is already supported. Maybe we should be more specific what we are trying to agree. |
| Huawei, HiSilicon  | Our intention is not to preclude the chance to do multiplexing for one PUCCH overlapping with more than PUCCH at early stage, thus feel safer to do the decision after we achieve consensus on how to do the multiplexing for two channels. Therefore, our final target is to similar as what option 2 describes here, support if conditions (e.g. multiplexing timeline, latency requirement, specific overlapping scenarios) are met, however I think we will have to discuss the conditions at later stage.  |
| Ericsson | Option 2However, it is important to clarify first what it is the overlapping resolution procedures between PUCCH resources. In our view, we can reuse the Rel-15 when defining the set Q. If there are more PUCCH resources are in set Q, that is not issue. We have addressed how to address different possible cases. |
| Nokia, NSB | Option 2, as indicated and explained in our contribution |

#### 1st round proposal and discussion

Potential proposal 2.2.2:

For multiplexing UCIs of different priorities in a PUCCH in R17,

* Support multiplexing in case a PUCCH overlaps with more than one PUCCH if conditions (e.g. multiplexing timeline, latency requirement, specific overlapping scenarios) are met.
	+ FFS details.
* Nokia/NSB, Intel, Lenovo/Moto, Spreadtrum, CMCC, ZTE, HW/HiSi, CATT, TCL, vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, QC, NEC, WILUS, OPPO

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support  |
| Intel | Support |
| Lenovo, Motorola Mobility | Support the proposal |
| Spreadtrum | Support the proposal |
| CMCC | Support |
| ZTE | Support the FL’s proposal. |
| Huawei, HiSilcion | Fine with the FL proposal  |
| CATT | Fine with the proposal |
| TCL | Support the FL’s proposal |
| vivo | Support the FL’s proposal. |
| Sony | Support |
| Ericsson | Support thr FL proposal. |
| Samsung | Support the FL’s proposal. |
| Sharp | Support |
| Panasonic | Support the FL proposal. |
| InterDigital | Support |
| DOCOMO | Support |
| QC | Support FL proposal |
| NEC | Support |
| WILUS | Fine with the proposal |
| OPPO | Support |

#### Agreements

See Section 2.2.1.2.

## Timeline requirements

* Option 1: Reuse R15 timeline (or as the starting point)
	+ HW, vivo, CATT, IDC, Spreadtrum, Xiaomi, CMCC, Sharp, NEC, ZTE, Pana, Ericsson, Nokia/NSB (at least as a basis)
* Option 2: Consider additional conditions
	+ LGE, DCM
	+ Arguments:
		- A processing time (symbol) margin may require to be added to the current timeline (for intra-priority multiplexing in Rel-16) considering additional inter-priority multiplexing.
		- The timing of the last symbol in the PUCCH resource selected to multiplex the LP UCI and HP UCI, may need to be checked whether it is allowable in terms of latency from the perspective of the HP UCI.

MTK proposal:

*Proposal 3: Guard gap timeline of the new multiplexed PUCCH is of the earliest PUCCH*

DCM proposal:

* *Define new timeline for multiplexing UL channels with different priorities. The timeline can be as follows:*
	+ *New* $S\_{0}$*, i.e.* $S\_{0}'$*, is defined;* $S\_{0}'$ *is the first symbol of the latest PUCCH or PUSCH on which other UL channels are multiplexed among a group overlapping PUCCHs and PUSCHs in a slot as shown in Fig.2 below.*
	+ *UE checks whether the* $S\_{0}'$ *is not before a symbol with CP starting after* $T\_{proc,2}+X$ *symbol after a last symbol of the corresponding PDSCH or corresponding SPS PDSCH release, where* $X$ *should be discussed carefully considering UE complexity on the multiplexing with different priorities.*
	+ *If the timeline requirement is met, UE multiplexes the LP PUCCH and HP PUCCH using PUCCH resource for HP UCI.*
	+ *Otherwise, UE drops LP PUCCH and transmits only HP PUCCH as long as the Rel-16 prioritization timeline (i.e.* $T\_{proc,2}+d\_{1}$*) is met.*

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Option 1 as a starting point. We need at least to satisfy Rel-15 timeline. |
| CMCC | Option 1 |
| Sharp | As a baseline, UCI multiplexing is allowed if the LP PUCCH channel can be fully dropped by the existing timeline. Otherwise, if the LP PUCCH transmission already starts, the Rel-16 dropping method should be applied. FFS if extra processing delay is needed upon the dropping timeline for UCI multiplexing.  |
| Samsung | TBD |
| DOCOMO | We prefer Option 2 for more possibility of multiplexing, which would lead to better eMBB performance. The following is what is in our mind. Basically, difference from Rel-15 multiplexing timeline is newly defined $S\_{0}'$. $S\_{0}'$ is defined as the first symbol of the latest PUCCH or PUSCH on which other UL channels are multiplexed among a group overlapping PUCCHs and PUSCHs in a slot. Then, UE checks the time gap between $S\_{0}^{'} $and the corresponding PDSCH or PDCCH. There can be two cases; Case 1: the PUCCH on which other UL channels are multiplexed is earlier, and Case 2: the PUCCH on which other UL channels are multiplexed is later. For Case 1, there is no difference for UE behavior from Rel-15 multiplexing as the definition of $S\_{0}'$ is same as $S\_{0}$. In other words, there is no UE complexity. For Case 2, $S\_{0}'$ is different from $S\_{0}$ but still there may not be UE complexity because the partial cancellation or partial transmission of non-overlapping UL channel is supported in Rel-16. Potential complexity that needs to be considered is the processing time for encoding the multiplexed UCI but $X$ in the equation can take it into account. |
| InterDigital | Option 1. However, there is also requirement for the last symbol (see issue 2.3.4) |
| NEC | Support option 1. Rel-15 timeline can be a starting point.  |
| Intel | Option 1 can be a starting point |
| TCL | Option 1, the timeline condition in Rel-15 could be a starting point.. |
| QC | Option 1. Reuse Rel-15 timeline seems sufficient enough, because Rel-15 timeline is defined with respect to UL and DL processing capabilities, which is transparent/orthogonal to what priorities of the channels are. Adding two different priorities into the multiplexing scenario does not impact the decision on timeline.  |
| ZTE | Option 1. The current timelines for multiplexing should be as the baseline. In addition, we are open to discuss the how the UE does when the multiplexing timeline is not met as mentioned by DCM. |
| Xiaomi | Option 1 |
| OPPO | Timeline depends on specific solution. After solution is determined, we could revisit this issue. |
| WILUS | Option 1 as baseline. |
| Panasonic | Option 1 can be a starting point. In order to minimize the impact on the latency for high priority channels, the conditions for the ending symbol may need to be introduced. |
| CATT | Option 1 |
| Huawei, HiSilicon  | Rel-15 timeline should be met with necessary additional conditions if needed. e.g. multiplexing LP UCI with HP UCI is allowed only when the PUCCH carrying the multiplexed UCI ends no later than the PUCCH carrying HP UCI as discussed in issue 2.3.4. |
| Ericsson | Option 1. Reuse Rel-15 timelineWe share the same view as QC. No need for optimization. We don’t prefer to specify too complicated solutions with too much changes for corner cases. In our view, if there is an issue with delay, it is better for the gNB to indicate to skip multiplexing that come up with solutions that are optimized for corner cases and put an scheduling and operation constraint. |
| Nokia, NSB | In principle, we think that Rel-15 timeline could be used at least as a basis.In our view, timeline requirements could be discussed at a later stage. |

#### 1st round proposal and discussion

Potential proposal 2.2.3:

For multiplexing UCIs of different priorities in a PUCCH in R17,

* Reuse R15 timeline as the starting point.
* FFS on whether to consider additional conditions.
* **Support:** Nokia/NSB, Intel, Lenovo/Moto, Spreadtrum, CMCC, ZTE, HW/HiSi, CATT, TCL, vivo, Sony, E///, Sharp, Pana, IDC, DCM, QC, NEC, WILUS, OPPO
* **Discuss later:** Samsung

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support  |
| Intel | Support |
| Lenovo, Motorola Mobility | Support in principle. |
| Spreadtrum | Support |
| CMCC | Support |
| ZTE | Support FL’s proposal. |
| Huawei, HiSilcion | Fine with the FL proposal  |
| CATT | Support |
| TCL | Support |
| vivo | Support |
| Sony | Support |
| Ericsson | We don’t think we need to spend time on defining new timeline. The proposal, suggest that is the exercise to pursue. Hence, with the following update, we would be fine with the proposal:Update proposal:For multiplexing UCIs of different priorities in a PUCCH in R17, * Reuse R15 timeline as the starting point.
* FFS on whether to consider additional conditions.
 |
| Samsung | Not supportAs recommended by Nokia, this issue can be discussed at a later stage. |
| Sharp | Support |
| Panasonic | Support the FL proposal and the update proposal by Ericsson is also fine. |
| InterDigital | Support |
| DOCOMO | Support the FL proposal that R15 timeline is baseline. |
| QC | Support |
| NEC | Support |
| WILUS | Fine with the FL’s proposal |
| OPPO | Support |

## Other conditions

* HARQ-ACK codebook types for multiplexing
	+ Case a) Multiplexing of LP Type-1 HARQ-ACK and HP Type-1 HARQ-ACK
	+ Case b) Multiplexing of LP Type-2 HARQ-ACK and HP Type-2 HARQ-ACK
	+ Case c) Multiplexing of HP Type-1 HARQ-ACK and LP Type-2 HARQ-ACK
	+ Case d) Multiplexing of HP Type-2 HARQ-ACK and LP Type-1 HARQ-ACK

Samsung proposal:

*Proposal 4: Support LP Type-1/Type-2 HARQ-ACK codebook multiplexing with HP Type-1/Type-2 HARQ-ACK codebook on a same PUCCH. Consider solutions to ensure the reliability of multiplexing of two HARQ-ACK codebooks with different priorities. FFS whether to support multiplexing of HARQ-ACK codebooks of different types.*

* + HW, vivo, CATT

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | Prioritize cases a) and b)The scenarios of Cases c) and d) need clarification. |
| Intel | Prioritize cases a) and b) |
| OPPO | Unified solution is required for all above case.  |
| Huawei, HiSilicon  | Yes we can prioritize case a) and case b), and can further study case 3) and case 4).  |
| Ericsson | Case a and Case bThe benefit for operation based on other cases is not clear. Please note that Type-3 can be configured in addition to Type.1 or Type-2. So, this discussion does not concern Type-3. |
| Spreadtrum | Prioritize cases a) and b). Considering that the reliability of type-1 HARQ-ACK codebook is generally higher than type-2 HARQ-ACK book, Cases d) can also be considered. Cases c) is FFS. |
|  |  |

## Details for multiplexing schemes

## How to encode the UCIs with different priorities (e.g. separate coding vs. joint coding)

* Option 1: Separate coding
	+ HW, CATT, Samsung, Nokia, Spreadtrum, DCM, CMCC, ETRI, Sharp, WILUS, LG (baseline) , ZTE, Pana
	+ Arguments:
		- Joint coding cannot provide distinguished latency/reliability protections for UCIs of different priorities.
		- For Type-2 HARQ-ACK codebook, the size is determined by the DAI values and a miss detection of a ‘last’ DCI format can lead to UE and gNB have different understanding of the size of HARQ-ACK codebook (e.g. in case of single-cell operation). In such case, separate coding can also help HP UCI detection to not be affected by an incorrect assumption for the size of the LP HARQ-ACK codebook.
	+ Problems:
		- New mapping rules and resource determination scheme need to be defined.
* Option 2: Joint coding
	+ CATT, Sharp, LG (for some cases) , Intel, MediaTek
	+ Arguments:
		- Simple and the current multiplexing scheme can be reused as much as possible.
	+ Problems:
		- Since only one coding rate is used for joint coding, the UE must either sacrifice the reliability of the HP UCI if a high coding rate is selected, or provide an over-designed reliability for the LP UCI leading to a great resource waste if a low coding rate is selected.
* Option 3: Need further study how to decide between separate and joint coding
	+ Ericsson

|  |  |
| --- | --- |
| Company | Comments |
| LG | We also prefer separate coding as baseline. On the other hand, for some cases where UCI payload size of a priority is relatively small, it would be better to apply joint coding (rather than separate coding) for the cases.  |
| Sony | Option 1. Make sense to have separate coding since LP & HP UCI have different reliability requirements. |
| Sharp | Both separate coding and joint coding should be supported. Separate coding can satisfy different reliability requirements and is more resource efficient with large payload. Joint coding is simpler and should be applicable for small payload size. For example, for up to 2 bits of HARQ-ACK for each codebook, joint coding can allow joint reporting use PUCCH format 0/1. In general, joint coding is preferred for small payload, separate coding is better for large payload. The conditions for code method determination should be further discussed. |
| Samsung | Option 1 as baseline. Can consider possibility for option 2 for some cases with small payloads where coding gain from separate coding. |
| InterDigital | Option 1 as a baseline. Joint coding could be considered for smaller payload size unless it creates codebook ambiguity issue. |
| NEC | Both separate coding and joint coding should be supported. It is related to the multiplexing schemes and UCI payload size of each priority, for example, if LP HARQ-ACK is bundled as 1 bit when multiplexed with HP HARQ-ACK, it seems joint coding is sufficient.  |
| Intel | Option 2 should be baseline since it can build upon legacy design and may require less specification efforts. Schemes such as threshold on LP UCI payload, bundling can be considered so that reliability of HP UCI is minimally impacted. |
| QC | In general, we have concerns on separate encoding. 1. Need new rate matching and RE mapping rule for HP UCI and LP UCI mux on PUCCH, and HP UCI and LP UCI multiplexing on PUSCH. Quite significant spec impact is a factor we need consider. On the other hand, if joint encoding is adopted, then Rel-15 RM and RE mapping rules can be reused.
2. How many Polar encoder UE needs to budget for the worst case? It seems 6 to me: HP HARQ-ACK, LP HARQ-ACK, HP CSI-part 1, LP CSI-part 1, HP CSI-part 2, LP CSI-Part 2, if RAN1 allow simultaneous HP and LP CSI. Even if considering to drop LP CSI, it seems 4 Polar encoder is needed for the worst case, which increase UE implementation complexity. Of course, if it is well justified, we are OK to accept proposal which increase UE complexity and cost. However, we don’t see strong justification to do separate encoding.

The advantage of separate encoding is not well justified. Please see the following. Regarding this “Joint coding cannot provide distinguished latency/reliability protections for UCIs of different priorities.” – If UE compress LP UCI and treat compressed HARQ-ACK as if it is HP UCI. Latency/reliability of both HP/LP UCI can be achieved. For the lost info due to compression, if gNB want, gNB can schedule reTx of the LP UCI by type-3 codebook for HARQ-ACK for example. Because they are LP, certain delay is tolerable. One should also notice that, there are advanced compression techniques (rather than simple bundling of UCI) which can minimize the information loss due to compression. Regarding this “For Type-2 HARQ-ACK codebook, the size is determined by the DAI values and a miss detection of a ‘last’ DCI format can lead to UE and gNB have different understanding of the size of HARQ-ACK codebook (e.g. in case of single-cell operation). In such case, separate coding can also help HP UCI detection to not be affected by an incorrect assumption for the size of the LP HARQ-ACK codebook.” – Unless using separate PUCCH resources to transmit HP and LP UCI, I don’t see separate encoding helps to resolve the missing last DCI issue. If LP and HP UCI are put together in a PUCCH resource, that resource set is determined based on the total UCI size. Missing last DCI can change the resource set and separate encoding does not offer any help here. Furthermore, unless gNB always guarantee PRI in last DCI is the same as PRI in previous DCI, otherwise missing the last DCI will lead to a wrong PRI and UE ends up using a wrong PUCCH resource to transmit HP+LP UCI. Separate encoding does not help neither in this error event.  |
| ZTE | Option 1. It can reuse existing rules for high and low priority UCI respectively. |
| Xiaomi | Support Option 1, separate encoding, |
| OPPO | Option 2.We share the same view as Intel |
| WILUS | Option 1.  |
| ETRI | Option 1 |
| vivo | In NR R15/R16, for UCI on PUCCH, the number of separate coding UCI is at most two. For different priorities UCI, if separate coding is supported, the maximum number of separate coding UCI will be increased, which should be took into consideration. |
| Panasonic | Slightly prefer Option 1. Separate coding would provide more optimized resource usage for HARQ-ACK, while it will require more specification effort such as resource mapping of multiple HARQ-ACK coded bit sequences to one PUCCH. |
| CATT | We would like to clarify whether 1-2 bit HARQ-ACK and SR with different priorities is included. In addition, we share the similar view as LG that for some cases, joint coding may be more appropriate. |
| Huawei, HiSilicon  | We also think that option 1 should be the baseline from different protection on UCI of different priorities perspective. For joint coding, it may result in either low spectrum utilization or degraded performance. Moreover, separate coding for AN/CSI-part-1 and CSI-part-2 has been supported in R15, we think it is reasonable to extend it to separate coding for UCIs of different priorities. |
| Ericsson | Option 3 (or Study further Option 1 and Option 2 to decide):**Study joint and separate encoding of high and low priority HARQ feedback to further understand in which scenarios separate encoding performs better, especially from a link budget perspective**If the single PUCCH resource is of format 2,3,4, our view on separate or joint encoding, as well as target code rate, is as follows:From a complexity point of view, joint encoding of HARQ feedback does not require separate decoding attempts and is simpler at the receiver. Furthermore, separate block coding of 1-2 bits is only supported on PUSCH in Rel. 16. From a performance perspective, joint encoding of high and low priority HARQ feedback at low code rates might require more resource elements than separate encoding of high priority HARQ feedback at low code rate and low priority HARQ feedback at higher code rate. For small payloads however, additional CRC overhead and smaller coding gain might offset this.From a link budget perspective, the performance benefits of separate coding need to be compared to PUSCH coverage. If coverage is limited by PUSCH rather than PUCCH, improving PUCCH performance by separate coding is not worth the added complexity and does not increase coverage. Conversely, for cell center UEs operating at high SNR, separate coding might not bring sufficient added benefits due to steep BLER curves and similar code rates for low and high priority HARQ feedback. There are likely to be scenarios where some UEs should perform joint encoding, and some UEs should perform separate encoding. |
| Nokia, NSB | As commented by other companies, Option 1 should be at least the baseline.  |
| MediaTek | Option 2. Bundling can be considered to maintain the reliability of HP UCI. |

**Other proposals:**

vivo proposal:

*Proposal 3: For encoding the UCIs with different priorities, it should be clarified firstly whether the number of separately encoded UCIs need be extended for both PUCCH and PUSCH.*

#### 1st round proposal and discussion

Potential proposal 2.3.1:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17

* Support separate coding for HP HARQ-ACK and a LP HARQ-ACK.
	+ FFS: Conditions
* FFS whether joint coding is also supported for some cases.
* **Support:** Nokia/NSB, Lenovo/Moto, Spreadtrum, CMCC, ZTE, HW/HiSi, CATT (PF 2/3/4), vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, NEC, WILUS
* **Not support:** Intel (first support joint coding as baseline), QC, OPPO, MediaTek
* **Postpone the decision:** E///

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support |
| Intel | Not support. Joint encoding can be also made to work and may require less specification efforts since it is based on legacy design |
| Lenovo, Motorola Mobility | Support |
| Spreadtrum | Support. Joint coding can also be considered under the conditions that reliability of HP can be guaranteed.  |
| CMCC | Support |
| ZTE | Support FL’s proposal. |
| Huawei, HiSilcion | Support the FL proposal |
| CATT | Support the proposal for PF 2/3/4. We propose to add an FFS for PF 0/1. |
| vivo | Support |
| Sony | Support |
| Ericsson  | We do not support.As explained, we think it is better to investigate before making decision. Suggest to postpone the decision to next meeting and companies provide evaluations to make a proper decision. |
| Samsung | SupportRegarding QC’s concern on separate encoding, we have different understanding.1. Separate coding on PUCCH has been supported since Rel-15 for CSI part2, similar rate matching and RE mapping rule can be used for LP HARQ-ACK in Rel-17. We don’t think there is significant spec impact.
2. The second concern is not relevant, this issue discusses multiplexing on PUCCH. For the supported scenarios, at most two Polar encoders are needed. There is no difference compared with Rel-15 CSI part 2.
 |
| Sharp | Support in principle. FFS conditions for joint coding and separate coding if joint coding is also supported. |
| Panasonic | Support the FL proposal. |
| InterDigital | Support |
| DOCOMO | Support. |
| QC | Disagree with the proposal. In general, we have concerns on separate encoding. 1. Need new rate matching and RE mapping rule for HP UCI and LP UCI mux on PUCCH, and HP UCI and LP UCI multiplexing on PUSCH. Quite significant spec impact is a factor we need consider. On the other hand, if joint encoding is adopted, then Rel-15 RM and RE mapping rules can be reused.
2. How many Polar encoder UE needs to budget for the worst case? It seems 6 to me: HP HARQ-ACK, LP HARQ-ACK, HP CSI-part 1, LP CSI-part 1, HP CSI-part 2, LP CSI-Part 2, if RAN1 allow simultaneous HP and LP CSI. Even if considering to drop LP CSI, it seems 4 Polar encoder is needed for the worst case, which increase UE implementation complexity. Of course, if it is well justified, we are OK to accept proposal which increase UE complexity and cost. However, we don’t see strong justification to do separate encoding.

