**3GPP TSG-RAN WG1 Meeting #105-e****R1-210XXXX**

e-Meeting, May 19th – 27th, 2021

**Agenda item: 8.3.1.1**

**Source: Moderator (Nokia)**

**Title: Moderator summary #3 on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT**

**Document for: Discussion and Decision**

# Introduction

As per chairman’s guidance, the email discussion is planned according to the following schedule:

[105-e-NR-R17-IIoT-URLLC-01] Email discussion on UE feedback enhancements for HARQ-ACK – Klaus (Nokia)

* 1st check point: 5/21
* 2nd check point: 5/25
* Final check: 5/27

Based on Mr chairman’s guidance, only ‘Retransmission of cancelled HARQ’ and ‘PUCCH carrier switching for HARQ feedback’ are to be handled during RAN1#105-e in AI 8.3.1.1. Therefore, any additional input provided by companies is not considered in this moderator summary, but related proposals are still included in Appendix B.

**This document is structured as follows:**

* Sections 2 focuses on Retransmission of cancelled HARQ
* Section 3 focuses on PUCCH carrier switching for HARQ feedback
* There are two appendices, Appendix A containing the RAN1 agreements reached in AI 8.3.1.1 so far and Appendix B summarizing the companies’ proposals for easier referencing.

# Retransmission of cancelled HARQ

## 2.1 Summary of companies input in their contributions

On the **scenarios to be supported / focused on**, the following input was provided:

* Focus on LP HARQ-ACK: ZTE [4] (LP prioritized, same principle could be applied to HP HARQ)
* Equal support for LP & HP HARQ-ACK: vivo [5] (unified solution), Mediatek [23] (unified solution), APT/FGI [26]
* Canceled PUSCH carrying HARQ-ACK (e.g. due to intra-UE mux): QC [9] (see description of scenario 2.1, support related enhancements)
* Dropping LP PUCCH should not be the driver: QC [9]
* Focus on /main solution is network controlled mechanism (not autonomous re-tx): QC [9]
* SPS HARQ-ACK deferral is only able to handle the collision with semi-static DL symbols – for dropping concerning flexible symbols this is not sufficient: China Telecom [11], Intel [12]

Suggested **methods to support re-transmission of canceled HARQ-ACK**:

* **Alt. 0 (10 Yes – 1 No) – Type 3 CB enhancements that are not codebook size related for Rel-16 URLLC enhancements (unchanged codebook construction, i.e. without smaller size)**
	+ **PHY priority indication** in the triggering DCI of the PUCCH carrying the Type 3 CB: Ericsson [1], Nokia/NSB [3], Spreadtrum [6], CATT [7], Apple [13], Interdigital [19], Sharp [21], DoCoMo [22], APT/FGI [26], WILUS [27] – **No:** QC [9]
		- Focus on this aspect, before discussing payload size optimizations: Sharp [21]
	+ Support Type 3 CB **triggering using** **DCI format 1\_2**: Ericsson [1], Nokia/NSB [3], CATT [7], China Telecom [11], Sony [14] (for Rel-16 Type 3 CB), Mediatek [23] (for Rel-16 Type 3 CB), APT/FGI [26], WILUS [27]
	+ Do not support Type 3 CB triggering using DCI format 0\_1: QC [9]
* **Alt. 1 (18 Yes – 3(2?) No)- Support enhanced Type 3 CB(s) with smaller size (compared to Rel-16):**
	+ *Definition:*
		- *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook is at least determined by RRC configuration*
		- *The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)*
	+ **Yes:** Ericsson [1], HW/HiSi [2] (based on RRC configuration only, but not essential), Nokia/NSB [3], vivo [5], Spreadtrum [6], CATT [7], QC [9], OPPO [10], China Telecom [11], Intel [12], Apple [13], Panasonic [15] (but not essential), ETRI [16], Interdigital [19], LGE [20], DoCoMo [22], Moto/Len [25] (no triggering needed), WILUS [27]
	+ **No:** Sony [14], Samsung [18] (unnecessary / not meaningful), Mediatek [23] (reuse as is)(?)
	+ **Suggested Type 3 CB enhancements with smaller size:**
		- Allow the **dynamic triggering to indicate a sub-set of HARQ processes / cells or different Rel-17 Type 3 CBs**: Nokia/NSB [3], ZTE [4], vivo [5] (based on configured lists), Spreadtrum [6], QC [9], OPPO [10] (subset of cells), Intel [12] (index to a configured table), Apple [13], NEC [17], Interdigital [19], LGE [20], APT/FGI [26] – **No - only single Rel-17 Type 3 CB size supported at a time (e.g. based on RRC configuration):** Ericsson [1] (only activated CCs), HW/HiSi [2], CATT [7], China Telecom [11], Panasonic [15] (or activation), ETRI [16], DoCoMo [22] (RRC or time window)
			* Only for DCI not scheduling PDSCH: Nokia/NSB [3] (reuse unused field, for DCI scheduling PDSCH only a single fixed CB can be triggered), vivo [5], Interdigital [19] (‘use unused bitfields)
			* Also for DCI scheduling PDSCH: Spreadtrum [6], Intel [12] (?)
			* Index to configured lists / tables: Nokia [3], vivo [5], Intel [12]
			* Indication to differentiate SPS HARQ collision, cancelled HARQ or if both should be re-transmitted: QC [9] (Proposal 7 indicates that there is no need to have more than one Type 3 CB sizes configured)
			* Triggering DCI indicating the HARQ-IDs: QC [9]
			* Using RNTI (for M=2): NEC [17], LGE [20] (for SPS & general Type 3 CB)
			* Explicit indication in DCI (M>2): NEC [17], LGE [20] (reuse or extend one-shot request field)
			* **Priority based CB construction / CB size** (based on the priority indication): ZTE [4], Apple [13], Interdigital [19], LGE [20], APT/FGI [26] – **No (i.e. same CB)**: Ericsson [1] (all HARQ processes), Nokia/NSB [3], Spreadtrum [6], CATT [7], QC [9], DoCoMo [22], WILUS [27]
				+ Separate configuration of NDI & CBG for ‘LP & HP’ Type 3 CB: Apple [13], APT/FGI [26]
				+ Separate configuration of applicable CCs and HARQ-IDs for ‘LP & HP’ Type 3 CB: Apple [13]
				+ Pre-configured CB size per priority: Interdigital [19]
				+ Only applicable to SPS Type 3 CB: LGE [20]
		- Only **SPS HARQ processes**: CATT [7], China Telecom [11] (activated ones), Intel [12] (configured or activated), ETRI [16] (activated ones), NEC [18], LGE [20], QC [9]
			* Including dynamic indication of subset of SPS configurations: NEC [18]
			* Including a reduced set of DL HARQ processes of SPS configurations using RRC: NEC [18]
			* PUCCH resource determination needs to be studied: NEC [18]
			* SPS HARQ Type 3 CB per priority: LGE [20]
		- Only **HARQ processes within a time window** (reference is triggering DCI): QC [9], OPPO [10] (for SPS only), DoCoMo [22]
		- Only consider **activated CCs**: Ericsson [1], China Telecom [11], Panasonic [15], ETRI [16], QC [9]
		- Only **subset of configured CCs**: Nokia/NSB [3], QC [9], Intel [12], Moto/Len [25]
		- Only configured **subset of HARQ processes**: Nokia/NSB [3], QC [9], LGE [20], Moto/Len [25], QC [9]
		- How to **differentiate Rel-16 or Rel-17 Type 3 CB(s)**:
			* Bit on the DCI: Spreadtrum [6], QC [9]
			* Based on RNTI: ETRI [16]
			* Based on RRC: Intel [12], NEC [17]
		- Define a **reference time** for the Type 3 CB construction **to avoid ambiguity**: ETRI [16]
		- **Autonomous Type 3 CB on CG PUSCH**: Moto/Len [25] (as for NR-U operation)
		- **Include SPS release HARQ-ACK** to Type 3 CB: WILUS [27]
* **Alt. 3 (9(?)(8) Yes – 2 No) – DCI scheduling new PUCCH resource for HARQ re-transmission / One-shot triggering of dropped HARQ-ACK on PUCCH:**
	+ *Definition:*
		- *The UE is provided a trigger and a PUCCH resource to transmit the dropped HARQ-ACK.*
			* *This may or may not include in addition some time windowing*
	+ **Yes:** Nokia/NSB [3], ZTE [4], CATT [7] (‘if supported’, see detail below)(? CATT to confirm), ~~QC[9]~~, OPPO [10], Sony [14], Samsung [18], DoCoMo [22] (if time window for Type 3 CB not supported), Mediatek [23], Ericsson[1]
	+ **No:** vivo [5] (no need), QC (error in case DCI scheduling LP PDSCH & LP PUCCH is missed)
	+ **Details:**
		- For triggering with DL assignment on PUCCH, support dynamic indication of the dropped PUCCH instance: Nokia/NSB [3], CATT [7] (offset between triggering DCI and the dropped PUCCH), OPPO [10] (x-bit explicit indication) – **No** (there is no need for indication): Samsung [18]
		- Triggering possible as soon as the conflict is determined (e.g. after the DCI scheduling HP PUCCH which cancels the LP PUCCH): ZTE [4]
		- Indication of requested HARQ processes: QC [9]
		- Implicitly, if scheduling a re-transmission of a HARQ process whose HARQ CB had been cancelled: OPPO [10]
		- Implicitly, the original DL assignment includes already the information of the re-transmission in case of dropping (i.e. DL assignment indicating PRI, K1, PRI\_rext, K1\_retx): Intel [12]
		- Trigger is a DL assignment without DL-SCH / PDSCH: Sony [14]
		- Consider all 3 options (last dropped, timing window and/or dynamic indication): Sony [14]
		- Apply a time window to define the HARQ-ACK to be re-transmitted: DoCoMo [22]
* **Alt. 4 (6(?)(5) Yes – 2 No) – DCI scheduling new PUSCH for HARQ re-transmission / One-shot triggering of dropped HARQ-ACK on PUSCH:**
	+ *Definition:*
		- *The UE is provided a trigger and a PUSCH resource to transmit the dropped HARQ-ACK.*
			* *This may or may not include in addition some time windowing*
	+ **Yes:** Nokia/NSB [3], ZTE [4](? ZTE to confirm), Sony [14], Samsung [18], Mediatek [23], Ericsson[1]
	+ **No:** vivo [5] (no need), QC (high specification effort, PUSCH less efficient than PUCCH, error cases if DCI lost)
	+ **Details:**
		- For triggering with UL grant on PUSCH, only support for re-transmission (with the same CB mapped): Nokia/NSB [3] – **No**: Samsung [18] (applicable for each PUSCH)
		- Triggering possible as soon as the conflict is determined (e.g. after the DCI scheduling HP PUCCH which cancels the LP PUCCH): ZTE [4]
		- Trigger is an UL grant without UL-SCH / PUSCH: Sony [14]
		- Consider all 3 options (last dropped, timing window and/or dynamic indication): Sony [14]
	+ Similar handling of stored HARQ-ACK info as A-CSI on PUSCH without UL-SCH: Mediatek [23]
* **Alt. 5 (1 Yes) – Automatic re-tx of canceled HARQ-ACK (if multiplexed on PUSCH) on the PUSCH re-transmission with the same resource allocation:** QC [9]
	+ Limited to UL-CI operation (i.e. dropping due to DCI format 2\_4 reception): QC [9]
	+ If a PUSCH incl. HARQ is canceled, the cancelled HARQ-ACK is multiplexed on the PUSCH re-transmission automatically with the same resource allocation including same NDI, TBS, MCS, HARQ Process ID: QC [9]
	+ Only HARQ-ACK is to be re-transmitted (drop CSI): QC [9]
	+ No multiplexing of new UCI on the PUSCH re-tx: QC [9]
	+ No support for partial re-transmission of cancelled HARQ-ACK bits: QC [18]
	+ Can be configured together with Type 3 CB operation and mapped to the earlier occasion of the Type 3 CB or the PUSCH re-transmission: QC [9]
* **Alt. 6 (1 Yes – 1 No): Enhanced Type 2 CB:** Clarification that PDSCH grouping for Enh-Type2 CB is within each PHY priority:vivo [5] (then readily available) – No: Samsung [18] (not generally feasible)

**Multiplexing of re-transmitted and new HARQ-ACK information**:

* Concatenation of two Type 1 CBs (re-tx CB is appended): QC [9] (modifications to Type 1 CB will result in high specs impact, issues in case of missed UL-CI)
* Concatenation of two Type 2 CBs (re-tx CB is appended): QC [9] (modifications to Type 1 CB will result in high specs impact, issues in case of missed UL-CI)

**Additional things that need consideration:**

* Interaction of SPS HARQ skipping (if supported) and re-transmission of cancelled HARQ: Apple [13]

## 2.2 1st Round

**Moderator comments:**

Looking at the input given, the following is noted:

* There are **enhancements to the Rel-16 Type 3 CB triggering** suggested to take Rel-16 URLLC enhancements into account (**Alt. 0**), **that do NOT change the REl-16 Type 3 CB construction / definition / size**, but triggering with DCI format 1\_2 and PHY priority handling of the PUCCH carrying the Rel-16 Type 3 CB is suggested (noted as Alt. 0). **About 10 companies** suggesting such enhancements.

It is the moderator’ understanding, that these suggested enhancements are somehow independent of any real Type 3 CB enhancements in terms of size or configurability (of Alt. 1) and therefore could be independently agreed. Both suggested enhancements there seem to require only very minor specification and implementation impact.

***So maybe we could try to agree such enhancements at least for the Rel-16 Type 3 CB (so independently of the decision to support Type 3 CB of smaller size, i.e. Alt. 1)***

* There is rather strong support from companies **(~18 companies) suggesting Type 3 CB with smaller size at least based on RRC configuration (Alt. 1, based on the definition and as discussed already during RAN1#104bis-e).**

On the details, the positions are slightly diverse in what could be actually supported. This includes if only a single Rel-17 HARQ-ACK Type 3 CB of smaller size can be configured or if dynamic indication of one of more than one configured Rel-17 HARQ-ACK Type 3 CB of smaller size is possible. The same applies to if different RRC configuration of the Rel-16 Type 3 CB parameters (e.g. CBG & NDI) should be possible for PHY priority 0 & 1. And then there are varying positions on how a single reduced size Rel-17 Type 3 CB could look like (such as activated CCs only, SPS HARQ processes only, configured subset of HARQ processes and/ CCs, …).

The moderator has the feeling, that discussing more on the details (of the previous paragraph) before having a generic decision as we tried during RAN1#104bis-e is not really helping as the companies that do not want to see enhancements to Type 3 CB size are suggesting from their side one-shot-triggering of PUSCH and/or PUCCH (i.e. Alt. 3 / Alt. 4, as the codebook size is then only covering dropped HARQ-ACK) independently of the detailed definition of a Rel-17 Type 3 CB of reduced size. ***Therefore, the moderator thinks we need to have a generic decision if at least one Rel-17 Type 3 CB of reduced size is supported.***

* Looking at the **one-shot triggering for new PUCCH resource for HARQ-ACK retransmission using DL assignment (Alt. 3)** there seems to be still good support for it but clearly less compared to Alt. 1 (10Y vs. 1N). There seems to be slightly more support for Alt. 3 compared to Alt. 4 of re-transmission on new PUSCH using an UL grant to triggering (6Y vs. 1N).

On the details, there are mixed opinions how to determine the HARQ-ACK codebook that is dynamically explicitly triggered for retransmission (window, last dropped, dynamically indicated PUCCH occasion and/or HARQ-ID and/or CB containing the HARQ-DI of the scheduled PDSCH). Also implicit triggering in the initial DL assignment is suggested.

***As this seems to be more popular enhancement enabling the CB size tailored to the dropped HARQ-ACK (compared to Alt. 4), it is suggested to see if Alt. 3 could be supported and at least in the initial phase focus the discussions more on Alt. 3 (compared to Alt. 4 below)***

* For **one-shot triggering for new PUSCH for HARQ-ACK retransmission using DL assignment (Alt. 4) using an UL grant for triggering (6Y vs. 1N)** there seems to be less support compared to Alt. 4 (and less technical details provided by supporting companies). As discussed above, it is ***suggested to focus the discussions at least initially not on Alt. 4 but more on Alt. 3*** (as there seems to be more support by companies and is at least more in line with the HARQ-ACK triggering using DL assignments for Enh. Type 2 and Type 3 CB).
* **For Alt. 5 &Alt. 6, only one company each mentioned the support in their contribution.** Therefore, the discussions on these are suggested to take place after having more clarity on other alternatives with more indicated support.

Based on the current status and summary above, the following proposals come to mind here with respect to Alt. 0, 1 and Alt. 3:

**FL proposal 2.1: Support Rel-16 Type 3 CB triggering using DCI format 1\_2.**

* **The triggering using DCI format 1\_2 is RRC configured.**
* ***Note: the Rel-16 Type 3 CB parameters, construction & size is not affected***

**Question 2.1.1: Do you support FL proposal 2.1? (Only Yes / No here – please add your company name, please provide your additional comments to next question / table below separately)**

|  |  |
| --- | --- |
| *Yes - Support*  | Sharp, CATT, OPPO, Spreadtrum, Sony, WILUS, Nokia/NSB, Intel, vivo, InterDigital, DOCOMO, Huawei (can accept), NEC, Panasonic, China Telecom, Samsung, Ericsson, QC |
| No – Do not support | ZTE |

**Question 2.1.2: Do you have any additional comments on FL proposal 2.1, including your arguments for or against the support?**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Sharp | Agree with FL proposal and I wonder whether the formation could be improved. As mentioned by FL, Alt.0 can be independently discussed from Alt.1 and others. Then, it would be clearer to change Alt.0 from an alternative to an independent proposal/topic. |
| OPPO | Further clarification. If Rel-16 Type 3 CB triggering using DCI format 1\_2 is supported, the mechanism that Type 3 CB request with/without PDSCH transmission will be reused for DCI format 1\_2 directly. |
| Intel | We support the spirit of the proposal, but would like to remove the note, which can be misused when potential discussions on CB size optimizations are discussed.On a general note, we would like to see a general agreement on supporting enhanced operation for retransmission of cancelled/dropped HARQ FB based on a trigger, with detailed option (eType 3 CB, one-shot, etc) to be down-selected later this meeting or next meetings. This way we can avoid mutual objections on the progress for separate options preferred by different companies. |
| ZTE | If type-3 CB is applied, the codebook size could be reduced to a smaller size, for example, a smaller size can be achieved by differentiating the codebook for high priority or low priority HARQ process, e.g., maximum 8 processes for high priority codebook construction and maximum 8 processes for low priority codebook construction.Another important issue about Rel-16 Type 3 codebook. Rel-16 Type3 codebooks can’t support HARQ-ACKs for release DCI and SCell dormancy indication. If the dropped HARQ-ACK codebook contains HARQ-ACKs for release DCI or SCell dormancy indication and need be retransmitted by triggering a type3 codebook, the Rel-16 type3 codebook cannot contain HARQ-ACKs for release DCI and SCell dormancy indication. Suppose the enhanced Type 3 codebook construction can append the HARQ-ACK of release DCI into the codebook, but the release DCI missing issue should be another problem to be handled. |
| Huawei, HiSilicon | We don't see strong motivation to support type 3 CB with DCI format 1\_2, however if anyway type 3 CB with enhancements would be introduced for Rel-17 URLLC, then no need to restrict the applicability of DCI format 1\_2.  |
| QC | Agreement with the moderator’s comment (“***So maybe we could try to agree such enhancements at least for the Rel-16 Type 3 CB (so independently of the decision to support Type 3 CB of smaller size, i.e. Alt. 1)”*** ). However, the group should target not to spend much time on these changes that enable the use of Rel. 16 Type 3 CB in URLLC. |

**FL proposal 2.2: Support PHY priority handling for a PUCCH carrying the Rel-16 Type 3 CB in Rel-17.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 CB.**
* ***Note: the Rel-16 Type 3 CB parameters, construction & size is not affected by the indicated PHY priority***

**Question 2.2.1: Do you support FL proposal 2.2? (Only Yes / No here – please add your company name, please provide your additional comments to next question / table below separately)**

|  |  |
| --- | --- |
| *Yes - Support*  | Sharp, CATT, OPPO, Spreadtrum, Sony, WILUS, Nokia/NSB, Intel, vivo, InterDigital, DOCOMO, Huawei, NEC, Panasonic, China Telecom, Ericsson, Yes |
| No – Do not support | ZTE, Samsung (tentative) |

**Question 2.2.2: Do you have any additional comments on FL proposal 2.2, including your arguments for or against the support?**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Intel | Same comment as in Q2.1.2 applies. |
| ZTE | From our perspective, the codebooks should be separated for high priority or low priority HARQ process. I am not sure the proposal to indicate PHY priority in the triggering DCI defining the PHY priority of the PUCCH carrying the Type 3 CB can separate the codebooks for high priority or low priority HARQ process. This need more clarification. |
| Samsung | It will be good to first discuss the need and implications from supporting multiple priorities.  |
| Ericsson | Currently, a DCI that is configured with 2-level priority indication can not be used for triggering One-shot. With this proposal, our understanding is that such combination of configurations of DCI fields would be allowed (onr-shot trigger + 2-level priority). Otherwise, the usage for URLLC would be questionable.The indicated priority based on existing procedure is sued to determine the PUCCH config and corresponding PUCCH resource, etc. |
| QC | The use of priority indication for the PUCCH transmission is self-explanatory. No strong opinion on whether there is a need to have a separate or the same CB for high priority and low priority HARQ bits. This is a minor arguments, since the use of Rel. 16 Type 3 CB is by default not suitable and hence not efficient for URLLC. The group should not spend time arguing on this topic. |

**FL proposal 2.3: Support enhanced Type 3 CB(s) with smaller size (compared to Rel-16)**

* + ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***

**Question 2.3.1: Do you support FL proposal 2.3? (Only Yes / No here – please add your company name, please provide your additional comments to next question / table below separately)**

|  |  |
| --- | --- |
| *Yes - Support*  | Sharp, CATT (with additional constraint), OPPO, Spreadtrum, WILUS, Nokia/NSB, Intel, vivo, InterDigital, DOCOMO, Huawei (with modification), NEC, Panasonic, Lenovo/Motorola Mobility, China Telecom, Ericsson, QC |
| No – Do not support | Sony, ZTE, Samsung |

**Question 2.3.2: Do you have any additional comments on FL proposal 2.3, including your arguments for or against the support?**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Sharp | We support FL proposal in principle and are open to discuss. |
| CATT | We are in general supportive to enhance Type 3 CB to reduce the payload size with small specification impact, e.g. to include HARQ-ACKs for SPS PDSCH only, and/or to include HARQ-ACKs for the DL HARQ processes of active DL CCs only. But we do not support further enhancements to construct enhanced Type 3 CB based on dynamic indication in DCI. If companies would like to do such enhancements, we think one-shot triggering is more efficient and has less specification impact. Therefore, we would like to add the sub-bullet in red in the proposal.**Support enhanced Type 3 CB(s) with smaller size (compared to Rel-16)** * + ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook size of enhanced Type 3 HARQ-ACK codebook is not determined based on DCI indication***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
 |
| Spreadtrum | Support FL proposal in principle and are open to discuss. |
| Sony | We do not support enhancing Type 3 CB for the sake of overhead reduction. Any enhancement proposed to reduce Type 3 CB size would be ***sub-optimal*** since Type 3 CB was introduced to be have a static size.If overhead is an issue, it is far more beneficial and efficient to use a new *dynamic* CB, e.g. Type 4 CB, with the sole purpose of retransmitting ONLY dropped HARQ-ACKs**. No matter what magical enhancement any company proposed for *static* Type 3 CB for overhead reduction, it can NEVER EVER perform better or more efficient than a new *dynamic* CB that retransmits only dropped HARQ-ACKs.**Hence, we simply cannot see why RAN1 needs to spend all this time trying to enhance something that would *knowingly* produce sub-optimal results. *This is like trying to enhance a train to make it fly like a plane. No matter what enhancement you put on a train, it will never fly as well as a plane*. |
| Nokia/NSB | Support the proposal. The potential dynamic indication can be further discussed (.. if not agreeable by the group, there anyhow then will not be any dynamic indication in the DCI).  |
| Intel | We support the proposal, but suggest another approach, as mentioned in Q2.1.2 comment. We would like to see a general agreement on supporting enhanced operation for retransmission of cancelled/dropped HARQ FB based on a trigger, with detailed option (eType 3 CB, one-shot, etc) to be down-selected later this meeting or next meetings. This way we can avoid mutual objections on the progress for separate options preferred by different companies. |
| ZTE | Not support only one codebook can be triggered. According to our explanation above, if the codebooks are separated to codebooks for high priority HARQ process and low priority HARQ process, there are at least two codebooks if any. But we are fine to support codebook size of any of the codebook for high priority HARQ process or low priority HARQ process is determined by RRC configuration. |
| vivo | We support FL proposal as it is. Rel-16 Type 3 realizes basic functions for HARQ-ACK retransmissions. It is easier compared to design the one-shot e-transmission from the scratch.  |
| InterDigital | We support the FL proposal. We think that an enhanced type 3 CB should have a fixed or semi-statically configured size. |
| Huawei, HiSilicon | As we commented before, the motivation to support type 3 CB is not clear. Therefore, we would avoid much time and effort on optimizing the support of it, which means that we should support it in a simple way, specifically no need to involve dynamic signalling. Therefore, we would like to modify the proposal as below:**Support enhanced Type 3 CB(s) with smaller size (compared to Rel-16)** * + ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook ~~at least~~ determined only by RRC configuration***