The advantage of separate encoding is not well justified. Please see the following. Regarding this “Joint coding cannot provide distinguished latency/reliability protections for UCIs of different priorities.” – If UE compress LP UCI and treat compressed HARQ-ACK as if it is HP UCI. Latency/reliability of both HP/LP UCI can be achieved. For the lost info due to compression, if gNB want, gNB can schedule reTx of the LP UCI by type-3 codebook for HARQ-ACK for example. Because they are LP, certain delay is tolerable. One should also notice that, there are advanced compression techniques (rather than simple bundling of UCI) which can minimize the information loss due to compression. Regarding this “For Type-2 HARQ-ACK codebook, the size is determined by the DAI values and a miss detection of a ‘last’ DCI format can lead to UE and gNB have different understanding of the size of HARQ-ACK codebook (e.g. in case of single-cell operation). In such case, separate coding can also help HP UCI detection to not be affected by an incorrect assumption for the size of the LP HARQ-ACK codebook.” – Unless using separate PUCCH resources to transmit HP and LP UCI, I don’t see separate encoding helps to resolve the missing last DCI issue. If LP and HP UCI are put together in a PUCCH resource, that resource set is determined based on the total UCI size. Missing last DCI can change the resource set and separate encoding does not offer any help here. Furthermore, unless gNB always guarantee PRI in last DCI is the same as PRI in previous DCI, otherwise missing the last DCI will lead to a wrong PRI and UE ends up using a wrong PUCCH resource to transmit HP+LP UCI. Separate encoding does not help neither in this error event.  |
| NEC | Support |
| WILUS | Support the FL’s proposal. |
| OPPO | Not support. Same comment as Intel. |
| MediaTek | Not support. There are much simpler ways (e.g. bundling) to maintain the reliability of HP UCI. |

#### 2nd round proposal and discussion

|  |
| --- |
| **Analysis on Separate coding** |
|  | Arguments | Counter arguments |
| Advantages | Resource efficiency | Would provide more optimized resource usage for HARQ-ACK[E///] If the single PUCCH resource is of format 2,3,4, joint encoding of high and low priority HARQ feedback at low code rates might require more resource elements than separate encoding of high priority HARQ feedback at low code rate and low priority HARQ feedback at higher code rate. For small payloads however, additional CRC overhead and smaller coding gain might offset this.[LG] Since separate coding would be applied for different priorities by using the max coding rate configured for each priority, it is more resource-efficient in terms of coded bit generation and RE mapping compared to joint coding where the max coding rate configured for HP, which might be much lower than that for LP, would be applied even for LP. | [QC] compress the LP HARQ-ACK before joint encoding with HP HARQ-ACK can achieve the same goal of more optimized resource usage. In extreme case, HP HARQ-ACK can be bundled to 1 bit and almost all REs be used for HP HARQ-ACK. gNB can use type-3 codebook to trigger UE reTx LP HARQ-ACK, with the cost of additional delay. But for LP HARQ-ACK, latency is not major concern. Furthermore, instead of seeing performance gain, I see potential performance loss with separate encoding. like E/// mentioned, additional CRC overhead may degrade the performance of separate encoding. The impact of additional CRC has to be studied. Unfortunately, proponents of separate encoding did not provide any simulation results to address this open issue.  |
| Latency  | [SS] For PUCCH format 3/4, HP HARQ-ACK can be mapped on the earlier symbols with separate coding.  | [QC] This is a secondary comment. Yes, it might be true HP HARQ-ACK can be mapped earlier. But this will impact the mapping of LP HARQ-ACK and make it noncompatible to Rel-15. A better design should be backward compatible to legacy, meaning the LP HARQ-ACK RE mapping follows Rel-15, while HP HARQ-ACK RE mapping just walks around it. With this proposal, we don’t see RE mapping is backward compatible.  |
| Robustness against DCI mis-detection | [SS] For Type-2 HARQ-ACK codebook, the size is determined by the DAI values and a miss detection of a ‘last’ DCI format can lead to UE and gNB have different understanding of the size of HARQ-ACK codebook (e.g. in case of single-cell operation). In such case, separate coding can also help HP UCI detection to not be affected by an incorrect assumption for the size of the LP HARQ-ACK codebook.[SS] Regarding QC’s counter arguments, it seems QC misunderstood our point. The missed last DCI we mentioned in our contribution is LP DCI. As mentioned by Ericsson in 2.3.3, the last DCI indicating PRI should be a HP DCI. The PUCCH resource issue mentioned by QC is not valid. Regarding changing the resource set due to last LP DCI missing, it can only happen when the total size is around the set boundary, this can be taken as a corner case.[HW] Separate DCI can help protect HP HARQ-ACK against DCI mis-detection. In theory, the mis-detection of low priority DCI would be more often than high priority DCI, if we do joint coding then the performance of HP HARQ-ACK would be impacted. As to the argument that for joint coding the PUCCH resource set would be changed if some DCI mis-detection happens, we don’t think this is always true, since the PUCCH resource set would correspond to a range of UCI payload, therefore changing of PUCCH resource set will not always happen.[LG] Separate coding could be a bit more robust compared to joint coding in some cases, for example, in case when UE receives all HP DCIs but misses some LP DCI, it wouldn’t affect the coded bits and RE mapping for HP UCI. | [QC] Don’t see separate encoding helps to resolve the missing last DCI issue. If LP and HP UCI are put together in a PUCCH resource, that resource set is determined based on the total UCI size. Missing last DCI can change the resource set and separate encoding does not offer any help here. Furthermore, unless gNB always guarantee PRI in last DCI is the same as PRI in previous DCI, otherwise missing the last DCI will lead to a wrong PRI and UE ends up using a wrong PUCCH resource to transmit HP+LP UCI. Separate encoding does not help neither in this error event.[QC] To Samsung: We understand SS’s proposal 😊. By the way, there is no HP or LP DCI. The priority in DCI is indicating the priority of PUCCH. With separate encoding, let’s assume the PUCCH resource for HP A/N + LP A/N is indicated by last DCI associated HP A/N, the missing DCI can still happen for that last DCI. And I don’t see how separate encoding can improve the reliability of DCI decoding. The way to reduce the DCI detection error is using more power or larger AL for DCI. But gNB can apply the same technique for the last DCI with joint encoding.  |
| Problems | Coverage gain | [E///] From a link budget perspective, the performance benefits of separate coding need to be compared to PUSCH coverage. If coverage is limited by PUSCH rather than PUCCH, improving PUCCH performance by separate coding is not worth the added complexity and does not increase coverage. Conversely, for cell center UEs operating at high SNR, separate coding might not bring sufficient added benefits due to steep BLER curves and similar code rates for low and high priority HARQ feedback. There are likely to be scenarios where some UEs should perform joint encoding, and some UEs should perform separate encoding. | [SS] We don’t think separate coding add additional complexity, there is no big difference compared with CSI part 2.[HW] In our understanding the support of HP HARQ doesn’t mean that HP PUSCH will be supported also, therefore it seems we don’t need to use the bottle neck of the channel to determine whether there is any beneficial to improve the coverage or not. In addition, in general it would always be good to take a mechanism that would have better coverage even it might not be the bottle neck channel under some condition, because the evaluation of whether bottle neck or not would depend on some assumption like the UCI payload, but overall we need to ensure the performance for all UCI payload for HP HARQ-ACK. |
|  | Standardization efforts | [QC] Need new rate matching and RE mapping rule for HP UCI and LP UCI mux on PUCCH, and HP UCI and LP UCI multiplexing on PUSCH. Quite significant spec impact is a factor we need consider. On the other hand, if joint encoding is adopted, then Rel-15 RM and RE mapping rules can be reused.[QC] to Samsung: Just consider a scenario: LP HARQ-ACK, HP HARQ-ACK, HP CSI part 1, and HP CSI part 2. With separate encoding, UE need do RM for LP HARQ-ACK, RM for HP HARQ-ACK+CSI-1, RM for HP CSI-2. What is the RM order? New RM equations are needed. New RE mapping pseudo codes are needed. Please check section 6.3.1.6 of 212 to see how complicated the pseudo codes already are. The above is just one scenario, now consider different combinations of priorities, can proponent of separate encoding please study how many combinations of priority + UCI type and provide answers to how to do Rate matching and how to do RE mapping? To me, the spec impact is HUGE. With joint encoding, the Rel-15 spec can be reused. | [SS] Separate coding on PUCCH has been supported since Rel-15 for CSI part2, similar rate matching and RE mapping rule can be used for LP HARQ-ACK in Rel-17. We don’t think there is significant spec impact.[QC] to Samsung, please see the comment from left column. There are a lot need to be specified on top of rel-15 CSI port 2 separate encoding, because now you need run 3 encoders. |
|  | UE complexity | [QC] How many Polar encoder UE needs to budget for the worst case? It seems 6 to me: HP HARQ-ACK, LP HARQ-ACK, HP CSI-part 1, LP CSI-part 1, HP CSI-part 2, LP CSI-Part 2, if RAN1 allow simultaneous HP and LP CSI. Even if considering to drop LP CSI, it seems 4 Polar encoder is needed for the worst case, which increase UE implementation complexity. [E///] If the single PUCCH resource is of format 2,3,4, joint encoding of HARQ feedback does not require separate decoding attempts and is simpler at the receiver. Furthermore, separate block coding of 1-2 bits is only supported on PUSCH in Rel. 16.[LG] This aspect seems to be mainly involved with the max number of UCI encodings allowable on PUCCH/PUSCH, then if necessary, proper limitation could be applied as for UCI on CG PUSCH in NR-U where at most 3 encodings are applied including CG-UCI. | [SS] This issue discusses multiplexing on PUCCH. For the supported scenarios, at most two Polar encoders are needed. There is no difference compared with Rel-15 CSI part 2.[QC] For UCI multiplexing on PUCCH, at least three Polar encoders: HP HARQ-ACK/CSI part1, LP HARQ-ACK/CSI part 1, HP or LP CSI part 2, if RAN1 does not support HP and LP CSI part 2 mux on a PUCCH. If support HP and LP CSI part 2 on same PUCCH, then 4 Polar encoders are needed. In any case, I don’t see two Polar encoders (as in Rel-15) are enough.  For UCI multiplexing on PUSCH, even more polar encoders are needed if do separate encoding. Please notice that UE implementation has to budget for the worse case, which is UCI multiplexing on PUSCH. So we have strong concern on increase UE implementation complexity and cost, without seeing the benefit of separate encoding yet. |
| **Analysis on Joint coding** |
| Problems | Priority protection | Joint coding cannot provide distinguished latency/reliability protections for UCIs of different priorities, thus results in either low spectrum utilization or degraded performance. | [QC] If UE compress LP UCI and treat compressed HARQ-ACK as if it is HP UCI. Latency/reliability of both HP/LP UCI can be achieved. For the lost info due to compression, if gNB want, gNB can schedule reTx of the LP UCI by type-3 codebook for HARQ-ACK for example. Because they are LP, certain delay is tolerable. One should also notice that, there are advanced compression techniques (rather than simple bundling of UCI) which can minimize the information loss due to compression.[Intel] Schemes such as threshold on LP UCI payload, bundling can be considered so that reliability of HP UCI is minimally impacted. |

Potential proposal 2.3.1:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, down-select from the following options in RAN1#104-e:

* Option 1: Support joint coding at least for the case PF0/1.
	+ FFS other PF for joint coding.
	+ FFS Separate coding.
* Option 2: Support separate coding at least for PF2/3/4.
	+ FFS other PF for Separate coding.
	+ FFS Joint coding.
* Option 3: Support joint coding at least for PF0/1. Support separate coding at least for PF2/3/4.
	+ FFS other PF for joint coding.
	+ FFS other PF for Separate coding.

|  |  |
| --- | --- |
| Company | Comments |
| Huawei, HiSilicon  | Firstly we have some question for clarification on the proposal:1. So will we still do any down-selection in this meeting? Or just list the three options for further consideration?
2. For option 3, does it mean that both joint coding and separate coding may be supported for a certain PF?

In our understanding, that would be too complicated, it would be simpler to only have either joint coding or separate coding for a certain format, unless there is strong benefit to support both. Among the three options, we prefer option 2 at this stage. 1. We think separate DCI can help protect HP HARQ-ACK against DCI mis-detection. In theory, the mis-detection of low priority DCI would be more often than high priority DCI, if we do joint coding then the performance of HP HARQ-ACK would be impacted. As to the argument that for joint coding the PUCCH resource set would be changed if some DCI mis-detection happens, we don’t think this is always true, since the PUCCH resource set would correspond to a range of UCI payload, therefore changing of PUCCH resource set will not always happen.
2. As to the coverage issue, in our understanding the support of HP HARQ doesn’t mean that HP PUSCH will be supported also, therefore it seems we don’t need to use the bottle neck of the channel to determine whether there is any beneficial to improve the coverage or not. In addition, in general it would always be good to take a mechanism that would have better coverage even it might not be the bottle neck channel under some condition, because the evaluation of whether bottle neck or not would depend on some assumption like the UCI payload, but overall we need to ensure the performance for all UCI payload for HP HARQ-ACK.
3. As to standardization effort, I guess it is hard to say whether joint coding or separate coding would have less impact, and we think if possible the main target should focus on providing better performance first, unless the standard effort will be really unacceptable, which we feel may not happen as long as involving reasonable design.
 |
| MediaTek | Not support separate coding. There are much simpler ways (e.g. bundling) to maintain the reliability of HP UCI. |
| LG | First of all, we think separate coding should be baseline, and joint coding may need to be conditionally applied for some cases with consideration of UCI payload size for all or each of LP and HP. In this sense, it is better to formulate potential proposal for separate/joint coding according to UCI payload size rather than PUCCH format.On the aspect of analysis, the followings are our views.1) Resource efficiencySince separate coding would be applied for different priorities by using the max coding rate configured for each priority, it is more resource-efficient in terms of coded bit generation and RE mapping compared to joint coding where the max coding rate configured for HP, which might be much lower than that for LP, would be applied even for LP.2) Robustness against DCI mis-detectionWe think that separate coding could be a bit more robust compared to joint coding in some cases, for example, in case when UE receives all HP DCIs but misses some LP DCI, it wouldn’t affect the coded bits and RE mapping for HP UCI.3) Coverage gainThis aspect could be handled (for both separate coding and joint coding) by gNB’s tools such as PUCCH resource (symbol) allocation, max coding rate configuration, beta offset configuration/indication, PUCCH power control, and so on.4) Standardization effortsWe think that standard efforts by adopting separate coding would be reasonable since as some companies already commented, separate coding for different UCI types was introduced/specified for both PUCCH and PUSCH in terms of UCI coding and RE mapping, then given that, same principle can be largely reused.5) UE complexityThis aspect seems to be mainly involved with the max number of UCI encodings allowable on PUCCH/PUSCH, then if necessary, proper limitation could be applied as for UCI on CG PUSCH in NR-U where at most 3 encodings are applied including CG-UCI.6) Priority protectionSince HP UCI would occupy REs first based on its max coding rate and the remaining REs are occupies by LP, it wouldn’t cause any impact to HP protection. |
| Samsung | Can accept the proposal for some progress at this meeting. We should aim to conclude down-selection at the next meeting. Note that a UE already supports separate coding for UCI - e.g. for CSI part 1 and CSI part 2. There is no additional UE complexity. Some further comments are added in the table above. |
| Nokia, NSB | We support Option 2 in principle. For PF 2/3/4, we support separate encoding of HP and LP HARQ-ACKs to avoid impacting the HP HARQ-ACK. Whether joint encoding should be used in some cases, e.g. in case of small payload sizes, could be studied further.However, we think that some further details are needed from the proposal. * Firstly, our interpretation is that any of the PUCCH formats mentioned in the proposal corresponds to the format of the resulting PUCCH resource on which the HP and LP HARQ-ACK are multiplexed. This should be further clarified in the proposal.
* Secondly, it’s not clear to us what is exactly meant by separate encoding for PUCCH Formats 0 and 1, as to our understanding there is no UCI ‘encoding’ as such for these formats. Anyhow, we suggest removing the first FFS under Option 2, and updating the other options accordingly, so that the discussion focus on PF 2/3/4.
 |
| Sony | We can support the proposal of listing the options to be down selected in next meeting.If we have to select an option this meeting, then we would prefer Option 2 |
| With respect to formulation of proposal, we agree with the previous comments that the proposal is a bit unclear. Does PF0/1 or PF2/3/4 refer to the PUCCH resource including both HP and LP HARQ-ACK or refer to PUCCH resources that their corresponding LP or HP HARQ-ACK are going to be multiplexed on a single PUCCH resource (irrespective of join or separate coding)?The proposal seems to address two cases. * Case 1: Support joint coding at least for PF0/1.
	+ Question 1: Which of the following is intended by Case 1?
		- a) Total number of LP and HP HARQ-ACK is at most 2
		- b) Number of LP is at most 2 and number of HP HARQ-ACK is at most 2
* Case 2: Support separate coding at least for PF2/3/4.
	+ Question 2: Which of the following is intended by Case 2?
		- a) Total number of LP and HP HARQ-ACK is more than 2.
		- b) Number of LP is more than 2 and number of HP HARQ-ACK is more than 2

The issue is that as categorizing based on PUCCH format, as it can see above, leads to miss some cases. The choice of separate or joint coding is in fact a bit unclear for us at this stage.Perhaps, one can categorize the problem at number of LP HARQ-ACK and HP HARQ-ACK bits.

|  |  |  |
| --- | --- | --- |
|  | 1-2 LP HARQ-ACK | 3 or more LP HARQ-ACK |
| 1-2 HP HARQ-ACK | * Case A1: LP+HP HARQ-ACK more than 2
* Case A2: LP+HP HARQ-ACK at most 2
 | Case C |
| 3 or more HP HARQ-ACK | Case B | Case D |
|  |  |  |

The question we have and we would like to study further (see below) can be better explained with Case A to D above with respect to the proposal.* Does separate coding for Case B and C, mean puncturing for LP/HP 1-2 HARQ-ACK bits?
* Does separate coding in Case D apply where there in large imbalance between the number of HP and LP HARQ-ACK bits?

 We think there are cases where separate coding will see gains, e.g. where the LP payload is very large, but there are also cases where the gains are negligible, e.g. when both payloads are small. In this case the additional coding gain from joint coding offsets the increased reliability requirements on the LP payload. A trivial example is where the target coding rates of both LP and HP payload are similar. In this case separate coding performs worse. Therefore, we would prefer to evaluate the different options before committing to a single scheme.It is also a bit unclear to us what separate coding means in the case of PF0/1.  |
| InterDigital | Support Option 2 in principleAgree with points made by LG, Nokia and Ericsson above:* As there is no encoding for PUCCH formats 0/1, not sure what is under discussion there
* Better to make decision for different LP/HP payload sizes rather than for different PUCCH formats. The table proposed by Ericsson could be a good starting point.
* Expect that joint coding would perform better at least in certain cases, such as when there is only 1 or 2 bits for HP or LP.
 |
| Sharp | Support the proposals in principle.* Joint coding should be supported at least for PF 0/1.
* Joint coding may be better if the total payload is small, e.g. 1) there is no effective coding method for 1 or 2 bits, and for less or equal to 11 bits, RM code is used, where no CRC is available for error detection. The joint coding can solve these potential issues in case of total payload is small.
* Separate coding is the baseline if the payload is large. The PUCCH resource utilization is optimized with different coding rates for UCI with different priorities.
* In fact, a HP PUCCH may carry more than the configured max payload size considering different code rates. For example. the total payload may be estimated by (HP payload + scale\_factor \* LP payload), where the scale\_factor may be given by (HP\_max\_codetate/LP\_max\_Coderate).

Thus, both joint coding and separate coding have pros and cons, and should be determined based on the multiplexing conditions.FFS the conditions or signaling for joint coding and separate coding. |
| NEC | We do not support this proposal. If the intention of this proposal is to list conditions to make a decision on whether to use separate or joint coding, we think it is better to make this decision based on payload sizes.  |
| Intel | We support joint coding. As few companies already mentioned, joint encoding is expected at least for PF 0/1 as in legacy PF 0/1 design, there is no encoding as such. It remains to be seen whether to apply joint or separate coding for PF2/3/4. Also, as E/// mentioned separate coding may not always result in intended gain, despite more specification efforts due to potentially new RE mapping and rate matching design**. Hence, we suggest to move forward with Option 1 as first step** |
| Xiaomi | Agree with Intel to agree on Option 1 as a starting point. |
| CATT | We also would like to clarify whether PF in the proposal is determined by the original PUCCH resource or the multiplexed PUCCH resource.In addition, we share the same view with some of the companies that payload size should also be taken into account to determine whether separate coding or joint coding should be adopted. |
| CMCC | Support Option 2 in principle. As other companies mentioned, there is no encoding for PUCCH formats 0/1, so the FFS bullet in option 2 needs further clarification. |
| DOCOMO | We are fine with the proposal to list up possible options, if it is the intention. If down-selection is also in-scope, we prefer Option 2 in principle.* Reason to support Option 2:
	+ Resource efficiency: separate coding with different max coding rate ensures HP HARQ-ACK reliability.
	+ Latency: agree with SS’s analysis. If HP HARQ-ACK is mapped earlier than LP HARQ-ACK with separate coding, the latency of HP can be reduced.
	+ Standardization efforts: not much large modification is expected as separate coding is already supported since Rel-15 for CSI part 1/part 2. It can be baseline for different priority HARQ-ACK case.
* Reason to not support Option1/Option 3:
	+ Option 3: It seems Option 3 would allow both joint coding/separate coding for all the PFs due to “at least.” This would lead to UE complexity/operation complexity
	+ Option 1: Similar to Option3, if both Option 1 and Option 2 is agreed, there would be possibility that both joint/separate coding are supported for certain PFs. This should be avoided.
 |
| OPPO | We share view with Intel |
| vivo | We also have the concern as comment above, the current formulation is not clear.* Case 1: Support joint coding at least for PF0/1.
	+ Question 1: Which of the following is intended by Case 1?
		- a) Total number of LP and HP HARQ-ACK is at most 2
		- b) Number of LP is at most 2 and number of HP HARQ-ACK is at most 2
* Case 2: Support separate coding at least for PF2/3/4.
	+ Question 2: Which of the following is intended by Case 2?
		- a) Total number of LP and HP HARQ-ACK is more than 2.
		- b) Number of LP is more than 2 and number of HP HARQ-ACK is more than 2
 |
| Spreadtrum | Agree with LG’s view and support Option 2 in principle. |
| QC | Regarding the proposal, we have a question for clarification. The “PF0/1” in the proposal is the PF before or after UCI multiplexing? We guess it is after multiplexing. It will be great if FL can clarify this ambiguity. The support Intel’s suggestion to agree option 1 for PF0/1 as a starting point. This can be a baby step to move forward, although strictly speaking, PF0/1 has no channel coding to begin with. As for the debate of joint vs separate encoding (regardless it is for UCI mux on PUCCH or PUSCH), we really don’t see that RAN1 has to make a rash decision in this meeting WITHOUT any simulation results to study the performance of the two schemes. We suggest to postpone the decision to next meeting. Companies should bring results to support their proposal.  |
| WILUS | We support separate coding in principle, but we are fine with listing options and down-select in next meeting. For option 1, our understanding is there are no coding schemes in PF0/PF1. What is difference between separate coding and joint coding in PF0/PF1.  |
| ZTE | We also think the PF in the proposal is based on the PUCCH resources resulting from multiplexing. The resulting PUCCH resources could be either the original PUCCH resource with high priority or the new PUCCH resource with high priority. The below modified option1 is a simple method and could be treated as a baseline.For the modified option2, if the UCI size of the HP and LP to be multiplexed are both greater than 11 bits, the separate encoding is also a simple method. But for other combinations of UCI size, FFS.Therefore, we prefer the modified option3, which is a combination of the modified option1 and option2.* Modified Option 1: Support multiplexing at least for the case where the multiplexing result is PF0/1.
* FFS other PF for joint coding.
* FFS Separate coding.
* Modified Option 2: Support separate coding at least for the case where the multiplexing result is PF2/3/4.
* FFS other PF for Separate coding.
* FFS Joint coding.
* Modified Option 3: Support multiplexing at least for the case where the multiplexing result is PF0/1. Support separate coding at least for the case where the multiplexing result is  PF2/3/4.
* FFS other PF for joint coding.
* FFS other PF for Separate coding.
 |

#### 3rd round proposal and discussion

The following proposal is considered for email approval by end of the meeting.

Potential proposal 2.3.1:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, down-select from the following options in RAN1#104-e (evaluation results from companies are encouraged):

* Option 1: Support joint coding at least in case the resulting PUCCH after the multiplexing is small-payload.
* Option 2: Support separate coding at least in case the resulting PUCCH after the multiplexing is large-payload.
* Option 3: Combination of Option1 and 2.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We are fine with the proposal. I take for Option 3, we need to work out under what conditions we use Option 1 or Option 2. |
| Nokia, NSB | The formulation of Options 1 and 2 is not clear to us.Specifically, it’s not clear what is exactly meant e.g. by “in case the resulting PUCCH after the multiplexing is large-payload”. Hence, we can be OK with the intention of the proposal but would suggest the following changes:Potential proposal 2.3.1:For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, down-select from the following options in RAN1#104-e (evaluation results from companies are encouraged):l  Option 1: Support joint coding ~~at least in case the resulting PUCCH after the multiplexing is small-payload~~.l  Option 2: Support separate coding ~~at least in case the resulting PUCCH after the multiplexing is large-payload.~~l  Option 3: Combination of Option1 and 2.* FFS the details

In general, we support separate encoding of LP and HP HARQ-ACKs as this avoids impacting the latency and the reliability of the HP HARQ-ACK. Whether joint encoding should be used in some cases could be FFS. It should be noted (again) that here we don’t consider the cases where the resulting PUCCH resource is with PF0 and PF1, as there is no encoding as such in these cases, this is the same comment that LGE provided by Email. Such potential extension of the agreement including PF 0/1 as provided by LGE could be added in addition to make the proposal complete.  |
| Ericsson | We are fine in principle. However the formulation of proposal creates ambiguity.TWe prefer the formulation of Nokia.We agree the for the case that the total LP and HP HARQ-ACK bits is tow bits should be addressed.It is good to add that case. But we are not fine with LG proposal because it is solution specific.A suggestion for completeness is as the following ;Potential proposal 2.3.1:For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits are more than 2 bits, down-select from the following options in RAN1#104-e (evaluation results from companies are encouraged) l  Option 1: Support joint coding ~~at least in case the resulting PUCCH after the multiplexing is small-payload~~.l  Option 2: Support separate coding ~~at least in case the resulting PUCCH after the multiplexing is large-payload.~~l  Option 3: Combination of Option1 and 2.* FFS the details

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17, when the total number of LP and HP HARQ-ACK bits is 2 bits, provide design details for decision for the following cases in RAN1#104-e (evaluation results from companies are encouraged) * Multiplexing on a PUCCH format 0
* Multiplexing on a PUCCH format 1
 |
| Sharp | Support the proposal. FFS details to determine joint coding or separate coding. |
| Apple | We agree with Nokia’s comment, the version from Ericsson above is fine for us. The formulation from Ericsson is general enough, and it should be compatible with FL’s proposal. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## How to guarantee the target code rate (e.g. payload control, multiplexing priority, LP HARQ-ACK compression/compaction)

* Option 1: Separate coding. If no enough resource is left for LP UCI,
	+ Configure two coding rates for HP UCI and LP UCI.
	+ Reuse the coding rates of HP and LP UCI on their original PUCCH resource.
	+ HP UCI is mapped first. If no enough resource is left,
		- Option 1a: LP UCI is dropped.
			* HW, vivo, ETRI
		- Option 1b: LP HARQ-ACK is partially dropped.
			* CATT, LGE, , DCM, ZTE
			* Problem: the priority order within the low-priority HARQ-ACKs should be clarified, e.g., based on scheduling order or resource order.
		- Option 1c: LP HARQ-ACK is compressed/bundled.
			* CATT, LGE (bundling for LP HARQ-ACK in spatial domain and/or CBG domain), Nokia (bundled), MTK, OPPO, ~~CMCC?,~~ NEC, WILUS, Sharp, DCM, vivo, Apple
* Option 2: Joint coding. The maximum number of LP UCI is configured to X bits.
	+ vivo

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Option 1. It is sufficient to say at this point that some of the LP UCI information will be lost, e.g. via dropping or bundling. The details can be FFS. |
| CMCC | Option 1 with the code rate determination FFS. |
| Sharp | For separate coding, two maximum code rates may be configured for HP PUCCH, or a scale factor can be configured to determine the LP UCI code rate. If the resource is not enough, LP UCI compression and dropping can be considered. |
| Samsung | Option 1a as starting point. Option 1c with spatial domain bundling can also be considered as the first step (separate configuration whether to apply than in Rel-15).  |
| DOCOMO | Option 1b or 1c |
| InterDigital | Option 1c. |
| NEC | We support HARQ-ACK compression/bundling but do not support to always bundle LP HARQ-ACK. Since URLLC is designed for high reliability, URLLC HARQ-ACK codebook may be carrying ACK in most cases. In such cases, we think that multiplexing original eMBB feedback with compressed URLLC feedback can be a better solution. Therefore, decision that which codebook is compressed can be based on the codebook content as follows.- If URLLC codebook carries ACK only or NACK only: if eMBB codebook carries both ACK and NACK, bundle URLLC HARQ-ACK codebook bits into 1 bit and append at the end of the eMBB codebook. Otherwise, bundle eMBB codebook bits into 1 bit and append at the end of the URLLC codebook.- If URLLC codebook carries both ACK and NACK, bundle eMBB HARQ-ACK codebook bits into 1 bit and append at the end of the URLLC codebook. In this case, if bundled eMBB feedback indicates NACK, full eMBB codebook is transmitted later. Features, e.g. Type 3 codebook, enhanced Type 2 codebook and NNK1, developed in Rel-16 can be used for transmission of original eMBB HARQ-ACK feedback later.Therefore, we propose joint coding such that one of the two codebooks is bundled to one bit. |
| Intel  | Option 2, which should be revised as follows. We actually did not propose separate coding, so Intel is removed from Option 1b* Option 2: Joint coding.
	+ Option 2a: The maximum number of LP UCI is configured to X bits.
		- Vivo
	+ Option 2b: A threshold on LP HARQ-ACK payload can be configured and LP HARQ-ACK can be partially dropped, if above threshold.
		- Intel

We added our proposal below. |
| QC | We prefer Option 2. The maximum number of LP UCI is configured to X bits. Compression/bundling is performed if the # LP UCI bits exceeds X. However, we suggest to hold on discussion on this until the separate encoding vs joint encoding discussion is settled.  |
| ZTE | Option 1b. Compared with option 1a, LP HARQ-ACK has a opportunity of transmission. For option 1c, the problem may still be there, e.g., the bundled bits still cannot be overloaded on the remaining resources. |
| Xiaomi | Support Option 1a |
| OPPO | We prefer to separate coding, so OPPO is removed from Option 1cWe add our proposal in option 2 below* Option 2: Joint coding.
	+ Option 2a: The maximum number of LP UCI is configured to X bits.
		- Vivo
	+ Option 2b: A threshold on LP HARQ-ACK payload can be configured and LP HARQ-ACK can be partially dropped, if above threshold.
		- Intel
	+ Option 2c: The remaining PUCCH after HP UCI is allocated can be used for LP UCI. For limited remaining PUCCH resource, HARQ-ACK bundling can be considered, e.g. CBG-based bundling, Time domain bundling.
		- OPPO
 |
| WILUS | Option 1c.  |
| ETRI | Option 1a is preferred because partial dropping (Option 1b) or compression (Option 1c) often lose information and in worst case all data should be retransmitted |
| vivo | One direction is either multiplexing all HARQ-ACK bits (when LP HARQ-ACK is no more than X bits) or dropping all HARQ-ACK bits (when LP HARQ-ACK is more than X bits) is supported for simplicity.Another direction is to support partially multiplexing of LP HARQ-ACK (Option 1b or 1c). and Option 1c is slightly preferred between Option 1b and Option 1c |
| Panasonic | Option 1 |
| CATT | Option 1b and 1c. |
| Huawei, HiSilicon | We prefer option 1b. For option 1c, if the bundling is done across slots or across carriers, the performance might be not that good because the channel quality would be different for these cases.  |
| Ericsson | Option 1 (in case we do separate coding, see previous comment).**We are against solutions relying on partial dropping, bundling, etc.** Either we send the LP UCI or not. None of these solutions would be used and it is optimization.If there is an issue. gNB commands not to multiplex. |
| Nokia, NSB | Support Option 1c Option 1b could be further considered. Specifically, in case the LP HARQ-ACK codebook comprises two sub-codebooks for TB-based and CBG-based operations, if the selected PUCCH resource cannot carry all the LP HARQ-ACK payload, partial dropping could be adopted where e.g. one sub-codebook is dropped/multiplexed |
| Apple | We prefer option 1C. LP HARQ codebook compaction can be used. |

IDC proposal:

*Proposal 4: For multiplexing PUCCH transmissions of different priorities:*

* *Multiplexing is over a high-priority PUCCH resource;*
* *Multiplexing can only occur if a maximum code rate applicable to high-priority UCI is not exceeded*

CMCC proposal:

*Proposal 7: For determining the code rates for HP UCI and LP UCI when multiplexing, the following alternatives can be further studied:*

* + *Two maxCodeRates are configured for PUCCH resource used for multiplexing, one is used for LP UCI and the other is used for HP UCI.*
	+ *One maxCodeRate is configured for PUCCH resource used for multiplexing, the configured maxCodeRate is used for UCI with the corresponding priority indicated by the last DCI format, the code rate of UCI with the other priority is adjusted based on the configured maxCodeRate of the PUCCH resource for multiplexing, or determined by the configured maxCodeRate of the original PUCCH resource if exists.*

NEC proposal:

*Proposal 1: Multiplexed feedback consists of original codebook for one service followed by one bit representing the result of bundling the other codebook’s bits. Content of the two codebooks determine which codebook’s bits are bundled.*

*Proposal 3: Support transmitting 1-bit indicator with multiplexed HARQ-ACK feedback as proposed in proposal 1 to explicitly indicate which codebook is bundled.*

ETRI proposal:

*Proposal 3: Further study how to adjust the power of PUCCH for payload from the other priority.*

*Proposal 4: Whenever being transmitted, all the LP HARQ-ACK bits are multiplexed.*

Intel proposal:

*Proposal 4: Support the following for multiplexing HP and LP HARQ-ACKs onto a PUCCH:*

* *Multiplexed HARQ-ACK payloads are transmitted using PUCCH configuration of HP codebook*
* *LP and HP HARQ-ACK payload bits are concatenated and jointly encoded*
* *LP HARQ-ACK payload bits can be partitioned or a threshold on the payload can be considered to maintain target code rate.*

#### 1st round proposal and discussion

Potential proposal 2.3.2:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* ~~For~~If separate coding for HP HARQ-ACK and a LP HARQ-ACK is supported,
	+ At least the following alternatives are to be further studied for code rate determination:
		- Two coding rates can be separately configured for HP HARQ-ACK and a LP HARQ-ACK.
		- Reuse the ~~coding rates~~ maxCodeRate of HP HARQ-ACK and a LP HARQ-ACK on their original PUCCH resource if configured.
			* FFS if maxCodeRate is not configured
	+ HP HARQ-ACK is mapped into the PUCCH resource first. Then LP HARQ-ACK is mapped into the PUCCH resource left.
		- FFS solutions if no enough resource is left for LP HARQ-ACK.
	+ FFS other details

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support the proposal in principle – the first and second sub-bullet are somehow redundant / contradicting.If the second sub-bullet is agreed (‘reuse…’), it is clear already that separate coderates for LP and HP apply given by the Rel-16 specifications on two PUCCH configs. Moreover, the understand of coding rate in the second subbullet may need some clarification (i.e. max. coderate or actual coderate on the PUCCH). |
| Intel | Suggest to discuss this after 2.3.1.1 is decided |
| Spreadtrum | Support the proposal. We think previous actual coderate should be applied for HP HARQ-ACK, the coderate of LP HARQ-ACK should be based on actual available resources after multiplexing.  |
| CMCC | Support in principle, however, the proposal is not so clear to us.We share similar view with Nokia that the first and the second sub-bullet are different alternatives for code rate determination of HP HARQ-ACK and LP HARQ-ACK. It should be clarified that whether the two alternatives are to be down selected or both of them are supported. So we prefer the proposal to be modified as:For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,* For separate coding for HP HARQ-ACK and a LP HARQ-ACK,
	+ At least the following alternatives are to be further studied for code rate determination:
		- Two coding rates can be separately configured for HP HARQ-ACK and a LP HARQ-ACK.
		- Reuse the ~~coding rates~~ maxCodeRate ~~of HP HARQ-ACK and a LP HARQ-ACK on their original PUCCH resource~~ of a same PUCCH format, if configured.
			* FFS if maxCodeRate is not configured
	+ HP HARQ-ACK is mapped into the PUCCH resource first. Then LP HARQ-ACK is mapped into the PUCCH resource left.
		- FFS solutions if no enough resource is left for LP HARQ-ACK.
	+ FFS other details
 |
| ZTE | Support the main bullet and the third sub-bullet. We share the view of QC that hold on this discussion until the separate encoding vs joint encoding discussion is settled.  |
| Huawei, HiSilcion | Support the FL proposal. Considering the comments from Nokia and CMCC, we can use the following two sub-bullets to replace the first two sub-bullets in the FL proposal.* Two coding rates can be separately configured for HP HARQ-ACK and a LP HARQ-ACK.
* Reuse the ~~coding rates~~ maxCodeRate of HP HARQ-ACK and a LP HARQ-ACK on their original PUCCH resource if configured.
	+ FFS if maxCodeRate is not configured
 |
| CATT | We would like to clarify the first two sub-bullets. In our view, the meaning is that separate max code rates are configured for two PUCCH-Configs associated with different PHY priorities and the configured max code rates are used to determine the number of REs for HARQ-ACK for HP and LP respectively. |
| Vivo | The proposal is not clear. First, separate encoding has not been agreed. Then, the three sub-bullets seems need to be down select, the following update can be considered:For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,* if separate coding for HP HARQ-ACK and a LP HARQ-ACK is supported, further study the followings:
	+ Two coding rates can be separately configured for HP HARQ-ACK and a LP HARQ-ACK.
	+ Reuse the coding rates of HP HARQ-ACK and a LP HARQ-ACK on their original PUCCH resource.
	+ HP HARQ-ACK is mapped into the PUCCH resource first. Then LP HARQ-ACK is mapped into the PUCCH resource left.
		- FFS solutions if no enough resource is left for LP HARQ-ACK.
	+ FFS other details
 |
| Sony | Support the principle of the proposal. However, as most companies had commented, the 1st & 2nd sub-bullet is unclear. We are fine with CMCC’s proposal, i.e. the 1st & 2nd sub-bullets are options on configuring the code rates. Alternatively, we can make this general and just delete the 2nd sub-bullet and just simply say the code rates separately configured. |
| Ericsson | We agree in principle but the proposal needs update before being agreed.In addition to previous comments, not clear it is meant by : Isn’t it that a each PUCCH-Config has its own configured maxCoderate which is used for the original PUCCH resource?* + Reuse the coding rates of HP HARQ-ACK and a LP HARQ-ACK on their original PUCCH resource.
 |
| Samsung | Support in principle.We are generally fine with CMCC’s updates, regarding the second alternative, we think the same PUCCH format should be considered instead of the original PUCCH resource, the original LP PUCCH and the result HP PUCCH can have different formatsWe suggest the following updatesFor multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,* For separate coding for HP HARQ-ACK and a LP HARQ-ACK,
	+ At least the following alternatives are to be further studied for code rate determination:
		- Two coding rates can be separately configured for HP HARQ-ACK and a LP HARQ-ACK.
		- Reuse the ~~coding rates~~ maxCodeRate ~~of HP HARQ-ACK and a LP HARQ-ACK on their original PUCCH resource~~ of a same PUCCH format, if configured.
			* FFS if maxCodeRate is not configured
	+ HP HARQ-ACK is mapped into the PUCCH resource first. Then LP HARQ-ACK is mapped into the PUCCH resource left.
		- FFS solutions if no enough resource is left for LP HARQ-ACK.

FFS other details |
| Sharp | Support in principle. Maybe it is better to discuss this after the PUCCH resource determination.For the first two sub-bullets, we can first agree that “two max coding rates are applied for HP HARQ-ACK and LP HARQ-ACK, FFS on how to configure/determine the two coding rates. |
| Panasonic | Support in principle. We share the similar view with other companies that the clarification of 1st and 2nd sub-bullet would be necessary. We are fine with the suggestion from Samsung. |
| InterDigital | Do not support except third sub-bullet. As commented above, the proposal is unclear for the first two sub-bullets.Update from Samsung seems acceptable. One question is if the intention of the first sub-sub-bullet that these coding rates are RRC configured? |
| DOCOMO | We support the main bullet but not support for the sub-bullets. Detailed scheme for separate coding should be FFS. The listed schemes in the several sub-bullets are proposed by only one or two companies and we think it should not be simply agreed without further consideration and discussion by others. |
| QC | Same comment as Intel.  |
| NEC | Support the updated proposal by vivo. |
| WILUS | Support in principle. The first two sub-bullets seem to be different alternatives to determine code rate, and we support the proposal updated by Samsung.  |
| OPPO | Same comment as Intel. |

## How to determine the PUCCH resource used for multiplexing (e.g. HP or LP PUCCH resource, or a dedicated PUCCH resource for the multiplexing)

**For multiplexing between HARQ-ACKs with different priorities:**

* Option 1: Determine the PUCCH resource sets for HP and LP UCIs respectively according to the total payload size by merging LP UCI and HP UCI. Select one resource between the two indicated by DCI using some rule.
	+ Option 1a: Select the HP HARQ-ACK resource
		- CATT, ZTE, Nokia, IDC, Intel, Pana, MTK, Spreadtrum, OPPO, Sony, NEC, Sharp, vivo
	+ Other sub-options:
		- LGE (e.g. using configured priority or resource size or symbol timing)
		- DCM (If there is no resource set to accommodate total UCI bits, new cyclic shift scheme or eMBB PUCCH resource can be used instead.)
		- Xiaomi (PUCCH resource from the PUCCH resource sets with lower maximum coding rate)
		- CMCC (depending on the priority indicator in the last DCI format, if dedicated PUCCH resource for multiplexing is not configured)
		- WILUS (select a PUCCH resource without considering sub-slot boundary and select a PUCCH resource in a symbol set where the first symbol of the set is the earliest symbol among overlapping PUCCHs and the last symbol of the set is the latest symbol among overlapping PUCCHs.)
* Option 2: Use a dedicated PUCCH resource, e.g. configuring additional PUCCH resource set (on top of the PUCCH resource sets configured per each of LP and HP) which is dedicated for the multiplexing/transmission of UCIs with different priority
	+ LGE, HW, CMCC, ETRI
	+ Arguments:
		- DCI mis-detection issue

**Other proposals:**

IDC proposal:

*Proposal 3: A necessary condition for the UE to multiplex PUCCH and/or PUSCH transmissions of different priorities is that the last symbol of the resource onto which multiplexing takes place is not later than the last symbol of the resource of a high-priority transmission.*

Nokia proposal:

*Proposal 3.2: RAN1 to study how to avoid discrepancy between the UE and the gNB on the determination of PUCCH resource set and number of RBs for UCI containing multiplexed high-priority and low-priority HARQ-ACKs.*

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Option 1a. The HP PUCCH is scheduled to handle the URLLC reliability & latency requirement, therefore this is the logical resource to use to ensure the reliability of the HP UCI is met. |
| CMCC | The “last DCI format” can be either the DCI scheduling HP HARQ-ACK or the DCI scheduling LP HARQ-ACK, especially for DL heavy TDD frame structure with only one UL slot in a periodicity. Hence either HP PUCCH resource or LP PUCCH resource may be used, depending on the priority indicator in the last DCI format.In addition, we think the PUCCH resource determination and guarantee the target code rate of HP HARQ-ACK can be separately discussed, i.e. separate encoding and mapping of UCI with different priorities with different coding rates can be used to guarantee the reliability of HP UCI. Alternatively, dedicated PUCCH resource which is configured for multiplexing UCIs with different priorities can also be considered. |
| Sharp | Option 1a. The HP PUCCH resource is configured to satisfy the URLLC requirements. The multiplexing of LP UCI should not sacrifice the HP UCI performance.  |
| Samsung | Option 1.DCI mis-detection issue can be avoided by other mechanisms. E.g., explicit indication of multiplexing/UL DAI of LP HARQ-ACK.A dedicated PUCCH resource is not necessary. Moreover, the dedicated PUCCH resource may bring up other issues. E.g., overlapping with another PUCCH. |
| InterDigital | Option 1a, to ensure reliability of HP UCI. |
| NEC | Option 1a. We share same view with Sony. |
| Intel | Option 1a, HARQ-ACK resource according to HP codebook configuration |
| QC | We prefer Option 1a in general, except for a few corner cases that resource selection is performed. For example, case 1: HP HARQ-ACK in PF1 overlaps with LP SR in PF1; case 2: LP HARQ-ACK in PF1 overlaps with HP SR in PF0; Case 3: HP SR in PF1 overlaps with LP HARQ-ACK in PF0; Case 4: HP SR in PF1 overlap with LP HARQ-ACK in PF1. Regarding option 2, we don’t see the benefit of it, despite its cost of additional resource reservation dedicated for multiplexing. Missing last DCI is still an issue with option 2. Given that the UCI range of multiplexed HP and LP UCI could be large, we assume multiple dedicated resources for multiplexing are needed. Then a PRI is needed to indicate which dedicated resource to use. With that, missing last DCI still cause confusion because UE may use a wrong PRI to transmit PUCCH in a wrong PUCCH resource.  |
| ZTE | Option 1a. The resource configured for high priority UCI can ensure the reliability after multiplexing. |
| Xiaomi | Support Option 1. |
| OPPO | Option 1a,Determine a HP PUCCH resource set according to the total payload size by merging LP UCI and HP UCI. Select one resource from the HP PUCCH resource set according to PRI and/or PDCCH resource allocation. |
| WILUS | Option 1 and 1a is ok when there is at least one DCI format indicating a PUCCH resource.  |
| ETRI | We have clarifying questions about the resource set selection for Option 1. In our understanding, when the total number of UCI bits are 3, the coding scheme should be applied to either 1 or 2 UCI bits per priority. If joint coding is adopted, then the coding scheme should be extended for each UCI priority. There are also similar cases to choose a resource set. We think that more detailed explanation is necessary for Option 1. |
| CATT | Option 1a |
| Huawei, HiSilicon | We still prefer option 2. The concern on option 1 is that gNB is not able to identify if the multiplexing is done or not between low priority UCI and high priority UCI, which will result in ambiguity at UE and gNB side. For explicit indication in DCI, it will increase the DCI overhead. In addition, it may not work well in the cases involving SR and/or configured PUSCH.  |
| Ericsson | Option 1aOur complete solution is the following:**When PUCCH with HP SR overlaps with PUCCH with LP HARQ-ACK:*** For 1-2 LP HARQ-ACK bits: The PUCCH resource for HARQ-ACK is used for multiplexing of the HP SR and LP HARQ-ACK. If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.
* For more than 2 LP HARQ-ACK bits: Rel-15 rules are used for multiplexing HARQ-ACK and SR in a PUCCH resource. If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the PUCCH resource.

**When PUCCH with HP HARQ-ACK/SR overlaps with PUCCH with LP HARQ-ACK:*** First, a PUCCH resource set associated to HP HARQ-ACK based on the total number of HP HARQ-ACK/SR and LP HARQ-ACK is determined. Then, a PUCCH resource in the PUCCH resource set to carry both HP and LP HARQ-ACK based on the last DCI corresponding to the HP HARQ-ACK is determined.
 |
| Nokia, NSB | Option 1aIn addition to selecting HP PUCCH resource, it should be also discussed how to avoid discrepancy (between the UE and the gNB) on the determination of PUCCH resource set and number of RBs for UCI containing multiplexed high-priority and low-priority HARQ-ACKs. This discrepancy would be mainly caused by missing some DCIs, which would cause different understanding of the LP codebook size between the UE and the gNB. This can result in selecting a different number of RBs and/or resource set for the multiplexed HARQ-ACKs than what the gNB expects. |

#### 1st round proposal and discussion

Potential proposal 2.3.3:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* ~~If no dedicated PUCCH resource is configured,~~
* Determine the PUCCH resource sets for HP HARQ-ACK and LP HARQ-ACK respectively according to the total payload size by merging LP HARQ-ACK and HP HARQ-ACK.
* Select the HP HARQ-ACK resource between the two indicated by DCI
* ~~FFS whether dedicated PUCCH resources can be configured for the multiplexing HP HARQ-ACK and LP HARQ-ACK.~~

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Do not support: 1. The determination of the payload size is unclear. The first sentence seems to imply to choose the PUCCH resource set for LP and the PUCCH resource set for HP (i.e. two sets) – but then the ‘merged’ HARQ-ACK payload size is used for that? If the intention of the bullet would be to select the PUCCH resource for multiplex both (HP & LP) HARQ-ACK, also there the payload sizes necessarily do not need to be merged / added (e.g. for partial dropping or bundling, the LP HARQ payload size would be smaller than when multiplexed on LP PUCCH).
2. In the second sub-bullet, it is assumed that LP and HP HARQ-ACK are both ‘scheduled’ by a DCI, how about SPS HARQ? If this is only for the case of DG PDSCH HARQ only, that it would be good to clarify in the overall description of the proposal.