***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)*** |
| Panasonic | We support the FL proposal in principle and also support the additional constraint proposed by CATT. |
| Samsung | The proponents should justify the proposal. Any enhancement to Type-3 cannot be better from any perspective (e.g. ensuring useful HARQ-ACK information, minimizing useless HARQ-ACK/overhead, minimizing spec/UE impact) than retransmitting what was dropped.  |
|  | In general supportive of the proposal. Slightly different view on the organization of the work. Step 1: Agreement in the group if there is a need to specify a mechanism for transmission of cancelled/dropped packets.Step 2: Agreement in the group if the solution for cancelled/dropped HARQ should be common for the solution of SPS PUCCH HARQ collision with DLStep 3: Agreement in the group if the solution should be based 1. In a network controlled mechanism (via DCI)
2. Autonomous UE transmission (similar to SPS PUCCH HARQ deferral to the 1st available slot)

Step 4: If the agreed mechanism is DCI based, which DCI (and in which channel) triggers the HARQ transmission.Step 5: Which CB type and constructionSupport to CATT’s proposal. With regards to Sony’s comment, an initial comment is that the proposal here is for a solution for cancelled/dropped/colliding with DL HARQ bits. The transmission of these HARQ bits should be triggered with any type of DCI and transmitted in PUCCH rather than PUSCH, due to higher efficiency of PUCCH. The CB construction can be of any type. Type 3 CB construction could be the starting point. Partial agreement with Sony’s argument: in case Rel. 16 CB is enhanced and the size is given only via RRC configuration, then, there is going to be some inefficiency there due to redundant HARQ process reported. In case the DCI specifies dynamically the CB size, then, the solution is efficient. In general, since the discussion is about collisions/cancellations/dropping due to priorities and error cases are expected, it is not harmful if the network gets a few extra HARQ bits, even redundant ones. To the contrary, the network would want this in most cases. Agreement with Intel.Answer to Samsung: there are no details in your proposed methods.How will the network indicate in the DCI that only (LP?) dropped bits should be reported?Your proposal generates DL L1 signaling overhead since DCI is transmitted without any DL or UL PDSCH or PUSCH allocation.PUSCH is less efficient than PUCCH. PUSCH does not support 1 symbol transmission.One shot PUCCH transmission is a waste of resources in cases of CI. |

**FL proposal 2.4: Support one-shot triggering (by a DL assignment) of dropped HARQ-ACK on a new PUCCH resource (i.e. Alt. 3)**

* + ***Details are FFS***

**Question 2.4.1: Do you support FL proposal 2.4? (Only Yes / No here – please add your company name, please provide your additional comments to next question / table below separately)**

|  |  |
| --- | --- |
| *Yes – Support*  | CATT, OPPO, Spreadtrum, Sony, Nokia/NSB, ZTE, InterDigital, DOCOMO (if smaller type 3 CB size based on time window is not supported), Samsung, Ericsson |
| No – Do not support | Intel, Lenovo/Motorola Mobility |

**Question 2.4.2: Do you have any additional comments on FL proposal 2.4, including your arguments for or against the support?**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Spreadtrum | If enhanced Type 3 CB(s) with smaller size can be supported, the flexibility and resource efficiency of Alt. 3 may can also be appropriately obtained by enhanced Type 3 CBs. In addition, since some possible features under discussion of enhanced Type 3 CB are similar as Alt.3, such as time window and certain HP ID(s) constraint, we suggest to delay the discussion of detailed feature of Alt.3 after more details of enhanced Type 3 are determined.  |
| Nokia/NSB | Support, but as noted in our input contribution we see a need to (dynamically) indicate the specific instance of the PUCCH CB that is to be re-transmitted  |
| Intel | Further clarifications on the intended operation is required to proceed. For example, what “one-shot” means, what “dropped HARQ-ACK” means, how this is different from Type3 and eType2 CBs.Also as commented in the previous section, we suggest making a smaller step first, i.e. agree on having something in R17, and then discuss what, e.g. eType3, one-shot, etc. |
| vivo | We are open to discuss it. But would like know the exact difference between Alt. 1 and Alt. 3. Alt.1 also has the feature of triggering new PUCCH transmission. |
| DOCOMO | If type 3 CB with smaller CB size by indicated time winow is not supported, we are supportive of FL proposal 2.4. |
| Huawei, HiSilicon  | The motivation to support FL proposal 2.4 is not clear if type 3 CB is supported also, since with type 3 CB the cancelled HARQ-ACK can be transmitted already. In our understanding, the cancelled HARQ-ACK is most likely LP HARQ-ACK, thus the motivation to optimize the codebook size is not strong.  |
| NEC | We are open to discuss it. But we are not clear of the relation between Alt.1 and Alt.3 that only one of them can be adopted or both of them can be adopted for different HARQ-ACK retransmission scenarios?  |
| Lenovo, Motorola Mobility | Rel-17 supports multiplexing of low-priority HARQ-ACK into high priority PUCCH/PUSCH instead of dropping and also supports HARQ-ACK deferring. With these features, chances that HARQ-ACK feedback is cancelled will be significantly reduced. We think enhanced type-3 HARQ-ACK codebook together with HARQ-ACK deferring and enhanced HARQ-ACK multiplexing are sufficient to increase HARQ-ACK feedback opportunity without increasing radio resource overhead.  |
| Samsung | Any enhancement to Type-3 cannot be better from any perspective (e.g. ensuring useful HARQ-ACK information, minimizing useless HARQ-ACK/overhead, minimizing spec/UE impact) than retransmitting what was dropped. The triggering and PUCCH resource for the retransmission can follow the same mechanism as for the Rel-16 Type-3 CB. OK with the suggestion from Nokia to indicate a slot, if needed – that should be more than enough for any possible enhancement.LP/HP multiplexing will also be supported, all will be optional features, but it is rather clear that it would be much more complex for a UE to implement LP/HP multiplexing. |
| QC | Neutral. Do not see the benefit of this solution. It is only tailored to a very specific case, LP PUCCH dropped, which can be avoided. The solution is inefficient when CI happens. The group should focus on agreeing the basics rather than spreading out in different directions and consequently delaying the progress. |

## 2nd Round

### Discussion

#### Follow up question on PHY priority configuration & DCI 1\_2:

Based on the feedback in the first quick round, there seems to be rather good consensus on the DCI format 1\_2 and PHY priority handling. Based on the some of the comments received, the following updates are suggested:

**Updated 2 FL proposal 2.1: Support at least Rel-16 Type 3 HARQ-ACK CB triggering using DCI format 1\_2 in Rel-17.**

* **The triggering using DCI format 1\_2 is RRC configured.**
* ***Note: the Rel-16 Type 3 CB parameters, construction & size is not affected***
* ***FFS: DCI format 1\_2 triggering for potential support of enhanced Type 3 HARQ-ACK CB (i.e. Alt. 1) ~~are FFS~~***

**Updated 2 FL proposal 2.2: Support PHY priority handling at least for a PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB in Rel-17.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB.**
* ***Note: the Rel-16 Type 3 CB parameters, construction & size is not affected by the indicated PHY priority***
* ***FFS: PHY priority handling for potential support of enhanced Type 3* HARQ-ACK *CB (i.e. Alt. 1) as well as PHY priority specific Type 3 CB parameters (such as CBG & NDI)***

**If you have any additional comments on these updates, please provide your input below (if fine with the updates, no need to comment):**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| vivo | We support the Updated FL proposal 2.1.For Updated FL proposal 2.2, we support it in principle. But we would like to remove the “as PHY priority specific Type 3 CB parameters (such as CBG & NDI)”. From our understanding it is covered by the first part of the FFS “PHY priority handling for potential support of enhanced Type 3 CB (i.e. Alt. 1)”. |
| CATT | Some editorial comments highlighted in cyan to make the proposals more accurate and consistent.**Updated FL proposal 2.1: Support at least Rel-16 Type 3 HARQ-ACK CB triggering using DCI format 1\_2 in Rel-17.** * **The triggering using DCI format 1\_2 is RRC configured.**
* ***Note: the Rel-16 Type 3 HARQ-ACK CB parameters, construction & size is not affected***
* ***FFS: DCI format 1\_2 triggering for potential support of enhanced Type 3 HARQ-ACK CB (i.e. Alt. 1) ~~are FFS~~***

**Updated FL proposal 2.2: Support PHY priority handling at least for a PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB in Rel-17.** * **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB.**
* ***Note: the Rel-16 Type 3 HARQ-ACK CB parameters, construction & size is not affected by the indicated PHY priority***
* ***FFS: PHY priority handling for potential support of enhanced Type 3 HARQ-ACK CB (i.e. Alt. 1) as well as PHY priority specific Type 3 CB parameters (such as CBG & NDI)***
 |
| Sony | We fine with both proposals but do not think we need the FFS in red fonts since we are discussing them anyway. |
| Moderator (Nokia) | Update 2 on the proposed edits by CATT (thanks Yanping). On the FFS, we could discuss if that one is needed in a potential final agreement (but keep it there still for the moment, easy to remove if the group thinks we can survive without it) |
| ZTE | @FL, would you like clarify the FFS in 2.2, I am not quite understanding ***PHY priority specific Type 3 CB parameters (such as CBG & NDI)***, does it mean the NDI will be reinterpreted as the priority indication? |
| DOCOMO | We are generally OK with principle of the two proposals but one comment for the proposal 2.2.According to the note, type 3 CB parameters, construction & size is not affected by the indicated PHY priority. We understand it means the type 3 CB includes HARQ-ACKs of both priorities. But the “PHY priority specific Type 3 CB parameters (such as CBG & NDI)” in the FFS seems to be based on type 3 CB with only one priority.  |
| Intel | Supportive of both proposals |
| Samsung | Support proposal 2.1. Do not support (for now) proposal 2.2. The use-case for priority handling needs to first be identified and the FFS regarding the NDI and the CBG to be resolved.  |
| Sharp | We support both proposals. |
| WILUS | We support both proposals |
| Spreadtrum | We support both proposals. |
| Ericsson | We support both proposals. |
| OPPO | Support 1st proposalSupport 2nd proposal without FFS  |
| Apple | We support both proposals |
| Xiaomi | We support both proposals. |
| NEC | We support both proposals. |

**Question 2.2.3: If Type 3 CB is supported together with PHY priority (i.e. two PUCCH config):**

* **Option 1: the Type 3 CB parameters of NDI and CBG operation can be independently configured for a Type 3 CB with a triggering DCI indicating PHY priority 0 and 1**
	+ ***Moderator comments: please check the details described in the Apple contribution in [1]***
* **Option 2: the Rel-16 configuration of NDI and CBG usage for Type 3 CB applies to both Type 3 CB triggering with PHY priority 0 and 1**
* **Option 3: Other**

Please indicate your preference on Question 2.2.3 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| *Option 1: separate config of NDI & CBG for different PHY priorities*  | Vivo(if the Type 3 CB contains all the HARQ processes, the PHY priority is only used to determine the PHY priority of the PUCCH carrying the Rel-16 Type 3 CB), CATT, APT/FGI, Nokia/NSB, Intel, InterDigital, Ericsson (see our comment) |
| Option 2: Rel-16 configuration of NDI & CBG applies to both  | Vivo (if the Type 3 CB does not contain all the HARQ processes, only contains the HARQ processes for the indicated PHY priority), LG, Sony, Huawei, HiSilicon, DOCOMO, Panasonic, Sharp, WILUS, Spreadtrum, Lenovo/Motorola Mobility, OPPO, NEC |
| Option 3: other |  |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| vivo | If NDI and CBG operation can be independently configured for different prioritise, and PHY priority is only used to determine the PHY priority of the PUCCH carrying the Rel-16 Type 3 CB, then option 1 that separate configure the NDI and CBG for each priority is more flexible and no complexity is involved. While if the Type 3 CB does not contain all the HARQ processes, only contains the HARQ processes for the indicated PHY priority, then option 2 is preferred in order to avoid the miss-understanding between gNB and the UE on the codebook size due to the DCI miss detection if the HARQ IDs is shared for PDSCHs with different prioritise. So, the assumption for the two options should be clarified first.  |
| LG | Regarding HARQ process based codebook construction, we don’t think that it is necessary to consider priority. Basically HARQ process are independent from priority. Thus, even if PHY priority is supported to determine channel priority during UL multiplexing, it could be redundant to distinguish HARQ process according to priority. According to Apple’s contribution (I assume contribution [13] instead of [1]), it could give controllability on inclusion of NDI and CBG. However, it seems not providing technical benefit. To make this meaningful, there should be the case that smaller group of HARQ process for HP and reliable NDI management for HP so that UE can omit NDI from the codebook. As we mentioned, HARQ process are unrelated to priority and NDI is also shared by both priority. In our view, there is no such case. |
| Sony | The L1 priority is for the PUCCH carrying Type 3 CB. It isn’t clear how Type 3 CB which has a semi-static size can carry only HP or LP HARQ-ACK since L1 priority is not tied to HARQ Process ID and L1 priority is dynamically indicated.Again, if overhead is a **REAL** concern, then we should not waste time tinkering with Type 3 CB with all sorts of *sub-optimal* solutions to try to reduce its overhead that can never effectively target the dropped HARQ-ACK. The specs impact is not trivial judging from the enhanced Type 3 CB proposals especially when some proposals require DCI to indicate MULTIPLE different Type 3 CBs. The amount of time, effort, discussion and argument on how to enhance Type 3 CB can be better spent designing a simple dynamic CB that retransmit only dropped HARQ-ACK. If overhead is NOT an issue, then we should just reuse Rel-16 mechanism of Type 3 CB, ie. not enhance Type 3 CB and forget about a new one-shot trigger for a new dynamic CB. |
| Nokia, NSB | We think the codebook should still contain all HARQ processes /IDs (i.e. earlier low and high PHY priority), but that does not prevent to e.g. operate with CBG when triggered as low priority and with CBG when triggered as high priority. Therefore, we are open to enable independent configuration (if agreeable for the group).  |
| DOCOMO | We think Option 1 is based on the type 3 CB with HARQ-ACK of only one priority. Option 2 is based on the type 3 CB with HARQ-ACKs regardless of priorities.  |
| Intel | Although we think this level of details is not going to be discussed this meeting in online, we support Option 1 as more flexible. |
| InterDigital | We are ok with a separate configuration for the different priority. |
| Samsung | If proposal 2.2 is agreed, the CBG configuration can be independent but the same NDI configuration should apply to minimize/avoid changes to the Type-3 codebook construction. |
| Apple | We support Option 1Since physical layer priority can be indicated in the DL DCI, depending on whether the focused HARQ for retransmission is for URLLC or eMBB, the need can be totally different. With Option 1 the overhead incurred by each case can be separately controlled. |
| QC | Request to not treat the proposals now and treat them at the next meeting. The topic of discussion is solutions to cancelled/dropped/collided HARQ bits. There is not a single company suggesting that Rel. 16 Type 3 CB is a solution for cancelled/dropped bits. Hence, the moderator’s motivation is totally unclear considering that the group has not even agreed to adopt a high-level solution. Request to the FL to add the proposal:**Proposal 2.0: Support a mechanism for the retransmission of cancelled/dropped/collided with DL HARQ bits, in which mechanism transmission of cancelled/dropped/collided HARQ bits is triggered via DCI.**Request to the FL to focus on progressing the work towards useful solutions. The whole group agrees that there is a need to specify a solution for cancelled/dropped/collided HARQ bits controlled by the network. There is not a single proponent of the use of Rel. 16 Type 3 CB as a solution for cancelled/dropped/collided HARQ bits.Considering the electronic format of the meetings, hence slow pace, and the limited time, proposals 2.1 and 2.2 should be treated after proposal 2.0. |
| Spreadtrum | We do not see much necessity to associated NDI and CBG configuration with PHY priority. |
| Lenovo, Motorola Mobility | We agree with LG’s comments. PHY priority indicates a PUCCH priority, and no substantial benefit is foreseen from different codebook construction for different PHY priorities. |
| Ericsson | It is not clear why in Option 1 or 2, we have the cyan text due to the main bullet, “together with PHY priority”. If this is proposed, we prefer not to have the cyan text at least in Option 1.**If Type 3 CB is supported together with PHY priority (i.e. two PUCCH config):** * **Option 1: the Type 3 CB parameters of NDI and CBG operation can be independently configured for a Type 3 CB with a triggering DCI indicating PHY priority 0 and 1**
	+ ***Moderator comments: please check the details described in the Apple contribution in [1]***
* **Option 2: the Rel-16 configuration of NDI and CBG usage for Type 3 CB applies to both Type 3 CB triggering with PHY priority 0 and 1**
* **Option 3: Other**
 |
| OPPO | PHY priority in the triggering DCI only defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB. No further enhancement on PHY priority issue. |
| Xiaomi | Option 2 is sufficient. There is no substantial benefit separate configuration for the different priority. |
| China Telecom | We think whether the type 3 CB should contain all HARQ processes needs to be discussed firstly. |

#### Follow up Question on Alt. 1 / Type 3 CB of smaller size:

***Moderator comments:*** The main comments on the wording of the proposal on the Type 3 CB enhancements of smaller size have been if there is a dynamic indication or not, and if the CB is defined by RRC only or by something else (e.g. CC and/or SPS activation).

No update to the proposal is suggested there yet, but let’s see where the group stands with respect to some different options mentioned in the different company contributions on the details (… the proposal could be updated then accordingly)

**Question 2.3.3: If at least one Type 3 CB of smaller size (compared to Rel-16) is supported,**

* **Alt. 1: Only a single reduced size Type 3 CB can be configured for a UE and its size is determined by RRC configuration**
* **Alt. 2: Only a single reduced size Type 3 CB can be configured for a UE and its size is determined by RRC configuration and activation (e.g. activated CCs and/or activated SPS config)**
* **Alt. 3: More than one reduced size Type 3 CB can be configured for a UE, and the applicable Type 3 CB is determined by some unused field (e.g. HARQ-ID field) for a triggering DCI not scheduled PDSCH (i.e. Type 3 trigger without DL-SCH)**
* **Alt. 4: More than one reduced size Type 3 CB can be configured for a UE, and the applicable Type 3 CB is determined by some additional field in the triggering DCI (i.e. same behavior for triggering DCI with DL-SCH and without DL-SCH)**
* **Alt. 5: A separate reduced size Type 3 CB can be configured for PHY priority 0 and 1 for a UE, and the applicable Type 3 CB is determined based on the PHY priority indication in the triggering DCI**
	+ ***.. the meaning here is in addition to NDI & CBG of Question 2.2.3, but e.g. different subset of HARQ processes, CCs etc. for different priorities***
* **Alt. 6: One SPS specific and one ‘generic’ enhanced Type 3 CB configured for the UE, and the applicable Type 3 CB is determined by the RNTI scrambling the triggering DCI**
	+ ***e.g. . CS-RNTI for SPS – C-RNTI for ‘generic’***
* **Alt. 7: other**

Please indicate your preference(s) on Question 2.3.3 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 | LG, APT/FGI, Huawei, HiSilicon, InterDigital, QC (1st preference), WILUS, Spreadtrum, Lenovo/Motorola Mobility, Ericsson |
| Alt. 2 |  Vivo (2nd preference), CATT, DOCOMO, Panasonic, QC (3rd preference), Ericsson, NEC, China Telecom |
| Alt. 3 | Vivo (1st preference), Nokia/NSB, DOCOMO, Intel, InterDigital, QC (2nd preference), WILUS, Spreadtrum, Ericsson (maybe),OPPO,Xiaomi, NEC |
| Alt. 4 | LG, Intel, OPPO |
| Alt. 5 | APT/FGI, ZTE (Only support main bullet for now as the NDI & CBG here is not clear for me), Apple |
| Alt. 6 | LG (for type-3 CB based on SPS), NEC |
| Alt. 7 | Sony (no enhancement), Samsung (no enhancement) |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| vivo | Our first preference is Alt.3 which can give gNB the most flexibility for triggering the dropped HARQ-ACK and the design is not complex. We can also accept Alt.2 for progress.Alt.1 is cannot save the codebook size much; Alt.4 will increase the DCI overhead which is not desirable for URLLC; For Alt.5, if the Type 3CB only contains the feedback for the indicated priority, to avoid miss understanding between gNB and UE, the HARQ IDs cannot be shared for PDSCHs with different prioritises, which may cause scheduling delay for URLLC PDSCH.For Alt.6, we think one ‘generic’ enhanced Type 3 CB should be enough for URLLC considering the SPS HARQ deferral is supported.  |
| LG | We support Alt. 1, 4 and 6.Since we prefer simple and semi-static manner to remove missing DCI issue. Regarding Alt. 6, this would be beneficial when enhance type-3 CB for SPS is supported. If SPS is configured, CS-RNTI is already assigned, so there would be no issue of RNTI budget. |
| CATT | We think Alt. 2 is sufficient. Any further enhancements complicate the design and are suboptimal. |
| Sony | We do not see a need for enhancing Type 3 CB to optimise overhead. The specs impact is not trivial especially for proposals with multiple Type 3 CB.If overhead is an issue, it is better to design a mechanism that targets only dropped HARQ-ACK than to waste time coming up with a sub-optimal solution trying to dressed up Type 3 CB.If overhead is not an issue, then there is no need to enhance Type 3 CB and no need to design any new dynamic CB. |
| Huawei, HiSilicon  | As we commented before, the motivation to support type 3 CB is not clear. Therefore, we would avoid much time and effort on optimizing the support of it, which means that we should support it in a simple way, specifically no need to involve dynamic signalling. |
| Nokia/NSB | Alt. 3: We think that not using the ability for a DCI triggering a Type 3 CB without scheduling a PDSCH to triggered different Type 3 CBs (e.g. SPS / generic, different subsets of carriers etc.) would be loosing an opportunity here that we get for free (as unused DCI fields such as the HARQ-ID field could be used). In contrast to Alt. 4, which we do understand companies may not want to increase the DCI size. Otherwise, we may be stuck with Alt. 1 and/or Alt. 2, that is not able to use the full potential otherwise. We do not see Alt. 5 really feasible, as it is not just about the codebook but also the priority of the PUCCH. For Alt. 6, using CS-RNTI for the triggering may be impacting the activation / release (especially if only the re-transmission is to be triggered).  |
| DOCOMO | For Alt1 and Alt2 with single configured reduced size type 3 CB, Alt2 is more flexible than Alt1.For Alt 3 and Alt 4 with multiple configured reduced size type 3 CB, Alt 3 is preferred since DCI field extension by Alt 4 is not preferred.Alt 5 needs to configured mapping relationship of HAR process and PHY priority, which may limit scheduling flexibility.Alt 6 only works for SPS HARQ-ACK retransmission. |
| Intel | Type 3 CB should be enhanced to be constructed in most efficient way, thus dynamic indication is preferred: Alt 3 or 4. For Alt 5 we see some issue in relating the priority indication for PUCCH and the CB construction which are different matters. |
| InterDigital | We support Alt. 3 and we are ok with Alt. 1 as well.  |
| Samsung | Regarding “activated” vs. “configured” CCs/SPS configs, we generally support to use ‘activated’. However, there seems to be a tunnel vision to Type-3 CB which is neither of primary importance (optional) nor the one benefiting most from such adjustment. Focus should be on Type-1 CB and maybe also on PDCCH monitoring (for CA) which are mandatory features and more impacted by the “configured” vs. “activated”. It does not make sense to agree to “activated” for Type-3 while keeping “configured” for Type-1 or for PDCCH monitoring. Agree with Nokia’s comments on the various alternatives. Alt. 1/2 make any change to the Rel-16 Type-3 useless, there is no point to increase DCI size (Alt. 4), Alt. 5 is not feasible or meaningful, and Alt. 6 is a sub-case of Alt. 3 and does not require special handling or hardcoding in the specifications. Before any further discussion on “reduced” Type-3, the flavour/Alt should be identified. |
| Panasonic | We think Alt.2 is straightforward extension to remove the useless bits of inactivated cells from the codebook. |
| QC | Alt 1, 2 and 3 could be configured and used on a per case rule. In discussion Round 1, 16 (17 with Huawei ?) companies support FL’s proposal 2.1 and 2.2, 18 companies support FL’s proposal 2.3 and 10 companies support FL’s proposal 2.4. In Round 2 of discussion, FL’s proposals 2.1 and 2.2 and proposal 2.4 are brought back with an update, whilst there is no updated proposal 2.3. There is one question with regards to FL’s proposal 2.3.Request to the moderator to bring back the proposal:**Updated FL proposal 2.3: Support enhanced Type X CB(s) with smaller size (compared to Rel-16)** * + ***Definition of enhanced Type X CB:***
		- ***The codebook size of a single triggered enhanced Type X HARQ-ACK codebook at least determined by RRC configuration***