We do not see a need for the FFS – no need for separately configured PUCCH config / resource identified |
| Intel | Do not support this version. We propose consider Option 1a. which seems to have majority support |
| Spreadtrum | We support Option 1a. PUCCH resource set should be determined based on total payload size, and if no HP HARQ-ACK resource is found for multiplexing, LP HARQ-ACK resource can also be considered. |
| CMCC | The proposal is not clear to us. As commented by Nokia, if total payload size of HP HARQ-ACK and LP HARQ-ACK is used, then it would be natural that one PUCCH resource set is selected. Moreover, we have one clarification question for the second sub-bullet “Select the HP HARQ-ACK resource between the two indicated by DCI”. If the DCI scheduling LP HARQ-ACK arrives later than the DCI scheduling HP HARQ-ACK, then which DCI is used for PUCCH resource determination if HP PUCCH resource is selected? If R15/16 principle is followed and PRI field in the “last DCI format” (DCI scheduling LP HARQ-ACK) is responsible for PUCCH resource determination, then the logic would be DCI scheduling LP HARQ-ACK corresponds to a HP PUCCH-Config when multiplexing? |
| ZTE | Support |
| Huawei, HiSilicon  | We can understand the effort from FL to make this proposal to address concern from all sides, however we still cannot agree on using HP resource to carry the multiplexed UCI. As commented before, the concern on using HP PUCCH resource is that gNB is not able to identify if the multiplexing is done or not between low priority UCI and high priority UCI, which will result in ambiguity at UE and gNB side. For explicit indication in DCI proposed by some companies to address the issue, it will increase the DCI overhead. In addition, it may not work well in the cases involving SR and/or configured PUSCH. |
| CATT | The two sub-bullets are not clear to us. |
| Vivo | Do not support the proposal, agree with Nokia.  |
| Sony | We share similar views with Nokia, i.e. the proposal isn’t clear. We prefer a simple solution, i.e. Option 1a. |
| Ericsson | Proposal is not clear. What is “dedicated PUCCH resource”?Also, important to clarify PUCCH resource sets from high priority (second PUCCH-Config)Update proposal:For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,* ~~If no dedicated PUCCH resource is configured,~~
	+ Determine ~~the~~ a PUCCH resource set~~s~~ from second PUCCH-Config for HP HARQ-ACK and LP HARQ-ACK respectively according to the total payload size ~~by merging~~ of LP HARQ-ACK and HP HARQ-ACK.
	+ Select the HP HARQ-ACK resource ~~between the two~~ indicated by the corresponding DCI

FFS whether dedicated PUCCH resources can be configured for the multiplexing HP HARQ-ACK and LP HARQ-ACK |
| Samsung | We are general fine with Ericsson’s update proposal, just would like to clarify as followingUpdate proposal:For multiplexing a high-priority (HP) HARQ-ACK with a scheduling DCI and a low-priority (LP) HARQ-ACK into a PUCCH in R17,* ~~If no dedicated PUCCH resource is configured,~~
	+ Determine ~~the~~ a PUCCH resource set~~s~~ from second PUCCH-Config for HP HARQ-ACK and LP HARQ-ACK respectively according to the total payload size ~~by merging~~ of LP HARQ-ACK and HP HARQ-ACK.
	+ Select the HP HARQ-ACK resource ~~between the two~~ indicated by the corresponding DCI

FFS whether dedicated PUCCH resources can be configured for the multiplexing HP HARQ-ACK and LP HARQ-ACK |
| Sharp | Do not support. Option 1a is preferred. Also, the total payload method is applicable for joint coding only. For separate coding, the total payload should consider the different max coding rates of HARQ-ACK with different prioprities. |
| Panasonic | We are fine with the update proposal by Ericsson. |
| InterDigital | Agree with above concerns. Suggest to agree on using the resource indicated for HP HARQ-ACK as a first step before going into details (Option 1a). |
| DOCOMO | Do not support the proposal. The proposal is not clear to us. |
| QC | We agree with the spirit of the proposal. But the formulation of the proposal has some problem. It excludes the resource selection as a way to do multiplexing. And we think in some cases, resource selection should be considered. For example, the cases for resource selection are the following: case 1: HP HARQ-ACK in PF1 overlaps with LP SR in PF1; case 2: LP HARQ-ACK in PF1 overlaps with HP SR in PF0; Case 3: HP SR in PF1 overlaps with LP HARQ-ACK in PF0; Case 4: HP SR in PF1 overlap with LP HARQ-ACK in PF1. |
| NEC | The proposal is not clear to us.For the first sub-bullet, not clear of the motivation to determine two PUCCH resource sets with different priorities. In our understanding, it seems determine a HP PUCCH resource set is sufficient. gNB is expected to configure HP resource such that latency and reliability of HP HARQ-ACK is satisfied when intra UE HARQ-ACK multiplexing is supported. If such a HP PUCCH resource set cannot be found, whether to reselect a LP PUCCH resource set or directly drop LP HARQ-ACK can be FFS.  |
| WILUS | We support the proposal in principle in case that dedicated PUCCH resources for multiplexing is not supported. However, since overall PUCCH resource set and PUCCH resource selection rule could depend on configurability of the dedicated PUCCH resource, we think RAN1 discuss first whether to introduce dedicated PUCCH resources for multiplexing. |
| OPPO | Proposal is not clear.  |

## How to minimize impact on the latency for high-priority HARQ-ACK?

* Option 1: Multiplexing LP UCI with HP UCI is allowed only when the PUCCH carrying the multiplexed UCI ends no later than the PUCCH carrying HP UCI.
	+ HW, ITRI, ZTE
* Option 1a: The latency requirement can be defined as the ending symbol of PUCCH resource for multiplexed UCI transmission is not later than X symbols after the ending symbol of PUCCH for the higher priority UCI. FFS value of X.
	+ CATT, LG, CMCC
* Option 2: Controlled by gNB by dynamic indication whether to multiplex LP with HP or not.
	+ Ericsson, Nokia/NSB

|  |  |
| --- | --- |
| Company | Comments |
| LG | We prefer Option 1a (as added in the above). We think Option 1 which always requires early ending of multiplexed PUCCH than HP PUCCH, would force unnecessary tight requirement in some cases.  |
| Sony | If the HP PUCCH resource is used to carry the mux UCI then the latency is always met. Option 1 will be automatically met. |
| Sharp | Not sure if this is an issue. All HP PUCCH resources should be configured to satisfy the latency requirements. Therefore, if a HP PUCCH resource is used, the new selected HP PUCCH should be within the same subslot/slot of the original HP PUCCH resource.So, this problem can be discussed after PUCCH resource determination in 2.3.3. |
| Samsung | Both options should not be supported. The latency can be ensured by gNB scheduling. E.g., sub-slot length for PUCCH configuration. If HP PUCCH resource is used as the result PUCCH after MUX, the latency can be controlled within the HP sub-slot boundary. Note that UCI can be multiplexed in the PUSCH in Rel-16 and there are no conditions – it is a gNB implementation issue. |
| DOCOMO | Slightly prefer Option 1a but this could be discussed with the timeline in 2.2.3. |
| InterDigital | Option 1. However, this may not add restriction in practice if multiplexing is on a HP PUCCH. |
| NEC | Option 1 implies that the latency requirement for HP UCI is always met. |
| Intel | Ok with either option |
| TCL | Option 1 could guarantee the low latency of HP UCI. |
| QC | We think option 1 and 1a are very similar. A WF can be formulated based on the commonality of the two schemes. For example, in option 1a, if X=0, then it seems automatically reduced to option 1. In other words, option 1 seems a special case of option 1a.  |
| ZTE | Option 1. It is a simple way to ensure the latency requirement of high priority UCI. |
| Xiaomi | Agree with Samsung. |
| OPPO | Both option 1 and 1a are not required.If PUCCH resource for multiplexing is selected from PUCCH resources for HP, latency is not an issue. |
| WILUS | If HP PUCCH resource is used for multiplexing, there is no impact on the latency |
| Panasonic | We agree with Sony. |
| CATT | Agree with QC that option 1 is a special case of option 1a. Depending on the multiplexing rule and scenario, the multiplexed UCI may not always multiplex on the HP channel, e.g. HP SR + LP HARQ-ACK so that the latency cannot be always ensured. |
| Huawei, HiSilicon  | We prefer option 1 for simplicity. As to the utilization of HP resource, as commented before it is not good from addressing the ambiguity perspective. In addition, we don’t think it can ensure no impact on latency as long as using the HP resource, especially if the sub-slot length is long, e.g. 7 symbol.  |
| Ericsson | We do not support any of these Options. We support Option 2.Our preference is Option 2. If there is issue with latency, gNB can decide to skip LP UCI. Other solutions impose a general restrictions for occasional cases that is not reasonable. |
| Nokia, NSB | In general, dynamic indication for enabling/disabling multiplexing could be used to avoid impacting the latency of HP HARQ-ACK, as discussed in our contributionWe are thus OK with the suggested option by Ericsson  |

#### 1st round proposal and discussion

Potential proposal 2.3.4:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* The latency requirement is defined as the ending symbol of PUCCH resource for multiplexed UCI transmission is not later than X symbols after the ending symbol of PUCCH for the higher priority UCI.
	+ FFS value of X.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Do not support the proposal.This is related to issue 2.3.5. Actually, the impact on latency can be avoided e.g. by relying on explicit indication for enabling/disabling multiplexing. Thus, issue 2.3.4 could be revisited after reaching a consensus on 2.3.5.  |
| Intel | Support. |
| Spreadtrum  | Do not support the proposal, agree with Nokia.  |
| CMCC | Support. |
| ZTE | Not support, it is fine to directly define the requirement without determining X. |
| Huawei, HiSilicon | We can support the proposal.  |
| CATT | Support. |
| Vivo | Do not support the proposal, agree with Nokia.  |
| Sony | This issue would be automatically resolved if:1. Agree that gNB indicates whether to mux or not
2. Use the HP PUCCH to carry the muxed UCI, in which case the latency is met and the above condition (with X=0) is automatically fulfilled.

Hence, we share similar view with Nokia that we can resolve the issue 2.3.4 and 2.3.5 first. |
| Ericsson | Disagree strongly with this proposal.Same concern as Nokia. This is not a proper way of design. |
| Samsung | Not support.We share similar views as Nokia and Ericsson. |
| Sharp | Not support. This should be discussed after 2.3.3.1 on PUCCH resource determination. If a HP PUCCH resource is selected, the selected PUCCH should be within the same subslot as the original HP PUCCH. Subslot level PUCCH configuration should already satisfy the latency requirements, no extra restriction is needed. |
| DOCOMO | Support |
| QC | We are fine with the proposal.  |
| NEC | Support |
| WILUS | Support. |
| OPPO | Not support, agree with Nokia. |

## Explicit indication for enabling multiplexing

* Option 1: Support explicit indication
	+ Vivo, E/// (semi-static and dynamic indication), ~~E/// (dynamic),~~ Samsung, ZTE, Nokia (dynamic), QC (RRC, robust and simpler), Sony (dynamic), Intel (configured DCI indication), ETRI (RRC+DCI field), Pana
	+ Arguments:
		- Straightforward method to select from Rel-16 and Rel-17 behaviors
		- Semi-static indication for periodic or predictable URLLC transmissions. Dynamic indication based on multiplexing conditions, e.g. latency requirement, channel condition, number of UCI bits.
* Option 2: Not support
	+ MTK
	+ Arguments:
		- Very complex to handle at the UE side and requires a lot of implementation effort as the UE needs to accommodate two scenarios for each case which will complicate the implementation.
* Option 3: Semi-static configuration with dynamic switching implicitly
	+ OPPO

**Further enhancements:**

Samsung proposal:

*Proposal 2: The UCI types with first priority that can be multiplexed on a PUCCH/PUSCH of a second priority are configurable by the network.*

QC proposal:

*Proposal 12: If the Rel-17 intra-UE multiplexing feature is enabled via RRC configuration, UCI multiplexing is performed conditioning on the delay of starting time and/or ending time of high priority UL transmissions due to multiplexing is less than a preconfigured delay threshold.*

WILUS proposal:

*Proposal 6: TDMed or FDMed mapping can be used to map UCIs with two priorities in a PUCCH.*

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | Option 1. UE can handle multiplexing (and can handle no multiplexing). There is no complexity issue by indicating one and allows the network to handle a variety of services and conditions. |
| Intel | Option 1 |
| TCL | Option 1 |
| QC | First of all, I think the issue is about semi-static RRC configuration vs dynamic indication by DCI. The issue is not about whether support explicit indication or not, if I understand the situation clearly.Regarding semi-static RRC configuration vs dynamic indication by DCI, RRC configuration to enable/multiplexing has to be supported as a baseline. This is not just for CG and DL SPS, but also for DG PDSCH and DG PUSCH. The reason is because: for fallback DCI, or for UE just go through initial access where the size of non-fall back DCI is not configured yet, the dynamic indication (either option 1a or option 1b) can not work. The situation is similar to the discussion of semi-static beta configuration vs dynamic beta indication in Rel-15. Semi-static beta configuration has be introduced as a baseline because the system has to work when dynamic beta indication is not available. So, we should agree on semi-static enabling of multiplexing between HP/LP first. Then we discuss if dynamic enabling of this feature is needed.  |
| ZTE | Option 1 |
| Xiaomi | Maybe UE can report its capability to gNB whether it support multiplexing or not. |
| OPPO | Option3. We do not see dynamic indication is required. We could dynamically switch between multiplexing and prioritization based on conditions.* For PUCCH multiplexed in PUSCH, beta configuration can be reused to indicate multiplexing or prioritization. If beta=0, prioritization otherwise, multiplexing.
* For PUCCH multiplexed in PUCCH, dropping rule based on PUCCH resource can be considered. If all LP UCI are dropped, it fall backs to prioritization.
 |
| WILUS | At least semi-static enabling/disabling would be beneficial at least for semi-statically configured PUCCHs (e.g., LP/HP-PUCCH for SPS HARQ-ACK). Dynamic indication for enabling multiplexing is FFS.  |
| Panasonic | Option 1 |
| CATT | We think semi-static enabling/disabling is sufficient. |
| Huawei, HiSilicon  | For explicit indication in DCI, it will increase the DCI overhead. In addition, it may not work well in the cases involving SR and/or configured PUSCH. |
| Ericsson | Option 1Strongly support Option 1 (dynamic indication on top of semi-static) As we mentioned earlier, we have to be careful how complicated the multiplexing procedures becomes. Our view is that mux procedure would be enabled by RRC.However, during operation, there will be cases that gNB should have the possibility to sip mux.  |

#### 1st round proposal and discussion

Potential proposal 2.3.5:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* Support a mechanism for gNB to enable/disable the multiplexing.
	+ FFS the type of the mechanism, e.g. DCI indication, RRC configuration~~Down-select from the following options for the mechanism:~~
		- ~~Option 1: RRC configuration~~
		- ~~Option 2: DCI indication~~
		- ~~Option 3: RRC configuration + DCI indication~~
	+ FFS other details.
* Support: Nokia/NSB, Intel, Spreadtrum, ZTE,TCL, vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, NEC, WILUS, OPPO
* Not support: HW/HiSi (use predefined rule)

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support the proposal.We think that Option 2 should be supported at least for the cases where the HP HARQ-ACK is dynamically scheduled. Difference of Option2 and 3 would need to be further clarified.  |
| Intel | Support |
| Spreadtrum | Support, and we prefer Option 2 as a starting point.  |
| ZTE | Support the FL’s proposal.  |
| Huawei, HiSilicon  | We still don’t support the proposal. We think some predefined rule can work well to determine whether to do the multiplexing or not. We don’t think gNB is able to judge well whether multiplexing can be done or not, especially if the the cases involving SR and/or configured PUSCH. In addition, the RRC solution is not flexible, the DCI solution would increase the DCI overhead.  |
| CATT | We support the proposal in principle and also would like to understand the difference between Option 2 and Option 3. |
| TCL | Support the FL’s proposal. |
| Vivo | Support the FL’s proposal. |
| Sony | Support the proposal |
| Ericsson | Support.Option 3 is our preference (dynamic indication **on top of** semi-static).  |
| Samsung | Support |
| Sharp  | Support  |
| Panasonic | Support the FL proposal. |
| InterDigital | Support |
| DOCOMO | Support |
| QC | Regarding semi-static RRC configuration vs dynamic indication by DCI, RRC configuration to enable/multiplexing has to be supported as a baseline. This is not just for CG and DL SPS, but also for DG PDSCH and DG PUSCH. The reason is because: for fallback DCI, or for UE just go through initial access where the size of non-fall back DCI is not configured yet, the dynamic indication (either option 1a or option 1b) can not work. The situation is similar to the discussion of semi-static beta configuration vs dynamic beta indication in Rel-15. Semi-static beta configuration has be introduced as a baseline because the system has to work when dynamic beta indication is not available. So, we should agree on semi-static enabling of multiplexing between HP/LP first. Then we discuss if dynamic enabling of this feature is needed.Our proposal is the following: Proposal: Support using RRC configuration to enable/disable Rel-17 intra-UE multiplexingFFS: Use dynamic DCI to enable/disable Rel-17 intra-UE multiplexing |
| NEC | Support  |
| WILUS | Support in principle. Intention of option 3 is not clear to us.  |
| OPPO | Support |

#### Void

#### 3rd round proposal and discussion

Potential proposal 2.3.5:

For multiplexing a high-priority (HP) HARQ-ACK and a low-priority (LP) HARQ-ACK into a PUCCH in R17,

* Support a mechanism for gNB to enable/disable the multiplexing.
	+ FFS the type of the mechanism, e.g. DCI indication, RRC configuration
	+ FFS other details.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We are fine with proposal. |
| Nokia, NSB | Support the proposal  |
| Ericsson | Support the proposal.However, the formulation suggests that DCI enabling/disabling on top of RRC enabling is excluded. The reason is that the proposal suggests to support “a mechanism”, and in FFS, each of these considered as “one mechanism”. Our understanding is that case is not precluded |
| Sharp | Support the proposal. |
| Apple | RRC configuration is preferred, there is no need to complicate the situation even more. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Multiplexing HARQ-ACK and SR with different priorities

E/// proposal:

[*Proposal 5 When PUCCH with HP SR overlaps with PUCCH with LP HARQ-ACK:*](#_Toc54415344)

1. [*For 1-2 LP HARQ-ACK bits: The PUCCH resource for HARQ-ACK is used for multiplexing of the HP SR and LP HARQ-ACK. If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the HARQ-ACK PUCCH resource.*](#_Toc54415345)

[*ii. For more than 2 LP HARQ-ACK bits: Rel-15 rules are used for multiplexing HARQ-ACK and SR in a PUCCH resource. If SR is positive, an offset (e.g. 1 PRB) is added to the starting PRB of the PUCCH resource.*](#_Toc54415346)

[*Proposal 6 When PUCCH with HP HARQ-ACK/SR overlaps with PUCCH with LP HARQ-ACK:*](#_Toc54415347)

1. [*First, a PUCCH resource set associated to HP HARQ-ACK based on the total number of HP HARQ-ACK/SR and LP HARQ-ACK is determined. Then, a PUCCH resource in the PUCCH resource set to carry both HP and LP HARQ-ACK based on the last DCI corresponding to the HP HARQ-ACK is determined.*](#_Toc54415348)

LGE proposal:

*Proposal #7: Consider to support HARQ-ACK + SR on HARQ-ACK PUCCH for the combination between LP HARQ-ACK of up to 2 bits on PF0 and HP SR on PF0/1.*

*Proposal #8: Consider to support HARQ-ACK + SR on HARQ-ACK PUCCH for the combination between LP HARQ-ACK of up to 2 bits on PF1 and HP SR on PF0.*

ZTE proposal:

*Proposal 3: Adopt the following rules to multiplex high priority SR and low priority HARQ-ACK.*

|  |  |  |  |
| --- | --- | --- | --- |
| *HARQ-ACK**SR* | *PUCCH format 0* | *PUCCH format 1* | *PUCCH format 2/3/4* |
| *PUCCH format 0* | *For positive SR, the UE transmits the PUCCH in the resource using PUCCH format 0 in PRB(s) for SR. The same way in Rel-15 can be reused for the UE to determine the value of  and  for computing the value of cyclic shift .**For negative SR, the UE transmits only a PUCCH with HARQ-ACK information.* | *For positive SR, the UE transmits only a PUCCH with the SR and drops the PUCCH with HARQ-ACK information.**For negative SR, the UE transmits only a PUCCH with HARQ-ACK information and drops the PUCCH with negative SR.* |
| *PUCCH format 1* | *For positive SR, the UE transmits the PUCCH in the resource using PUCCH format 1 in PRB(s) for SR. The value of cyclic shift of sequence, i.e., , of this PUCCH format 1 is determined by HARQ-ACK, and the bit, i.e., b(0), of this PUCCH format 1 is determined by SR**For negative SR, the UE transmits only a PUCCH with HARQ-ACK information and drops the PUCCH with negative SR.* | *Reuse Rel-15 rules.* |

Nokia proposal:

*Proposal 3.7: For the scenario where a PUCCH carrying high-priority SR overlaps with a PUCCH carrying low-priority HARQ-ACK, the SR is prioritized and the HARQ-ACK is dropped for all the cases of PUCCH format combinations except the case where both SR and HARQ-ACK are with PUCCH format 1.*

* *FFS whether to allow multiplexing of high-priority SR with PUCCH format 1 and low-priority HARQ-ACK with PUCCH format 1.*

*Proposal 5:*

* *For multiplexing a low-priority HARQ-ACK and a high-priority SR into a PUCCH, following HARQ-ACK/SR PUCCH format combination should be studied.*
	+ *High-priority SR and low-priority HARQ-ACK in a resource using PUCCH format 0*
	+ *High-priority SR in a resource using PUCCH format 0 and low-priority HARQ-ACK information bits in a resource using PUCCH format 1*
	+ *High-priority SR in a first resource using PUCCH format 1 and low-priority HARQ-ACK in a second resource using PUCCH format 1*
	+ *High-priority SR and low-priority HARQ-ACK in a resource using PUCCH format 2, 3, or 4*

*Proposal 6:*

* *For multiplexing a low-priority HARQ-ACK, a high-priority HARQ-ACK and high-priority SR into a PUCCH, following two procedures are studied.*
	+ *Option 1: UE first resolve the overlapping for PUCCH transmission of high-priority HARQ-ACK and high-priority SR. After resolving the overlapping, multiplexing of low-priority HARQ-ACK is handled.*
	+ *Option 2: How UCIs are concatenated up to certain size is handled as one step procedure, e.g., with the priority of high-priority HARQ-ACK > high-priority SR > low-priority HARQ-ACK.*

DCM proposal:

*Proposal 4:*

* *Agree the table for UE behavior on multiplexing eMBB HARQ-ACK and URLLC SR as a baseline. Further considerations are needed for down-selection.*

|  |  |  |
| --- | --- | --- |
|  | **URLLC SR PF0** | **URLLC SR PF1** |
| **eMBB HARQ-ACK PF0** | * Same as Rel-15/16 multiplexing for same priority using URLLC PF0
 | * Opt 1:
	+ If latency requirement can be fulfilled for eMBB PF0 resource, same as R15/R16 multiplexing for same priority, i.e. URLLC SR and eMBB HARQ-ACK multiplexed on eMBB PF0 resource.(possible reliability issue for URLLC SR);
	+ Otherwise, eMBB HARQ-ACK is dropped.
* Opt 2: eMBB HARQ-ACK transmitted on URLLC PF1 resource if URLLC SR positive, while eMBB HARQ-ACK transmitted on eMBB PF0 resource if URLLC SR negative.
 |
| **eMBB HARQ-ACK PF1** | * Opt 1:
	+ If latency requirement can be fulfilled for eMBB, URLLC SR and eMBB HARQ-ACK multiplexed by the new cyclic shift method on URLLC PF0 resource.
	+ Otherwise, eMBB HARQ-ACK is dropped.
* Opt.2: eMBB HARQ-ACK transmitted on URLLC PF0 resource if URLLC SR positive, while eMBB HARQ-ACK transmitted on eMBB PF1 resource if URLLC SR negative.
 | * Same as Rel-15/16 multiplexing for same priority
 |
| **eMBB HARQ-ACK PF2/3/4** | * Same as Rel-15/16 multiplexing for same priority
	+ Opt.1: using PUCCH resource set assigned for URLLC that can accommodate the total UCI bits.
	+ Opt.2: using the eMBB PUCCH resource with some restriction, e.g. timeline for latency requirement
 |

QC proposal:

***Proposal 2*: In NR Rel-17, if a HARQ-ACK transmission on PUCCH format 0 or PUCCH format 1 collide with one SR, the UE performs the actions in Table 1 to resolve the collision.**

Table 1. Collision resolution for overlapping HARQ-ACK and SR in NR Rel-17

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Ack: PF0, LP | Ack: PF1, LP  | Ack: PF0, HP | Ack: PF1, HP |
| SR: PF 0, LP | Same as Rel-15 (i.e., multiplex on HARQ-ACK resource).  |  Same as Rel-15 (i.e., drop SR) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | Same as Rel-15 (drop SR). |
| SR: PF1, LP  | Same as rel-15 (i.e., multiplex on HARQ-ACK resource) | Same as Rel-15 (RB selection) | Multiplex the HARQ-ACK and SR on the HARQ-ACK resource (as in Rel-15), with a power boost to the multiplexed transmission. | RB selection (as in Rel-15) but with the enhancement that, if SR is positive, the power of the PUCCH transmission follows the power of the HARQ-ACK resource. |
| SR: PF0, HP | Use the SR resource to transmit multiplexed SR and HARQ-ACK, with a power boost to the multiplexed transmission. | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. Otherwise, transmit HARQ-ACK on the SR resource.)  | Same as Rel-15 | Same as Rel-15 |
| SR: PF1, HP  | Perform RB selection (i.e., if SR is negative, then transmit HARQ-ACK on the HARQ-ACK resource. If SR is positive, transmit HARQ-ACK on the SR resource.) | Same as Rel-15 (i.e., RB selection).  | Same as Rel-15 | Same as Rel-15 |

*Proposal 3: In NR Rel-17, if a HARQ-ACK transmission on PUCCH format 2/3/4 collide with K SR transmissions including* $K\_{1}$ *HP SRs and* $K\_{2}$ *LP SRs, the UE append* $log\_{2}(1+K) $*bits to the HARQ-ACK payload. Furthermore, if any of the* $K\_{1}$ *HP SR is positive, the*$ log\_{2}(1+K) $*bits shall indicate a positive HP SR.*

Xiaomi proposal:

*Proposal 5: Solutions such as direct puncture or treating HP SR as HARQ-ACK/CSI bit in multiplexing can be considered for HP SR on LP PUSCH.*

CMCC proposal:

*Proposal 8: Multiplexing of LP HARQ-ACK and HP SR for all PF combinations are supported in case that the multiplexing conditions discussed above can be met and same multiplexing rule as Rel-15 can be considered.*

*Proposal 9: For multiplexing of HP SR with PF0 and LP HARQ-ACK with PF1, similar multiplexing rule with scenario of SR with PF1 and HARQ-ACK with PF1 can be used.*

Intel proposal:

*Proposal 8: Adopt the following tables for collision handling behavior of SR and HARQ-ACK of different priorities.*

Collision handling HP SR and LP HARQ-ACKs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **HARQ-ACK with PF0** | **HARQ-ACK with** **PF1** | **HARQ-ACK with PF2** | **HARQ-ACK with** **PF3 or PF4** |
| SR with PF0 | Multiplexed UCI is transmitted using PF0 on HARQ-ACK resource | Drop HARQ-ACK and transmit SR on SR resource | Multiplexed UCI is transmitted using PF 2 on HARQ-ACK resource or any other valid PUCCH resource based on PF 2 | Drop HARQ-ACK and transmit SR on the SR resource. |
| SR with PF1 | Multiplexed UCI is transmitted using PF 0 or 1 | Multiplexed UCI is transmitted using PF 1 on SR or HARQ-ACK resource |

Collision handling LP SR and HP HARQ-ACKs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **HARQ-ACK with PF0** | **HARQ-ACK with** **PF1** | **HARQ-ACK with PF2** | **HARQ-ACK with** **PF3 or PF4** |
| SR with PF0 | Multiplexed UCI is transmitted using PF0 on HARQ-ACK resource | Drop SR and transmit HARQ-ACK on HARQ-ACK resource | Multiplexed UCI is transmitted using PF 2 on HARQ-ACK resource if SR is with PF 0. SR is dropped if it is PF 1  | Multiplex HARQ-ACK and SR according to Rel-15 procedure. |
| SR with PF1 | SR is dropped | Multiplexed UCI is transmitted using PF 1 on HARQ-ACK resource |

## Multiplexing rule and order

E/// proposal:

*Resolve overlapping between PUCCH resources based on Rel-1****5 procedures where the overlapping is resolved starting from the first set of mutually overlapping PUCCH resources in a slot (a.k.a. set Q) until there are no overlapping PUCCH resources in the slot.***

*To determine a single PUCCH resource for a set of mutual****ly overlapping PUCCH resources with different priority, drop SR and CSI of low priority, if any. Then, use sub-slot PUCCH resources if there is a sub-slot HARQ-ACK PUCCH in the set, starting from the earlier and smaller sub-slot.***

Samsung proposal:

*Proposal 5: Intra-UE multiplexing should be performed in the following order,*

* *Step1: Multiplexing PUCCH(s) and/or PUSCH(s) with the same priority.*
* *Step2: Multiplexing PUCCH(s) and/or PUSCH(s) with the different priorities.*

Vivo proposal:

*Proposal 11: Define UCIs of different priorities multiplexing rule at least for the following cases*

* *LP HARQ-ACK using PF 1 and HP HARQ-ACK and LP SR using PF 0.*
* *HP HARQ-ACK using PF 1 and LP HARQ-ACK and HP SR using PF 0.*

ZTE proposal:

*Proposal 4: For the overlapping between more than two PUCCHs with different priorities UCI, the UE can first resolve overlapping between the same UCI type, and then resolve overlapping between different UCI types.*

Nokia proposal:

*Proposal 3.6: The scenario where a PUCCH carrying high-priority HARQ-ACK+SR overlaps with a PUCCH carrying low-priority UCI is handled in the same way as the scenario where a PUCCH carrying high-priority HARQ-ACK (only) overlaps with a PUCCH carrying low-priority UCI.*

Panasonic proposal:

*Proposal 4: For multiplexing a high-priority HARQ-ACK and a low-priority HARQ-ACK into a PUCCH, after resolving the overlapping for PUCCH transmissions of smaller priority index, UE procedure for multiplexing HARQ-ACK codebooks with different priority indexes should be performed.*

DCM proposal:

*Proposal 5:*

* *For collision handling among LP HARQ-ACK, HP HARQ-ACK, and HP SR, following UE behaviour is proposed:*
	+ *Step 1: multiplexing of HP HARQ-ACK and HP SR by following Rel-16 procedure.*
	+ *Step 2: multiplexing of the outcome of step 1 and LP HARQ-ACK by following Case 1.*

QC proposal:

*Proposal 4: In NR Rel-17, if a LP HARQ-ACK, a HP HARQ-ACK and an SR collide, the UE shall perform the following two steps*

* *Step 1: multiplex the LP HARQ-ACK and the HP HARQ-ACK by bundling the LP HARQ-ACK into X bits (e.g., X=1) and append the bundled X bits to the HP HARQ-ACK payload, and place the multiplexed HARQ-ACK on the HP HARQ-ACK resource*
* *Step 2: resolve the collision between the multiplexed HARQ-ACK and the SR (if any) by treating the multiplexed HARQ-ACK as high priority transmission, and by using the rules proposed in Table 1 or Proposal 3.*

Xiaomi proposal:

*Proposal 6: The R16 agreement about multiplexing/cancelling order is not applicable in some cases and needs to be reconsidered. It is more nature for UE to operate in a“first come first process” manner.*

CMCC proposal:

*Proposal 4: The low priority PUCCH/PUSCH and the first high priority PUCCH/PUSCH satisfying the multiplexing conditions are multiplexed only if the PUCCH/PUSCH carrying multiplexed UCI(s) and UL-SCH(s) do not overlap with any other high priority PUCCH/PUSCH.*

# Multiplexing UCIs of different priorities in a PUSCH

## Agreements in previous meetings

Agreements:

*Support multiplexing for following scenarios in R17:*

* *Multiplexing a low-priority HARQ-ACK in a high-priority PUSCH (conveying UL-SCH only).*
* *Multiplexing a high-priority HARQ-ACK in a low-priority PUSCH (conveying UL-SCH only)*
* *Multiplexing a low-priority HARQ-ACK, a high-priority PUSCH conveying UL-SCH, a high-priority HARQ-ACK and/or CSI.*
* *Multiplexing a high-priority HARQ-ACK, a low-priority PUSCH conveying UL-SCH, a low-priority HARQ-ACK and/or CSI.*

*For the above multiplexing scenarios,*

* *Support separate configurations of at least beta-offset values (FFS for alpha) for multiplexing with different priority combinations.*
	+ *FFS for other separate configurations.*
	+ *FFS: value range of beta-offset (e.g. <1).*
* *FFS the conditions, if needed, for multiplexing, e.g.*
	+ *FFS: Whether to support multiplexing in case a PUCCH/PUSCH overlaps with more than one PUCCH/PUSCH.*
	+ *Timeline requirements.*
* *FFS: details, if needed, of the multiplexing scheme, e.g.*
	+ *How to minimize impact on the latency for high-priority HARQ-ACK.*
	+ *How to multiplex the HARQ-ACK bits (e.g. multiplexing, bundling)?*
	+ *How to encode the UCIs with different priorities (e.g. separate coding vs. joint coding).*
	+ *How to guarantee the target code rate (e.g. payload control, multiplexing priority, LP HARQ-ACK compression/compaction).*
	+ *Explicit indication for multiplexing.*
	+ *Multiplexing rule and order (e.g. HP/LP multiplexing is after resolving collision within the same priority).*
	+ *How to handle multiplexing of UCI of different priorities and CG-UCI in a CG-PUSCH*

## Separate configurations for multiplexing with different priority combinations

## Number of separate configurations

* Option 1: Separate configurations for different UCI priorities
	+ Most of companies
* Option 2: Separate configurations for different UCI/PUSCH combinations
	+ QC, Intel

QC proposal:

*Proposal 5: In NR Rel-17, up to four sets of beta offset values can be configured to the UE to indicate separate beta offset values for the following cases:*

* *Multiplexing LP HARQ-ACK/UCI on LP PUSCH*
* *Multiplexing LP HARQ-ACK/UCI on HP PUSCH*
* *Multiplexing HP HARQ-ACK/UCI on LP PUSCH*
* *Multiplexing HP HARQ-ACK/UCI on HP PUSCH*

|  |  |
| --- | --- |
| Company | Comments |
| LG | It seems the title of Issue 3.2.1 is to be updated as “Number of separate configurations for beta-offsets”. Besides, observing QC proposal in the above, Option 1 and 2 seem to be the same way. |
| Sony | The title of 3.2.1 is unclear. I take it this is regarding whether to have separate beta-offset configurations depending on the priority of the UCI & priority of the PUSCH. If so, then Sony agrees to have different offsets. |
| Samsung | Option 1 should be supported. The necessity of Option 2 needs further discussion. |
| InterDigital | Option 2 (if this is about beta offsets, i.e. Proposal 5 above). For example, the fraction of resources for HP UCI in LP PUSCH needs to be higher than for HP UCI in HP PUSCH since in former case the LP PUSCH may be sent with lower power. |
| CMCC | Option 2If I understand correctly, separate configurations of beta-offset for different HARQ-ACK codebooks has already supported in Rel-16. In last RAN1 meeting, we have the following agreement and I suppose the “different priority combinations” here means different HARQ-ACK and PUSCH combinations, as listed in QC’s proposal. (Please correct me if I missed something)* *Support separate configurations of at least beta-offset values (FFS for alpha) for multiplexing with different priority combinations.*
 |
| NEC | The title of issue 3.2.1 is unclear for us. If our understanding is right that the option 1 means up to two sets beta-offset values can be configured, then we support option 2.  |
| Intel | We prefer Option 2 since it includes Option 1 and is more flexible. We added Intel to Option 2.**Also, note that the following bullet needs to be addressed by the group, but not captured in FL summary.*** + ***How to handle multiplexing of UCI of different priorities and CG-UCI in a CG-PUSCH***

**In our view, if CG PUSCH is transmitted, then CG-UCI should not be dropped, i.e., it becomes of high priority. We think the topic should be discussed in Intra-UE agenda.** |
| QC | Agree with LG. It is not clear to us the different between option 1 and option 2. I think another way to formulate the issue is: how many sets of beta offset values are needed? Our view is that 4 sets are needs to be configured, as listed in our proposal. I’d like to understand how many sets are needed in option 1 and which UCI/PUSCH scenario is each set for? |
| ZTE | Option1 |
| Xiaomi  | Agree with LG’s opinion. |
| OPPO | Option 2. We share the same view as CMCC. |
| WILUS | Option 2. We agree with CMCC that the “different priority *combinations*” means different HARQ-ACK and PUSCH combinations.  |
| Panasonic | We share the same view with CMCC. |
| CATT | Agree with LG. |
| Huawei, HiSilicon | Support option 2 because it is clear on what to the separate configurations are for. Option 1 is not that clear what the scheme is. |
| Ericsson | Option 1. We also understand the intention is configuration of beta offset as LG indicated. Good to clarify. |

#### 1st round proposal and discussion

Potential proposal 3.2.1:

In NR Rel-17, up to four sets of beta offset values can be configured to the UE to indicate separate beta offset values for the following cases:

* Multiplexing low-priority (LP) HARQ-ACK/UCI on LP PUSCH
* Multiplexing LP HARQ-ACK~~/UCI~~ on high-priority (HP) PUSCH
* Multiplexing HP HARQ-ACK~~/UCI~~ on LP PUSCH
* Multiplexing HP HARQ-ACK/UCI on HP PUSCH
* FFS how to determine the beta offset values
* Support: Nokia/NSB, Lenovo/Moto, Spreadtrum, CMCC, HW/HiSi, CATT, vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, QC, NEC, WILUS, OPPO
* Not support: Intel (consider other types of UCI), ZTE (RRC overhead)

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | We would like to clarify the scope of UCI in the potential proposal. Since the only scenarios considered are beta offset configuration for HARQ-ACK, suggest to remove UCI from the proposals. Suggested version as below:“In NR Rel-17, up to four sets of beta offset values can be configured to the UE to indicate separate beta offset values for the following cases:* Multiplexing low-priority (LP) HARQ-ACK/UCI on LP PUSCH
* Multiplexing LP HARQ-ACK~~/UCI~~ on high-priority (HP) PUSCH
* Multiplexing HP HARQ-ACK~~/UCI~~ on LP PUSCH
* Multiplexing HP HARQ-ACK/UCI on HP PUSCH “

Note: the 1st case and the last case are given by Rel-16 configuration. |
| Intel | We suggest to make general agreement first before identifying special cases. There can be other types of UCI, CG-UCI/P-CSI for which priority is under discussion.* Separate configurations for different UCI/PUSCH combinations

**Also, as there was an FFS point in agreement in last meeting and company has discussed this in tdoc, we suggest to note company proposal on CG-UCI multiplexing in a sub-section under Section 3** |
| Lenovo, Motorola Mobility | Support in principle. |
| Spreadtrum | Support in principle. |
| CMCC | Support in principle. |
| ZTE | Not support slightly. We think that when a UE determines to multiplex HARQ-ACK and PUSCH, which set of beta-offset values to select should refer to the priority of HARQ-ACK. It means that only two sets of beta-offset values are needed. Specifically, UE determines which set of beta-offset values is used according to the priority of HARQ-ACK scheduled by a DL DCI and which value in this set is used according to UL DCI that schedule the transmission of PUSCH. Of course, option 2 is more flexible, but it comes at the expense of RRC overhead. We doubt the necessity of configuring so many sets of beta-offset. |
| Huawei, HiSilicon | Fine with the proposal. |
| CATT | Support in principle.  |
| Vivo | Support in principle. |
| Sony | Support the proposal. |
| Ericsson | OK with proposal. Same comment as Nokia. What is meant by UCI? Considering the cases that CSI is involved?Proposal needs larification. |
| Samsung | OK with the proposal |
| Sharp | Support in principle. However, please clarify the mapping between the sets and use cases, e.g. one-to-one mapping between set and use case, or still need an indication. |
| Panasonic | Support the FL proposal. |
| InterDigital | Support |
| DOCOMO | Support |
| QC | Support the proposal |
| NEC | Support in principle. |
| WILUS | Support. |
| OPPO | Support |

## Value range of beta-offset

* Option 1: Support beta-offset < 1 at least for LP UCI multiplexing on HP PUSCH carrying data
	+ HW, E///, ZTE (such as 0.8, 0.5), Nokia (e.g. 0) , Pana (e.g. 0, specific and non-numerical value), MTK, Spreadtrum (e.g. 0), DCM, CMCC, Intel (e.g. 0) , vivo
	+ Arguments:
		- Better protection of the HP data transmission.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Agree that we should have beta-offset < 1, at least for beta-offset = 0. This should only be applicable when the UCI is LP and the PUSCH is HP (hence the need for separate set of beta-offsets). |
| Samsung | Support Option 1 |
| InterDigital | Agree (Option 1) |
| CMCC | Option 1 |
| NEC | Support option 1.  |
| Intel | Support Option 1, however we do not need to capture any condition. It is up to gNB configuration.* Option 1: Support beta-offset < 1
 |
| QC | We don’t see introduce beta<1 is necessary. Beta<1 seems only useful when LP HARQ-ACK is multiplexed on HP PUSCH and it is useless in other scenarios. It seems too much unnecessary effort to introduce this feature only for a single use case. For this particular use case, there are other alternatively to achieve same goal. Alt 1: use alpha value to protect the HP PUSCH. Alt 2: compress the LP UCI to reduce the RE usage of UCI thus protect the HP PUSCH. At least, before the pros and cons of different alternatives are studied/discussed, we don’t think beta<1 should be introduced.  |
| ZTE | Support option 1. Explicit indication for enabling multiplexing discussed in section 2.3.5 has the same functionality with setting beta-offset=0. |
| Xiaomi | Support option 1. |
| OPPO | Support |
| WILUS | We are ok to support beta\_offset<0. Beta\_offset =0 is one way to indicate enabling/disabling multiplexing so that it can discussed in 3.4.4.  |
| Panasonic | Support Option 1 |
| CATT | Support option 1. |
| Huawei, HiSilicon | Support option 1, which is a simple to protect the high priority PUSCH.  |
| Ericsson | Support Option 1 |

QC proposal:

*Proposal 6: In Rel-17, if both HP and LP UCI can be piggybacked on a PUSCH at the same time, the beta offset can be indicated via the following:*

* *Option 1: One beta offset field (2 bits) is configured in the DCI that schedules the PUSCH, if the HP and LP UCI are jointly encoded*
* *Option 2: Two separate beta offset fields (in total 4 bits) are configured in the DCI that schedules the PUSCH, if the HP and LP UCI are separately encoded.*

#### 1st round proposal and discussion

Potential proposal 3.2.2:

Support beta-offset < 1 ~~at least for low-priority (LP) UCI multiplexing on high-priority (HP) PUSCH carrying data~~

* ~~At least beta-offset = 0 is supported. FFS other values.~~
* Support: Nokia/NSB, Intel, Spreadtrum, CMCC, ZTE, HW/HiSi, CATT, vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, NEC, WILUS, OPPO
* Not support: QC (consider other alternatives for the same target)

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | We would like to clarify the scope of UCI here in the proposal. Since the only scenarios considered are beta offset configuration for HARQ-ACK, suggestion to remove UCI from the proposals. Suggested version as below:“Support beta-offset < 1 at least for low-priority (LP) HARQ-ACK ~~UCI~~ multiplexing on high-priority (HP) PUSCH carrying dataAt least beta-offset = 0 is supported. FFS other values.” |
| Intel | Beta offset is part of configuration and it is up to gNB. We only need to decide Support beta-offset < 1. Capturing a certain case is not needed. So suggest revision as Support beta-offset < 1 At least beta-offset = 0 is supported. FFS other values |
| Spreadtrum | Support in principle, and agree with Intel’s revision.  |
| CMCC | Support in principle. |
| ZTE | Partially support. We support the main bullet, but object to the sub-bullet. The reason can be found in above table. |
| Huawei, HiSilicon | Fine with the proposal.  |
| CATT | Support |
| vivo | According to the current Beta offset configuration, for PUSCH with data and without data, them share the same Beta offset configuration. It is no need to capture “carrying data”. |
| Sony | Support the principle. Do note that beta-offset = 0 cannot be used to mux HP UCI into LP PUSCH as this will result in HP UCI being dropped. We can alternatively allow an entry in the beta-offset to simply means “No Multiplexing” which would means dropping the LP channel (i.e. LP UCI or LP PUSCH). |
| Ericsson | Support. |
| Samsung | Support |
| Sharp | Support |
| Panasonic | Support the FL proposal. |
| InterDigital | Support |
| DOCOMO | Support |
| QC | We don’t see introduce beta<1 is necessary. Beta<1 seems only useful when LP HARQ-ACK is multiplexed on HP PUSCH and it is useless in other scenarios. It seems too much unnecessary effort to introduce this feature only for a single use case. For this particular use case, there are other alternatively to achieve same goal. Alt 1: use alpha value to protect the HP PUSCH. Alt 2: compress the LP UCI to reduce the RE usage of UCI thus protect the HP PUSCH. At least, before the pros and cons of different alternatives are studied/discussed, we don’t think beta<1 should be introduced. |
| NEC | Support the main bullet. |
| WILUS | Support. |
| OPPO | Support |

## Separate configurations of alpha values?

* Yes
	+ HW, LGE, Nokia, Spreadtrum, CMCC, Sony, Samsung, DCM, NEC, Pana, CATT
	+ Arguments:
		- To guarantee HP PUSCH reliability (with LP UCI piggybacking), similar to the reason for beta offset.
		- R16 has supported separate alpha values for HP PUSCH and LP PUSCH.
* No
	+ E///, Intel
	+ Arguments:
		- The same goal on controlling number of REs can be achieved with combination of alpha and different beta values