***The codebook construction uses the same procedure as the one of Rel. 16 Type 3 CB construction, hence, HARQ processes are used as the base of the CB.*** |
| WILUS | We support Alt 3, which provides good flexibility, and we are also fine with Alt 1.  |
| OPPO | We prefer to indicate Type 3 CB containing a given subset of carriers dynamically, which adjusts service scheduling situation flexibility and maximizes Type 3 CB size reduction with small spec effort.To support dynamic indication on subset of carriers, both option 3 and 4 can work. Option 4 is first preference due to it is more straightforward. Option 3 is acceptable.  |
| Apple | We support Alt. 5 |
| Xiaomi | We prefer alt 3. |
| NEC | Regarding the enhanced Type-3 HARQ-ACK codebook construction, both Alt.2 and Alt.3 can be applied for DG HARQ-ACK and SPS HARQ-ACK, Alt.2 is straightforward, and Alt.3 is flexible and can achieve smaller CB size, so our first preference is Alt.3 and second preference is Alt.2. In addition, we think two separate enhanced Type-3 HARQ-ACK codebooks can be supported, one is for SPS HARQ-ACK only, another one is for DG HARQ-ACK with/without SPS HARQ-ACK. We are not sure if the indication in the DCI of Alt.3 contains which HARQ-ACK codebook was triggered, if not, UE can identify which HARQ-ACK codebook is triggered by the RNTI scrambling the triggering DCI, so Alt.6 can also be supported. |

#### Follow up Question on Alt. 3 / one-shot triggering on PUCCH:

Based on the feedback that ‘dropped’ HARQ-ACK is unclear and some editorial change to the proposal is suggested (i.e. re-transmission actually was missed). So the following update is proposed:

**Updated FL proposal 2.4: Support one-shot triggering (by a DL assignment) of ~~dropped~~ HARQ-ACK re-transmission on a new PUCCH resource (i.e. Alt. 3)**

* + ***Details are FFS***

**If you have any additional comments on these updates, please provide your input below (if fine with the updates, no need to comment):**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| vivo | We can support it in general with the understanding that the proposal may include all alternatives as listed in Question 2.4.3.  |
| LG | We understood it is for re-transmission of HARQ-ACKs which had been transmitted and dropped by higher priority. Then, it should be clarified what the difference between enhanced type-3 and one-shot triggering is and what is a benefit to support both.  |
| Sony | We support this if overhead is an issue in using Rel-16 Type 3 CB. That is we rather focus on Proposal 2.4 than to enhance Type 3 CB.  |
| Huawei, HiSilicon  | The motivation to support FL proposal 2.4 is not clear if type 3 CB is supported also, since with type 3 CB the cancelled HARQ-ACK can be transmitted already. In our understanding, the cancelled HARQ-ACK is most likely LP HARQ-ACK, thus the motivation to optimize the codebook size is not strong. |
| ZTE | Support |
| DOCOMO | We support proposal 2.4 to trigger retransmission for indicated HARQ-ACKs on PUCCH if such optimization is not supported for enhanced type 3 CB size reduction. |
| Intel | As we suggested in the 1st round, may be better to put both ‘eType3’ and ‘one-shot’ to a single proposal, and down-select later this meeting or next meetings. Note, still the meaning of the main bullet is ambiguous, and it can even cover Type 3 CB design. |
| Samsung | Optimal with no/minimal complexity/specification impact. Triggering/resource mechanism is similar to Rel-16 Type-3 CB - no new CB construction. |
| Panasonic | We can support the proposal if Type 3 CB of smaller size is not supported. |
| QC | No support. The proposal is not working in case of not aligned understanding of the amount of cancelled/dropped/collided HARQ bits (between gNB and UE). Example:Time t1: DCI 1\_x allocating resources for LP PDSCH and LP PUCCH DCI 1\_x missed (LP traffic)Time t2: DCI 1\_x allocating resources for HP PDSCH and HP PUCCH HP PUCCH overlaps with LP PUCCH and PRI indicates resources only for HP PUCCHNetwork assumes that UE drops the LP PUCCH. UE does not drop anything since first DCI 1\_x missed.Network sends DCI with request to the UE to transmit dropped/cancelled/collided HARQ bits.UE does not have anything to transmit.Other cases can be found. Important details are missing from the proposal. The network indication in the DCI is the field “send cancelled/dropped/collided HARQ bits”? Or “HARQ Process IDs”, or something else?There is the question 2.4.3 below. This is not the approach FL uses in other topics; namely the FL should clarify the details of the proposal first and then make the proposal. The moderator’s approach varies per proposal/alternative. E.g. despite the vast majority of support to Alt 1 since #103 the moderator delays bringing into table concrete proposals. This Alt 3 is brought up only 2 meetings ago and with less support, the moderator urges the group to agree on Alt. 3 with basic details not being discussed.  |
| Spreadtrum | Support in general.  |
| Lenovo, Motorola Mobility | We think down-selection between enhanced Type3 CB and one-shot triggering of HARQ-ACK retransmission is necessary. |
| Ericsson | Support with modification belowWe suggest to remove the word “new” because it may create unnecessary discussions. By definition, the trigger is for “retransmission”. When the DCI which triggers the retransmission, indicate the same PUCCH resource or not, is not important. **Updated FL proposal 2.4: Support one-shot triggering (by a DL assignment) of ~~dropped~~ HARQ-ACK re-transmission on a ~~new~~ PUCCH resource (i.e. Alt. 3)** |
| OPPO | Support |
| Xiaomi | Support in general if enhanced type 3 CB is not supported. |
| NEC | We can support the proposal if Type 3 CB of smaller size is not supported. |
| China Telecom | UE and gNB may have different understanding on which HARQ-ACK is dropped when DCI missing happens as QC’s example shows. The ambiguity of the retransmitted HARQ-ACK should be avoided. The motivation to support both enhanced type-3 CB and one-shot triggering needs clarification.  |

And some further related question:

**Update Question 2.4.3: If one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a new PUCCH resource (i.e. Alt. 3) is supported,**

* **Alt. 1: the last ‘dropped’ HARQ-ACK codebook is re-transmitted**
	+ ***Definition of ‘dropped’ HARQ-ACK codebook required***
* **Alt. 2: the HARQ-ACK codebook to be re-tx is explicitly indicated in the triggering DCI**
	+ ***E.g. for triggering DCI not scheduling PDSCH ~~scheduled PUSCH~~, some unused bit-field could be used***
	+ ***E.g. using offset to the triggering DCI or new PUCCH slot/sub-slot***
* **Alt. 3: the (dropped) HARQ-ACK of one or more ‘dropped’ PUCCH occasions / codebooks within a time window (reference time is the triggering DCI) is re-transmitted**
	+ ***Definition of ‘dropped’ HARQ-ACK codebook required***
* **Alt. 4: explicit indication of the HARQ IDs for which HARQ-ACK is re-transmitted**
	+ ***See QC [9]***
* **Alt. 5: implicit indication of the HARQ-ACK codebook when scheduling a re-transmission of a HARQ process whose HARQ CB had been cancelled**
	+ ***See OPPO [10]***
* **Alt. 6: implicitly if dropped / canceled as the initial DL assignment contains the information for the re-transmission scheduling already**
	+ ***See description by Intel in [12]***
* **Alt. 7: Other**

Please indicate your preference(s) on Question 2.3.3 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 | InterDigital, Samsung, Ericsson |
| Alt. 2 | CATT, APT/FGI, Nokia / NSB, DOCOMO, InterDigital, Samsung,Xiaomi |
| Alt. 3 | Vivo, DOCOMO |
| Alt. 4 | Vivo, QC |
| Alt. 5 | OPPO |
| Alt. 6 | Intel |
| Alt. 7 | ZTE |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CATT | We think there are typos in Alt. 2.* **Alt. 2: the HARQ-ACK codebook to be re-tx is explicitly indicated in the triggering DCI**
	+ ***E.g. for triggering DCI not ~~scheduled PUSCH~~ scheduling PDSCH, some unused bit-field could be used***
	+ ***E.g. using offset to the triggering DCI or new PUCCH slot/sub-slot***
 |
| Moderator | Question correct based on CATT input.  |
| ZTE | One or multiple (dropped) HARQ-ACKs of the same priority can be retransmitted together. The HARQ process IDs are indicated in the RRC configuration. |
| Nokia, NSB | As discussed in our contribution in [3], we think a dynamic indication of the PUCCH occasion / CG to be re-transmitted would be needed. Otherwise, there could be ambiguity issues (Alt. 1 & Alt. 3) and there would be a need to combined multiple CBs (for Alt. 3) in one transmission. We fail to see the motivation for Alt. 4 (and how this would be working), and are thinking if this would not be actually more of a ‘Enhanced Type 3 CB’ (where a subset of HARQ-IDs is indicated to be re-transmitted). Alt. 5 is limited to re-transmission at the same time [OPPO] Our solution is to reuse HARQ process ID and NDI field in a DCI to indicate “dropped” PUCCH to be transmitted. The DCI does not trigger PDSCH retransmission. Motivation for Alt. 6 missing a bit as well (especially, as the PUCCH resource for re-tx needs to be pre-determined well ahead of time)  |
| DOCOMO | For a DCI not scheduling PDSCH, unused fields e.g. TDRA field can be used to indicated the offset and duration for a window of retransmitted HARQ-ACKs. |
| Samsung | For Alt. 3, the need to support multiple dropped HARQ-ACK CBs is unclear, especially considering the sporadic nature of URLLC. Even if there are more than one dropped HARQ-ACK CBs, scaling by the probability for each number of CBs, practically all gains from retransmission are obtained for one HARQ-ACK CB. However, if a solution is directly extendable to multiple HARQ-ACK CBs (and up to the gNB what to do), we’re fine to consider it.Alt. 4 seems to be “enhanced” Type-3.Alt. 5 is inefficient – it loses some benefit (depending on the CB size) of the HARQ-ACK CB retransmission if the gNB has to reschedule for an “affected” HARQ process in order to obtain the dropped HARQ-ACK CB (cost of extra DCI is smaller than cost of extra PDSCH).[OPPO] Our solution does not transmit PDSCH when HARQ-ACK retransmission is triggered. Our solution is to reuse HARQ process ID and NDI field to indicate “dropped” PUCCH to be transmitted. When HARQ process ID field indicates a given HARQ process which is included into the dropped HARQ ACK codebook in PUCCH and NDI does not toggle, it triggers a retransmission of the dropped HARQ ACK codebook in PUCCH. Alt. 6 requires constant DCI overhead for a rare use/event (not a major issue but need-based DCI would be overall better) and prediction of the PUCCH resource in advance (a bigger problem).  |
| QC | Alt 1 and 2 do not work in case of different understanding of the amount of dropped/cancelled/collided HARQ bits between gNB and UE.In general, the comments of Samsung, Sony that enhanced Type X CB for Rel. 17 IIOT is not optimal, results in signaling overhead and require specification effort are not solid. In order to propose a solution for cancelled/dropped/collided HARQ bits, some effort is needed. As an example, their proposal requires standardization work as well. Samsung’s proposal (Alt 3) also requires a bit in the DCI to trigger the request, there is a need to indicate which HARQ processes should be reported (in order to avoid error cases). Then, the question is what is the difference between Alt 1 (Enhanced Type 3 (or Type X) codebook) with Alt 3?The differences are:* Alt 3 wastes resources since there is no option for the gNB to schedule new PDSCH
* Alt 3 requires significant specification effort since there is a need to specify new DCI type scheduling PUCCH only.

Alt 1 can be used for multiple cancellations/droppings/collissions with DL symbols, whilst Alt 3 is only a patch working at very benign conditions of a single occasion of LP HARQ bits being dropped. |
| Ericsson | Alt 2, although has some supports, but the description is wage and unclear. So, it is not clear to us what it is intended and if all supporting companies have same view or not.Also, what does the main bullet mean? Is the intention to somehow give ID to different CBs , so they can be explicitly triggered ? Is there some timing indication?We were under impression that this alternative is intended to be simple and just request the dropped codebook.  |
| OPPO | Our preference is to reuse existing field to indicate “dropped” PUCCH to be retransmitted. One solution is to reuse HARQ process ID and NDI field. When HARQ process ID field indicates a given HARQ process which is included into the dropped HARQ ACK codebook and NDI does not toggle, it triggers a retransmission of the dropped HARQ ACK codebook.For 1st example in Alt 2, it is not clear for us how to indicate “dropped” PUCCH. However, we support reuse existing field.@Nokia, Samsung, add explanation on alt.5 below your comment. |
| Xiaomi | We prefer alt 2. It is simple and straightforward. |

### Updated proposals for potential email approval on May 21st

#### Support of DCI format 1\_2 for Type 3 CB

Based on the feedback received on FL proposal 2.1, as several companies suggested to remove the FFS, which is implemented below. The proposal is the same as in summary #2 (presented in the GTW session).

**Update 3 FL proposal 2.1: Support at least Rel-16 Type 3 HARQ-ACK CB triggering using DCI format 1\_2 in Rel-17.**

* **The triggering using DCI format 1\_2 is RRC configured.**
* ***Note: the Rel-16 Type 3 CB parameters, construction & size is not affected***
* ***~~FFS: DCI format 1\_2 triggering for potential support of enhanced Type 3 HARQ-ACK CB (i.e. Alt. 1)~~***

|  |  |
| --- | --- |
| *Support (list of companies)* | DOCOMO, vivo, Sony, Nokia/NSB, Samsung, Panasonic, Ericsson, NEC |
| Object(list of companies) | Qualcomm-proposal to be agreed later- after the high-level solution is accepted. |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table (i.e. no need to repeat your arguments for the support from the 1st and 2nd round prior to the May 25th GTW session).**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| QC | As mentioned at the previous rounds, there is no meaning in trying to specify solution for Rel. 16 Type 3 CB to work in a Rel. 17 URLLC/IIOT context, since there is not a single company who thinks that Rel. 16 Type 3 CB is the solution for cancelled/deferred/dropped HARQ bits. Accepting these proposals now will open up many other questions on CB construction with priorities, handling of different requests for type 3 CB, overriding priorities, etc. This is not desired if the group wants to find a real solution for cancelled/dropped/colliding HARQ bits. |
| Ericsson | We beg to differ. We stated from the start of the release that we could reuse Type-3 to get cancelled LP feedback.We repeatedly emphasized that the focus should on enabling the feature which has minimum spec impact. Enhancements/size reduction, are of secondary importance. |
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#### Support of (at least baseline) PHY priority handling for Type 3 CB

Based on the feedback received on FL proposal 2.2, as several companies suggested to remove the FFS, which is implemented below. The proposal is the same as in summary #2 (presented in the GTW session).

**Update 3 FL proposal 2.2: Support PHY priority handling at least for a PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB in Rel-17.**

* **The indicated PHY priority in the triggering DCI defines the PHY priority of the PUCCH carrying the Rel-16 Type 3 HARQ-ACK CB.**
* ***Note: the Rel-16 Type 3 CB parameters, construction & size is not affected by the indicated PHY priority***
* ***~~FFS: PHY priority handling for potential support of enhanced Type 3~~* ~~HARQ-ACK~~ *~~CB (i.e. Alt. 1) as well as PHY priority specific Type 3 CB parameters (such as CBG & NDI)~~***

|  |  |
| --- | --- |
| *Support (list of companies)* | DOCOMO, vivo, Sony, Nokia/NSB, APT/FGI, Panasonic, Ericsson, NEC |
| Object(list of companies) | QC |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table (i.e. no need to repeat your arguments for the support from the 1st and 2nd round prior to the May 25th GTW session).**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| QC | The same reasons for not accepting updated proposal 2.1 |
| Samsung | Discussion is first needed on the scenarios and use cases where indication of priority would be needed. The proposal is made without required justification. |
| Ericsson | To QC/Samsung:We explained our understanding of Rel-16 (please others correct us if we are wrong) that it was concluded two-level priority and one-shot can be enabled together.It means that a DCI for URLLC that needs to indicate two-level priority cannot trigger one-shot unless it is “reconfigured”.This restriction can be simplify removed and spec impact is minimum. |
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#### Support of HARQ-ACK re-transmission enhancements of Alt. 1 & Alt. 3

On the enh. Type 3 CB support and one-shot triggering on PUCCH, based on some comments the following changes are suggested and the moderator has the following thinking:

* On the enh. Type 3 CB
	+ As there is still the discussion ongoing on how many new Type 3 CBs could be supported, maybe the common denominator could be that at least one could be supported.
	+ We could continue the discussion between the smaller list of favorite alternatives there from the second round in the 3rd round (hopefully after having the proposal agreed by email on May 25th)
* On the one-shot triggering:
	+ Remove the ‘new’ as suggested by Ericsson
	+ Based on the good comment by Intel, the proposal is not clear as it may also actually contain the Type 3 CB. Therefore, the moderator proposes to clarify this as not being ‘Type 2’ or ‘Type 3’ CB type.
* **Maybe we could try to agree to support both (in a similar spirit, as the discussions on PUCCH carrier switching during the GTW session) as a compromise.**

The following combined proposal of the support of Alt. 1 and Alt. 3 is brought forward,

* The Enh. Type 3 CB part is the same as in the FL summary presented in the GTW session
* For the one-shot triggering, some additional changes in green have been made (i.e. correction on enh. Type 2 and Type 3 CB).

**FL proposal 2.5: For HARQ-ACK re-transmission:**

* **Support at least one enhanced Type 3 HARQ-ACK CB~~(s)~~ with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a ~~new~~ PUCCH resource other than ~~(~~enhanced~~)~~ Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***

|  |  |
| --- | --- |
| *Support (list of companies)* | DOCOMO, vivo, Nokia/NSB, ZTE, APT/FGI, Panasonic, NEC |
| Object(list of companies) |  |

**In case you object to the proposal or have any other comments, please provide your input in the table below.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Sony | We still think reducing the size of Type 3 CB is sub-optimal and not a good use of RAN1 time. It would be far less complex to design a new CB for retransmission of cancelled HARQ-ACK if overhead is an issue, than to try to twist and turn Type 3 CB to reduce its size so that it fits a dynamic scenario such as cancelled HARQ-ACK. |
| QC | Moderator’s wish to come up with a proposal covering all aspects is appreciated. We welcome the moderator’s initiative in other topics as well, e.g. SPS PUCCH HARQ collision with DL symbols. Alt 3 lacks important details in its design and as such Alt cannot be supported. In case the UE is asked to transmit the list of the dropped/cancelled/colliding with HARQ bits, the solution does not work in case of missed DCI.In case the UE is requested to transmit HARQ bits from indicated (via DCI) HARQ processes, then, Alt 3 is a subset of Alternative 1 (alternative 1 without providing a solution for PUSCH and HARQ cancelled with CI and generating L1 signalling overhead).**For HARQ-ACK re-transmission:** * **Support at least one enhanced Type X HARQ-ACK CB~~(s)~~ with reconfigurable size** **in Rel-17**
	+ ***Definition of enhanced Type X CB:***
		- ***The codebook size of a single triggered enhanced Type X HARQ-ACK codebook at least determined by RRC configuration***

***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells, similarly to Rel. 16 Type 3 CB)*** |
| ZTE | We can accept the parallel solutions for retransmission of HARQ for sake of progress. For Alt.3, it is so straightforward to provide such a mechanism for retransmission of HARQ, and easy on specification effort. For DCI missing, it is not a real issue, as it is not a new problem, whatever whether the retransmission of HARQ is used, DCI missing always exists. When UE can’t retransmit the HARQ as this reason, gNB would know something wrong with the initial DL reception for UE and normal handling on DCI missing will process as usual. |
| Samsung | Appreciate the FL’s efforts but we would repeat our basic question and echo Sony’s input above. Under what circumstances would the proposal in the first sub-bullet (modified R16 Type-3 CB) be better than the proposal in the second-sub-bullet (retransmit what was dropped)? We have been asking that question for several meetings but never received a response (or at least one without inaccuracies). Almost all inputs in support of a modified R16 Type-3 CB were “we support”. As we should not be specifying things for the sake of specifying things, if we are to agree to the above proposal, the following are hopefully reasonable requests. First, we make a working assumption, not an agreement. The WA can be promoted to an agreement if both solutions can be shown to offer meaningful complementary benefits; otherwise, if one is always better than the other, the worse one is dropped. Second, the “at least one” in the first sub-bullet is removed – there is even less justification to go from the 2 solutions above to N>2 solutions when really 1 is probably enough. |
|  |  |
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|  |  |

## 3rd Round

Unfortunately, we were not able on Friday to approve any of the proposals before the quiet-period.

Looking at the situation where we are, it seems the following can be noted:

* **DCI format 1\_2 support (Update 3 FL proposal 2.1):** there had been no comments on the wording, just that this should be discussed /agreed later on (especially when having more clarify on the potential support of Enh. Type 3 CB of Alt. 1).

Therefore, let’s keep this proposal as it is for the moment (for later consideration). It seems another round of comments would not change the companies’ positions / opinions here (as this was discussed in the previous two rounds without significant editorial changes).

* **PHY priority handling for Type 3 CB (Update 3 FL proposal 2.2):** There had been similar comments on the proposal as for the DCI format support.

Therefore, let’s keep this proposal as it is for the moment (for later consideration). Also on this one, another round of comments most probably would not change the companies’ positions / opinions here (also also this proposal was discussed in the previous two rounds without significant no editorial changes).

In addition, there had been question Question 2.2.3, if there is interest to support separate NDI & CBG configuration for low & high PHY priority (in case PHY priority with Type 3 CB is to be supported). As a majority of companies (12 vs. 7) thinks no enhancements would be needed there (and as a matter of fact, if no enhancement is agreeable - the Rel-16 configuration would automatically apply) there is no follow-up planned.

* **Enh. Type CB (Alt. 1) and/or one-shot triggering on PUCCH support in Rel-17:** The same discussion has been there since round 1, and also the Friday compromise proposal to support both of them was not agreeable. Clearly, we are a bit stuck here and the moderator is lacking ideas on how to move this forward, except trying Alt. 1 only, Alt. 3 only or trying to jointly agree both of them (as with the compromise proposal on Friday). A follow-up question is there so check where the companies preferences in the end are below.
* **On the details of Enh. Type 3 CB (Alt. 1) and one-shot triggering (Alt. 3)**
	+ From the feedback on the details of Alt. 1 & Alt. 3 in the 2nd round, there seems to be no clear winner that seems to make sense to agree assuming that Alt. 1 and/or Alt. 3 would be supported.
	+ On Enh. Type 1 CB enhancements details, the only thing that could be tried is to exclude some alternatives from the lists of options to be considered further based on Question 2.3.3. The following can be noted:
		- Alt. 1 (RRC only), Alt. 3 (RRC & activation) and Alt. 3 (dynamic indication using unused bit-field) received some sizeable support and could be further considered, as the remaining options of Alt. 4 to 6 received only little backing.
		- *Moderator suggestion*: Focus the further related discussions on Alt. 1-3 (but this can be potentially agreed later on in this meeting, assuming we agree on the support of Enh. Type 3 CB overall.
	+ On one-shot triggering details of Question 2.4.3, similarly here the only thing one could think of is to exclude some alternatives from the lists of options to be considered. The following can be noted:
		- Alt. 1 (last dropped CB, 3 companies), Alt.2 (explicit indication, 7 companies), Alt. 3 (time window, 2 companies) are supported by more than one company. It had been mentioned by several companies that Alt. 4 is more a Enhanced Type 3 CB (where the triggering DCI indicates some sub-set of HARQ IDs, incl. a subset size of 1 HARQ-I) and therefore should be considered as part of Enhanced Type 3 CB of smaller size. Alt 5-7 only received backing by the proponent company itself (i.e. 1 company).
		- *Moderator suggestion*: Focus the further related discussions on Alt. 1-3 (but this can be potentially agreed later on in this meeting, assuming we agree on the support of one-shot triggering on PUCCH (Alt. 3) overall).

Based on the discussions above, it seems the only thing we could try to see again is how many companies actually would be willing to support Alt. 1 only, Alt. 3 only or as a compromise would be willing to support both Alt. 1 and Alt. 3.

**Question X: Please indicate your preference below on the following below to see which Option to be taken as the next proposal to be discussed (i.e. Alt. 1 only, Alt. 3 only or both):**

* **Option 1 – Alt. 1 only:** **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Option 2 – Alt. 3 only: Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***
* **Option 3 – both, Alt. 1 & Alt. 3: For HARQ-ACK re-transmission:**
* **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***
* **Option 4 – other / none: none of the both or no support of HARQ-ACK re-transmission enhancements in Rel-17**

**Preference only (list of companies), reasons & further explanation in the 2nd table below:**

|  |  |
| --- | --- |
| Option 1 *Enh. Type 3 CB only*  | Vivo (1st preference), APT/FGI (1st preference) , Huawei (the enhanced Type 3 CB construction is not determined based on DCI), LG, Intel (1st preference), Panasonic (1st preference), Ericsson, Sharp, DOCOMO (1st preference), NEC(1st preference), WILUS(1st preference), China Telecom |
| Option 2*One-shot triggering on PUCCH with different CB only*  | Sony, ZTE, Samsung, Ericsson, MTK |
| *Option 3Enh. Type 3 CB* AND *One-shot triggering on PUCCH with different CB* | Vivo (we can accept as a compromise), OPPO, CATT (the enhanced Type 3 CB construction is not determined based on DCI), Nokia/NSB, Xiaomi, APT/FGI, Intel (3rd preference), Samsung (2nd preference, only as WA), Panasonic, Ericsson, MTK (2nd preference) , DOCOMO (2nd preference, can accept), NEC(2nd preference for progress), Spreadtrum, WILUS(2nd preference), ZTE (for sake of progress) |
| Option 4 *other or no support* | Other, updated proposal* **~~Support at least one Type 3.X (or Type X) HARQ-ACK CB with small and reconfigurable size (compared to Rel-16)~~****~~in Rel-17~~**
	+ ***~~Definition of enhanced Type 3.X (or Type X) CB:~~***
		- ***~~The codebook size of a single triggered enhanced Type 3.X (or Type X) HARQ-ACK codebook at least determined by RRC configuration~~***
		- ***~~The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells in a similar manner to Type 3 CB construction)~~***

Intel (2nd preference) (see the comment), China TelecomQC: ***PROPOSAL: Support a Type X HARQ-ACK CB for the transmission of cancelled/dropped/colliding with DL HARQ bits.*** * + ***Definition of Type X CB:***
		- ***Request for Type X CB is issued via DCI***
		- ***Type X CB size and content, i.e. list of HARQ Processes to be reported, is decided by the gNB***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells in a similar manner to Type 3 CB construction)***

***FFS 1: DCI type and content to trigger Type X CB request******FFS 2: Type X CB size configuration (and reconfiguration)*** |

**If you have further comments or any editorial suggestions to the Options above please provide your input below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| QC | Although compromises are always welcome, proposing both Alt 1 and Alt 3 to be accepted together is not a technically sound proposal. Reasons are the following:* Alt 3 generates error cases when the network indicates with a DCI that the network wants from the UE to report cancelled/dropped/colliding with DL HARQ bits. In case of missed DCI 1\_x or in case of SFI missed, the network might request from the UE to report what was cancelled/dropped/collided with DL and the UE does not have anything to repot. In case Alt 3 is supported with the option of the network indicating the HARQ processes to be reported, then, Alt 3 becomes identical to Alt 1 in that part. Alt 3 is a subset of Alt 1, since Alt 1 is a solution for dropped HARQ bits (due to intra-UE prioritization), for HARQ bits cancelled together with PUSCH when PUSCH is cancelled via CI, for SPS PUCCH HARQ bits colliding with DL
* Alt 3 results in waste of L1 DL control signalling, since PDSCH allocation is not allowed (Alt 1 making use of the major building blocks of Type 3 CB and DCI 1\_1 requesting the transmission of Type 3 CB, allows PDSCH scheduling together with the DCI requesting the transmission of Type 3x CB). If Alt 3 is modified so as DCI requesting the missing HARQ bits allows PDSCH, then, Alt 3 is identical to Alt 1.
* Alt 3 requires a seriously high specification work, since DCI triggering the request to the UE for transmission of cancelled/dropped/colliding with DL HARQ bits is going to be the first DCI in NR to trigger PUCCH only transmission (without the option of triggering PDSCH)
* Alt 3 lacks significant details and explanations of how it operates in certain cases
* How does Alt 3 work in case of HARQ bits multiplexed with PUSCH and PUSCH cancelled with CI? In case the network requests immediately after the PUSCH + HARQ cancellation, new PUSCH transmission (via DCI 0\_x), the network would wait till the Alt 3 DCI is issued?
* How does Alt 3 work in case multiple sets of dropped HARQ bits (requested via separate DCIs) have to be retransmitted?
* How does Alt 3 work when both cancelled and dropped HARQ bits – initially requested from different DCIs – should be retransmitted?

By accepting Alt 3 the group risks in entering lengthy discussions to make Alt 3 work in most of cases. Numerous patches for all of the different scenarios will be needed (similarly to what the group is going through with the “deferral to the 1st available PUCCH”). In general very serious concerns on the moderator’s intention to promote a proposal which will be accepted. The feature lead brings Option 1 again for discussion since it is already rejected. In addition what is brought into discussion is how the CB size will be configured. The technical concern of companies rejecting Alt 1 was the CB size will not match the intended CB size. As explained in the meetings and via emails, the Enhanced Type 3x CB size can match exactly the intended CB size, if the size is indicated via DCI. In case the network wants to have some higher level of confidence and or the network wants to reduce the DCI size of the DCI requesting the enhanced Type 3X CB, the network can request an RRC configured CB size. * In addition, the moderator’s intention to put together 2 proposals/alternatives with so much difference in support is not explainable (from above:

**Alt. 1 (18 Yes – 3(2?) No)- Support enhanced Type 3 CB(s) with smaller size (compared to Rel-16): Alt. 3 (9(?)(8) Yes – 2 No) – DCI scheduling new PUCCH resource for HARQ re-transmission / One-shot**) |
| vivo | Our first preference is to support Alt.1 only. But given the situation as summarized by FL, we would be OK to support option 3 as compromise.  |
| CATT | As commented earlier, we think the enhanced Type 3 HARQ-ACK codebook based on dynamic DCI should not be supported. We support Option 3 with the addition in red.* **Option 3 – both, Alt. 1 & Alt. 3: For HARQ-ACK re-transmission:**
* **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook size of enhanced Type 3 HARQ-ACK codebook is not determined based on DCI indication***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***
 |
| Nokia, NSB | We support the compromise to support both Alt. 1 & Alt. 3.  |
| Sony | Firstly, Type 3 CB as per Rel-16 works as a HARQ-ACK retransmission scheme and this has the least specification work. We just need to attach an L1 priority for the PUCCH carrying Type 3 CB for PUCCH resource selection and for handling of intra-UE prioritisation. If overhead is ***not*** an issue, then our job is done for this topic.Secondly, we still have not got a response why there is a need to reduce the size of Type 3 CB since the enhancement focuses on size reduction. If overhead is an issue, then Type 3 CB is a poor choice for reselection and as said multiple times, enhancing a semi-static sized CB like Type 3 to adapt to a dynamically changing number of HARQ-ACK retransmission will produce sub-optimal solutions. For example:* A proposal where Type 3 CB retransmit only activated CC. If there are 2 activated CCs, this Type 3 CB would retransmit 16 HARQ-ACK x 2 CC = 32 HARQ-ACKs. If only 2 HARQ-ACKs are cancelled, this scheme would be retransmitting an additional 30 HARQ-ACKs. Hence, sub-optimal by a large margin.
* A proposal where gNB configures which HARQ Process ID to retransmit in an attempt to reduce overhead. If gNB configures HARQ Process ID 0-7 for retransmissions but HARQ Process ID 9 was being cancelled, then the UE cannot retransmit that HARQ-ACK which means this method failed to meet the objective of the topic. Alternatively, the gNB is forced to never schedule HARQ-ACK with HARQ Process ID 8-15 that would result in cancellation which restricts the gNB scheduling for the sake of imposing this solution. This method is not only sub-optimal but failed to meet the objective.
* Proposal to allow multiple enhanced Type 3 CB configurations and dynamically indicate which one to use. Given the nature that Type 3 CB is semi-static, this method tries to adapt the CB size to the number of cancelled HARQ-ACKs, with the hope that one of the multiple e-Type 3 CBs would have a size close to the actual number of cancelled HARQ-ACKs. This seemed to create extra complexity for the sake of trying to force Type 3 CB to adapt to dynamically changing number of cancelled HARQ-ACK. Plus whichever Type 3 CB that is configured and dynamically selected, it would never be as efficient as a SINGLE dynamic CB that retransmits only cancelled HARQ-ACK. Hence sub-optimal and high specs impact.

Thirdly, the specs impact is not trivial in enhancing Type 3 CB. I disagree with QC that a dynamic CB specs impact would be astronomically huge. In fact, defining a dynamic CB that retransmits dropped HARQ-ACK would not only be far more efficient but also far simpler than trying to force a Type 3 CB into adapting to dynamic sized cancelled HARQ-ACK with multiple Type 3 CB configurations and coming up with DCI indicators to indicator one of multiple Type 3 CBs. How is having multiple different Type 3 enhancements configurations be simpler than having to configure 1 dynamic CB that retransmit only cancelled HARQ-ACKs?Lastly, if overhead is an issue, then address the problem directly by designing a dynamic CB that retransmits only dropped HARQ-ACK. As Samsung said and we repeated a few times, there is no way any enhancement in Type 3 CB for size reduction would match the effectiveness of a dynamic CB designed for this purpose. Some may say enhancing Type 3 CB is easier because Type 3 CB already existed but so far this seemed to show the opposite. The effort used to enhance Type 3 CB creates more specs impact and does not even effectively address the overhead issue.Again, trying to turn a train into a plane would be far more complex and extremely ineffective than to just fly a plane if the intention is to fly.We are ok with Option 3 *if companies can at least answer my questions*, i.e.:* Is overhead an issue in existing Type 3 CB?
* If overhead is an issue, why is enhancing Type 3 CB more effective than defining a dynamic CB in terms of addressing the overhead issue?
 |
| ZTE | The scheme of one shot triggering on PUCCH should not be considered as a competition scheme with **enhanced** type 3 codebook. One shot is not intended for codebook size reduction, and not an optimization solution but potentially a basic scheme for HARQ retransmission which can compete with the legacy Rel-16 type 3 codebook. As the reason explained before, this scheme should be supported. |
| Huawei, HiSilicon | We can be fine with Alt.3 also as long as only one of Alt.1 and Alt.3 would be supported as compromise, otherwise too much effort/time would be needed without clear motivation yet for this re-transmission direction.  |
| LG | Our preference is to support Alt. 1 only. But we are open to discuss with alt. 3 with its details. We feel that there are many various details for one-shot triggering |
| Intel | Potentially, a higher level agreement would help in this situation, w/o referring to “enhaced Type 3 CB”, or “one-shot triggering”, as in the end the mechanism is to retransmit some/all HARQ processes using a new CB. We think the Alt.2 still can be formulated as a new CB, since the changes to Type 1 / Type 2 are inevitable with this approach.* **Support triggering by a DL assignment of HARQ-ACK (re-)transmission on a PUCCH resource using a new HARQ-ACK codebook with a “compact” size in Rel-17**
	+ ***Details are FFS, including which CB type to base the new CB on***

If this does not work, our first preference is Alt. 1 and then Alt. 2 as a third preference. |
| Samsung | There are no error cases with retransmissions (Option 2) – UE transmits what the UE dropped. Triggering and PUCCH resource can be similar to (enhanced/non-enhanced) Type-3 CB (Option 1) – no difference in L1 overhead. If retransmissions can be triggered by UL grant, L1 overhead for retransmissions will actually be less than for Type-3 CB (“enhanced” or “not enhanced”).Retransmission has clear benefits over any Type-3 enhancement – no new codebook is designed, no reliance on implementing an optional feature, “optimal” information is provided with minimum overhead (without redundancy or loss of HARQ-ACK information). The pros-cons should be clear to anyone – there isn’t even a trade-off.We can accept Option 3 as a compromise because the overall feature is useful/beneficial. |
| Ericsson | Please see our comments in previous section related to proposal 2.1 and 2.2. for DCI 1\_2 and Type 3.We are fine with Option 3. |
| MTK | We prefer Option 2 but willing to compromise for Option 3 if there is consencus for this option.We still think type 3 HARQ-ACK codebook may show some limitations to support a URLLC service as it is not very flexible and enhancing an existing mechanism may become very complex and time consuming. Introducing minor enhancements to enable the feature is fine, like supporting the triggering with DCI format 1\_2. However, some other enhancements like size reduction and DCI signaling of the size, or using HARQ processes as basis for construction will require substantial effort to specify. |
| Sharp  | Regarding Option 3, does it mean both Enh. Type 3 CB AND One-shot triggering on PUCCH with different CB are support and thus specification efforts are needed to enable two solutions? Regarding Option 4, it seems that debation on adopting Type-3X or Type-X codebook would happen anyway even if Option 4 is agreed. |
| QC | Answer to Sony’s comment“Firstly, Type 3 CB as per Rel-16 works as a HARQ-ACK retransmission scheme and this has the least specification work. We just need to attach an L1 priority for the PUCCH carrying Type 3 CB for PUCCH resource selection and for handling of intra-UE prioritisation. If overhead is ***not*** an issue, then our job is done for this topic.”QC: As also explained in the previous round, proposing modifications for Rel. 16 Type 3 CB in Rel. 17 is fine. There is not a single company claiming that Rel. 16 Type 3 CB as is, is a solution for cancelled/dropped/colliding with Dl HARQ bits. However, it would be useful to provide the option to have Rel. 16 Type 3 CB working in Rel. 17. This can be decided later. Different view though that the activation of this feature is simply achieved by introducing DCI priority in DCI 1\_1.There are several other issues to be solved1. What does it happen if the UE has a LP and HP codebook configured? How would the UE would be requested to report Type 3 CB?
2. What would be the starting point for the Type 3 CB construction in the case above?
3. What is the behaviour in case of more than DCI requests for Type 3 CB feedback?
4. What is the behaviour in case the 2 different CBs of point 1 have different CBG sizes?
5. ..

Regarding Sony’s questions, since they are listed here, replies are here as well:* 1. “Is overhead an issue in Type 3 CB?:

QC: (Yes, it is an issue. As an example, Sony’s response in the discussion document on this topic “A proposal where Type 3 CB retransmit only activated CC.  If there are 2 activated CCs, this Type 3 CB would retransmit 16 HARQ-ACK x 2 CC = 32 HARQ-ACKs.  If only 2 HARQ-ACKs are cancelled, this scheme would be retransmitting an additional 30 HARQ-ACKs.  Hence, sub-optimal by a large margin.”The overhead would be even higher if Rel. 16 Type 3 CB)* 1. “If overhead is an issue, why is enhancing Type 3 CB, which is a semi-static CB to try to adapt to a dynamic number of cancelled HARQ-ACK more effective and a better use of RAN1’s time than to address the problem directly by designing a dynamic CB for this purpose?”QC: First of all, it seems that what is proposed is similar: a new CB type making use of Type 3 CB features. First of all, Alt 1 captures both cases of i) semi-static configuration via RRC and ii) of dynamic configuration via DCI. Hence, Alt 1 provides the option of dynamically configuring the CB size and its contents. However, this option of dynamically configuring the Type X CB size comes at a cost of PDCCH overhead. Therefore, it is useful for the system to have the option to trigger this request with 1 bit – as in Release 16 Type 3 CB. The CB size can be adapted to any number by RRC. The main building blocks of Type X (or Type 3X) CB are
		1. DCI triggered (either RRC configured CB size, or DCI indicated CB) – so as to make it different from solutions of automatic retransmission by the UE, such as “deferral to 1st available PUCCH”
		2. The network decides the CB size and content to be reported – so as to differentiate this option from the option of the UE deciding the CB size and content.
		3. CB constructed in a similar manner as Type 3 CB (by parsing the list of indicated HARQ process IDs, similarly to [38.213] paragraph 9.1.4) – so as to make it different from CB construction based on timespans (Type 1 CB), or on counters (Type 2 CB)
		4. List of HARQ Process to be reported either i) predetermined via RRC, e.g. N HARQ processes after time slot #N, or ii) dynamically indicated via DCI
		5. Option to schedule PDSCH together with the type X CB transmission.

This solution is robust and it covers all cases of dropped/cancelled/colliding with DL HARQ bits.What is not clarified with Alt 3 is how the network will request the dropped/cancelled/colliding with DL HARQ bits. If the network indicates this in a general form “Transmit cancelled/dropped/colliding with DL HARQ bits”, Alt 3 does not work. See the example below:In case the gNB requests a list of HARQ processes to be reported, then, Alt 3 is a subcase of Alt 1. Regarding Sony’s comments:“If gNB configures HARQ Process ID 0-7 for retransmissions but HARQ Process ID 9 was being cancelled, then the UE cannot retransmit that HARQ-ACK which means this method failed to meet the objective of the topic.”QC: What is the rationale behind this example? In case HARQ Process ID 9 is cancelled, why would the network request retransmission of HARQ Process IDs 0-7? With Alt 1 the network would request a range of HARQ process IDs with the HARQ Process ID 9 included.QC: Regarding Samsung’s comments“There are no error cases with retransmissions (Option 2) – UE transmits what the UE dropped.”QC: If the UE is left alone – without any network indication – to transmit “what is cancelled/dropped/colliding with DL”, then, the error described above occurs. See the figure and explanation when a DCI is missed.QC: With regards to Samsung’s comment “If retransmissions can be triggered by UL grant, L1 overhead for retransmissions will actually be less than for Type-3 CB (“enhanced” or “not enhanced”).”QC: can this be clarified? DCI contents are comparable in size for DCI 1\_x and for 0\_x. Drawbacks with the UL grant are* DCI waste (with Alt 1 DCI 1\_x can be used for PDSCH allocation as well)
* DCI 0\_x requires at least an extra bit in the DCI to indicate that DCI 0\_x does not grant PUSCH, but “PUSCH for cancelled/dropped/colliding with HARQ bits”
* PUSCH is less robust than PUCCH in general.
* PUSCH transmission in 1 UL symbol is not supported.
* What type of CB would it be built when more than sets of HARQ bits are dropped, in more than 1 occasions?
* What type of CB and how the CB when there is a set of HARQ bits dropped due to internal prioritization and a set of HARQ bits cancelled together with PUSCH via DCI 2\_4? Alt 3 is far from complete solution.

QC : With regards to Samsung’s comment “Retransmission has clear benefits over any Type-3 enhancement – no new codebook is designed, no reliance on implementing an optional feature, “optimal” information is provided with minimum overhead (without redundancy or loss of HARQ-ACK information)”, the understanding is that there is a need to build a new codebook if the retransmission of cancelled HARQ bits is based on simply appending Type 1 or Type 2 CBs (read QC’s contribution explaining the problems with multiple sets of dropped/cancelled/colliding with DL HARQ bits. Alt 1 does not require support of any Rel. 16 feature, so Samsung’s argument is void.In general, Alt 3 lacks important details and it is not fair to put it at the same level as Alt 1. Alt 3 has several missing pieces, such as the case of multiple sets of cancelled/dropped/colliding with DL HARQ bits occurring in different occasions. DCI contents triggering the request are also missing. CB construction is not defined.QC: For the way forward, it seems that there all partners agree on the need to specify something for the cases of cancelled/dropped/colliding with DL HARQ bits. This should be the starting point. Moreover, there are some commonalities between Alt 1 and Alt 3* 1. DCI triggering request
	2. DCI requesting a set of HARQ processes to be reported (CB size and content indicated by the network) (assuming the option of Alt 2 according to which the UE is requested to report a list of HARQ bits)
	3. CB construction based on HARQ processes

               Based on the above, the following proposal for the way forward***PROPOSAL: Support a Type X HARQ-ACK CB for the transmission of cancelled/dropped/colliding with DL HARQ bits.*** * + ***Definition of Type X CB:***
		- ***Request for Type X CB is issued via DCI***
		- ***Type X CB size and content, i.e. list of HARQ Processes to be reported, is decided by the gNB***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells in a similar manner to Type 3 CB construction)***

***FFS 1: DCI type and content to trigger Type X CB request******FFS 2: Type X CB size configuration (and reconfiguration)*** |
| Apple | For the sake of progress, we support Alt. 3 |
| DOCOMO | Our first preference is option 1. But we can accept option 3 for progress. |
| NEC | Our preference is option 1, i.e., Alt. 1 only. But we can accept option 3 to support both Alt.1 and Alt.3 for progress. |
| Spreadtrum | Fine with Option 3. |
| WILUS | We support Opt 1, but we can accept Opt 3 for the sake of progress. If RAN1 supports both Alt 1 and Alt 3, a simpler solution should be strived to minimize standardization efforts. |
| China Telecom | We think support both one-shot triggering and enhanced type 3 CB would spend too much specification effort, as the HARQ-ACK re-transmission goal can be achieved either way. We agree there are some commonalities and can agree Option 4. |
| ZTE2 | Although we support option 2 firstly, but we can compromise to option 3.For the LP DCI missing issue on one shot, this is not valid. If UE has nothing to retransmit, gNB can know the LP DCI situation. For example, the base station schedules an HP DCI and an LP DCI for the UE, respectively corresponding to an HP HARQ-ACK codebook and an LP HARQ-ACK codebook, and the two codebooks conflict with each other, the transmission of the LP HARQ-ACK codebook is assumed to be cancelled. Suppose the UE missed the LP DCI detection, when the DCI that triggers the retransmission of the cancelled LP HARQ-ACK codebook is received, the UE can’t generate the cancelled LP HARQ-ACK codebook, then the UE does not retransmit the HARQ on the PUCCH resource expected by the gNB. gNB will not receive the retransmitted HARQ-ACK codebook, and the gNB will determine that the UE missed the LP DCI and will resend the LP PDSCH. The LP DCI missing issue is valid for Alt1 either, if NDI is not configured. The UE transmits the HARQ-ACK of all HARQ processes to the gNB, but the HARQ-ACK corresponding to the missed LP DCI is NACK. Finally, the gNB will also resend the LP PDSCH, but the gNB does not know the UE missed the LP DCI. Therefore, both Alt.1 and Alt.3 can ensure the retransmission of LP PDSCH if DCI missed, and for Alt.3, the gNB can distinguish the UE missed the LP DCI further.  |

### Updated proposals to prepare for May 25th GTW session

The moderator suggests in this intermediate round to focus on things that (in case we get online time) could be discussed today.

Few things to note based on the input received in the 2nd round:

* Not surprising the preferences on their preferred method (Alt. 1 and Alt. 3) is not really changing. Clearly both have it’s pros and cons, as extensively discussed earlier.
* Option 1 of Alt. 1 only (i.e. enh. Type 3 CB), as in previous rounds got rather good support of 12 companies (with many indicating this as their first preference).
* Option 2 of Alt. 3 only (i.e. one-shot trigger of other CB), received support 5 companies. 3 of these companies would also be fine with the compromise in Option 3.
* Option 3 of the compromise to support both received the largest backing of 16 companies, but many companies see this really only as a compromise (but would prefer Option 1 or Option 2 as their first choice).
	+ There had been some questions (e.g. by Sharp) if Option 3 means both are specified:
		- Moderator understanding of Option 3 would mean that we support both features in Rel-17 (i.e. specification effort is needed for both of them).
		- HW/HiSi & CTC raised the issue of the workload of supporting both of them. *Moderator comment:* This clearly has to be acknowledged by the group. If we really support both of them, we may not be able to really optimize both of them in order to complete the feature within the Rel-17 timeframe.

Based on the feedback received, looking at the feedback received the only chance of moving forward here would be to either go with the compromise of Option 3 (but then as pointed out, there will be ‘double’ the specification effort) or we restrict us to Option 1 of enh. Type 3 B only. The moderator based on the feedback received, in the 2nd round does not see a real chance here for Option 2 of only supporting the one-short triggering to achieve consensus in the group.

Therefore, another round (sorry) with two proposals on Option 1 and Option 3 only (i.e. support - not support/object). The moderator really sees these two as the only possible proposals 2.6 & 2.7 that we reach consensus on. Please provide your input below on the two related separate proposals, proposal 2.6 Enh. Type 3 CB – or proposal 2.7 Enh. Type 3 CB and one-shot triggering of another CB.