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Alpha factor determines how much of PUSCH resources can be used for UCI. Here it should depends on whether the UCI is LP or HP since we do not want a HP PUSCH to use up too much resources for a LP UCI. Threfore, we should have separate alpha values for the different UCI priorities. |
| Samsung | YesSeparate configurations of alpha values can provide additional flexibility. Alpha is used to control the ratio of UCI to UL data. This ratio can be different for LP and HP UCI on a same PUSCH. |
| DOCOMO | We are also supportive for separate alpha values to guarantee HP PUSCH reliability. |
| InterDigital | Same reason as for beta offset. |
| CMCC | Alpha is used to limit the number of resource elements assigned to UCI on PUSCH, so smaller alpha may be expected for LP HARQ-ACK multiplex on HP PUSCH to ensure that enough resources are reserved for HP PUSCH, while for HP HARQ-ACK multiplex on HP PUSCH, both the reliability of HP HARQ-ACK and HP PUSCH needs to be guaranteed. Therefore, different alpha values need to be configured. |
| NEC | We support separate configurations of alpha values for different UCI/PUSCH combinations. |
| Intel | NoWe do not think separate configuration for alpha is strictly needed. Number of REs can be flexibly controlled by choosing separate beta offsets, for a given alpha. |
| QC | Separate alpha value for HP and LP PUSCH looks reasonable.  |
| ZTE | Yes. Is it common understanding that R16 has supported separate alpha values for HP PUSCH and LP PUSCH? In our comprehension, only one alpha set is configured for a PUSCH with specific priority if the PUSCH is scheduled by a specific DCI format in R16, whereas the intention here is to support two alpha sets for a PUSCH with specific priority scheduled a specific DCI format since a DCI format can scheduled a PUSCH with different priorities in R17. |
| OPPO | Reuse Rel-16 rule, separate alpha values for HP PUSCH and LP PUSCH |
| WILUS | Yes. Separate alpha values are beneficial to protect HP/LP PUSCH differently.  |
| CATT | Section 3.2.4 is talking the same thing. |
| Huawei, HiSilicon | We slightly prefer Yes from flexibility perspective, However, we agree with some companies that separate configuration for alpha is not that necessary, since the motivation can be achieved by different setting of beta offset also. |
| Ericsson | NoAs we explained, the gNB can achieve the goal by combination of alpha and beta.  |

#### 1st round proposal and discussion

Potential proposal 3.2.3:

For HARQ-ACK~~/UCI~~ multiplexing on PUSCH,

* Support separate configurations of alpha values for multiplexing with different priority combinations.
	+ FFS values
* Support: Nokia/NSB, Lenovo/Moto, Spreadtrum, CMCC, CATT, Sony, Samsung, IDC, DCM, QC, NEC, WILUS
* Not support: Intel, ZTE, E///, OPPO

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Removing UCI from the proposal, then we are fine.“For HARQ-ACK/UCI multiplexing on PUSCH, * Support separate configurations of alpha values for multiplexing HARQ-ACK with different priority combinations.”
 |
| Intel | Not essential. Different beta offset configurations seem to be sufficient. |
| Lenovo, Motorola Mobility | Support |
| Spreadtrum | Support |
| CMCC | Support |
| ZTE | Not support fully. The UE determines of sets of alpha values should refer to the priority of HARQ-ACK/UCI rather than different priority combinations of HARQ-ACK/UCI and PUSCH. Same reason as 3.2.1.1. |
| CATT | Support |
| Sony | Support |
| Ericsson | Not support. We are not convinced yet additional parameter is needed. Separate beta offset should be sufficient. |
| Samsung | Support |
| InterDigital | Support |
| DOCOMO | Support |
| QC | Fine with the proposal. |
| NEC | Support |
| WILUS | We support the proposal in principle. Similarly as in 3.2.1, it needs to discuss how many alpha values are configurable.  |
| OPPO | Not support. We share same comment as Intel and Ericsson. |

## Other separate configurations?

* Higher layer parameter *scaling* in the *UCI-OnPUSCH* IE
	+ CATT

## Conditions for multiplexing

## Whether to support multiplexing in case a PUCCH/PUSCH overlaps with more than one PUCCH/PUSCH

* Support
	+ E///, ~~Samsung~~, ZTE, CMCC, Intel, LG, Sharp, DCM, NEC, ETRI

**Is it related to multiplexing between two PUCCH/PUSCH?**

* Leave this question open before the UCI multiplexing rule for two overlapping PUCCHs is clear.
	+ HW
* RAN1 needs to take the cases of more than two overlapping channels (involving at least one PUSCH) of different priorities into account when deciding whether to support certain multiplexing enhancements in first place.
	+ This is specifically of importance when considering the support of multiplexing of high-priority UCI on low-priority PUSCH.
	+ Nokia

|  |  |
| --- | --- |
| Company | Comments |
| LG | Support of the multiplexing is preferred (as added in the above). We are understanding this case is differentiated from the issue 3.3.3 below, in terms of whether the overlapping channels are all within a same time unit (all are within a same slot or sub-slot in this case). |
| Sony | We support more than one PUCCH/PUSCH multiplexing but agree with HW that we should consider this when the multiplexing rules for one pair of colliding PUCCH/PUSCH is clear. |
| Sharp | This is a valid problem esp. for HP HARQ-ACK multiplexing on LP PUSCH. It is better to consider this issue on the design of UCI multiplexing, esp. on the multiplexing location, e.g. starting symbol, and latest symbol, etc.  |
| Samsung | The proposal is not clear to us. Multiplexing of a PUCCH overlaps with more than one PUCCH is discussed under 2.2.2. This case should be excluded under this issue.Multiplexing in case a PUCCH overlaps with more than one PUSCH is supported in Rel-15 and Rel-16, no need further discussion.Multiplexing in case a PUSCH overlaps with more than one PUSCH should not be supported.Multiplexing in case a PUSCH overlaps with more than one PUCCH may depends on the order of MUX. |
| DOCOMO | We prefer to support it but it should be discussed after single PUCCH/PUSCH collision case. |
| InterDigital | Support the scenario of multiplexing 2 PUCCHs and 1 PUSCH. This is already agreed since we have agreed on e.g. scenario HP HARQ-ACK + LP HARQ-ACK + LP PUSCH. |
| NEC | We support multiplexing in case a PUCCH/PUSCH overlaps with more than one PUCCH/PUSCH if the requirements of HP data/UCI can be met. |
| Intel | Support the scenario. RAN1 needs to identify suitable UE behavior. Some of the cases are already agreed as InterDigital mentioned |
| ZTE | Support, We agree to prioritize the discussion on the UCI multiplexing rule for two overlapping channels. For more than 2 overlapping channels, we can discuss later. |
| Xiaomi | Agree with HW that we should consider this later. |
| OPPO | Support |
| WILUS | Support this case but deprioritize this case after defining UE behaviors for a PUSCH overlapping with single PUCCH.  |
| CATT | Support |
| Huawei/HiSilicon  | Our intention is not to preclude the chance to do multiplexing in case a PUCCH/PUSCH overlaps with more than one PUCCH/PUSCH at early stage, thus feel safer to do the decision after we achieve consensus on how to do the multiplexing for two channels. Therefore, our final target is to support at least for some cases if conditions (e.g. multiplexing timeline, latency requirement, specific overlapping scenarios) are met, however I think we will have to discuss the conditions at later stage.  |
| Ericsson | SupportWe agree that this question is better answered when procedure for resolution of overlapping between PUCCHs are clarified which makes it clear what are the PUCCHs that may be multiplexed on PUSCH.  |
| Nokia, NSB | We share similar view as Samsung. It should be clarified what scenarios exactly are we considering here; also the title of this subsection is not fully clear. |
| Spreadtrum | We agree with Samsung that the multiplexing condition should be further clarified. At least one PUSCH overlaps with more than one PUCCHs should be supported.  |

ZTE proposal:

***Proposal 7:*** *For the overlapping between more than two PUCCH with different priorities and low/high priority PUSCH,*

* *the UE first resolves overlapping channels between the same UCI type, e.g., high priority HARQ-ACK and low priority HARQ-ACK,*
* *then resolves overlapping channels between UCI and low/high priority PUSCH if the overlapping still exists after overlapping processing between the same UCI type.*

Intel proposal:

*Proposal 11: If a PUSCH overlaps with two sub-slot based PUCCHs, multiplex the UCIs from the PUCCHs onto the PUSCH if timeline conditions are met. If timeline conditions are not met, drop the low priority channel and transmit the high priority channel.*

* *FFS: whether to apply Rel16 intra-UE prioritization in this case.*

*Proposal 12: If a PUCCH overlaps with two PUSCHs, following behaviors can be considered, assuming timeline conditions are met:*

* *If PUCCH is of high priority, PUCCH is multiplexed onto first PUSCH.*
* *If first (second) PUSCH is of high (low) priority, UCI from PUCCH is multiplexed onto second PUSCH if the PUCCH is of low priority.*

*Proposal 13: If a PUSCH overlaps with a PUCCH repetition in a slot, multiplex the UCI onto the PUSCH and drop the PUCCH repetition.*

* *FFS whether this is only applicable if PUSCH is of high priority and/or PUCCH is of low priority.*

## Timeline requirements

* Option 1: Reuse R15 timeline (or as the starting point)
	+ HW, vivo, CATT, Nokia, IDC, QC, Xiaomi, CMCC, Sharp, ZTE, Pana, Ericsson

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We should at least meet Rel-15 timeline, i.e. use this as starting point. |
| Sharp | The Rel-15 timeline can be the start point to determine the starting symbol for UCI multiplexing on PUSCH. |
| Samsung  | TBD |
| DOCOMO | We prefer to define new timeline requirement as presented in 2.2.3 for more possibility of multiplexing, which would lead to better eMBB performance. |
| InterDigital | Option 1. |
| Intel | Option 1 as starting point |
| TCL | Option 1 |
| QC | Reuse Rel-15 timeline can be reused here, because Rel-15 timeline is defined with respect to UL and DL processing capabilities, which is transparent/orthogonal to what priorities of the channels are. Adding two different priorities into the multiplexing scenario does not impact the decision on timeline. |
| ZTE | Support. At present, there is no problem with the R15 timeline, but the UE behavior should be clarified when the timeline is not met. |
| OPPO | Option 1 is starting point. |
| WILUS | Option 1 as baseline |
| CATT | Option 1 |
| Huawei, HiSilicon  | Rel-15 timeline should be met with necessary additional conditions if needed. e.g. multiplexing is only allowed when the ending symbol of the PUSCH (or the ending symbol of REs carrying HP HARQ-ACK on PUSCH) is no later than the ending symbols of PUCCHs carrying HP HARQ-ACK. |
| Ericsson | Option 1No need to update timeline requirements |

#### 1st round proposal and discussion

Potential proposal 3.3.2:

For multiplexing ~~UCI~~HARQ-ACKs of different priorities in a PUSCH in R17,

* Reuse R15 timeline as the starting point.
* FFS additional conditions, if any.
* **Support:** Nokia/NSB, Intel, Lenovo/Moto, Spreadtrum, CMCC, ZTE, HW/HiSi, CATT, TCL, vivo, Sony, E///, Sharp, Pana, IDC, DCM, QC, NEC, WILUS, OPPO
* **Discuss later:** Samsung

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support the proposal with the following change (i.e. changing UCI to HARQ-ACK):“For multiplexing ~~UCIs~~ HARQ-ACKs of different priorities in a PUSCH in R17, * Reuse R15 timeline as the starting point.

FFS additional conditions.” |
| Intel | Agree |
| Lenovo, Motorola Mobility | Support in principle. |
| Spreadtrum | Support in principle. |
| CMCC | Support |
| ZTE | Support FL’s proposal. |
| Huawei, HiSilicon | Support the FL propsal |
| CATT | Support |
| TCL | Support |
| vivo | Support in principle. |
| Sony | Support |
| Ericsson | Support in case following changes are made.Updated proposal:For multiplexing UCIs of different priorities in a PUSCH in R17, * Reuse R15 timeline as the starting point.
* FFS on whether to consider additional conditions.
 |
| Samsung | Not support at the moment. We can revisit later. |
| Sharp | Support in principle |
| Panasonic | Support the FL proposal and the updated proposal by Ericsson is also fine. |
| InterDigital | Support.Ok with original “FFS”, but to address Ericsson concern I would rather use this wording (FFS already means to study):“FFS additional conditions, if any” |
| DOCOMO | Support in principle. |
| QC | Support the proposal |
| NEC | Support |
| WILUS | Support |
| OPPO | Support the updated proposal by Ericsson |

## Whether to support multiplexing in a PUSCH not confined within a sub-slot

* Multiplexing of HARQ-ACK on PUSCH resource only if the PUSCH resource is contained within the sub-slot configured for the HARQ-ACK which would multiplex with the PUSCH.
	+ CATT, LG

|  |  |
| --- | --- |
| Company | Comments |
| LG | We also prefer to allow multiplexing of HARQ-ACK on PUSCH resource only if the PUSCH resource is contained within the sub-slot configured for the HARQ-ACK. |
| Samsung | Multiplexing in a PUSCH not confined within a sub-slot is supported in Rel-16.  |
| InterDigital | It depends on the priorities of HARQ-ACK and PUSCH. If the HARQ-ACK is LP, multiplexing on PUSCH may be allowed. |
| TCL | We support multiplexing in a PUSCH not confined within a sub-slot. |
| ZTE | Not agree. A PUSCH with low priority usually takes more OSs in time domain, which means it is likely to cross the sub-slot boundary. Such restriction proposed by CATT will lead the PUSCH with low priority be dropped in most cases. So the PUSCH resource should not be confined in the sub-slot. |
| OPPO | Support |
| WILUS | We prefer to keep legacy UCI multiplexing rules if the timeline is met, i.e, HARQ-ACK is mapped to earliest non-DM-RS symbol(s) after the first DM-RS symbol(s). This rule provides low latency and high reliability to HARQ-ACK.  |
| CATT | Support. We would like to avoid the following case. |
| Huawei, HiSilicon  | We should support multiplexing in a PUSCH not confined within a sub-slot, otherwise it will be too restricted considering it is very likely the low priority PUSCH would be long. As to the latency, some other mechanism can be used to reduce the impact also, e.g. multiplexing is only allowed when the ending symbol of the PUSCH (or the ending symbol of REs carrying HP HARQ-ACK on PUSCH) is no later than the ending symbols of PUCCHs carrying HP HARQ-ACK |
| Ericsson | No. We don’t supportInstead by explicit dynamic indication, we would disable multiplexing if NW sees an issue.In all discussion, it appears that if a transmission is confined within a sub-slot, the delay requirements are not met. This is a wrong assumption for system design. Sub-slot is RRC configured and can improve delay. However, it does not mean that there would be always issue with a transmission that fall outside sub-slot, occasionally. |

## Details for multiplexing schemes

## How to encode the UCIs with different priorities (e.g. separate coding vs. joint coding)

* Option 1: Separate coding
	+ HW, Nokia, NEC, Intel, WILUS, LG, Sharp, Samsung, DCM ,CMCC, NEC, ZTE, ETRI, vivo, Pana, Ericsson
	+ Arguments:
		- Match different reliability requirements to different maximal coding rate.
		- Separate beta-offsets are supported for different priority combinations.

|  |  |
| --- | --- |
| Company | Comments |
| LG | We also prefer separate coding (as added in the above). |
| Sony | Separate coding. |
| Sharp | Separate coding |
| Samsung | Support Option 1. |
| DOCOMO | Support Option1. |
| InterDigital | Option 1 as baseline. |
| NEC | Support Option 1.  |
| Intel | Option 1 |
| QC | Same reason as we expressed in Section 2.3.1, we disagree with separate encoding and prefer joint encoding with compression of LP UCI.  |
| ZTE | Support. |
| OPPO | Support option1, separate coding |
| WILUS | Option 1.  |
| vivo | We prefer separate coding in fact. But one issue may be related with the discussion is the maximum number of separate coding UCI types when UCI multiplexed on PUSCH. In R15, it is 3, i.e., HARQ-ACK, CSI part 1 and CSI part 2. And in R16 NRU CG-UCI discussion, this limit is kept considering UE’s implementation complexity. For encoding the UCIs with different priorities, it should be clarified firstly whether the number of separately encoded UCIs need be extended for UCI on PUSCH. |
| CATT | Support |
| Huawei, HiSilicon  | We also think that option 1 should be supported from different protection on UCI of different priorities perspective. In addition, since we have separate configuration of beta offset for different prioirities, it would be straightforward to use separate coding here.  |
| Ericsson | Support Option 1 |

IDC proposal:

*Proposal 6: For the scenario of low-priority and high-priority HARQ-ACK multiplexed in PUSCH, RAN1 supports solution that allows for PUSCH decodability if one HARQ-ACK codebook has less than 2 bits and the UE misses the corresponding DL assignment*.

#### 1st round proposal and discussion

Potential proposal 3.4.1:

For multiplexing ~~UCI~~HARQ-ACKs of different priorities in a PUSCH in R17,

* Support separate coding for the ~~UCI~~HARQ-ACKs with different priorities.
	+ FFS for conditions.
* FFS for other UCIs
* **Support:** Nokia/NSB, Intel, Lenovo/Moto, Spreadtrum, CMCC, ZTE, HW/HiSi, CATT, vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, NEC, WILUS, OPPO
* **Not support:** QC

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support the proposal with the following change (i.e. changing UCI to HARQ-ACK):“For multiplexing ~~UCIs~~ HARQ-ACKs of different priorities in a PUSCH in R17, Support separate coding for the ~~UCIs~~ HARQ-ACKs with different priorities.” |
| Intel | Support FL’s proposal. Do not support Nokia’s change. As mentioned above, it has been under discussion whether other UCI types can have a priority associated. |
| Lenovo, Motorola Mobility | Support |
| Spreadtrum | Support |
| CMCC | Support |
| ZTE | Support FL’s proposal. |
| Huawei, HiSilicon | Support the FL proposal  |
| CATT | Support |
| vivo | Support the proposal in principle. Can leave FFS for detailed conditions. |
| Sony | Support |
| Ericsson | Support |
| Samsung | Support |
| Sharp  | Support  |
| Panasonic | Support the proposal in principle. We agree with vivo’s comment. |
| InterDigital | Support |
| DOCOMO | Support |
| QC | In general, we have concerns on separate encoding. 1. Need new rate matching and RE mapping rule for HP UCI and LP UCI mux on PUCCH, and HP UCI and LP UCI multiplexing on PUSCH. Quite significant spec impact is a factor we need consider. On the other hand, if joint encoding is adopted, then Rel-15 RM and RE mapping rules can be reused.
2. How many Polar encoder UE needs to budget for the worst case? It seems 6 to me: HP HARQ-ACK, LP HARQ-ACK, HP CSI-part 1, LP CSI-part 1, HP CSI-part 2, LP CSI-Part 2, if RAN1 allow simultaneous HP and LP CSI. Even if considering to drop LP CSI, it seems 4 Polar encoder is needed for the worst case, which increase UE implementation complexity. Of course, if it is well justified, we are OK to accept proposal which increase UE complexity and cost. However, we don’t see strong justification to do separate encoding.

The advantage of separate encoding is not well justified. Please see the following. Regarding this “Joint coding cannot provide distinguished latency/reliability protections for UCIs of different priorities.” – If UE compress LP UCI and treat compressed HARQ-ACK as if it is HP UCI. Latency/reliability of both HP/LP UCI can be achieved. For the lost info due to compression, if gNB want, gNB can schedule reTx of the LP UCI by type-3 codebook for HARQ-ACK for example. Because they are LP, certain delay is tolerable. One should also notice that, there are advanced compression techniques (rather than simple bundling of UCI) which can minimize the information loss due to compression. Regarding this “For Type-2 HARQ-ACK codebook, the size is determined by the DAI values and a miss detection of a ‘last’ DCI format can lead to UE and gNB have different understanding of the size of HARQ-ACK codebook (e.g. in case of single-cell operation). In such case, separate coding can also help HP UCI detection to not be affected by an incorrect assumption for the size of the LP HARQ-ACK codebook.” – Unless using separate PUCCH resources to transmit HP and LP UCI, I don’t see separate encoding helps to resolve the missing last DCI issue. If LP and HP UCI are put together in a PUCCH resource, that resource set is determined based on the total UCI size. Missing last DCI can change the resource set and separate encoding does not offer any help here. Furthermore, unless gNB always guarantee PRI in last DCI is the same as PRI in previous DCI, otherwise missing the last DCI will lead to a wrong PRI and UE ends up using a wrong PUCCH resource to transmit HP+LP UCI. Separate encoding does not help neither in this error event.  |
| NEC | Support |
| WILUS | Support |
| OPPO | Support |

## How to guarantee the target code rate (e.g. payload control, multiplexing priority, LP HARQ-ACK compression/compaction)

* Option 1: Different beta-offset/alpha values. Then (partly or fully) dropping, bundling/compression /compaction LP UCI can be considered if no enough resource is left.
	+ HW, vivo, LGE, Apple, OPPO, NEC, Intel, Sharp, DCM, ZTE, Pana, Nokia/NSB

Other enhancements:

QC proposal:

*Proposal 1: Study modulation order and code rate selection for UCI multiplexed on PUSCH based on beta scaled spectrum efficiency of UCI.*

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We support Option 1. Details of LP UCI reduction can be FFS.  |
| Sharp | We are fine with Option 1. |
| Samsung | Support dropping. Regarding bundling/compression /compaction LP UCI, there can be quite a lot of spec work and should be of low priority. |
| InterDigital | Option 1 is ok but not sufficient for the case of multiplexing on LP PUSCH. There also needs to be sufficient resource allocated to HP UCI to ensure reliability. If allocation is capped by the “alpha” term, reliability is not met and LP PUSCH should be dropped. |
| Intel | Option 1. Partial or full dropping can be considered if sufficient resource is not available.  |
| QC | The direction of Option 1 in general seems fine. But we’d like to see a more concrete proposal.  |
| ZTE | Option 1. It seems Option 1 is more flexible in case of no enough resources is left.  |
| OPPO | Support option 1 |
| WILUS | Fine with Option 1. |
| CATT | Support option 1. |
| Huawei, HiSilicon | We support partial dropping in case the resource is not sufficient for low priority. |
| Ericsson | Option 1 with some modification:Different alpha is not neededWe do not support solutions based on compression/bundlingPartially or fully dropping should be based on already existing schemes. |
| Nokia, NSB | Option 1, bundling of LP UCI is preferred if not enough resource left.  |
| Spreadtrum | Support partial or full dropping to reduce spec. work.  |

‘

IDC proposal:

*Proposal 5: For multiplexing UCI of high-priority over PUSCH transmission of low-priority:*

* *Multiplexing can only occur if the number of modulated symbols Q’ for the high-priority UCI is below the limit set by alpha parameters.*

ETRI proposal:

*Proposal 9: For HARQ-ACK codebook construction, sub-slot based HARQ-ACK codebooks are concatenated, and can be transmitted for either PUSCH or PUCCH.*

*Proposal 10: DL-DCI for HP UCI which is received after UL-DCI for LP TB may affect the PUSCH mapping.*

*Proposal 11: HP UCI may not be mapped at the second hop of the PUSCH.*

*Proposal 12: Further study how to adjust the power of PUSCH for payload from the other priority.*