**Proposal 2.6: Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**

* ***Definition of enhanced Type 3 CB:***
	+ ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
	+ ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***

**Question: Do you support the proposal 2.6 above? (please provide your company name in the table below; for further wording suggestions on the proposal and your comments please use the 2nd table)**

|  |  |
| --- | --- |
| *Support (list of companies)* | CMCC, vivo (1st preference) , DOCOMO(1st preference) , CATT (2nd preference), InterDigital, Lenovo/Motorola Mobility, Ericsson (please see our comments), Nokia/NSB (2nd preference), Intel, QC |
| Object(list of companies) | Sony, Samsung, ZTE |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CMCC | If re-transmission only deals with LP HARQ which cannot be multiplexed, then the scenarios is limited. Hope this solution can solve deferral as well.  |
| Sony | So far ONLY Qualcomm bothered to answer my questions and I truly appreciated it. And judging from QC’s response, it seemed that they agreed that there is a need to adapt to the dynamic changing sizes of cancelled HARQ-ACK and the proposal is to define a new CB not just one that is based on semi-static configuration.**Since no other companies could provide a justification on why Enhancing Type 3 CB for the sake of size reduction with ridiculous amount of specs impact and complexity is more effective than defining a new dynamic CB, we have no choice but to object to this proposal.**On QC’s comment:QC: What is the rationale behind this example? In case HARQ Process ID 9 is cancelled, why would the network request retransmission of HARQ Process IDs 0-7? With Alt 1 the network would request a range of HARQ process IDs with the HARQ Process ID 9 included.That is exactly my point. How would a Type 3 CB with a size that semi-statically configured can adapt to a dynamically changing number of cancelled HARQ-ACKs. One of the proposals is to **semi-statically configure specific HARQ Process IDs** in the “enhanced” Type 3 CB, where the UE is configured as set of HARQ Process ID in which to retransmits its HARQ-ACK when the Type 3 CB is triggered. This method failed to even meet the objective of the topic but yet it was listed as an “enhancement”. |
| vivo | To Sony, size reduction is to save the overhead and/or ensure the reliability. About the spec impacts, from our understanding, Type 3 as baseline has smaller impacts compared to the one-shot new dynamic CB which needs to be designed from the scratch.  |
| Samsung | “Enhanced Type-3” won the beauty contest but lost every aspect of the technical contest. It is telling that no proponent of “Enhanced Type-3” explained (in any accurate way) what about it is technically better than the “one-shot”. Completely disagree with every comment from Vivo – there is no new CB for ‘one-shot’, the UE does not generate anything it does not already do, and nothing needs to be re-designed about the DCI signalling (e.g. even the one for Rel-16 Type-3 may be re-used – instead of Type-3, the UE transmits what was dropped).As a reminder, RAN1 is a technical working group, not a Eurovision contest ^^.  |
| ZTE | Share the same view with Sony and Samsung. |
| CATT | Our understanding of supporting enhanced Type 3 HARQ-ACK CB for HARQ-ACK retransmission is the smaller specification impact given that Type 3 HARQ-ACK CB is already supported. Therefore, the specification impact should be minimized and enhanced Type 3 HARQ-ACK CB based on dynamic indication should not be supported which diminish the advantage of HARQ retransmission via enhanced Type 3 CB and it is not efficient. In order to have a more efficient scheme for HARQ-ACK retransmission, support of one-shot triggering of HARQ-ACK retransmission is desirable. That is why our first preference is to support both enhanced Type 3 HARQ-ACK CB and one-shot triggering. However, if that is not agreeable, we can also compromise to support enhanced Type 3 HARQ-ACK CB only in Rel-17, but still we do not think the CB construction should base on dynamic indication.  |
| InterDigital | Enhancing type 3 CB can help reducing the overhead as vivo mentioned, which is important for IIoT deployment.  |
| Ericsson | @Sony, @Samsung, @ZTE, all:I would like to reiterate our view on the whole story, and I speak only from Ericsson side:Our view from day one was **that main goal** **to find a way to request the dropped LP HARQ-ACK**. The reason we promoted Type-3 CB that it would serve the purpose if it is enabled with two-level priority, without any beautifying (== enhancement for size reduction). **Our motivation is simply that Type-3 CB already exists and it had the minimum spec impact if it is only enabled for two-level priority**. We mentioned repeatedly size reduction is secondary and it should not be a show-stopper. In my view, **large size of Type-3 as I already mentioned is not an issue**. Because if NW tries to request LP, it the effort would be justified if many PDSCHs are scheduled (that is large CB for LP). It is NW choice, to request to send them in a big PUCCH resource, or reschedule again. If the size is big, and carries redundant information, it does the job, in not a beautiful way.We also see **there is a perception built that all of a sudden, URLLC can not afford a PUCCH resource with expected reliability if the size is slightly large which we disagree with.** It is all about how much resource NW want to spend. **From the beginning, we supported Type-3 by enabling that, and not changing that to another CB.** Because of limited spec impact and its usefulness. But the discussion is focused on enhancements and we don’t share the same view as other companies, while respecting that.**We were also supportive of triggering the cancelled one by DCI whenever it was proposed.** That also **does the job for the main goal**. But we tried to enable Type-3 due to its limited spec impact.From our point of view, **does not matter if we go for enabling Type-3 for URLLC, or trigger only cancelled one, as long as we have one of them, or both of them** because any of these, help to reach the goal. That means we are not focused on solution.So, I hope the above explains that how we see the thing, specially as a company that spent a lot of efforts in Rel-16 to enable Type-3 CB for licensed as well, for the sake of reusing it, and not to redo the same exercise again.  |
|  Nokia/NSB | If only Enh. Type 3 CB is to be supported, maybe more time can be spent on discussing optimizations of the CB size (compared to supporting both – based on proposal 2.7). But we are open to both options.  |
| Sony | **@Ericsson:** I share the same initial view. The assumption was that Type 3 CB as it is does the job of retransmitting HARQ-ACKs. We can define an L1 priority or default it to low priority (or high priority) for the PUCCH carrying the Type 3 CB. This would have minimum specs impact.**@InterDigital:** If overhead is such a big concern, why then spent all the time optimising a **semi-static** CB when we all know that the number of cancelled HARQ-ACK cannot be predicted semi-statically? How would trying to optimise a Type 3 CB has less overhead than a simple dynamic CB that simply retransmit dropped HARQ-ACKs?**@vivo:** How is having multiple enhanced Type 3 CB and then defined a DCI indicator to indicate which enhanced Type 3 CB be less complex than introducing a simple dynamic CB that simply retransmits dropped HARQ-ACK? How is any of the proposed schemes to reduce Type 3 CB overhead be more effective than a CB that retransmit dropped HARQ-ACK?**@Nokia:** Why do we want to spend any RAN1 time optimising Type 3 CB when we know that it will never have an overhead that is as efficient as a dynamic CB that simply retransmit dropped HARQ-ACK? |
| Intel | Support, although we’ve suggested several times to have a smaller step forward by a generic proposal w/o using CB Type references |
| QC | Some replies to our questions/comments. Reply to ZTE’s example. There is no problem with Alt 1 in the example described. In case of one DCI being missed (DCI allocating LP PDSCH and LP PUCCH), the network will request feedback for the HARQ process corresponding to this LP PUCCH. The UE having missed the DCI, simply transmits NACK. The problem with Alt 3 is that there is a need to specify the UE behaviour for the case of UE receiving an indication to report cancelled/dropped HARQ bits. Hence, another task for the group if Alt 3 is adopted.Agreement with CMCC, the scenario of LP PUCCH being dropped is very unlikely to happen in reality (as explained at QC’s contribution). Therefore the solution should cover all cases of SPS PUCCH deferral, CI, and of dropping.Answer to Sony: indeed, there is a need to adapt to the dynamic nature of the system, as always, but the argument was the same in the unlicensed operation as well. There also, the amount of missed HARQ process is dynamic. The situation is the same here. In case of multiple SPS PUCCH HARQ deferrals, CIs, internal UE dropping there might be a variable number of HARQ processes feedback missing. Moreover, considering the cases of errors in DCI 1\_x reception, the errors in DCI 2\_0 (SFI) reception, then, the network – even in the case of dynamic CB size- might want some extra feedback. E.g. consider the case of 2 SPS PUCCH HARQ deferrals, 2 Cis and 1 LP PUCCH being dropped, the network might want some extra feedback for the sake of robustness, i.e. the network might need 7 HARQ processes to be fed back, but the network asks feedback for 10 HARQ processes.Answer to Sony: The reason for objecting this proposal lacks rationality. How many answers from how different companies would it be needed so as to be convinced?Answer to Sony: the reply is not technically justified. The gNB would indicate 10 HARQ Process IDs and one of those would be the HARQ ID 9 missing.Answer to Samsung in general: request to respect the group and not being ironic. The group has vastly supported Alt 1 since the beginning, and using terms like “beauty contest” is not appropriate. The benefits of Alt 1 are explained in detail in 11 pages in QC’s contribution. A summary here* Requires less standardization effort than any other option, since important building blocks are there, CB construction, DCI format, …
* Covers the cases of multiple CIs, droppings
* Covers the cases of SPS PUCCH HARQ deferral, CI, HARQ dropping

To the contrary, Alt 3 has never really been described. * What exactly is it requested with the DCI?
* What type of CB does Alt 3 use?
* What type of CB is constructed when multiple LP PUCCH dropping happen?

Moreover, Alt 3 is a tailored solution for a single LP PUCCH HARQ dropping, which is very unlikely to happen.Disagreement with Ericsson that simply adding priority bit to DCI 1\_1 requesting Type 3 CB transmission the scheme works. Rel. 16 Type 3 CB generates way too much overhead.Reply to Sony: it seems that the view is directed in wrong direction. As explained above, in an environment requiring high robustness, it is not harmful to send a couple of extra HARQ bits which the network might need. Rel. 16 Type 3 CB is a solid feature that works. Alt 3 is a patch solution only for this theoretical problem. It does not work in all of the other cases, e.g. CIs, multiple dropping, etc. To the moderator: the intention to bring back the same proposals which have been rejected already 3 times is an obvious indication that the will is not to find a solution to the agreed topic. Companies rejecting Alt 1 do not give any technical justification for their rejectio. It is unfortunate but it is how the 3GPP procedure is. The moderator’s task is to find the common ground and honestly propose a way forward. Here is the updated proposal. Strong request to bring this one as well at the meeting.***PROPOSAL: Support a Type X HARQ-ACK CB for the transmission of cancelled/dropped/colliding with DL HARQ bits.*** * + ***Definition of Type X CB:***
		- ***Request for Type X CB is issued via DCI***
		- ***Type X CB size and content, i.e. list of HARQ Processes to be reported, is decided by the gNB***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells in a similar manner to Type 3 CB construction)***

***FFS 1: DCI type and content to trigger Type X CB request******FFS 2: Type X CB size configuration (and reconfiguration)*** |

**Proposal 2.7: For HARQ-ACK re-transmission:**

* **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***

**Question: Do you support the proposal 2.7 above? (please provide your company name in the table below; for further wording suggestions on the proposal and your comments please use the 2nd table)**

|  |  |
| --- | --- |
| *Support (list of companies)* | Vivo (as compromise), Samsung, DOCOMO (as compromise) , CATT (1st preference), InterDigital, Ericsson (please see our comments), Nokia/NSB (1st preference), Intel |
| Object(list of companies) | CMCC, QC |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Sony | We will not object or support to this proposal. The fact that after so many times we tried to ask the question and the only company that responded suggested a new CB rather than a Type 3 CB shows that there is no justification to enhance Type 3 CB for the sake of overhead reduction.  |
| Samsung | Far from ideal, as any enhancements to Type-3 are unnecessary given “one shot”, but the feature is important enough to prefer ‘2’ over ‘0’. Completely sympathise with Sony.  |
| CATT | As commented above, our first preference is to support both enhanced Type 3 HARQ-ACK CB and one-shot triggering. As we commented above, we do not think enhanced Type 3 HARQ-ACK CB base on dynamic indication should be supported from technical point of view. In addition, from specification efforts perspective, enhanced Type 3 HARQ-ACK CB base on dynamic indication should not be supported either considering the big spec impact. Therefore, we still propose to preclude enhanced Type 3 HARQ-ACK CB base on dynamic indication. |
| Lenovo, Motorola Mobility | Before agreeing to support both schemes, we would like to discuss details of each scheme. Since some of detailed proposals for the two schemes are quite similar, we should not spend time on specifying duplicated features. Once details are discussed, we have a better chance to get them merged.  |
| Ericsson | Please see our comments in previous section. Our view from day one was **that main goal** **to find a way to request the dropped LP HARQ-ACK**.From our point of view, **does not matter if we go for enabling Type-3 for URLLC, or trigger only cancelled one, as long as we have one of them, or both of them** because any of these, help to reach the goal. That means we are not focused on solution. |
| Nokia/NSB | Clearly one-shot triggering with dynamic indication of the PUCCH occasion to be re-transmitted has some technical merits here. But also Enhanced Type 3 CB is useful, specifically if dynamic indication is supported.If both are to be supported, maybe less optimizations for each of the schemes would be possible specifically for Enh. Type 3 CB operation (but this could be fine for us as well – if this is needed).  |
| Intel | OK as a compromise |
| QC | Reasons for objecting Alt 3 is that important descriptions of the feature are missing.Questions/drawbacks listed againDrawbacks with Alt 3 are* DCI waste (with Alt 1 DCI 1\_x can be used for PDSCH allocation as well)
* DCI 0\_x requires at least an extra bit in the DCI to indicate that DCI 0\_x does not grant PUSCH, but “PUSCH for cancelled/dropped/colliding with HARQ bits”
* What type of CB would it be built when more than sets of HARQ bits are dropped, in more than 1 occasions?
* What type of CB and how the CB when there is a set of HARQ bits dropped due to internal prioritization and a set of HARQ bits cancelled together with PUSCH via DCI 2\_4? Alt 3 is far from complete solution.

Request to Sony: for the sake of progress, it would be useful if all companies take a stand. Respond to Sony: the Type X CB is not a new CB, it is what was suggested from the beginning: the CB construction is based on Type 3 CB.Response to Lenovo: there is a detailed 7 pages description of Alt 1 in QC’s proposal.Disagreement with Ericsson: the LP PUCCH dropped is a marginal case. |

### Proposal for GTW session on May 25th

Let’s discuss based on this proposal. Please note, that we can get (if needed) proposal 2.7 by simply removing the 2 last lines here.

On the comment by QC, I don’t see how QCs alternative proposal would solve the issue, as this seems to be basically a Enh. Type 3 CB of Alt. 3 with a single RRC configured list of HARQ-IDs that is to be triggered (which is still anyhow covered by the Alt. 3 description, please note that other companies may have some different Type 3 CB configuration or operation in mind than just the specific QC proposal).

**Proposal 2.7: For HARQ-ACK re-transmission:**

* **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***

## 4th Round

The views are rather split between proposal 2.6 (i.e. Alt. 1 only) and proposal 2.7 (i.e. Alt. 1 & Alt. 3 both supported) based on the input given in the 3rd round in Sec. 2.4. And similarly, there seems to be the same deadlock as we had been having before (with 2 or 3 objecting companies).

As this 4th round it planned to be very short (FL will present new proposals based on your feedback) and the moderator lacks a bit of additional ideas, I limit this here to the following two things:

* Please provide your input on solutions on how to resolve this issue here by email / FTP documents in achieving consensus in the first table looking at the current proposal 2.6 and 2.7.
* So that it cannot be said that all has not been tried to resolve this, let’s check if the proposal by QC could help to resolve the issue.

**Proposal 2.6: Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**

* ***Definition of enhanced Type 3 CB:***
	+ ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
	+ ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***

**Proposal 2.7: For HARQ-ACK re-transmission:**

* **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***

**Question 2.5: Please provide in below’s table any quick input / ideas on how we could change the proposals 2.6 or 2.7 above or structure them differently, to resolve the deadlock between Alt. 1 and Alt. 3 camps here.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Samsung | Object proposal 2.6 (reasons were explained in previous rounds).Support proposal 2.7. It can be a working assumption.Would prefer to also add that down-selection will be made, if one design does not provide any meaningful benefit over the other, in order to avoid unnecessary specifications. The trade-offs should be simple to tabulate. Hopefully, proponents of proposal 2.6 would then be in favour. |
| DOCOMO | Our first preference is Proposal 2.6 but we can accept proposal 2.7 for progress. |
| vivo | Our first preference is Proposal 2.6 but we can accept proposal 2.7 for progress. |
| Sharp | Our first preference is Proposal 2.6.We can support Proposal 2.7 if it is intended to down-select one solution. |
| CATT | We can try to agree proposal 2.7 with restriction that the construction of enhanced Type 3 CB is not determined based on dynamic indication to address the concern on specification efforts on supporting both schemes. |
| QC | Support Proposal 2.6Object current proposal 2.7Support for Updated proposal 2.7 (see below).Justification of our positionThe wish is to focus on technical discussions and technical input. However, the moderator’s tactics and manipulations can not be left without comment. The moderator claims that the group is split between Alt 1 and Alt 3. This is not true. Many of the companies supporting the proposal 2.7 are proponents of proposal 2.6 as well (e.g. Vivo, DoCoMo, Intel, …). The only reason these companies support the proposal 2.7 is they want a way forward as all of us. Why the moderator is not making a separate proposal with Alt 3 only? This is the norm in 3 GPP when there are major proposals for a feature. Very likely the numbers will not be in the moderator’s favour and the moderator will have to go against his agenda and push his allies to compromise to accept Alt 1.As a proof, the numbers from #104e [R1-2101818] (Alt 1 was Alt 2 then and Alt 3 was alternative 4 then)**Alt. 2 - Support of Type 3 CB Enhancements:** 19x Yes – 1x No**Alt. 3 - UL grant scheduling PUSCH to carry dropped HARQ:** 3x Yes – 1x No**Alt. 4 - DCI scheduling new PUCCH / PUSCH resource for LP HARQ re-transmission:** 2x Yes – 1x NoThe falsified counting of the moderator and the moderator’s intention to avoid Alt 2 lead the group in having to decide between the new Alt 1 and Alt 3. Despite the wish to compromise and move forward, Alt 3 results in error cases. Error cases can be solved, but they require standardization work in specifying the UE and network behaviour. (Since there is no detailed description of Alt 3 in not a single contribution, the points below are based on the input during an earlier email exchange with Samsung-the champion of Alt 3. DCI 1\_x requests PUCCH transmission of the cancelled/dropped/colliding with DL symbols CB. In case of multiple occurrences of dropped/cancelled/colliding with DL HARQ CBs, the CBs are concatenated)**Alt 3 has the 2 error cases**:**Alt 3 Error Case 1: DCI 1\_2 for LP PDSCH and LP PUCCH lost.** The problem is explained in the figure below. At time instant t0, gNB schedules a LP PDSCH and its associated LP PUCCH via DCI 1\_2. DCI 1\_2 indicates the PUCCH resource, i.e. PRI 1 and CB #1 (it can be CB of type 2 for example).This DCI 1\_2 is lost.At a later instant t1, gNB schedules with the help of DCI 1\_2 a HP PDSCH and its corresponding HP PUCCH. The resource used for the HP PUCCH, PRI 2, overlaps with PRI 1. The CB indicated is CB #2. If the UE had decoded successfully the DCI 1\_2, due to intra-UE prioritization, the UE would have transmitted only CB #2 and the UE would have dropped CB #1. This is the gNB interpretation of the situation.The UE has not decoded the first DCI 1\_2 transmitted at time instant t0 and hence the UE transmits CB #2 only.At a later instant t2, the UE receives a DCI 1\_x with the request to transmit the dropped CB, i.e. CB #1 (Alt 3). The UE does not know how to react. The UE behaviour must be specified. This means extra standardization effort is needed. **Alt 3 Error Case 2: One of consecutive DCI 1\_2 for LP PDSCH and LP PUCCH lost.**Consider the same scenario as above but there are 2 occasions of LP PUCCH dropping. The error is described in the following figure.At time instant t0, gNB schedules a LP PDSCH and its associated LP PUCCH via DCI 1\_2. DCI 1\_2 indicates the PUCCH resource, i.e. PRI 1 and CB #1 (it can be CB of type 2 for example).This DCI 1\_2 is lost.At a later instant t1, gNB schedules with the help of DCI 1\_2 a HP PDSCH and its corresponding HP PUCCH. The resource used for the HP PUCCH, PRI 2, overlaps with PRI 1. The CB indicated is CB #2. If the UE had decoded successfully the DCI 1\_2, the UE due to intra-UE prioritization, the UE would have transmitted only CB #2 and the UE would have dropped CB #1. This the Gnb interpretation of the situation.The UE has not decoded the first DCI 1\_2 transmitted at time instant t0 and hence the UE transmits CB #2 only.At a later instant t2, gNB schedules a LP PDSCH and its associated LP PUCCH via DCI 1\_2. DCI 1\_2 indicates the PUCCH resource, i.e. PRI 3 and CB #3 (it can be CB of type 2 for example).At a later instant t3, gNB schedules with the help of DCI 1\_2 a HP PDSCH and its corresponding HP PUCCH. The resource used for the HP PUCCH, PRI 4, overlaps with PRI 3. The CB indicated is CB #4. The UE decodes successfully the DCI 1\_2, due to intra-UE prioritization, the UE transmits only CB #4 and the UE dropps CB #3. This is the gNb interpretation of the situation and it is indeed what happens.CB #1 and CB #3 have the same size and the same tDAI & cDAI.At a later instant t4, the UE receives a DCI 1\_x with the request to transmit the dropped CBs, i.e. CB #1 & CB #3 (Alt 3). The UE transmits CB #3. gNB expects a concatenated CB of CB #1 and of CB #3. Due to the same CB size of CB #1 and of CB #3, the gNB cannot identify for which LP PDSCH feedback is received. The gNB retransmits both of the LP PDSCHs. This means losses and delays. In order to build a robust CB for concatenating dropped CBs, more fields are needed in the CB. This means extra standardization effort is needed so as to design a new CB.* How does Alt 3 if DCI 1\_x requesting the “Alt 3 CB” schedules PDSCH? Is the new CB multiplexed to the dropped CB? How? Probably some specification effort is needed there as well so as to define a solution.
* How does Alt 3 work when there are 2 different occurrences of dropped HARQ – as in the example of figure above-all of DCIs are correctly decoded and the first LP PDSCH has expired? Hence, the gNB wants only the second dropped CB but not the first dropped CB.

Therefore the group should not requested to standardize a solution with known error cases and with the need for significant standardization work. Therefore **Updated Proposal 2.7: For cancelled/dropped/colliding with DL HARQ-ACK bits:*** **Support one-shot triggering (by a DL assignment) of cancelled/dropped/colliding HARQ-ACK bits (re)transmission on a PUCCH resource with a *codebook whose construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***

***FFS: CB size configuration/setting***[Moderator comment]: On the ambiguity issue raise, please note there had been some companies (e.g. CATT, Nokia,…) suggesting indication of the HARQ-ACK codebook that is to be retransmitted. Please check the related summaries in Sec. 2.1.  |
| OPPO | Support proposal 2.7 |
| Xiaomi | Prefer proposal 2.7 |
| ZTE | Support proposal 2.7. For the error cases of Alt. 3 mentioned above, they are not real issues. For error case 1, there is only one DCI missing and one CB to be retransmitted, and UE will transmit nothing when gNB schedule the retransmission of HARQ. But gNB expecting the reception of retransmission would know nothing is transmitted and something wrong of DCI missing is with the initial DL reception for UE, and then normal handling of DCI missing will process as usual, the PDSCH corresponding the missing DCI will be resent. This doesn’t need additional specification effort. For error case 2, there is a DCI missing, and multiple CBs need to be retransmitted. A simple way to solve this is that gNB makes sure that there will be no multiple CBs to be retransmitted. At any time, it will schedule only on CB lost to be retransmitted. |
| Intel | Support 2.6 or Qualcomm version (which is aligned with our previous attempts to propose a WF). As a last resort, fine with 2.7. |
| NEC | Our first preference is Proposal 2.6 but we can accept proposal 2.7 for progress. |
| Sony | Firstly, thanks the FL for trying to moderate and to conclude this topic.**Object to Proposal 2.6.** I am afraid, QC has not really answered my questions, in fact their later comments confirmed my objection.Qualcomm commented that:*Answer to Sony: indeed, there is a need to adapt to the dynamic nature of the system, as always, but the argument was the same in the unlicensed operation as well…*Which suggests that the Rel-16 Type 3 CB works fine since NR-U had the same issue, which supported our initial view that there is no need to enhance Type 3 CB.The “error” case that QC highlighted is a classic missing DCI which as ZTE demonstrated succinctly that it could be easily recovered. If a gNB received nothing or a zero HARQ-ACK reTx, gNB knows that UE missed the DCI. In fact, if we compared to Type 3 CB, the UE would report a “NACK” in which case gNB would not know whether UE decoded it incorrectly or had missed the DCI.As a summary, the reasons for objection are:* If overhead in Type 3 CB is not an issue then the Rel-16 Type 3 CB works fine as noted by QC.
* If overhead in Type 3 CB is an issue, then it is not clear how a semi-static sized Type 3 CB has a better overhead performance than a dynamic CB that retransmits only dropped HARQ-ACK. Or rather no company could give a rationale answer to this question.

**Proposal 2.7:** Neither support nor object. We do not support it, but we do not want to object to it for sake of progress. **NOTE: Objecting and Not Supporting are very different matters.**Summary on reasons for *Not Supporting* enhancing Type 3 CB for *overhead* reduction:* gNB cannot semi-statically predict the number of cancelled HARQ-ACK and since Type 3 CB has a semi-statically configured size, it cannot efficiently adapt to the number of dynamically cancelled HARQ-ACK. That is, no matter what optimisation scheme companies proposed, it can never perform as good as a dynamic CB that retransmits cancelled HARQ-ACKs.
* The more a semi-statically sized Type 3 CB tries to adapt to a dynamically number of cancelled HARQ-ACK, the higher the specs impact and the more complex the optimisation scheme will be. An example is the proposal of having multiple enhanced Type 3 CBs and designing a new DCI indicator to indicate which of these multiple enhanced Type 3 CBs the UE should use to try to adapt the semi-static sized Type 3 CB as close as possible to the number of dynamically cancelled HARQ-ACKs. Such a scheme will no doubt be way more complex than a simple dynamic CB that retransmit cancelled HARQ-ACK.