## How to minimize impact on the latency for high-priority HARQ-ACK

* Option 1: Multiplexing is only allowed when the ending symbol of the PUSCH (or the ending symbol of REs carrying HP HARQ-ACK on PUSCH) is no later than the ending symbols of PUCCHs carrying HP HARQ-ACK
	+ HW, ZTE, OPPO, ITRI, Sharp, NEC, Pana
* Option 1a: The latency requirement can be defined as the ending symbol of PUSCH resource for multiplexed UCI transmission is not later than X symbols after the ending symbol of PUCCH for the higher priority UCI. FFS value of X.
	+ CATT, CMCC, LG
* Option 2: Controlled by gNB by dynamic indication whether to multiplex LP with HP or not.
	+ Ericsson, Nokia/NSB

|  |  |
| --- | --- |
| Company | Comments |
| LG | We prefer Option 1a (as added in the above). We think Option 1 which always requires early ending of multiplexed PUSCH than HP PUCCH, would force unnecessary tight requirement in some cases.  |
| Sony | Option 1 is fine. |
| Sharp | We prefer option 1 as a condition to determine the UCI multiplexing location. |
| Samsung | Not support both optionsThe latency can be controlled by gNB scheduling. E.g., dynamic indication of MUX.Option 1 is not reasonable. HARQ-ACK is mapped around DMRS. If only a few symbols are used for the HP HARQ-ACK, option 1 is too restrictive. Option 2 will bring quite a lot of spec work. E.g., X for different SCS considering PDCCH, PUSCH, PUCCH for both priorities. |
| DOCOMO | Same comment as in 2.3.4. Slightly prefer Option 1a but this could be discussed with the timeline in 3.3.2. |
| InterDigital | Option 1 as baseline |
| NEC | We prefer option 1 |
| Intel | Agree that Option 1 can be too restrictive. Either Option 1a or it can be left upto gNB implementation/scheduling decision without capturing any conditions in specifications. |
| TCL | Option 1  |
| QC | Similar to our opinion for UCI multiplexing on PUCCH, we think option 1 and 1a are very similar. A WF can be formulated based on the commonality of the two schemes. For example, in option 1a, if X=0, then it seems automatically reduced to option 1. In other words, option 1 seems a special case of option 1a.  |
| ZTE | Option 1. For Option 1a, how to determine the value of X is a thorny problem. |
| OPPO | Option1. To relax multiplexing condition, the ending symbol for carrying HP UCI in PUSCH can be a reference for latency requirement.Option 2, the intention of X is not clear for us. |
| WILUS | We agree with QC. Option 1a is a super-set of option 1. Further discuss whether X=0 is sufficient or not. |
| ETRI | Dynamic indication can enable whether to multiplex. And some other enhancement such as mapping only on the first hop can also avoid the issue. |
| CATT | Agree with QC. |
| Huawei, HiSilicon  | We support option 1 for simplicity. For explicit indication, it may result higher DCI overhead.  |
| Ericsson | We do not support any of these Options. We support Option 2.Our preference is Option 2. If there is issue with latency, gNB can decide to skip LP UCI. Other solutions impose a general restriction for occasional cases that is not reasonable. |
| Nokia, NSB | Tend to agree with Ericsson.In our opinion, this is linked with supporting of explicit indication for multiplexing. gNB can flexibly enable/disable multiplexing of HP HARQ-ACK depending on the latency impact.  |
| Spreadtrum | We support option 2.  |

## Explicit indication for enabling multiplexing

* Option 1: Support explicit indication. Multiplexing is only supported when the latency impact to HP transmission is tolerable.
	+ Option 1a: By beta\_offset (e.g. beta=0 to disable mux)
		- E///, Nokia, DCM, Pana
	+ Option 1b: By new DCI field
		- CATT, ETRI (RRC+DCI), vivo
	+ Option 1c: By RRC configuration for CG PUSCH or HARQ-ACK corresponding to SPS PDSCH
		- Nokia, ETRI (when no DCI indication), ZTE, vivo, Ericsson

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Option 1a for LP UCI mux into HP PUSCH.For HP UCI mux into LP PUSCH, beta-offset=0 does not work as this would result in HP UCI being dropped. |
| Samsung | Support Option 1. |
| DOCOMO | Support Option 1a and open to discuss other options like RRC configuration. |
| InterDigital | Option 1a in case of HP PUSCH |
| Intel | Support Option 1. Further details can be discussed later.  |
| TCL | Option 1, and the details could FFS. |
| QC | RRC configuration to enable/multiplexing has to be there as a baseline. This is not just for CG and DL SPS, but also for DG PDSCH and DG PUSCH. The reason is because: for fallback DCI, or for UE just go through initial access where the size of non-fall back DCI is not configured yet, the dynamic indication (either option 1a or option 1b) can not work. The situation is similar to the discussion of semi-static beta configuration vs dynamic beta indication in Rel-15. Semi-static beta configuration has be introduced as a baseline because the system has to work when dynamic beta indication is not available. So, we should agree on semi-static enabling of multiplexing between HP/LP first. Then we discuss if dynamic enabling of this feature is needed.  |
| ZTE | Option 1c. Option 1 and Option 1b will increase the DCI overhead and no need to use the dynamic indication.  |
| OPPO | Option 1a and option 1c |
| WILUS | Support Option 1. At least, option 1c seems to be necessary.  |
| ETRI | Regarding Option 1b, an existing field may also be reused. For instance, type 1 HARQ-ACK codebook can be multiplexed by the DAI value. We can further discuss which combinations of HARQ-ACK codebook types can be multiplexed. |
| vivo | We think explicit indication in DCI can simplify UCI multiplexing condition, for example, for the latency for high-priority HARQ-ACK, it can be up to gNB to guarantee. That is, if gNB indicates multiplexing, then UE can do multiplexing and consider the latency is not a problem. |
| CATT | We support all the options. |
| Huawei, HiSilicon  | We don’t support explicit indication.Option 1b there is additional DCI overhead. Option 1c is not flexible. Option 1a can be used only for LP UCI and HP PSUCH since beta=0 is not supported for other cases.  |
| Ericsson | Option 1Strongly support Option 1 (dynamic indication on top of semi-static) As we mentioned earlier, we have to be careful how complicated the multiplexing procedures becomes. Our view is that mux procedure would be enabled by RRC.However, during operation, there will be cases that gNB should have the possibility to sip mux. |

WILUS proposal:

*Proposal 7. In case of HP-PUSCH or LP-PUSCH contains LP-A/N and HP-A/N, RAN1 studies how to indicate the presence of LP-A/N and/or HP-A/N to be multiplexed and “beta offset” for LP-A/N and/or HP-A/N.*

#### 1st round proposal and discussion

Potential proposal 3.4.4:

For HARQ-ACK~~/UCI~~ multiplexing on PUSCH of different priority in R17,

* Support a mechanism for gNB to enable/disable the multiplexing.
	+ FFS the type of the mechanism, e.g. DCI ~~field~~indication, RRC configuration, beta\_offset=0
	+ FFS other details.
* **Support:** Nokia/NSB, Intel, Spreadtrum, ZTE, CATT, TCL, vivo, Sony, E///, Samsung, Sharp, Pana, IDC, DCM, QC, NEC, WILUS, OPPO
* **Not support:** HW/HiSi

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Suggest removing UCI from the proposal, then we are fine:“For HARQ-ACK~~/UCI~~ multiplexing on PUSCH of different priority in R17, * Support a mechanism for gNB to enable/disable the multiplexing.
	+ FFS the type of the mechanism, e.g. DCI field, RRC configuration, beta\_offset=0

FFS other details.” |
| Intel | Support FL’s proposal. DCI field can be changed to DCI indication to make it more inclusive of different options |
| Spreadtrum | Support FL’s proposal. |
| ZTE | Support FL’s proposal. |
| Huawei, HiSilicon | We don’t support this proposal. We think some predefined rule can work well to determine whether to do the multiplexing or not. We don’t think gNB is able to judge well whether multiplexing can be done or not, especially if the the cases involving configured PUSCH. In addition, Option 1b there is additional DCI overhead. Option 1c is not flexible. Option 1a can be used only for LP UCI and HP PSUCH since beta=0 is not supported for other cases. |
| CATT | Support |
| TCL | Support |
| vivo | Support FL’s proposal. |
| Sony | Support |
| Ericsson | Support with changes proposed by Nokia |
| Samsung | Support |
| Sharp  | Support  |
| Panasonic | Support the FL proposal. |
| InterDigital | Support |
| DOCOMO | Support |
| QC | RRC configuration to enable/multiplexing has to be there as a baseline. This is not just for CG and DL SPS, but also for DG PDSCH and DG PUSCH. The reason is because: for fallback DCI, or for UE just go through initial access where the size of non-fall back DCI is not configured yet, the dynamic indication (either option 1a or option 1b) can not work. The situation is similar to the discussion of semi-static beta configuration vs dynamic beta indication in Rel-15. Semi-static beta configuration has be introduced as a baseline because the system has to work when dynamic beta indication is not available. So, we should agree on semi-static enabling of multiplexing between HP/LP first. Then we discuss if dynamic enabling of this feature is needed.  |
| NEC | Support |
| WILUS | Support |
| OPPO | Support |

#### Void

#### 3rd round proposal and discussion

Potential proposal 3.4.4:

For HARQ-ACK multiplexing on PUSCH of different priority in R17,

* Support a mechanism for gNB to enable/disable the multiplexing.
	+ FFS the type of the mechanism, e.g. DCI indication, RRC configuration, beta\_offset=0
	+ FFS other details.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We are fine with the proposal. |
| Nokia, NSB | Support the proposal  |
| Ericsson | Support the proposal, Plus similar comment as 3.2.5.However, the formulation suggests that DCI enabling/disabling on top of RRC enabling is excluded. The reason is that the proposal suggests to support “a mechanism”, and in FFS, each of these considered as “one mechanism”. Our understanding is that case is not precluded |
| Sharp | Support the proposal.  |
| Apple | RRC configuration should be used. With that said, we are fine to study further.  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Multiplexing rule and order

Nokia proposal:

*Proposal 3.16: RAN1 should discuss multiplexing order after Rel-16 UE behavior is clarified (still under discussion in Rel-16 maintenance work)*

LGE proposal:

*Proposal #11: Consider to keep the reserved HARQ-ACK REs for same priority with PUSCH in case of piggybacking HARQ-ACK on PUSCH for different priority.*

*Proposal #12: Consider the mapping of HP HARQ-ACK starting from the first symbol in LP PUSCH with consideration of latency requirement for HP UCI.*

Lenovo/Moto proposal:

*Proposal 4: Consider supporting repetitions of high priority UCI such as HARQ-ACK in low priority PUSCH to ensure both the low-latency and high reliability requirements.*

*Proposal 5: Support configuring more than one scaling value for the variable , to allocate different maximum numbers of resource elements to UCI with different priorities.*

*Proposal 6: UCI with different priorities are separately encoded and rate-matched.*

Spreadtrum proposal:

*The dropping rule should follow low priority->high priority with different priorities, and follow CSI->SR->HARQ-ACK with same priority.*

QC proposal:

*Proposal 7: When low priority HARQ-ACK overlap with high priority PUCCH/PUSCH, bundle the low priority HARQ-ACK codebook into X bits (e.g. X=1), append the X bits to the end of high priority HARQ-ACK codebook (if exist) and jointly encode them, and further multiplex the jointed encoded codeword on an overlapping high priority PUSCH (if exist).*

*Proposal 8: When high priority HARQ-ACK overlap with low priority PUSCH, high priority HARQ-ACK is multiplexed on low priority PUSCH by puncturing the low priority PUSCH.*

Intel proposal:

*Proposal 6: CG-UCI is regarded as high priority and can be multiplexed in a similar manner as HP HARQ-ACK onto PUSCH.*

*Proposal 7. If both HP and LP HARQ-ACK are to be multiplexed onto CG-PUSCH that includes CG-UCI, CG-UCI is jointly encoded with HP HARQ-ACK with same beta offset.*

# PHY prioritization between DG and CG PUSCHs with different priorities

## Agreements and discussion status in previous meetings

In Rel-16, it was agreed in the RAN1 #98b meeting that the HP PUSCH can puncture the LP PUSCH. However, this agreement was re-discussed in the RAN1 101-e meeting, and only the prioritization of two CG PUSCHs with different priorities was agreed while there was no consensus on the prioritization of DG PUSCH and CG PUSCH with different priorities. In the RAN1 #101-e meeting, the following proposals are provided.

|  |
| --- |
| **Proposal from Feature Lead*** For collision handling between high priority CG and low priority DG, down-select following options.
	+ Option 1: define a UE capability for collision handling between the CG and DG with different priorities in PHY layer.
		- If UE supports the capability, PHY layer can make the prioritization so that the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the PUSCH transmission scheduled by the PDCCH at latest starting at the first symbol of the PUSCH corresponding to the configured grant.
		- Otherwise, MAC layer should make the prioritization so that only one MAC PDU is delivered to PHY layer.
	+ Option 2: re-use Rel.15 timeline, MAC layer should make the prioritization so that only one MAC PDU (e.g. the one with higher priority) is delivered to PHY layer.
		- Supported by QC, Intel, LG, Apple
	+ Option 3: PHY layer can make the prioritization so that the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the overlapping low priority PUSCH scheduled by the PDCCH at latest starting at the first symbol of the PUSCH corresponding to the configured grant.
		- Supported by Nokia, NSB, Huawei/HiSilicon, CATT, NEC, MTK, ZTE
* No PHY collision handling necessary if MAC does not generate a PDU for the CG.
* PHY does not expect MAC to generate a PDU for a later, lower-priority, CG PUSCH, which overlaps with an earlier, higher-priority, DG PUSCH.

**Proposal from Feature Lead** * For collision handling between high priority DG and low priority CG, down-select following options:
	+ Option 1: Define a UE capability for collision handling between the CG and DG with different priorities in PHY layer.
		- If a UE supports the capability, the UE is expected to cancel the overlapping low priority CG by the first overlapping symbol at the latest. Further, a UE expects that the first [overlapping] symbol of the high priority DG is not earlier than Tproc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority DG.
		- Otherwise, the UE can only cancel the entire PUSCH transmission corresponding to the configured grant starting in a symbol 𝑗, if the end of symbol 𝑖 for PDCCH scheduling the PUSCH is at least 𝑁2 symbols before the beginning of symbol 𝑗.
	+ Option 2: Rel.15 timeline is reused to support cancellation of the low priority CG PUSCH.
		- A UE is not expected to be scheduled by a PDCCH ending in symbol *i* to transmit a high priority DG PUSCH on a given serving cell overlapping in time with a transmission occasion, where the UE is allowed to transmit a CG PUSCH with low priority, starting in a symbol *j* on the same serving cell if the end of symbol *i* is not at least *N2* symbols before the beginning of symbol *j*.
	+ Option 3: PHY layer can make the prioritization so that the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, a UE expects that the first [overlapping] symbol of the high priority DG PUSCH is not earlier than *T*proc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority channel.
* No PHY collision handling necessary if MAC does not generate a PDU for the CG.
 |

In the RAN1 #102-e meeting, the following agreement was achieved.

Agreements:

*Support PHY prioritization for the case where low-priority DG-PUSCH collides with high-priority CG-PUSCH in R17.*

* *FFS details*
* *Clarify R16 baseline if needed.*

## Solution for PHY prioritization the case where low-priority DG-PUSCH collides with high-priority CG-PUSCH in R17

**Down-select from R16 options:**

* Adopt Option 3 of R16 discussion
	+ HW, vivo, E///, CATT, Samsung, Nokia, MTK, CMCC, Sharp, DCM, NEC, ZTE, Pana

**Necessity of RAN1 work:**

DCM proposal:

* *No need to further discuss collision handling between DG PUSCH and CG PUSCH with different priorities as it has been resolved in Rel-16 URLLC agenda.*

Intel proposal:

*Proposal 1: PHY collision handling of low priority DG PUSCH and high priority CG PUSCH is left up to UE implementation and no RAN1 specification change is necessary.*

Apple proposal:

*Proposal 2: Clarify the Rel-16 UE behavior concerning DG/CG transmission.*

ZTE proposal:

*Proposal 8: RAN1 should clarify that for the overlapping scenario between low priority DG PUSCH and high priority CG PUSCH, the UE prioritizes the transmission with high priority index and drops the transmission with low priority index. Besides, the scheduling time of DG PUSCH need not be limited by the timeline defined in current spec.*

Xiaomi proposal:

*Proposal 7:* *The case of HP CG-PUSCH overlapping with LP DG-PUSCH should be handled by UE implementation.*

Samsung proposal:

*Proposal 8: If transmission of a CG-PUSCH with priority 1 starts after a transmission of a DG-PUSCH with priority 0 from a UE on a same serving cell and the two PUSCHs overlap, the UE is expected to cancel the DG-PUSCH before the first overlapping symbol.*

**Timeline:**

OPPO proposal:

*Proposal 6: PHY layer can make the prioritization and Rel-16 timeline is applied.*

QC proposal:

*Proposal 14: The cancellation time for CG-PUSCH and DG-PUSCH collision resolution does not reuse Rel-16 cancellation time for PUCCH/PUCCH or PUCCH/PUSCH collision.*

Sharp proposal:

*Proposal 5: For collision between a LP DG-PUSCH and a HP CG-PUSCH, the LP DG-PUSCH should be dropped before the first symbol overlapping with the HP CG-PUSCH transmission.*

* *The actual dropping time can be left as UE implementation.*

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We support Option 3. |
| Sharp | The current spec language can be extended to this case. Note HP CG-PUSCH transmiss occurs only if there is data in the buffer. In this case, LP DG-PUSCH can be cancelled by HP CG-PUSCH at least before the transmission of the CG-PUSCH. The exact location of dropping is up to UE implementation. |
| Samsung | Adopt Option 3 of R16 discussion |
| DOCOMO | We support to discuss the PHY prioritization so that prioritization can be done at PHY even after MAC PDUs are deliver to both UL channels. Option 3 should be adopted according to the discussion from Rel-16.  |
| InterDigital | Option 3. |
| NEC | We support option 3 of Rel-16 discussion |
| Intel | Option 3 is OK and achieved by UE implementation. No RAN1 spec impact is expected since timeline cannot be established. |
| QC | We don’t support option 3. We think the timeline should be revisit because this is a PUSCH channel cancel another PUSCH channel, while the timeline in option 3 is for cancellation between PUCCH and PUSCH.  |
| ZTE | We support option 3 in principle. Our proposal is that RAN1 should clarify the Rel-16 UE behavior concerning DG/CG transmission. |
| OPPO | Support option 3 |
| CATT | Option 3 |
| Huawei/HiSilicon  | Support option 3 based on all the discussions in Rel-16 and Rel-17.  |
| Ericsson | Option 3 |

#### 1st round proposal and discussion

Potential proposal 4.2.1:

For collision handling between high priority CG and low priority DG, ~~down-select following options.~~

* PHY layer can make the prioritization so that the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the overlapping low priority PUSCH scheduled by the PDCCH at latest starting at the first symbol of the PUSCH corresponding to the configured grant.
* **Support:** Nokia/NSB, Intel, Spreadtrum, ZTE, HW/HiSi, CATT, vivo, Sony, Samsung, Sharp, Pana, IDC, DCM, NEC, OPPO
* **Not support:** QC (gap between the end of the LP grant to start of the HP CG-PUSCH or the start of the LP DG-PUSCH is required), LG(relaxed timeline between the end of the LP grant and the first overlapping symbol needs to be satisfied)

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support ‘~~down-select following options~~’ should be removed from the first line of the proposal |
| Intel | Support. Also, we would like to add that this can be achieved by UE implementation |
| Spreadtrum | Support  |
| CMCC | Support with the following modification:For collision handling between high priority CG and low priority DG, down-select following options.* PHY layer can make the prioritization so that the UE is expected to transmit the PUSCH corresponding to the configured grant, and cancel the overlapping low priority PUSCH scheduled by the PDCCH at latest, from the first symbol that is overlapping with ~~starting at the first symbol of~~ the PUSCH corresponding to the configured grant.
 |
| ZTE | Support FL’s proposal |
| Huawei, HiSilicon | Support with the suggestion from Nokia. |
| CATT | We support the proposal and the updates from Nokia and CMCC. |
| vivo | Support in principle. |
| Sony | Support. Share similar views with Nokia, should remove the “down select following options” wordings. |
| Samsung | Support the proposal. Agree with Nokia’s suggestion. |
| Sharp  | Support  |
| Panasonic | Support the DFL proposal and agree with Nokia’s suggestion. |
| InterDigital | Support with fix suggested by Nokia. |
| DOCOMO | Support |
| QC | Do not support. A Tproc timeline should be defined as a minimum required gap between the end of the LP grant to start of the HP CG-PUSCH or the start of the LP DG-PUSCH, which ever comes earlier.A couple of more editorial comments: PHY layer does not make prioritization. MAC layer does prioritization between CG and DG and PHY just conduct cancellation when needed. So “PHY layer can make the prioritization” is not accurate. Also, “UE is expected to transmit the PUSCH corresponding to the configured grant” is not accurate. Whether UE transmit CG depends on there is MAC PDU for CG PUSCH or not. This sentence seems imply PHY layer of UE has to transmit CG PUSCH, which seems not accurate to me. |
| NEC | Support the DFL proposal and agree with Nokia’s suggestion. |
| OPPO | Support |
| LG | Not supportive to the proposal.Prioritization between LP DG and HP CG can be achieved by UE implementation or MAC operation with sufficient timeline, without any issue. From the FL proposal in the last meeting, we assume that this proposal is implying two MAC PDU case. For the case when MAC provides two MAC PDU, the additional processing time would be required at least so that PHY make something new. It is hard to support the proposal without the discussion on feasible solution for that. We already have agreed to support the prioritization between LP DG and HP CG. Thus, regardless of this proposal, we should discuss about possible solutions/options for that. And it seems related to cancelation behavior for LP channel which had been discussed in the late Rel-16. We don’t see the necessity of this proposal at this stage. |

## Support prioritization for the case LP CG collides with HP DG PUSCH or not?

* Support
	+ Nokia, IDC, MTK, Xiaomi, CMCC, Intel, Sharp, Samsung, DCM, NEC, ZTE, Pana
	+ Arguments:
		- Rel-17 WI description on intra-UE multiplexing and prioritization (see below) clearly mentions that this scenario should also be specified.

|  |
| --- |
| 1. *Specify PHY prioritization of overlapping dynamic grant PUSCH and configured grant PUSCH of different PHY priorities on a BWP of a serving cell including the related cancelation behavior for the PUSCH of lower PHY priority, taking the solution developed during Rel-16 as the baseline.*
 |

* Not support
	+ LGE, QC
	+ Arguments:
		- Collision between HP CG and LP DG may not be a big issue. Collision between LP CG and HP DG could be complicated.
		- Considering URLLC requirement, it is difficult to support URLLC service via DG PUSCH due to delay from SR to UL grant and from UL grant to PUSCH, as we have been discussing.
		- Not prioritized by RAN2.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | Support LP CG-PUSCH & HP DG-PUSCH collision. |
| Sharp | Support this case. It can be added to the spec with minimum impact, i.e. cancel LP channel at least from the starting symbol of HP DG-PUSCH, and no early than Tproc2+d1 after the PDCCH for the HP DG-PUSCH.  |
| Samsung | Support |
| InterDigital | Support. |
| NEC | Support |
| Intel | Support |
| QC | We don’t support this feature.  |
| ZTE | Support.  |
| OPPO | Support |
| vivo | Support LP CG-PUSCH & HP DG-PUSCH collision. |
| CATT | Support |
| Huawei/HiSilicon | Support. It is clear from the WI scope.  |
|  |  |

Nokia proposals:

*Proposal 2.3: The Rel-16 handling of the scenarios where a dynamically scheduled high-priority channel overlaps with a low-priority channel is adopted for the scenario of overlapping between high-priority DG PUSCH and low-priority CG PUSCH.*

LGE proposals:

*Proposal #13: Consider the framework designed in Rel-10 LTE-A as the baseline for supporting simultaneous transmission of PUCCH and PUSCH in Rel-17 NR.*

*Proposal #14: Consider to introduce new timeline or offset in case of PUSCH collision handling with different priority.*

*Proposal #15: Consider enhanced collision handling between HP PUSCH and LP PUSCH with UCI piggybacking.*

*Proposal #16: PHY prioritization for the case where low-priority CG-PUSCH collides with high-priority DG-PUSCH is not supported in R17.*

IDC proposal:

*Proposal 9: When DG PUSCH of higher priority overlaps with CG PUSCH of lower priority, the UE does not expect a DG PUSCH of higher priority to start earlier than Tproc,2 + d2 symbols after the end of the last symbol of the PDCCH.*

*Proposal 10: When DG PUSCH of higher priority overlaps with CG PUSCH of lower priority, the UE cancels the transmission of the CG PUSCH before the first symbol overlapping with the DG PUSCH transmission.*

*Proposal 11: When CG PUSCH of higher priority overlaps with DG PUSCH of lower priority, the UE cancels the transmission of the DG PUSCH before the first symbol overlapping with the CG PUSCH transmission.*

MTK proposal:

*Proposal 16: The UE is expected to transmit the HP-DG PUSCH and cancel the overlapping LP-CG PUSCH. Further, the UE expects that the first overlapping symbol of the high priority DG is not earlier than Tproc,2+d1 after the last symbol of the PDCCH scheduling the HP-DG PUSCH.*

Xiaomi proposal:

*Proposal 8: In the case of LP CG-PUSCH overlapping with HP DG-PUSCH, HP DG-PUSCH will be transmitted.*

CMCC proposal:

*Proposal 14: For collision handling between high priority DG-PUSCH and low priority CG-PUSCH, UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, a UE expects that the first overlapping symbol of the high priority DG PUSCH is not earlier than Tproc,2+d1 after the last symbol of the PDCCH with the DCI format scheduling the high priority channel.*

Intel proposal:

*Proposal 2. Define a new UE capability for collision handling between the LP CG and HP DG PUSCH in PHY layer.*

* *If UE supports the capability, the UE is expected to cancel the overlapping low priority CG PUSCH by the first overlapping symbol at the latest. Further, the UE expects that the first symbol of the high priority DG PUSCH is not earlier than Tproc,2+min(d1,d2) after the last symbol of the PDCCH with the DCI format scheduling the high priority DG PUSCH, where d1 and d2 can be from {0, 1, 2} symbols, and correspond to the additional margins for cancelation and preparation times respectively in case of intra-UE prioritization and reported as UE capability.*
* *Otherwise, the UE can only cancel the entire PUSCH transmission corresponding to the configured grant starting in a symbol 𝑗, if the end of symbol 𝑖 for PDCCH scheduling the PUSCH is at least Tproc,2 before the beginning of symbol 𝑗.*

Samsung proposal:

*Proposal 9: If transmission of a DG-PUSCH with priority 1 starts after a transmission of a CG-PUSCH with priority 0 from a UE on a same serving cell and the two PUSCHs overlap, a UE is expected to cancel the CG-PUSCH before the first overlapping symbol.*

#### 1st round proposal and discussion

Potential proposal 4.3.1:

Support PHY prioritization for the case where high-priority DG-PUSCH collides with low-priority CG-PUSCH in R17.