Hence, we do not think it is justified that RAN1 spend time in enhancing Type 3 CB for the sake of overhead reduction. If overhead is an issue, it is better to solve the issue directly with a dynamic CB otherwise, (if overhead is not an issue), then reuse the Rel-16 Type 3 CB without trying to enhance it for size. This would lead to a better solution with minimum specs impact. |
| Huawei, HiSilicon | As expressed before, our preference is proposal 2.6 with restriction that the construction of enhanced Type 3 CB is not determined based on dynamic indication. For proposal 2.7 our main concern is the workload to specify both. However, we do understand the difficult situation and appreciate the effort from the moderator, therefore we can live with the direction of proposal 2.7 in principle, but we would prefer to support it with restriction that the construction of enhanced Type 3 CB is not determined based on dynamic indication, e.g. do some change as below: **Proposal 2.7: For HARQ-ACK re-transmission:*** **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook is ~~at least~~ determined by RRC configuration, i.e. no dynamic signalling involved***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***

**Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17** |
| LG | Support proposal 2.6 and Qulcomm’s updated proposal 2.7. For the sake of progress, we think it would be good to take both as WA and keep studying. Due to number of alternatives and remaining details for One-shot HARQ-ACK, it seems difficult to agree everything for now.  |

And as an alternative to the earlier discussed Proposal 2.6 (i.e. Alt. 1 only) and Proposal 2.7 (Alt. 1 & Alt. 3), let’s see if this proposal from QC could bring us forward:

**Proposal 2.8: Support a Type X HARQ-ACK CB for the transmission of cancelled/dropped/colliding with DL HARQ bits.**

* + ***Definition of Type X CB:***
		- ***Request for Type X CB is issued via DCI***
		- ***Type X CB size and content, i.e. list of HARQ Processes to be reported, is decided by the gNB***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells in a similar manner to Type 3 CB construction)***
* ***FFS 1: DCI type and content to trigger Type X CB request***
* ***FFS 2: Type X CB size configuration (and reconfiguration)***

|  |  |
| --- | --- |
| **Support** *(list of companies)* | QC, Intel |
| **Don’t support or object** (*list of companies*) | Samsung, Nokia/NSB, OPPO, Xiaomi, ZTE, Sony, Huawei, HiSilicon |

**Please provide your reasons for support or not support / object as well as any other comments on Proposal 2.8.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Samsung | No need/justification for a “Type X” CB or for defining/implementing any new CB type.Semi-static configuration of the possible CB contents cannot address the problem that is intended to be solved. For the most important eMBB applications (TDD-CA), the difference over the Rel-16 Type-3 CB will likely be marginal. |
| DOCOMO | For progress, can we merge QC’s proposal in Alt 1 of proposal 2.6 or proposal 2.7?**Proposal 2.6: Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17*** ***Definition of enhanced Type 3 CB:***
	+ ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook can be ~~at least~~ determined by RRC configuration and/or via DCI***
		- ***FFS how to determine the enhanced type 3 CB size and retransmitted HARQ-ACK bits by RRC configuration and/or DCI***
	+ ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***

[Moderator comment] Please note, that a sizeable number of companies (HW/HiSi, CATT, Ericsson,..) do not want to support DCI based indication of a ‘subset’ for Enh. Type CB operation. Including this here would risk the related approval.  |
| QC | Support updated proposal 2.6 from DCM. |
| Nokia, NSB | The formulation of the Type X codebook seems to be a sub-set of the Enh. Type 3 CB (i.e. Alt. 1) discussed so far, and is very much restrictive here to our reading. First, there is only a single Type X codebook supported based on the main bullet 🡪 DCI triggering of different ‘sub-sets’ or similar is precluded. The triggering in the DCI is therefore limited to ‘trigger’ or ‘not trigger’ in the 2nd sub-bullet. Therefore, also the ‘decided by gNB’ in the 3rd sub-bullet here is limited to a single Type 3 CB, which seems to be hinting to RRC configuration (given by FFS2). So we in this respect we don’t really see any difference to Proposal 2.6 in this respect.  |
| OPPO | We do not support proposal but can compromise to merged solution suggested by DOCOMO.[Moderator]: Please see my comments to DoCoMo |
| Xiaomi | NO need to introduce a new type codebook. |
| ZTE | Can merge this into proposal 2.6. |
| Intel | This is aligned with our understanding of the situation in the group |
| Sony | Unclear whether this is a dynamic CB or semi-static CB. Initially, the description sounded like a dynamic CB where gNB indicates dynamically which HARQ Process ID to retransmit, but later QC commented that it was a semi-static CB based on Type 3 CB. |
| Huawei, HiSilicon  | As we expressed before, even for proposal 2.6 we would like to determine the HARQ-ACK codebook only based on RRC configuration, not involving dynamic signalling to reduce the potential specification impact.  |
| LG | Fine with merging by DoCoMo. |

## 5th Round

Thanks for the input in the short 4th round – and your suggestions to move forward.

Based on the input to Question 2.5 it seems that most companies could be still fine with Proposal 2.7. QC raised some issues on the ambiguity Alt. 3, where feedback from the moderator referring to some input documents to this meeting discussing this issue as well as ZTE provided some input.

The alternative proposal 2.8 seemed to be not that well perceived, compared to the input given to Question 2.5 in terms of support (at least as compromise) towards Proposal 2.7. DoCoMo & OPPO suggesting to include the DCI based indication to the Enh. Type 3 CB proposal, but several companies earlier indicated their preference to not support this – so this may not help the acceptability of the proposal there either.

Therefore, still Proposal 2.7 seems the be the proposal (from the feedback, at least as compromise) to receive most backing and having most chance of being acceptable to a larger group of companies. As of little alternatives here, again Proposal 2.7 is up for discussion – maybe we could agree this (at least as a WA as proposed by Samsung, but from moderator perspective clearly an agreement would be preferred). The moderator does not see any other proposal brough up to have a chance be being acceptable here. If we may not be able to agree to this, it seems that also after RAN1#105-e the support for HARQ-ACK re-transmission in Rel-17 stays unclear.

**Proposal 2.7: For HARQ-ACK re-transmission:**

* **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***

|  |  |
| --- | --- |
| *Support (list of companies)* | Ericsson, Panasonic, LG (as WA), Sony (as WA), InterDigital, ZTE, Samsung, Nokia/NSB, Intel (2nd preference, first is 2.8 version), Huawei (as WA), vivo, Sharp，OPPO, DOCOMO, CATT, NEC, Spreadtrum, WILUS |
| Object(list of companies) |  |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table (i.e. no need to repeat your arguments for the support of only Alt. 1 or Alt. 3 here from previous rounds, please take the overall situation of opinions in the group into account here).**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Ericsson | We are also fine with WA if that would be needed. |
| LG | We would like to have WA for each sub-bullet. Due to number of alternatives and remaining details for One-shot HARQ-ACK, it is difficult to agree everything for now to us. |
| Sony | We are fine as a WA as suggested by Samsung. |
| Samsung | Prefer to have it as WA and allow for possible down-selection. Possible designs were well captured by the FL and discussed in early rounds. A (near) finalization for the “enhanced Type 3” and the “one-shot” should be possible/targeted for at the next meeting, followed by a one-to-one comparison of relevant metrics/attributes. |
| Nokia/NSB | We would be fine with an agreement, and certainly with a WA if needed.  |
| Huawei, HiSilicon  | For sake of the progress, we can accept it as working assumption as a compromise. Later when better to see the whole picture of these two alternatives, we can further see whether to take both or only one of them.  |
| Sharp | We are fine with Proposal 2.7 as WA. Since anyhow detailed comparison between these two methods would be performed, it seems better to set a target to down-select one method. |
| QC | Some replies to comments/questions received.Regarding ZTE that the missing DCI in Alt 3 is not issue: hence, the UE receives a DCI with a field “transmit dropped/cancelled/colliding with DL CB #N”, the UE does not have this CB and the UE’s behaviour does not need specification? The UE can send NACK as you suggest and the network can infer that DCI was missed. This has to be specified. Moreover, arguments of the type “this is a typical missed DCI case” are of no value at this discussion. The group tries to describe a feature allowing the network to retrieve cancelled/dropped/colliding with DL HARQ bits in an URLLC setup. Proposing a solution for this case which has “the typical missed DCI” issue, does not seem appropriate. Especially, considering that Alt 1 does not have this “typical missed DCI” issue.Answer to Sony: as mentioned before “semi-static behaviour of Type 3 CB not adapting to dynamic conditions” is not a valid argument, since the same principle applies to everything configured by RRC. There are fundamental reasons why some things are done in L1 and some other in RRC.Question to Sony: is there any constructive proposal and design details for the “new dynamic CB adapting to dynamic conditions”? Regarding moderator’s comment that the modified proposal is very similar to the proposal 2.6, an updated proposal was circulated at the meeting.**Update Proposal 2.8: Support a feature for the transmission of cancelled/dropped/colliding with DL HARQ bits.** * + ***Feature Definition:***
		- ***Request for Type X CB via DCI 1\_x***
		- ***Type X CB size and content, i.e. list of HARQ Processes to be reported, is decided by the gNB***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* ***FFS 1: DCI content to trigger Type X CB request***
* ***FFS 2: Type X CB size configuration (and reconfiguration)***

The only thing that is suggested is that there is a mechanism controlled by the network for the transmission of cancelled/dropped/colliding with DL HARQ bits. The network requests the list of HARQ processes to be reported.Reply to the moderator’s comment on the DCI indicating the CB # to be transmitted: yes agreement. This is the only way Alt 3 works. There is a need to construct a new CB with concatenation of CBs and with indexes per reported CB. Hence, the argument that Alt 3 does not require a new CB is not valid.Even with this definition of this new CB, Alt 3 is not as flexible as Alt 1. What does it happen when 1 DL packet for which 1 HARQ bit is included in the dropped/cancelled/colliding with DL CB has expired? Dropped CB to be transmitted is equal to 2 bits, for example. The UE reports 2 HARQ bits whilst the network needs only 1. This means 50% overhead and no “adaptation to dynamic conditions”.For the sake of progress, the following proposal could be accepted**Updated Proposal 2.7: For HARQ-ACK (re)transmission due to dropping/cancellation/collision with DL:*** **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**
	+ ***Details are FFS***

The reason for the proposal is that re-transmission does not really happen in neither of cases of HARQ dropping or due to CI or due SPS PUCCH HARQ collision with DL; it is rather a delayed/deferred transmission of pending HARQ bits.Both of solutions are accepted and at the next meeting the group starts specifying details for both of these solutions. No need for down-selection. Alt 1 is well described in contributions and during the email discussion. Alt 3 to a lesser extent, but the main picture seems to be drawn. The pros and cons of both solutions are well understood. Alt 1 provides higher granularity than Alt 3 since the network has the option to indicate at HARQ process granularity level the requested codebook, whilst Alt 3 does not. The rest of features* DCI trigger
* PUCCH transmission
* Design of new/modified CB

Seem to be the same.Note 1: proposal accepted with new wording only, not as is.Note 2: Above proposal won’t be accepted as a working assumption. Based on the experience of the last meetings and despite the request to focus on discussing technical details of Alt 1 and Alt 3 and comparing them technically, there is very high likelihood that the comparison at the next meeting will be with the argumentation of the level “not meaningful”, “it does not make sense”, “beauty contest”, etc (in addition to the manipulated counting). This should be avoided, and the group should focus on specifying details for both solutions that allow the network to choose which solution to use. |
| CATT | We are fine to agree as a working assumption. |
| WILUS | We prefer to make an agreement but are fine with Proposal 2.7 as WA as suggested by Samsung.  |
| QC | As mentioned earlier, the updated proposal will be accepted only as an agreement, not as a working assumption. This means that the network and the UE will have to implement both mechanisms if the feature is fully supported. Flexibility on UE implementation, i.e. the option for UE supporting only one of the options is provided by specifying a UE Capability field indicating the option(s) supported. Hence, the updated proposal: **Updated Proposal 2.7: For HARQ-ACK (re)transmission due to dropping/cancellation/collision with DL:*** **Support at least one enhanced Type 3 HARQ-ACK CB with smaller size (compared to Rel-16)** **in Rel-17**
	+ ***Definition of enhanced Type 3 CB:***
		- ***The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook at least determined by RRC configuration***
		- ***The codebook construction uses HARQ processes as a bases (i.e. ordered according to HARQ-IDs and serving cells)***
* **Support one-shot triggering (by a DL assignment) of HARQ-ACK re-transmission on a PUCCH resource other than enhanced Type 2 or (enhanced) Type 3 HARQ-ACK CB (i.e. Alt. 3) in Rel-17**

***Details are FFS**** **Specify a UE Capability field indicating which of the above 2 option(s) is supported; including indication for support of both options.**
 |

# PUCCH carrier switching for HARQ feedback

In the RAN1#103-e meeting, the following agreement was reached.

|  |
| --- |
| Agreements: In the studies on PUCCH carrier switching for HARQ-ACK, PUCCH carrier switching for different cells operated is considered only for cells that are part of the active UL CA configuration. |

Moreover, during RAN1#104, the following additional agreement was reached:

|  |
| --- |
| Agreements: **For further study on** **whether and how to support** **PUCCH carrier switching** **in a PUCCH group, focus on the following three alternatives:*** **Alt. 1: PUCCH carrier switching is based dynamic indication in DCI**
* **Alt. 2B: PUCCH carrier switching is based on certain (semi-static) rules**
* **Alt. 2C: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
* Note: In above alternatives, it is assumed that HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group, can be sent on a PUCCH onan Scellalso instead ofonly onPcell/PScell/PUCCH-SCellin the same PUCCH group, as opposed to Rel-16 where HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group can only be sent on Pcell/PScell/PUCCH-SCell in the same PUCCH group.
* ***Note: Realistic deployment scenarios including TDD configurations should be considered for the study***
 |

During RAN1#104bis, based on the discussions the definition, a hybrid operation of the earlier Alt. 1 and Alt. 2B was discussed which is now denoted as Alt. 1B, i.e. the following methods had been discussed during RAN1#104bis-e:

* ***Alt. 1- PUCCH carrier switching is based dynamic indication in DCI***
* ***Alt. 1A -*** ***PUCCH carrier switching is based dynamic indication in DCI for scheduled PUCCH (as for Alt. 1) and based on certain (semi-static) rules for configured PUCCH (as for Alt. 2B)***
* ***Alt. 2B - PUCCH cell switching is based on certain (semi-static) rules***
* ***Alt. 2C - PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells***

## 3.1 Summary of companies input in their contributions

**Motivation for PUCCH carrier switching:**

**Pros:**

* Reduce latency for different UL/DL configurations: Ericsson [1], HW/HiSi [2], Nokia/NSB [3], ZTE [4], QC [9], Intel [12], ETRI [16], Samsung [18], Interdigital [19], Mediatek [23], CAICT [24], WILUS [27] , CMCC[8]
* Dynamic load balancing & f-selective gain: HW/HiSi [2], CAICT [24]
* Use CC with higher reliability: QC [9]
* Improves network capacity / efficiency – reduces resource utilization: Mediatek [23]

**Cons:**

* Limited use case: vivo [5] (realistic deployment scenarios not yet identified), OPPO [10], Apple [13]
	+ Reply: Identified use case is inter-band CA with unaligned frame boundary: CMCC [8], QC [9]
* Multiplexing on PUSCH already supported (based on Ran1#104-e Rel-16 agreement): vivo [5]

The following feedback on how to **support PUCCH carrier switching in Rel-17** was received:

* **Do not support PUCCH carrier switching:** vivo [5](deployment scenarios not identied, multiplexing on PUSCH supported already when PUCCH is overlapping with SSB/semi-static DL symbols),
* **Alt. 1 - PUCCH carrier switching is based dynamic indication in DCI:**
	+ **Support (15?) :** Ericsson [1] (and/or Alt. 2C), HW/HiSi [2] (?), Nokia/NSB [3] (2nd preference), ZTE [4], CATT [7], CMCC [8] (Alt. 2C to complement for configured PUCCH), China Telecom [11], Intel [12] (for dynamic PUCCH, Alt. 2C for scheduled PUCCH), Panasonic [15], Samsung [18] (for scheduled PUCCH, Alt. 2C for configured PUCCH), Interdigital [19], LGE [20] (if feature is necessary), Mediatek [23], CAICT [24], APT/FGI [26] (?)
	+ **No (1):** Apple [13] (exclude from further discussions)
	+ **FFS (-):**
	+ **Details:**
		- And indicated PUCCH carrier should not be changed further for UCI transmission: Ericsson [1]
		- PRI indicating the PUCCH carrier using extended PUCCH resource sets including different CCs: ZTE [4], Panasonic [15] (with potential size increase of PRI field), CAICT [24]
		- Add a carrier-switching field to the DCI: LGE [20], Mediatek [23]
		- The reference SCS of PDSCH to HARQ-ACK offset K1 is the SCS of the indicated target carrier: ZTE [4], China Telecom [11], Panasonic [15]
			* Issues with Type 1 CB and multiplexing of SPS PDSCH on scheduled PUCCH resource for mixed SCS identified: Nokia/NSB [3] (do not support mixed SCS)
		- The reference slot / SCS is determined by the smallest SCS: CATT [7]
			* Issues with Type 1 CB and multiplexing of SPS PDSCH on scheduled PUCCH resource for mixed SCS identified: Nokia/NSB [3] (do not support mixed SCS)
		- PUCCH carrier selection reliability due to missed DCI can be helped by not changing the indicated PUCCH carrier index: Panasonic [15], Interdigital [19], Mediatek [23]
		- Configure different K1 sets for carrier with different SCS (but the same set size): China Telecom [11], Panasonic [15] (either per carrier specific or SCS specific), CAICT [24] (per SCS)
		- Configure offset values for different SCS for the slot/sub-slot determination: Panasonic [15]
		- Consider MAC CE indication for SPS HARQ-ACK only: China Telecom [11]
		- SPS HARQ-ACK only switched, if overlapping dynamically indicated switched PUCCH: LGE [20], CAICT [24]
* **Alt. 1A - PUCCH carrier switching is based dynamic indication in DCI for scheduled PUCCH (as for Alt. 1) and based on certain (semi-static) rules for configured PUCCH (as for Alt. 2B)**
	+ **Support (2) :** HW/HiSi [2], APT/FGI [26]
	+ **No (5):** Nokia/NSB [3] , OPPO [10], China Telecom [11], CAICT [24], Ericsson[1]
	+ **FFS (-):**
	+ **Details:**
		- Multiplex SPS on the scheduled PUCCH resource in case of collision: HW/HiSi [2]
* **Alt. 2B – PUCCH cell switching is based on certain (semi-static) rules:**
	+ **Support (4):** QC [9], NEC [17], DoCoMo [22], Moto/Len [25]
	+ **No (~~4~~ 3)** Nokia/NSB [3], OPPO [10], ~~China Telecom [11]~~, Ericsson[1]
	+ **FFS (X):**
	+ **Details:**
		- Reference slot (using K1) is determined by the PCell numerology: QC [9], China Telecom [11], NEC [17], DoCoMo [22],
		- Reference slot is determined by the largest SCS: NEC [17]
		- The order of the cell selection is to take the SCS into account: HW/HiSi [2] (first same SCS, then closes smaller SCS), China Telecom [11] (higher SCS carrier having priority)
		- First CC having enough UL symbols is selected: QC [9] (CC based on predefined order, lowest indexed CC), China Telecom [11] (predefined ordering of CCs, SS-UL symbols highest priority in the search), NEC [17] (in order of priority), DoCoMo [22] (‘no invalid symbols’, in order of serving cell index), Moto/Len [25] (carrier priorities)
		- If selected CC has larger SCS, select the earliest available slot in the set of multiple slots: QC [9], China Telecom [11], NEC [17]
		- If selected CC has smaller SCS, multiplexing of HARQ-ACK of different slot’s would be needed: Nokia/NSB [3], China Telecom [11]
		- Simplified solution proposal for Alt. 2B by QC [9]
			* Limited to 2 cells (PCell & one Scell)
			* PUCCH TX not possible on the PCell (based on K1 & PRI interpretation on PCell), transmit on the SCell by interpretating K1 and PRI using Scell numerology & Scell PUCCH config
			* Regarded as gNB error if transmission on the Scell is not possible
				+ *Moderator question:* how about configured PUCCH? Is this then also a gNB error or only for scheduled PUCCH?
		- In the initial carrier, a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as needing carrier switching: China Telecom [11]
* **Alt. 2C - PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells –**
	+ **Support (6 + 3 for configured PUCCH):**
		- **For configured & scheduled PUCCH (6):** Ericsson [1] (and/or Alt. 1), Nokia/NSB [3] (1st preference), Apple [13] (more suitable, if to be supported), ETRI [16] (?), DoCoMo [22], WILUS [27]
		- **For configured PUCCH only (dynamic indication / Alt.** **1 for scheduled PUCCH**) **(3)**: CMCC [8], Intel [12], Samsung [18]
	+ **No (-):**
	+ **FFS (-):**
	+ **Details:**
		- Configure time-domain pattern directly defines the PUCCH slot: Nokia/NSB [3]
		- Reference SCS of the time-domain pattern could be the smallest SCS: China Telecom [11]
		- K1 uses the PCell numerology: China Telecom [11]
		- If selected CC has larger SCS, select the earliest slot in the set of multiple slots: China Telecom [11]
		- If selected CC has smaller SCS, multiplexing of HARQ-ACK of different slot’s would be needed: China Telecom [11]

**Additional / general input provided on the PUCCH carrier switching:**

* Configuration of pucch-Cell on PCell to indicate another serving cell within the same cell group to use for PUCCH: Ericsson [1]
* SCS / different numerologies within a PUCCH cell group:
	+ No restriction / limitations on the SCS: Ericsson [1], ZTE [4] (for Alt. 1), CATT [7] (for Alt. 1), QC [9], China Telecom [11], Intel [12] (no issues identified), Panasonic [15], Mediatek [23]
	+ Support PUCCH carrier switching only for cells with same UL SCS: Nokia/NSB [3], DoCoMo [22] (preferred)
		- Issues with Type 1 CB: Nokia/NSB [3]
		- Going from higher to lower SCS – overlapping PUCCHs from neighboring slots: Nokia/NSB [3]
		- Going from lower to higher SCS – unclear which slot is selected: Nokia/NSB [3]
			* Select the first available one: QC [9] – multiplexing timeline?
	+ For Alt. 1, target carrier should be same or higher SCS: LGE [20]
* Discuss joint operation of PUCCH carrier switching and simultaneous PUCCH/PUSCH: Ericsson [1] (incl. simultaneous PUCCH/PUCCH)
	+ PUCCH carrier switching is the first step, followed by PUCCH/PUSCH parallel transmission and/or UCI multiplexing on PUSCH in a second step: QC [9]
* Multiplexing limitations:
	+ Any CSI supported: ETRI [15], LGE [20] (?)
	+ No CSI multiplexed: Nokia/NSB [3], ZTE [4], Mediatek [23] (lower priority)
	+ SR multiplexing: Yes: Nokia/NSB [3], Samsung [18] – No: ZTE [4], Mediatek [23] (lower priority)
	+ SPS HARQ-ACK & DG HARQ-ACK are multiplexed: CATT [7], Nokia/NSB [3], LGE [20], – No: ZTE [4] (only DG PDSCH HARQ-ACK transmitted using Alt.1), QC [9] (?)
* PUCCH resource configuration:
	+ Per CC: QC [9], Mediatek [23]
	+ Combination of ‘per PUCCH group” and “per PUCCH carrier”: Mediatek [23]
	+ Depending on the Alt. chosen: Nokia/NSB [3] (Alt. 2B may require same configuration)
	+ Same number of PUCCH-configs expected (i.e. same handling for both PHY priorities): DoCoMo [22]
* Applicable cells for PUCCH carrier switching are configured by gNB: ZTE [4] (‘cell set’), QC [9] (per CC)
* Overlapping between PUCCH on switched cell and initial cell needs to be handled: CATT [7]
* PUCCH TPC operation on different CCS: NEC [17] (joint or separate TPC loop, handling of DCI format 2\_2), Mediatek [23] (separate TPC loop & TPC parameter settings)
* Compromise to support both, Alt. 1 and Alt. 2B (based on configuration):
* Should be limited to inter-band CA in Rel-17: Samsung [18]
* HARQ-ACK timing indicator counts only slots with PUCCH resources for PUCCH carrier switching:

## 3.2 1st Round

**Moderator comments / observations:**

Looking at the input given, the following is noted:

* There are still some company(s) not convince about the use-fullness of PUCCH carrier switching overall
* **Dynamic indication in the triggering DCI (Alt. 1) received most support by companies (15 Y vs. 1 N).** The arguments for the support of Alt. 1 include the ability for the gNB to dynamically indicate the PUCCH carrier to be selected as well as the simplicity of specification and operation. The drawback of supporting Alt. 1 (only) is that the handling of SPS HARQ-ACK (i.e. configured PUCCH) is not really supported if not multiplexed on a scheduled PUCCH – which was the reason for some companies during RAN1#104bis-e to suggest Alt. 1A. In this meeting, some companies are now suggesting to couple Alt. 1 for scheduled PUCCH with the support of Alt. 2C (which is simpler to specify and keeps control at gNB side as well) for configured PUCCH. Additionally, the signaling overhead in the DCI had been mentioned by some companies (

***Overall, looking at the strong support for Alt. 1 (compared to the other discussed alternatives) it seems that if PUCCH carrier switching is to be supported in Rel-17 then at least the support of Alt. 1 could be there.***

* **Alt. 1A tries to solve the short-coming of Alt. 1 with having additional semi-static rules for configured PUCCH, but there had been little support indicated (2Y vs. 5N).** The arguments from companies not supporting Alt. 1A had been the rather large specification effort (i.e. the combination of Alt. 1 and 2B).

***As there seem more companies thinking this should not be supported compared to companies actively supporting Alt. 1A, the moderator is initially trying to find some consensus on the other options including at least Alt. 1.***

* **Alt. 2B using semi-static rules to determine PUCCH carrier also received little support (4Y vs. 4N).** The advantages over Alt. 1 is the reduced DCI overhead and the handling of SPS HARQ-ACK (compared to Alt. 1 & 1A). The drawback mentioned by some companies is the complex specification (of the rules) as well as the little control for the gNB for the PUCCH carrier switching operation.

***As there seem more companies thinking this should not be supported compared to companies actively supporting Alt. 2B, the moderator is initially trying to find some consensus on the other options including at least Alt. 1.***

* **Alt. 2C of having a semi-static RRC configured time-domain pattern of PUCCH cells received the support by 6 companies (6Y vs 0N) for scheduled & configured PUCCH, with 3 companies mentioned to use this in cooperation with Alt. 1 for configured PUCCH (i.e. hybrid of Alt. 1 and Alt. 2C).** The mentioned advantages over Alt. 2B include the reduced specification effort / complexity as well as the ability to have some control at the gNB side. The mentioned drawbacks include the ability to react on dynamic change of TDD operation (e.g. SFI) as well as high RRC signaling overhead of the time domain pattern.

***From the feedback received, it seems that this option is maybe still worth considering. Potentially in combination with Alt. 1 to solve the problem of configured PUCCH operation.***

* **On the overall operation, there had been good input on the discussion of different SCS handling, PUCCH resource configuration, support for SR and/or CSI, beside some other issues.**

***It is the moderator’s understanding, that some of these points need specific discussion based on the Alternative(s) chosen in case PUCCH carrier switching is supported. Therefore, it would be preferable to first decide on the Alt.(s) to be supported in Rel-17 before being able to have detailed discussions on these issues.***

As discussed above, Alt. 1 received by far the highest support followed by Alt. 2C. Clearly the drawback of only supporting Alt. 1 is the limited support for configured PUCCH (e.g. SPS HARQ-Ack or SR on Scell), which some of the supporting companies of Alt. 1A, 2B and 2C pointed out. Thus, maybe some compromise to take the worries of the

So as input to the first GTW session based on the interest by different companies we could try the following two options:

* Option 1: We support Alt. 1 only (with the known limitations for configured PUCCH)
* Option 2: Compromise as suggested by some companies, we support Alt. 1 and Alt. 2C, including the combination of the two schemes
	+ If Alt. 1 only is configured for the UE, the UE is operated with Alt. 1 only (with its limitations in terms of e.g. SPS HARQ-ACK)
	+ If Alt. 2C only is configured, the UE operates based on Alt. 2C – i.e. the time domain pattern defines the PUCCH carrier for scheduled and configured PUCCH.
	+ If both Alt. 1 and 2C are configured, the configured PUCCH operates using the Alt. 2C time domain pattern. If a dynamic indication of a PUCCH carrier is available, the PUCCH cell and the PUCCH resource is determined based on the dynamic indication in the DCI scheduling the PUCCH.

Maybe we could see (based on initial input by companies) which of the options to discuss during the GTW session:

**FL Proposal Option 1: PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17.**

* ***Details are FFS***

**FL Proposal Option 2: PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) and based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells (i.e. Alt. 2C) is supported in Rel-17.**

* **Dynamic indication and/or RRC configured time-domain pattern can be independently configured for the UE.**
* **If only dynamic indication (i.e. Alt. 1) is configured, the PUCCH carrier switching is only supported for scheduled PUCCH based on the indication in the DCI scheduled the PUCCH.**
* **If only the RRC time-domain pattern (i.e. Alt. 2C) is configured, the PUCCH carrier switching for configured and scheduled PUCCH is based on the configured time-domain pattern of applicable PUCCH cells.**
* **If both dynamic indication and RRC configured time-domain pattern are configured for the UE, the UE selects the PUCCH carrier based on the dynamic indication in the DCI scheduling a PUCCH. If a dynamic indication of a PUCCH carrier is not available, the UE applies the RRC configured time-domain pattern to determine the PUCCH cell.**
* ***Details are FFS***

**Question 3.1:** Please provide your views with respect to Option 1 and Option 2 FL proposals above. (Please add your company name below to the rows if you prefer / support Option 1 and/or Option 2 or none of the above, please provide your additional comments to next question / table below separately)

|  |  |
| --- | --- |
| *Option 1: Alt. 1 only* | CATT, OPPO, ZTE, Panasonic, China Telecom, QC (with FFS: whether/how to support SPS A/N with carrier switch), APT/FGI |
| *Option 2: Alt. 1 & Alt. 2C* | CMCC, Spreadtrum, WILUS, Nokia/NSB, Intel, InterDigital, DOCOMO, Huawei, HiSilicon, Samsung, Ericsson |
| *None of the above* | vivo, NEC, Lenovo/Motorola Mobility |

**Question 3.2:** Do you have any additional comments on FL proposal Option 1 / Option 2, including your arguments for or against the support for Option 1 / Option 2?

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CATT | We currently prefer Option 1 although we are also open to support Alt. 2C. We would like to have more discussions on the details of Option 2 including the details of Alt. 2C and whether/how to support configuring Alt. 2C only etc. before agreeing on Option 2. |
| CMCC | A clarification: Option 1 does **NOT** support SPS HARQ-Ack, right? SPS is frequently applied in vertical industries so a solution supporting SPS is much more useful.  |
| WILUS | At least for SPS HARQ-ACK, RRC configured time pattern (Alt. 2C) have advantage over Alt 1. So, option 1 cannot cover some IIoT scenarios where DL traffic occurs periodically. Also, it seems that Alt. 2C can be used for dynamic scheduled HARQ-ACK without any dynamic indications. So, we slightly prefer to support Alt 2C for both DG HARQ-ACK and SPS HARQ-ACK, which reduces specification efforts.  |
| Nokia/NSB | We could be fine with supporting both Alt. 1 & 2C including the joint operation of the two.  |
| Intel | We suggest splitting the discussion on configured PUCCH and dynamic PUCCH, although there is relation. |
| ZTE | Alt. 1 can also support the CG PUCCH for SPS. For CG PUCCH, the DCI absence issue can be solved by the reactive DCI for SPS PDSCH, this type of DCI has been supported in specifications. The reactive DCI can carry the PUCCH switching indication as the normal DCI.  |
| vivo  | We are not convinced by the mentioned real deployment scenarios that can be benefit from the PUCCH carrier switching. Although there is one potential deployment proposed in contribution R1-2104604, we would like to point out that from the TDD configuration perspective, it is clear that the TDD carrier in 4.9GHz that has more balanced DU configuration and the 2.5milisecond frame structure is more suitable for operating URLLC. In this particular case uses 2.6GHz additionally does not bring meaningful latency reduction. We are interested and appreciate companies’ solutions from the innovation perspective. But for standardization, we are very worried that this feature would become a paper work and consumes a lot of RAN1 time given the complexity already observed from the contributions |
| InterDigital | We are ok with supporting Alt.2C in addition to Alt.1. |
| DOCOMO | We think the key motivation to support PUCCH carrier switching is the latency reduction for URLLC service. As SPS transmission is an important technique for IIoT/URLLC service, PUCCH carrier switching should be supported for SPS HARQ-ACK. Otherwise, the benefit to introduce PUCCH carrier switching is too much limited. |
| Huawei, HiSilicon | Although we originally prefer Alt.1 + Alt.2B, we can accept Alt.1+Alt.2C as compromise. We think PUCCH carrier switching should be supported for both scheduled PUCCH and configured PUCCH, therefore only support Alt.1 seems a little bit too limited. For Alt.2C, the key question is whether/how to handle the case that the indicated UL slot is modified to DL by dynamic SFI, since Alt.2C the pattern is configured by RRC signalling it cannot match the change of dynamic SFI. Of course, if we really want to go to Alt.2C, one potential way is to rely on gNB to avoid this kind of collision or have to drop the HARQ-ACK.  |
| NEC | As pointed out by other companies above, SPS transmission feature is important for URLLC service. But option 1 is not applicable for SPS HARQ-ACK, option 2 needs to support two alternatives (Alt.1 and Alt.2C) for PUCCH carrier indication for both DG HARQ-ACK and SPS HARQ-ACK. Then we slightly prefer a unified PUCCH carrier switching method for both DG HARQ-ACK and SPS HARQ-ACK, i.e., Alt.2B. |
| Panasonic | Our preference is Option 1 as the gNB can dynamically configure the target PUCCH carrier. This Option along with UCI multiplexing could be used for SPS as well.For Option 2C, the signalling overhead could be large when the employed SCS is high or/and the periodicity of the DL-UL slot pattern is high. Also, the timing pattern might become invalid after enabling/disabling a PUCCH carrier or receiving an SFI. This could entail frequent update for timing pattern. |
| Lenovo/Motorola Mobility | Option 1 cannot reduce SPS HARQ-ACK dropping or deferring. Option 2C does not provide flexible PUCCH transmission opportunity, so make it difficult to realize the benefit of PUCCH carrier switching. |
| China Telecom | We prefer to support Alt1 for dynamic scheduled PUCCH and FFS for SPS PDSCH HARQ-ACK feedback.For SPS PDSCH HARQ-ACK feedback, when it is multiplexed with dynamic scheduled PDSCH feedback in the same codebook, Alt 1 applies.For only the SPS PDSCH HARQ-ACK feedback case, as ‘NACK skipping’ discussed for SPS HARQ skipping of ‘skipped’ / ‘non-skipped’ SPS PDSCH, when all of the HARQ-ACK for these SPS PDSCH are going to be NACK, the NACK feedback is dropped. If there is ACK in the SPS HARQ-ACK feedback codebook, PDSCH MAC CE can be used to indicate the PUCCH carrier. However, this mechanism depends on whether ‘NACK skipping’ could be agreed by the group. |
| Samsung | Also OK with Alt. 2C only - but fine with Alt. 1 due to its simplicity and as an enhancement for the network to choose. |
| Ericsson | There should be no restriction on the SCC cells in the PUCCH group that PUCCH carrier switching is enabled.  |
| QC | We are OK with option 1 to support dynamic A/N. For SPS A/N, we don’t see Alt 2C is better than Alt 2B. With different numerologies cross CCs, Alt 2C also need to specify rules to support carrier switch. For example, rules are needed to define reference CC to check the pattern, to define reference slot to decide transmission slot, and to determine actual slot for PUCCH transmission if multiple actual slots fall into the reference slot. So, Alt 2C and 2B has similar spec impact in case of different numerology. However, Alt 2B has no RRC impact while 2C has. In summary, we think the following should be the WF**FL Proposal Option 1: For a PUCCH has corresponding scheduling DCI, PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17.** * ***Details are FFS***

***FFS: whether and how to support carrier switch for semi-static PUCCH (e.g., SPS A/N and SR)*** |
| Apple | We have concern on the specification change & implementation complexity with dynamic switching of PUCCH carrier. The case for PUCCH carrier switching was built on inter-band TDD with potentially different UL/DL split, which should not change with time in major use cases. If companies who proposed PUCCH carrier switching still believe in the inter-band TDD use case, let us exploit the semi-statically available UL/DL split across CCs, then semi-static switching is sufficient.  |
| APT/FGI | Agree with QC, we think applying DCI to dynamic PUCCH (Alt.1) and applying semi-static rules(Alt.2B) to configured PUCCH would be a good compromise (Alt1a). Regarding the drawback of applying 1A mentioned by some companies, it is unclear since spec impact has to be certainly introduced regardless which alternative is conducted. If option 2 is applied, it might result in increasing both DCI overhead and RRC signalling overhead. Thus, Opt2 is not a solution we could reach.  |

## 2nd Round

#### Alt. 1 Follow up: Questions on details of the potential support of Alt. 1

***Moderator comment:*** At least it had been moderator’s understanding going into this meeting (based on the discussions during RAN1#104bis-e), that Alt. 1 ONLY /itself would mean that SPS HARQ-ACK is only switching to another carrier, if it is to be multiplexed on a scheduled PUCCH which has been indicated by a scheduling DCI to use a different CC than the PCell. But based on some comments received before the first GTW session it seems that some companies think differently and think for Alt. 1 this should be FFS.

So maybe it would be good to clarify first here, if there is the same understanding between companies – i.e. if e.g. SPS HARQ can be moved to an Scell using some semi-static rules without being multiplexed on the scheduled PUCCH, this is not Alt. 1 but Alt. 1A (as discussed in the last meeting). In this meeting (based on the input by several companies), the combination of Alt. 1 for scheduled PUCCH and Alt. 2C for configured PUCCH had been brought up. But also here, the combination to moderator’s understanding is not really ‘Alt. 1 ONLY’ but is a combination / hybrid of Alt. 1A and Alt. 2C.

So it would be worth clarifying if the group is having a common understanding on this point:

**Question 3.3.1: Do you agree (Yes / No) with the following definition of Alt. 1:**

* **In case Alt. 1 ONLY is supported (i.e. Alt. 1 by itself), e.g. SPS HARQ can only be transmitted on an alternative PUCCH Scell if it is multiplexed on a scheduled PUCCH which had been indicated to be transmitted on the target SCell. A configured PUCCH (i.e. PUCCH not scheduled dynamically by a DCI) carrying HARQ-ACK is still located at the PCell.**
* **Hybrid solutions, e.g. combination of Alt.1 for scheduled PUCCH & Alt 2B for configured PUCCH (which had been denoted as Alt. 1A during RAN1#104bis-e) or combination of Alt. 1 for scheduled PUCCH & Alt. 2C for configured PUCCH (discussed above) are not Alt. 1 ONLY / Alt. 1 itself.**

Please provide your opinion (Yes / No) to Question 3.3.1 in the first table. Especially if your answers is now, please provide your comments to the 2nd comment table below:

|  |  |
| --- | --- |
| *Yes*  | Nokia/NSB, LG, CATT, Sony, APT/FGI, Huawei, HiSilicon, ZTE (with comments on SPS HARQ), DOCOMO, Intel, InterDigital, Panasonic, MTK, QC, WILUS, Spreadtrum, OPPO,Xiaomi, NEC, CMCC |
| No | China Telecom |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| ZTE | We support Alt. 1 only. The reactive DCI can indicate the PUCCH switching for SPS HARQ. |
| MTK | We support Option 1 (Alt. 1 only) and we think it should prioritized, but we are also open to accept Option 2 ( Alt-1 & Alt 2C). We acknowledge the importance of SPS for URLLC and also the importance of extending the enhancement to SR for the UL traffic and for CSI. The only concern we have with Option 2 is the specification effort.  |
| Apple | In our view, PUCCH carrier switching, if specified, will involve many specification changes and also implementation changes. We are approaching this topic with trepidation. We would like to see the benefit of dynamic PUCCH carrier switching vs semi-static PUCCH carrier switching(which itself is complicated already). When reviewing MTK’s contribution, first, the evaluation results provided in Appendix C (dynamic PUCCH carrier switching) are much appreciated. Second, for “CA baseline”, could MTK clarify whether it is with PUCCH carrier switching or not. We would like to understand any potential benefit of dynamic PUCCH carrier switching over semi-static PUCCH carrier switching.  |
| Ericsson | The description seems to make sense. |
| China Telecom | As we mentioned, for Alt. 1 ONLY and if ‘NACK skipping’ for ‘skipped’ / ‘non-skipped’ SPS PDSCH is supported by the group, when all of the HARQ-ACK for SPS PDSCH are going to be NACK in a codebook, the NACK feedback is dropped. If there is ACK in the SPS HARQ-ACK only codebook, PDSCH MAC CE can be considered to indicate the PUCCH carrier.This approach enables SPS HARQ not being multiplexed on the scheduled PUCCH being moved to an Scell for Alt. 1 ONLY, and avoids the specification effort for hybrid solutions to solve the problem of SPS HARQ. This should not be precluded for Alt.1 ONLY and be FFS depending on ‘NACK skipping’ discussion.[Moderator comment]: I guess this issue can be discussed, after having an agreement for the support of NACK skipping (and the details there).  |

**Question 3.3.2: If PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17, the dynamic indication in the triggering DCI is done through**

* **Alt. 1: the existing 3-bit PRI field**
	+ ***Only up to 8 combinations of CC and PUCCH resource indications are supported***
	+ ***FFS: mapping of CC and PUCCH resource combination to PRI states***
* **Alt. 2: an extended X>3 bit PRI field**
	+ ***Up to 2^X combinations of CC and PUCCH resource indications are supported***
	+ ***FFS: how to configure / define X, if you support please provide further details in the 2nd table***
	+ ***FFS: mapping of CC and PUCCH resource combination to PRI states***
* **Alt. 3: include a new DCI field for the carrier switching indication**
	+ ***e.g. DCI field size = ⎡log2(num\_candidate\_carriers)⎤***
* **Alt. 4: Other**

Please indicate your preference(s) on Question 3.3.2 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 | Huawei/HiSilicon (2nd preference), ZTE (first preference), Intel, Samsung (second), Panasonic (first preference), CMCC (second), China Telecom |
| Alt. 2 | ZTE (second preference), Nokia/NSB (2nd preference), Intel, Panasonic (second preference), China Telecom |
| Alt. 3 | LG, CATT, APT/FGI, Huawei, HiSilicon, Nokia / NSB (first preference), DOCOMO, InterDigital, Samsung (first), MTK, QC, WILUS, Spreadtrum, Ericsson , OPPO,Xiaomi, NEC, CMCC (first) |
| Alt. 4 |  |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CATT | We think Alt. 3 follows the design principle of cross-carrier scheduling which is the simplest. |
| Huawei, HiSilicon | Prefer alt.3 for flexibility. If increasing the DCI overhead is really a concern from companies, we can accept Alt.1.  |
| ZTE | From our understanding, one example of Alt.1 or Alt. 2 is shared, one CC group for PUCCH switching is configured, and one PUCCH resource set is configured, all the CCs in the group will be involved in the PUCCH resource set. The triggering DCI including the PRI to indicate the target CC and the specific PUCCH resource. For example, we have two CC, CC1 and CC2 in the switching group, and the PUCCH resource set can be {CC1 PUCCH resource 1, CC1 PUCCH resource 2, CC1 PUCCH resource 3, CC1 PUCCH resource 4, CC1 PUCCH resource 5, CC2 PUCCH resource 1, CC2 PUCCH resource 2, CC2 PUCCH resource 3}, the number of PUCCH resources for each CC doesn’t need to be equal or unequal. |
| Nokia/NSB | Clearly 8 states in total for combined PRI and CC for Alt. 1 seems to be too restrictive. We prefer Alt. 3 (as this really enables independent PUCCH configuration of different cells, no need to have a single ‘master PUCCH’ config for the mapping to PRI) as would be needed for Alt. 1/2.  |
| DOCOMO | Alt 3 is more straightforward and flexible. |
| Intel | Alt.1/2 could cover Alt.3, and can optimize the total PRI + CID overhead, since the switchable CCs can have a different set of PUCCH resources, especially if only HARQ-ACK info is considered for switching. We think there could be excessive combinations if PRI and PUCCH CID are separated. |
| InterDigital | Alt. 3 is simpler. |
| Samsung | No point for Alt. 2. Rel-17 deployments that are limited to inter-band CA should also be limited to one SCell (similar to having 2 CGs (inter-band) for PUCCH in Rel-16). Then either 1 bit (Alt. 3) or the PRI (Alt. 1) is enough.  |
| Panasonic | Our preferences are Alt.1 and Alt.2 as they provide more flexibility for configuring PUCCH resources in each carrier. While, Alt.3 entails using the same number of PUCCH configurations for all the carriers. |
| MTK | Alt 3 the simplest and the most flexible option. It will be similar to the existing Carrier Indicator Field. |
| QC | Alt 3 is the simplest approach. We don’t see the need to mix this indicator with PRI.  |
| China Telecom | We prefer Alt.1 and Alt.2 the same reason as Panasonic. Especially when the SCS of the candidate PUCCH carriers are different, the flexibility for configuring PUCCH resources in each carrier would be needed. |

**Question 3.3.3: If PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17, the *reference numerology /SCS for the PDSCH to HARQ-ACK offset K1* is determined by**

* **Alt. 1: the SCS of the indicated (i.e. target) CC**
* **Alt. 2: the SCS of the PCell**
* **Alt. 3: the highest / largest SCS of the involved candidate cells**
* **Alt. 4: the lowest / smallest SCS of the involved candidate cells**
* **Alt. 5: Other**

Please indicate your preference(s) on Question 3.3.3 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 | CATT, APT/FGI, Huawei, HiSilicon, ZTE, Nokia/NSB, DOCOMO, Intel, InterDigital, Samsung, Panasonic, MTK(1st), QC, WILUS, Spreadtrum, OPPO,Xiaomi, NEC, China Telecom |
| Alt. 2 | LG, APT/FGI, DOCOMO, MTK(2nd) |
| Alt. 3 |  |
| Alt. 4 | LG, APT/FGI |
| Alt. 5 | APT/FGI |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| APT/FGI | The reference SCS could be determined based on a configured reference cell (by RRC)  |
| Huawei, HiSilicon | For simplicity, we prefer Alt.1. In which case we only need to check the SCS of the cell with PDSCH and the SCS with PUCCH. For other carriers, some other SCS may be involved in addition to the ones for PDSCH and PUCCH.  |
| ZTE | gNB dynamic indicates the PUCCH carrier switching, as the target cell is determined by gNB, the K1 value can be determined by gNB also based on the SCS of the indicated CC. |
| Nokia/NSB | As the target cell is directly indicated, there seems to be no drawback of Alt. 1 (which makes the slot determination easier).  |
| Intel | Vote for Alt.1, although don’t see much difference in resulting behaviour. |
| Samsung | We consider this to be usual cross-carrier scheduling 🡪 Alt. 1. |
| Panasonic | We think these alternatives should be considered jointly with the ways of K1 interpretation. Alt.1 is preferred if K1 is interpreted differently for SCSs. While, Alt.3 is preferred if K1 is the same for all SCSs. |
| MTK | We prefer Alt 1 for the same reasons mentioned by Huawei. We are also OK with Alt.2 if it is easier for implementation to have a unified reference numerology for the k1 interpretation in the PUCCH group.  |
| QC | With dynamic switch indicator in DCI, Alt 1 is the natural choice. Actually, there seems no need to define reference numerology in this case.  |
| Ericsson | Although the simplest alternative is Alt 1 and our preference, we think it is better to wait with this aspect until the situation with semi-static PUCCH would be clearer and we have a better clarity on whole picture.There are few aspects needs consideration with respect to SCS, for example periodicity of semi-static PUCCH, where in combination with dynamic PUCCH carrier switching, would probably impact the design. |
| Xiaomi | Share the same view with Huawei and prefer alt1. |

**Question 3.3.4: If PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17, and the indicated target carrier defines the *reference numerology /SCS for the PDSCH to HARQ-ACK offset K1*,**

* **Alt. 1: support configuring different K1 sets per SCS**
* **Alt. 2: No – the legacy K1 sets are applied (independent of the SCS of the target CC for PUCCH transmission)**
* **Alt. 3: Other**

Please indicate your preference(s) on Question 3.3.4 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 |  |
| Alt. 2 | LG, Huawei, HiSilicon, Spreadtrum, OPPO |
| Alt. 3 | LG, CATT, ZTE, Nokia/NSB, DOCOMO, Intel, Samsung, Panasonic, MTK, WILUS,Xiaomi, NEC, CMCC, China Telecom |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| LG | As an Alt. 3, K1 set can be separately configured per carriers.  |
| CATT | We think we can simply follow the existing design to configure K1 set per UL BWP. |
| Huawei, HiSilicon | We slightly prefer Alt.2, which reuse the existing mechanism to configure the K1 set.  |
| ZTE | The K1value set is configured per CC. CCs are in the CC set for PUCCH carrier switching |
| Nokia/NSB | *dl-DataToUL-ACK* is part of the PUCCH config. Therefore, if different PUCCH configs are supported this would automatically mean that gNB can for different PUCCH configs on different candidate CCs configure different K1 values.  |
| DOCOMO | In current specification, K1 set is defined by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* configured in the IE *PUCCH-Config*. And the IE *PUCCH-Config* is configured per BWP. Therefore, in our understanding, all parameters in the IE *PUCCH-Config* can be independently configured, K1 set for different carriers are naturally independently configured. |
| Intel | Prefer to avoid 3rd level issue discussion: Q 3.3.4 depends on outcome of Q 3.3.3, while Q 3.3.3 depends on support of Alt.1. |
| Samsung | *PUCCH-Config* per CC (and per UL BWP). Basically, view the SCell as the PSCell and be done with everything. |
| Panasonic | Our first preference is Alt. 3 with having a separate K1 set for each carrier. Our second preference is Alt. 1. |
| MTK | Separate K1 sets per CC, each interpreted in uplink slot/sub-slots according to the slot/sub-slots partitioning and numerology on that CC |
| QC | Similar comment as Intel. This is too low level of details. The discussion can happen later. Furthermore, the is just a trivial issue, either option will work.  |
| WILUS | Our preference is to configure sperate K1 sets (as well as separate PUCCH resources) per CC. |
| Ericsson | Similar comment as before. Also, in our understanding from RRC, there is no restriction for configuration of pucch-Config.What is currently restricted in pdsch-Config that is linked to only one cell for PUCCH.Again, it is better to focus on baseline and attend these details later. |
| Xiaomi | Support configure separate K1 sets for each carrier |
| NEC | Separate K1 sets configuration per PUCCH carrier is preferred.  |
| CMCC | Support intel’s comments, this is a valid issue but maybe too detailed for now. |
| China Telecom | We also support configuring different K1 sets per CC. Our point is **the number of K1 values in the K1 sets for different CC should be the same, thus the bit width of PDSCH to HARQ indicator is fixed and not varied depending on the indicated carrier.** |