* FFS details
* Clarify R16 baseline if needed.
* **Support:** Nokia/NSB, Intel, Spreadtrum, CMCC, ZTE, HW/HiSi, CATT, vivo, Sony, Samsung, Sharp, Pana, IDC, DCM, NEC, OPPO
* **Not support:** QC, LG

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Support |
| Intel | Support |
| Spreadtrum | Support.  |
| CMCC | Support |
| ZTE | Support FL’s proposal. |
| Huawei, HiSilicon | Support |
| CATT | Support |
| vivo | Support |
| Sony | Support |
| Samsung | Support |
| Sharp  | Support  |
| Panasonic | Support the FL proposal. |
| InterDigital | Support |
| DOCOMO | Support |
| QC | Do not support |
| NEC | Support |
| OPPO | Support |
| LG | Not support |

#### Void

#### 3rd round proposal and discussion

Context in WID:

|  |
| --- |
| 1. *Specify PHY prioritization of overlapping dynamic grant PUSCH and configured grant PUSCH of different PHY priorities on a BWP of a serving cell including the related cancelation behavior for the PUSCH of lower PHY priority, taking the solution developed during Rel-16 as the baseline.*
 |

Potential observation 4.3.1:

It has been agreed in the WID that PHY prioritization of overlapping dynamic grant PUSCH and configured grant PUSCH of different PHY priorities on a BWP of a serving cell should be supported in R17.

* FFS the related cancelation behavior for the PUSCH of lower PHY priority and other details.
* Taking the solution developed during Rel-16 as the baseline.

|  |  |
| --- | --- |
| Company | Comments |
| Sony | We are fine with the observation. We thought this was understood and the aim is to work out the details, namely continue where we left off in Rel-16. |
| Nokia, NSB | We agree with the intention but would like to note here that it seems rather strange to have an observation that something ‘should be supported’. If we would agree to such observation, it would be more logical to make an agreement on the support directly. So why not having a proposal / agreement here directly? Companies that think it should not be supported equally will not agree to having such related observation using the ‘should be’ wording either. Moreover, PHY prioritization for the scenario HP CG PUSCH vs. LP DG PUSCH was already agreed in RAN1#102e, where the details are still FFS. Therefore, only an agreement on supporting PHY prioritization for the scenario HP DG PUSCH vs. LP CG PUSCH is needed, while it’s worth noting that such prioritization is supported by a large majority of companies. Based on these two issues, we think the following should be changed: Potential ~~observation~~ UPDATED proposal 4.3.1:~~It has been agreed in the WID that~~ Support PHY prioritization of overlapping high-priority dynamic grant PUSCH and low-priority configured grant PUSCH ~~of different PHY priorities~~ on a BWP of a serving cell ~~should be supported~~ in R17.l  FFS the related cancelation behavior for the PUSCH of lower PHY priority and other details.l  Taking the solution developed during Rel-16 as the baseline. |
| Ericsson | We share same view as Nokia |
| Sharp | Fine with the observation. However, we agree with Nokia, there should be an agreement on whether to support the cases or not. If supported, the Rel-16 baseline would be enough, so that the LP channel is cancelled at least from the starting symbol of HP PUSCH transmission.  |
| Apple | It is good some DG overriding CG behaviors from Rel-16 were clarified in the maintenance session in RAN1 102-e. In the discussion, it is good to consider Rel-16 candidate designs, we don’t have to start from scratch.  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Proposal for additional overlapping scenarios

Xiaomi proposal:

*Proposal 5: Solutions such as direct puncture or treating HP SR as HARQ-ACK/CSI bit in multiplexing can be considered for HP SR on LP PUSCH.*

CMCC proposal:

*Proposal 1: Support multiplexing a high priority SR in a low priority PUSCH conveying UL-SCH and/or low priority HARQ-ACK/CSI in R17.*

Panasonic proposal:

*Proposal 1: The collision handling between high-priority SR and low-priority PUSCH should be studied.*

Nokia proposal:

*Proposal 3.10: For the scenario where a PUCCH carrying high-priority HARQ-ACK overlaps with a PUCCH carrying low-priority SR:*

* + *For the cases (i) HARQ-ACK is with F0 and SR with F0, (ii) HARQ-ACK is with F2/F3/F4 and SR with F0/F1: multiplex HARQ-ACK and SR.*
	+ *For the cases (i) HARQ-ACK is with F1 and SR with F0, (ii) HARQ-ACK is with F1 and SR is with F1: prioritize HARQ-ACK and drop SR.*

*Proposal 3.17: Multiplexing high-priority SR in low-priority PUSCH is supported. FFS detailed ways of carrying high-priority SR information.*

*Proposal 3.18: Multiplexing low-priority SR on high-priority PUSCH is not supported.*

*Proposal 3.19: Multiplexing of low-priority P-/SP-CSI (on PUCCH) onto high-priority PUSCH is not supported.*

InterDigital proposal:

*Proposal 1: Support multiplexing for following additional scenarios:*

* *High-priority SR in a low-priority PUSCH (UL-SCH only)*
* *High-priority SR and HARQ-ACK in a low-priority PUSCH (UL-SCH only)*
* *High-priority SR in a low-priority PUSCH (UL-SCH + low-priority HARQ-ACK and/or CSI)*
* *High-priority SR and HARQ-ACK in a low-priority PUSCH (UL-SCH + low-priority HARQ-ACK/CSI)*

Panasonic proposal

*Proposal 1: The collision handling between high-priority SR and low-priority PUSCH should be studied.*

Lenovo proposal:

*Proposal 3: In Rel-17 NR, support multiplexing of low priority SR, SR/HARQ-ACK, or HARQ-ACK without SR into a high priority PUSCH without UL-SCH.*

*Proposal 4: Consider supporting repetitions of high priority UCI such as HARQ-ACK in low priority PUSCH to ensure both the low-latency and high reliability requirements.*

# Simultaneous x-CC PUCCH/PUSCH transmissions for inter-band CA

## Agreements in previous meetings

Agreements:

*Support simultaneous PUCCH/PUSCH transmissions on different cells at least for inter-band CA.*

* *FFS how to trigger this function.*
* *FFS for intra-band CA.*

## General principle

LGE proposal:

*Proposal #13: Consider the framework designed in Rel-10 LTE-A as the baseline for supporting simultaneous transmission of PUCCH and PUSCH in Rel-17 NR.*

Nokia proposal:

*The simultaneous transmission of PUCCH and PUSCH on different serving cells is applicable for the case when PUCCH and PUSCH are of different PHY priority only.*

#### 1st round proposal and discussion

Potential proposal 5.2.1:

* Consider the framework designed in Rel-10 LTE-A as the baseline for supporting simultaneous transmission of PUCCH and PUSCH in Rel-17 NR.
* The simultaneous transmission of PUCCH and PUSCH on different serving cells is applicable for the case when PUCCH and PUSCH are of different PHY priority only.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, NSB | Do not support the first bullet as we do not see a reason to support simultaneous PUCCH/PUSCH of the same priority as well as in the same band/carrier. Support the second bullet. |
| Intel | Support second bullet only. |
| Huawei, HiSilicon  | 1. It is still not clear to us whether we can support simultaneous PUCCH/PUSCH in the same band/carrier as discussed above. Suggest to modify it as below: * Consider the framework designed in Rel-10 LTE-A as the baseline for supporting simultaneous transmission of PUCCH and PUSCH for inter-band CA in Rel-17 NR.

2. As to the second bullet, we are wondering why we need this kind of restriction? If UE is capable of supporting simultaneous, why not use it for same priority case? |
| CATT | We would like to understand why simultaneous transmission of PUCCH and PUSCH is applicable to different PHY priority only. |
| vivo | Support the first bullet. For the second bullet, we think if a UE can the support simultaneous transmission of PUCCH and PUSCH on different serving cells for PUCCH and PUSCH of different PHY priority, the UE can also support the case when PUCCH and PUSCH are of the same PHY priority. |
| Ericsson | Do not supportAgree with Nokia.Not agree to support it only for different priority. |
| Samsung | Support the proposal in principle. The restriction of different priority in the second sub-bullet does not make sense. We suggest to remove it. |
| Sharp  | Support the second bullet. |
| DOCOMO | Do not support. Regarding the second bullet, we don’t see technical reason to add the restriction. |
| QC | Do not support the proposal. For the first bullet, it is too early to make a conclusion without study this topic. For the second bullet, 1) it is against previous agreement made in last meeting; 2) We don’t see any technical justification why this feature can not be applied to PUCCH/PUSCH with same priority.  |
| NEC | Support the second bullet. |
| OPPO | Do not support the second bullet |
| MediaTek | We don’t support the first bullet point.For the second bullet point, we believe this should be enabled/disabled by RRC. For a UE with mixed traffic, the gNB should have the control of enabling simultaneous transmission of PUCCH and PUSCH on different serving cells when PUCCH and PUSCH are of different PHY priority, and enable multiplexing between PUCCH and PUSCH when they are of the same PHY. |
| Nokia, NSB | To answer the questions from several companies, we would like to clarify the motivations of the second bullet:  * The maximum UE Tx power limitation applicable to CA case has been specified in TS 38.101. If we support simultaneous transmission of PUCCH/PUSCH with the same priorities (e.g. both with high priority) and no sufficient Tx power is available then, according to Tx power allocation order specified in Section 7.5 of TS 38.213, the performance of the high priority PUSCH may be degraded due to reduced Tx power which we should try to avoid.
* For the cases where PUCCH and PUSCH on different serving cells are overlapping, Rel-15 already specified the UE behavior, i.e. the UCI is multiplexed in a PUSCH of the service cell with the smallest *ServCellIndex* subject to the conditions for UCI multiplexing being fulfilled. Following this behavior, no information is dropped/cancelled and in addition no performance degradation to the overlapping channels.

More details can be found in our Tdoc [R1-2008843].  |
| QC | To Nokia: Multiplexing UCI on PUSCH is vulnerable to DCI miss detection in UL CA. If a UL grant is missed, UE may multiplex UCI on a wrong PUSCH. Of course, gNB may do blind detection to figure it out. But that needs extra effort at gNB. On the other hand, simultaneous PUCCH and PUSCH transmission in much cleaner and more robust to UL DCI miss detection. And we don’t see the Tx power is an issue. For HP UCI + HP PUSCH, if UE is in power limited region, do UCI multiplexing does not help neither.  |

## How to trigger this function?

* Signaling
	+ QC: RRC on per CC basis
	+ E///: RRC enable + dynamically disable
	+ Nokia: RRC, MAC CE or PHY signaling
	+ Intel: Configured
	+ OPPO: RRC for CC, and configured for HP PUCCH and LP PUCCH
	+ DCM: UE capability
	+ MTK:
		- separately configured for inter-band and intra-band
		- separately configured for different priorities
		- enabled based on specific conditions. E.g. LP-PUCCH carrying HARQ feedback

|  |  |
| --- | --- |
| Company | Comments |
| LG | On this simultaneous PUCCH+PUSCH transmission, basically, it is preferred to inherit the framework designed in Rel-10 LTE-A in terms of feature capability/enabling (e.g. configured UE-specifically by RRC) and UCI multiplexing behavior.  |
| Samsung | RRC enable + dynamically disable |
| DOCOMO | We are also supportive for RRC configuration. |
| Intel | The feature can be enabled by RRC configuration. We are also open to consider DCI based indication.  |
| QC | In general, we think RRC configuration of this feature is more robust to DCI detection error/miss detection. And we don’t see much benefit to do dynamic enable/disable this feature, which seems an over-design to us. The benefit of dynamic indication is not clear to us. |
| OPPO | RRC configuration. |
| CATT | We think RRC configuration per CG is sufficient. |
| Huawei/HiSilicon | RRC configuration similar as what we do for LTE. |
| Ericsson | RRC enable and dynamically disable to give more flexibility if needed. |
| Apple | RRC configuration is preferred. |

DCM proposal:

*Proposal 7:*

* *Introduce a UE capability to trigger the simultaneous PUCCH and PUCH transmission on different carriers.*

*Proposal 8:*

* *Discuss the interaction between capabilities for two PUCCH groups and the new capability for simultaneous PUCCH/PUSCH transmission on different carriers.*

QC proposal:

*Proposal 15: The enabling/disabling of the feature of simultaneous PUCCH/PUSCH transmission for inter-band CA is via RRC configuration on per CC basis. For a CC where RRC enables simultaneous PUCCH/PUSCH transmission, this CC is dedicated to PUSCH transmission and UCI is not multiplexed on this CC.*

*Proposal 16: Support the PHR for simultaneous PUCCH/PUSCH for inter-band CA with either of the following two options.*

* *Option 1: reuse LTE type 2 PHR for PUCCH transmission on PCC with a virtual/reference PUSCH*
* *Option 2: define a type 4 PHR for PUCCH transmission on PCC*

Intel proposal:

*Proposal 14: UE can be configured to transmit low priority PUCCH (PUSCH) in one carrier and high priority PUSCH (PUCCH) in a different carrier. UE may only multiplex channels of same priority in one carrier, and transmit different priority channel(s) in another carrier.*

* *If UE is configured with both simultaneous PUSCH and PUCCH transmissions over different carriers and Rel16 or Rel17 intra-UE prioritization, option of simultaneous transmissions should take precedence over the intra-UE prioritization.*

## Support simultaneous PUSCH/PUCCH transmission for intra band CA or not?

* Support.
	+ vivo (as optional UE feature), Samsung (no need to differentiate between intra-band CA and inter-band CA), MTK (for some cases), DCM, ZTE
	+ Arguments:
		- In NR Rel-15, multiple PUSCHs transmission on different carries and one among them with the piggy-backed UCI has been already supported for both inter band CA and intra band CA.
* Not support.
	+ Nokia
	+ Arguments:
		- Considering the most efficient implementation with a single PA (most likely case of intra-band CA), e.g. Tx discontinuity, Large Tx power back-off.

|  |  |
| --- | --- |
| Company | Comments |
| LG | As defined in LTE-A, it is to be UE capability per band and band combination. |
| Samsung | Support |
| DOCOMO | Support |
| Intel | More careful consideration is needed before it is supported. Whether the feature is only allowed if the overlapping transmissions are fully aligned. If yes, then scope seems quite limited.  |
| TCL | Support |
| QC | We are open to discuss this feature for intra-band CA. Alignment of the starting and ending of the simultaneous PUCCH/PUSCH transmission seems required in intra-band CA.  |
| ZTE | Support |
| OPPO | Support |
| CATT | Support |
| Huawei, HiSilicon  | We think it would be good to inquire RAN4 first to see the feasibility before making any decision in RAN1. |
| Ericsson | We need further discussion to understand the consequencesIf support for intra-band, results in limited use and limitation is scheduling, we are supportive of that. |
| Nokia, NSB | NoAs discussed in our Tdoc, potential issues related to support simultaneous PUCCH/PUSCH transmission for intra-band CA include at least Tx discontinuity and large Tx power back-off. Also, it can bring significant scheduling restrictions (and potential performance degradation to high priority channels) if trying to align the PUCCH/PUSCH in time. In contrast to PUSCH vs PUSCH, the gNB has little option to dynamically affect the length of PUCCH (especially for small HARQ payload sizes) to align with the length of the PUSCH (and vice versa)  |
| Apple | The use cases for supporting simultaneous PUCCH/PUSCH can be problematic in terms of phase discontinuity. More studies are needed to determine whether to support it for intra-band CAUpdate: we have concern on the proposal, it is fine to ask RAN4 for study first before further study. If decision needs to be made now, we don’t support it. |
| MediaTek | Support |

MTK proposal:

*Proposal 8: Support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA for the same numerology both with aligned and non-aligned channel case.*

*Proposal 9: Support simultaneous PUCCH/PUSCH transmissions on different cells for intra-band CA for different numerology if the transmissions are aligned on symbol-level (with the symbol of the lowest SCS as a reference).*

* *i.e. Allocation on the carrier with higher numerology doesn’t start during an ongoing symbol on the other carrier with the smaller numerology.*

## Support simultaneous PUSCH/PUCCH transmission on a same cell?

* Support.
	+ Samsung

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | Support |
| Intel | Not in scope |
| QC | We are open to discuss this. This should be carefully studied before making a decision, given that this feature was specified in LTE but never deployed.  |
| OPPO | Support for different priorities |
| CATT | Support |
| Huawei, HiSilicon  | We think it would be good to inquire RAN4 first to see the feasibility before making any decision in RAN1. |
| Ericsson | We need further discussion to understand the consequencesIf support on the same cell, results in limited use and limitation is scheduling, we are supportive of that. |
| Nokia, NSB | Not supportSame comments from our side as for intra-band CA support, aligning the start/end with PUCCH is very much limited – and TX power back-off etc. impacting negatively.  |
| Apple | It has to be studied carefully before any decision can be made.If decision needs to be made now, we don’t support it. |
| MediaTek | Not support |

Samsung proposal:

*Proposal 6: Send an LS to RAN4 to inquire about the feasibility/MPR for simultaneous PUCCH and PUSCH transmissions on a same cell.*

Panasonic proposal:

*Observation 1: Whether simultaneous PUCCH and PUSCH transmission in a carrier is useful or not should be studied.*

* *If the simultaneous transmission is restricted to adjacent or almost adjacent frequency resource, the gain would be limited.*
* *How to ensure the same transmit power for all symbols and how to handle PSD difference between PUCCH and PUSCH should be taken into account.*

# References

1. [R1-2007567](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2007567.zip) Intra-UE multiplexing enhancements Huawei, HiSilicon
2. [R1-2007658](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2007658.zip) Intra-UE Multiplexing/Prioritization for Rel-17 URLLC vivo
3. [R1-2007710](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2007710.zip) Intra-UE Multiplexing/Prioritization Enhancements for IIoT/URLLC Ericsson
4. [R1-2007852](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2007852.zip) Intra-UE multiplexing and prioritization CATT
5. [R1-2007901](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2007901.zip) Intra-UE multiplexing prioritization Beijing Xiaomi Software Tech
6. [R1-2008009](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008009.zip) Discussion on intra-UE multiplexing/prioritization CMCC
7. [R1-2008060](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008060.zip) Discussion on Intra-UE multiplexing/prioritization LG Electronics
8. [R1-2008162](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008162.zip) Uplink intra-UE multiplexing and prioritization Samsung
9. [R1-2008282](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008282.zip) Enhancements on intra-UE multiplexing/prioritization OPPO
10. [R1-2008358](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008358.zip) Considerations in intra-UE UL multiplexing Sony
11. [R1-2008463](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008463.zip) Discussion on Intra-UE Multiplexing/Prioritization Apple
12. [R1-2008824](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008824.zip) Discussion on enhanced intra-UE multiplexing ZTE
13. [R1-2008843](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008843.zip) On UL intra-UE prioritization and multiplexing enhancements Nokia, Nokia Shanghai Bell
14. [R1-2008848](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008848.zip) Discussion on Intra-UE prioritization and multiplexing NEC
15. [R1-2008937](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008937.zip) Intra-UE multiplexing and prioritization InterDigital, Inc.
16. [R1-2008955](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008955.zip) Discussion on Intra-UE multiplexing and prioritization of different priority Panasonic Corporation
17. [R1-2008987](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2008987.zip) On Intra-UE Multiplexing and Prioritization for Release 17 URLLC/IIoT Intel Corporation
18. [R1-2009013](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009013.zip) Intra-UE Multiplexing/Prioritization ETRI
19. [R1-2009066](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009066.zip) Methods for intra-UE multiplexing and prioritization MediaTek Inc.
20. [R1-2009104](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009104.zip) Intra-UE multiplexing enhancement for IIoT/URLLC Lenovo, Motorola Mobility
21. [R1-2009136](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009136.zip) Enhancements on intra-UE UCI multiplexing and PUSCH prioritization Sharp
22. [R1-2009149](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009149.zip) Discussion on intra-UE multiplexing/prioritization Spreadtrum Communications
23. [R1-2009185](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009185.zip) Discussion on intra-UE multiplexing/prioritization for Rel.17 URLLC NTT DOCOMO, INC.
24. [R1-2009214](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009214.zip) Discussion on intra-UE multiplexing ITRI
25. [R1-2009248](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009248.zip) Discussion on Intra-UE multiplexing/prioritization for URLLC/IIoT WILUS Inc.
26. [R1-2009260](file:///C%3A/Users/wanshic/OneDrive%20-%20Qualcomm/Documents/Standards/3GPP%20Standards/Meeting%20Documents/TSGR1_103/Docs/R1-2009260.zip) Intra-UE multiplexing and prioritization for IOT and URLLC Qualcomm Incorporated