**Question 3.3.5: If PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17, the PUCCH resource configuration**

* **Alt. 1: is the same for all candidate cells (independent of the SCS etc.)**
* **Alt. 2: is independently configured per candidate cell**
* **Alt. 3: is per candidate cell with a combination of ‘per carrier’ and ‘per PUCCH group’ parameters**
* **Atl. 4: is configured per SCS of the candidate cells**
	+ ***i.e. same SCS candidate cells have the same PUCCH resource config***
* **Alt. 5: Other**

Please indicate your preference(s) on Question 3.3.5 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 |  |
| Alt. 2 | LG, APT/FGI, Huawei, HiSilicon, Nokia /NSB, DOCOMO, Intel, InterDigital, Samsung, QC, WILUS, Spreadtrum, Lenovo/Motorola Mobility, Ericsson, OPPO,Xiaomi, NEC, CMCC, China Telecom |
| Alt. 3 | APT/FGI, ZTE, Panasonic, MTK |
| Alt. 4 |  |
| Alt. 5 | CATT |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CATT | Similar as the comment above, we think the PUCCH resource is configured per UL BWP. |
| Huawei, HiSilicon  | We slightly prefer Alt.2 for more flexibility. Agree with CATT that the configuration on the cell is per BWP though. Maybe we can change it to“per BWP per candidate cell” |
| Nokia/NSB | Agree with CATT, so basically not just per candidate cell but per UL BWP  |
| DOCOMO | Similar comment as above question. As the IE *PUCCH-Config* is configured per BWP as defined in TS38.331, we understand it implies that *PUCCH-Config* for each PUCCH carrier can be dependently configured. But maybe limitations for some parameters in *PUCCH-Config* of different PUCCH carriers are needed. For example, the same number of *PUCCH-Configs* for priority consideration. |
| Intel | No strong preference between Alt. 2 and Alt. 3, just would like to see same flexibility for a given carrier, as it was for the PUCCH carrier in R16. |
| Samsung | Same comment as for Q 3.3.4 - separate *PUCCH-Config* per CC (and per UL BWP). |
| MTK | We prefer to define two levels of PUCCH configuration: Per PUCCH group and Per PUCCH carrier, because some information could be redundant and could be defined per PUCCH group like PUCCH formats and some other information could be carrier specific like k1. |
| Ericsson | Please see our comment on previous question |
| Xiaomi | Support separate *PUCCH-config* per CC. |

#### Alt. 2C Follow up: Questions on details of the potential support of Alt. 2C

**Question 3.4.1: If PUCCH carrier switching based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells (i.e. Alt. 2C) is supported in Rel-17, the *reference numerology / SCS for the definition of the time domain pattern* is determined by**

* **Alt. 1: the SCS of the PCell**
* **Alt. 2: by a configured reference numerology / SCS (*similar as for the TDD UL/DL configuration*)**
* **Alt. 3: the highest / largest SCS of the involved candidate cells**
* **Alt. 4: the lowest / smallest SCS of the involved candidate cells**
* **Alt. 5: Other**

Please indicate your preference(s) on Question 3.4.1 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 | Huawei, HiSilicon, DOCOMO, Samsung (2nd), MTK, QC, Lenovo/Motorola Mobility,Xiaomi |
| Alt. 2 | LG, Nokia/NSB, InterDigital, NEC |
| Alt. 3 | Samsung (1st), Panasonic, Lenovo/Motorola Mobility, NEC |
| Alt. 4 | LG, CATT, Samsung (3rd), WILUS, China Telecom |
| Alt. 5 | CMCC |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CATT | We think Alt. 4 is the simplest solution to ensure same PUCCH carrier switching for all the PUCCHs within a same slot. |
| Huawei, HiSilicon | Slightly prefer Alt.1 since the baseline of the PUCCH transmission is on PCell.  |
| Nokia/NSB | As the time domain pattern configuration in some aspects should be aligned with the TDD UL/DL config (e.g. in terms of periodicity, max. 10ms), the reference numerology could be configured which enables Alt. 1, 3 & 4 by configuration.  |
| DOCOMO | Agree with Huawei that the baseline of the PUCCH transmission is on PCell. |
| Intel | By the SCS of cell where DCI is received. |
| Samsung | Not “cheating” by being OK with 3 Alts ^^ - explanation below.Alt. 3 first because it provides best granularity (highest SCS) – RRC signalling is a non-issue.If not highest SCS (not Alt. 3), it is then better to use the PCell SCS/Alt.1 because (although unlikely) the case of the PCell having higher SCS than the SCell is supported. If that case is to be precluded, Alt. 4 is OK. No point for Alt. 2 – can’t be better than Alt. 3 in terms or granularity while it needs to provision for same RRC signalling. |
| MTK | Need to align with the alternatives under Question 3.3.3. Ideally the reference numerology for K1 in the dynamic indication would be the same as the reference of the time domain pattern to simplify any multiplexing if there is overlapping. Probably in that case Alt-2 Question 3.3.3 should be selected with Alt-1 in Question 3.4.1 |
| QC | Again, we think this is a trivial issue. Either option would work. To answer the question, we prefer option 1, because Pcell is the legacy cell for PUCCH transmission.  |
| WILUS | Our preference is to use the lowest SCS because the lowest SCS can prevent PUCCH carrier switching in middle of a slot with the lowest SCS. Also, the lowest SCS may reduce RRC signaling overhead under a given periodicity. For example, the time pattern of 10ms may require 10 PUCCH cell indexes for 10 slots of 15kHz SCS, but 40 PUCCH cell indexes for 40 slots of 60kHz SCS.  |
| Ericsson | We appreciate the efforts from FL. But we think it is better to have a proper discussion on these aspects.As we explained before, there are other aspects involved for semi-static PUCCH resources such as periodicity and how that affects the so called reference SCS. |
| Xiaomi | Prefer option1, because Pcell is the common design for PUCCH transmission. |
| CMCC | Voting Alt 5 just to say this issue can be discussed after the overall solution is stable. |
| China Telecom | Same reason as CATT and WILUS. |

**Question 3.4.2: If PUCCH carrier switching based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells (i.e. Alt. 2C) is supported in Rel-17, the *granularity of the time domain pattern* is**

* **Alt. 1: a UL slot of the reference numerology (for slot- and sub-slot based PUCCH config)**
* **Alt. 2: a UL slot for slot-based PUCCH config, an UL sub-slot for sub-slot based PUCCH config**
	+ ***Note: This would require configuring separate patterns for slot- and sub-slot based PUCCH***
* **Alt. 3: an UL symbol of the reference numerology**
* **Alt. 4: Other**

Please indicate your preference(s) on Question 3.4.2 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 | LG, CATT, Huawei, HiSilicon, Nokia/NSB, DOCOMO, Intel, InterDigital, Samsung, MTK, QC, WILUS, Lenovo/Motorola Mobility,Xiaomi, NEC |
| Alt. 2 | Panasonic |
| Alt. 3 |  |
| Alt. 4 | China Telecom |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CATT | We think Alt. 2 is too complicated considering different configurations of slot/sub-slot in different carriers. |
| Nokia/NSB | We agree that CATT that with Alt. 2 this gets too complicated. The same applies to Alt. 3.  |
| DOCOMO | Same granularity for two codebooks is preferred from simplicity perspective. |
| MTK | Alt-1 is simple to support |
| Ericsson | Same comment as before |
| China Telecom | We think the granularity could be configurable by RRC. When several slots have the same TDD UL/DL configuration thus the same PUCCH carrier, a larger granularity could be configured to avoid configuring PUCCH carrier for every slot. |

**Question 3.4.3: If PUCCH carrier switching based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells (i.e. Alt. 2C) is supported in Rel-17, the PUCCH resource configuration**

* **Alt. 1: is the same for all candidate cells (independent of the SCS etc.)**
* **Alt. 2: is independently configured per candidate cell**
* **Alt. 3: is per candidate cell with a combination of ‘per carrier’ and ‘per PUCCH group’ parameters**
* **Atl. 4: is configured per SCS of the candidate cells**
	+ ***i.e. same SCS candidate cells have the same PUCCH resource config***
* **Alt. 5: Other**

Please indicate your preference(s) on Question 3.4.3 in the first table, with additional comments in the second table below:

|  |  |
| --- | --- |
| Alt. 1 |  |
| Alt. 2 | LG, Huawei, HiSilicon, Nokia/NSB, DOCOMO, InterDigital, Samsung, QC, WILUS, Lenovo/Motorola Mobility,Xiaomi, NEC, CMCC, China Telecom |
| Alt. 3 | Panasonic, MTK |
| Alt. 4 |  |
| Alt. 5 | CATT |

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| CATT | Similar as the comments above, we think the PUCCH resource is configured per UL BWP. |
| Huawei, HiSilicon | Similar reason as that for DCI indication manner, alt.2 can provide more flexibility. Similar as CATT, the configuration on each candidate cell should be per BWP.  |
| Nokia/NSB | Agree with CATT – seems the Nokia moderator missed that (at least it has been the intention). Therefore, still we indicate our support for Alt. 2 with the understanding, that this should be per UL BWP.  |
| DOCOMO | Similar comment as above. |
| Intel | No strong preference between Alt. 2 and Alt. 3, just would like to see same flexibility for a given carrier, as it was for the PUCCH carrier in R16. |
| Samsung | Separate *PUCCH-Config* per carrier (per UL BWP). |
| MTK | Redundant information could be in the ‘per PUCCH group’ parameters |
| Ericsson | Please see our comments on Q.3.3.4. |
| Xiaomi | Support separate *PUCCH-config* per CC |

## 3rd Round

As there been some comments that it is too early to discuss too many 2nd level details, the moderator restricts the 3rd round of discussions on main things (as well as some 2nd level details which seems to still show a clear majority by companies, and potentially could be agreed still in this meeting e.g. by email, to leave possible GTW time for the needed high-level decisions on the overall support and which Alternative(s) is/are to be supported).

#### Overall support of PUCCH carrier switching

During the GTW session on May 21st, we discussed PUCCH carrier switching with resulted in a compromise proposal from Mr. chairman to handle scheduled and configured PUCCH operation reads as (editorial note: I just change the proposal naming, as this is not the same as when going into the GTW session to prevent any miss-understanding):

**~~Update FL Proposal Option 1~~Compromise proposal from GTW: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration**

* **Details are FFS (including applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication vs. semi-static configuration will be subject to separate UE capabilities**

On this compromise proposal, please provide your input in the following two tables:

**Question: Do you support the Compromise proposal (at least in principle)? (please provide your company name in the table below; for further wording suggestions on the proposal and your comments please use the 2nd table)**

|  |  |
| --- | --- |
| *Support (at least in principle) (list of companies)* | QC, CATT, Nokia/NSB, Xiaomi, APT/FGI, ZTE, Huawei, HiSilicon, Intel, Samsung, Panasonic, Ericsson, MTK, DOCOMO, NEC, Spreadtrum, WILUS, China Telecom, CMCC, Lenovo/Motorola Mobility |
| Object(list of companies) |  |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| QC | A minor editorial comment on the UE capability: “Dynamic indication vs. semi-static configuration” in the proposal may imply that UE can only support either dynamic indication or semi-static configuration, which eliminate the possibility that some UEs may signal to support both. To allow these more advanced UEs, the sub-bullet can be modified as “**Dynamic indication and/or ~~vs.~~ semi-static configuration ~~will be~~ are subject to separate UE capabilities**”. The intention is to allow UE signal: 1) support dynamic indication only; 2) support semi-static configuration only; 3) support both |
| vivo | We do not object the proposal, but we think the main bullet supports both dynamic and semi-static way will surely not have small spec impacts. Although we are not convinced by usefulness, applicability of this feature, we are OK to compromise with supporting at least the semi-static configuration to minimize the spec impacts in Rel-17 at this moment and to have a complete solution for all dynamic and scheduled PUCCH. So we suggest following changes for the proposal: **Support PUCCH carrier switching at least based on ~~dynamic indication in DCI scheduling a PUCCH and~~ semi-static configuration** * **Details are FFS ~~(including applicability of dynamic and/or semi-static means)~~**
* **Aim for minimum specification impact**
* **FFS dynamic indication in addition to semi-static configuration**
* **~~Dynamic indication vs. semi-static configuration will be subject to separate UE capabilities~~**
 |
| APT/FGI | Agree with QC that we don’t have to preclude the possibility of supporting both dynamic indication and semi-static configuration.* **Apply dynamic indication ~~vs.~~ and semi-static configuration simultaneously or separately will be subject to separate UE capabilities**
 |
| LG | Honestly, we think dynamic indication has more simplicity than semi-static indication and we are not sure that it is really necessary to support dynamic PUCCH carrier switching for semi-static HARQ-ACK transmission. We would like to keep it open for further discussion. We understand current proposal is open to support whether to support both or either indication. To clarify this, it would be better to add “and/or” also in main bullet. **Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and/or semi-static configuration** |
| Intel | Support in principle, with the main bullet to be adjusted for better readability, i.e. “and semi-static configuration” is poorly connected to the beginning of the statement.  |
| Samsung | Would like to stress again the “Aim for minimum specification impact” – as explained next, we think the overall feature, as considered in this AI, would be of rather marginal usefulness. Marginal/no impact on UE procedures is all the more important for this particular case. |
| Ericsson | We are fine with FL proposal with modification by APT/FGI on capability.If companies have strong concern, one of them could be baseline (preferable semi-static) as vivo proposed. With respect to LG’s proposal, the proposal as formulated is not clear how it is different from FL proposal. I assume LG intention is opposite of vivo, to have dynamic as baseline and FFS if semi-static is added. Then I assume, it is better to be formulated like vivo’s by exchanging dynamic and semi-static. |
| MTK | We are fine with the proposal to make some progress, although our initial view was to focus on the dynamic PUCCH carrier switching for the scheduled PUCCH to minimize the specification effort and leave the semi-static option as lower priority for the moment. Also, we agree with QC comment on the UE capability. |
| Apple | We have concern on issues from specification development and implementation once dynamic PUCCH carrier switching is supported. It is important that the so-called PUCCH carrier switching should be between activated cells, the specification change should be minimized. For the sake of progress, we can accept the following**PUCCH carrier switching is between activated UL cells excluding SRS-only UL cells.****Support PUCCH carrier switching based on only semi-static configuration** **Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH** * **Details are FFS (including applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication vs. semi-static configuration will be subject to separate UE capabilities**
 |
| DOCOMO | Even though we desire only semi-static method in order to have a unified solution for dynamic PUCCH and semi-static PUCCH, we can accept the proposal for compromise. And we agree vivo/Ericssion’s suggestion that semi-static could be the baseline.  |
| Spreadtrum | Agree with VIVO to support at least the semi-static configuration as a baseline. |
| CMCC | Prefer a semi-static configuration only (like vivo, apple, spreadtrum) but can live with **the Compromise proposal** |

#### On ‘Semi-static configuration’ from chairman’s compromise proposal

In case the group is able to achieve consensus on the compromise proposal, there is of course a need to discuss what ‘semi-static configuration’ in this respect means.

There had been Alt. 2 B (using semi-static rules) and Alt. 2C (semi-static time domain pattern of PUCCH cell) discussed earlier. Qualcomm in the GTW session noted that they think their simplified compromise proposal (companies are encouraged to check Sec. 3.3. of the QC contribution [9]) is not to be regarded as a Alt. 2B derivate but should be discussed separately as Alt. 2D.

Based on the moderator’s understanding, the simplified PUCCH switching scheme of Alt. 2D (Sec. 3.3 of [9]) has the following specifics:

* The PUCCH carrier switching is limited to 2 CCs (e.g. Pcell and one SCell)
* The UE interprets k1 and the PRI per CC
* If PUCCH transmission on Pcell is not possible (based on the k1 & PRI interpretation on Pcell), the UE transmits the PUCCH on the SCell (based on the k1 & PRI interpretation on Scell)
* It is regarded an error case, if PUCCH transmission on Pcell and Scell is not possible

So let’s where the companies stand in terms in which way the ‘semi-static configuration’ would be operated:

**Question 3.5: In case PUCCH carrier switching based on ‘*semi-static configuration*’ is supported, which of the following alternatives do you prefer (Support / Yes; No / object)?**

* **Alt. 2B (excluding Alt. 2D) – PUCCH cell switching is based on certain (semi-static) rules (but not including Alt. 2D)**
* **Alt. 2C - PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
* **Alt. 2D - (New) Simplified PUCCH carrier switching scheme (see details in Sec. 3.3 of [9])**

**Please provide your company name in the first table with further explanations / comments in the separate table below.**

|  |  |  |
| --- | --- | --- |
| ***Alt. 2B(excluding Alt. 2D)******Semi-static rules***  | *Support (list of companies)* | QC, APT/FGI, Huawei, HiSilicon, LG, DOCOMO (2nd preference), NEC, Spreadtrum, China Telecom, Lenovo/Motorola Mobility |
| Object(list of companies) | CATT, Nokia/NSB, Samsung, Panasonic, Ericsson |
| ***Alt. 2CTime-domainpattern*** | *Support (list of companies)* | Vivo, CATT, Nokia/NSB, Xiaomi, ZTE (second preference) , Huawei/HiSilicon (with some modification), Intel, Samsung, Ericsson, MTK, Apple, DOCOMO, WILUS, China Telecom, CMCC |
| Object(list of companies) | Panasonic, QC |
| ***Alt. 2DSimplified proposal(Sec. 3.3. in [9])***  | *Support (list of companies)* | QC, APT/FGI, ZTE (first preference), Lenovo/Motorola Mobility (2nd preference) |
| Object(list of companies) | CATT, Nokia/NSB, LG, Samsung, Panasonic, Ericsson, DOCOMO |

**Further detailed comments on your position:**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| QC | We’d like to clarify the difference between option 2B and option 2D is the following. With option 2B, a “reference numerology” and a “reference slot” need to be defined. The reference slot is determined based on K1 + “reference numerology (based on PCC)”. The semi-static rule is then used to scan cross CCs while in time domain confined within the reference slot. In case of the target CC has larger numerology than the reference numerology, the multiple actual slots on the target CC in the reference slot is ordered from earliest slot to the latest slot. The earliest slot has enough semi-static UL/Flexible OFDM symbols is picked to transmit the PUCCH (similar to the rule in SPS A/N deferral). However, with option 2D, there is no need to “reference numerology” and a “reference slot”. UE just interpret K1 and PRI (or RRC configured PUCCH resource indicator for SPS A/N) multiple times (each interpretation on a CC following the CC’s numerology), following a predefine ordering of CCs. To simplify the multiple interpretation, we limit it to only 2 interpretation by allow PUCCH switch only between PCC + one additional CC configured by NW. We think the switching between two CCs can harvest the gain of PUCCH switch in most of the scenarios. The main advantage of option 2D is smaller spec impact. We then have a few comments/questions to option 2C. For option 2C, we would like to understand how it works with CCs with different numerologies. For example, if we take the majority view as in 2nd round for option 2C, which is use PCC to define reference numerology and the time domain pattern is define w.r.t. PCC. Then in the following example, if the time patten in the last reference slot use SCC to transmit PUCCH, on the SCC, UE should use which actual slot? Do we need to define similar rule as in option 2B, which is picking the earliest available actual slot on SCC in the reference slot? In summary, in option 2C, there **still** a lot of semi-static rules (similar to option 2B) need to be defined in spec. The rules are: definition of reference numerology, definition of reference slot, interpreting K1 based on reference numerology, deciding actual slot in reference slot in case target cell numerology > reference numerology. From this perspective, option 2C is not simpler than option 2B. The only difference between 2B and 2C is that 2B scans target CCs with a predefined order, while 2C points to the target CC directly based on RRC configuration, which makes this feature does not work for initial access or in duration of RRC reconfiguration. This might be a secondary issue but indeed is a drawback of option 2C. **Therefore, we think the formulation of option 2C in the proposal is incomplete, because by time-domain pattern only, the scheme does not work. We think option 2C should be updated to the following.** * **Alt. 2C - PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and certain semi-static rules (at least in case of different numerologies cross the PUCCH cells)**

With option 2D, those above mentioned rules are not needed in spec. That is why option 2D is a simplified scheme.  |
| Nokia/NSB | As already indicated in our input contribution, Alt. 2B and the new Alt. 2D lack the control for the gNB which we think is essential (so no need to repeat the full story here again). So as indicated earlier, we think that Alt. 2C is less complex and keeps more control to the gNB. Specifically on the new Alt. 2D, we see some limitations /issues: 1. Using the k1 values per CC (with potentially different SCS) with Alt. 2D seems to create some issue, that may need clarification by the proponent(s), let’s take this figure example below where Pcell has lower SCS than the SCell. There is a slot based PDSCH on PCell the boxes mark the UL slots on PCell and SCell and the values in the boxes are the k1 values for the PDSCH. The blue arrows show how the transition from the PCell check is then translated when interpreting the k1 on the SCell (with higher SCS).

* If on PCell the k1=1 slot is not available for PUCCH, then on Scell I guess slot 1, 2, 3 or 4 should be selected (to not have an additional delay)
	+ But, if k1=1 is indicated the PUCCH slot would be the slot immediately following the end of the PDSCH on Scell. The processing time may be too short to enable this – so gNB would need to use k1>1 to have the PUCCH on SCell operational.
	+ Therefore, gNB would need to indicate k1=2, 3 or 4. But what happens here now, if slots 2, 3, 4 are actually available for PUCCH transmission on Pcell (i.e. you would move to SCell if slots 2, 3, 4 could all carry the PUCCH)

 can this then really work (or work better), than using the PCell numerology to define the slot, and then select the first available slot considering the min. processing time and availability from the SCell slots 1, 2, 3 or 4 for transmission?* + With dynamic scheduling something like this could still somehow (not efficiently be operated), but how about SPS PDSCH where the k1 value is fixed??
* Is there an issue with UE processing time? (e.g. k1=4)
	+ The initial transmission on PCell would be happening much much later than the k1=4 slot (slot4) on the SCell
	+ Depending on when or how the move to SCell is to be determined (incl. dynamic SFI?), the UE may assume that it has much more processing time available (i.e. 3ms – i.e.3x 15kHz slots) but then the processing time to provide the HARQ-ACK is shrunken to ¼ of it!?
* For SPS with k1>1 and 1 slot periodicity, there would the out-of-order HARQ operation
	+ SPS PDSCH in slot 0 on PCell with e.g. k1=3 would create a PUCCH in slot#3 on PCell. Next SPS PDSCH in slot 1 on PCell (again with k1=3) would map to PCell slot #4 which is not available / valid – so the k1 is re-interprated for the SCell with the PDSCH end of slot #1, ending up in slot 8 on Scell. Therefore, for the same SPS configuration with 1 slot periodicity and k1=3, this would lead to out of order HARQ-ACK (as slot 8 on Scell with the HARQ-ACK of the 2nd SPS PDSCH is earlier than slot #3 on PCell with the SPS HARQ-ACK for the first SPS PDSCH)
* Similar considerations (especially in terms of out-of-order) would happen if the PCell is having higher SCS than the SCell when applying k1 interpretation per serving cell.
1. We fail to see the need to define it as a gNB error, if transmission on the Pcell/Scell would not be possible. According to our understanding if a PUCCH since Rel-15 needs to be dropped, it is not regarded as an error case. So why putting this restriction now here? Moreover, for SPS HARQ-ACK (with fixed k1 value) guaranteeing this by gNB implementation may not be possible overall (as e.g. for a fixed k1 value there could be both Cells having only DL symbols).
 |
| Huawei, HiSilicon  | 1. For Alt.2B, in our understanding it is not really necessary to define the reference numerology or reference slot, just similar as Alt.2D can just check the corresponding CC’s numerology, the only difference is that there might more carriers to be checked for Alt.2B. For Alt.2D, we think it is too restrictive to only limit to 2 CCs. If UE vendors think that more carriers to be checked would have impact on the UE complexity, probably UE capability can be allowed to report the number of carriers supported to be checked.
	1. Note that for Alt.2B, it seems we can set independent K1 and PUCCH configuration on all the candidate cells to avoid the k1 issue on Alt.2D as pointed by Nokia.
2. We accept Alt.2C just for compromise as explained before. However, it seems the issue raised by Qualcomm is true that Alt.2C doesn't work for initial access or in duration of RR C reconfiguration. One alternative to solve this problem is that UE can check PCell first, and only if PCell is not available then follow the pattern configured by 2C. Therefore, we can update Alt.2C as below:

**Alt. 2C - PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells if PCell is not available for PUCCH transmission**  |
| LG | In our view, Alt. 2D is one case of Alt. 2B with details on K1/PRI interpretation. Thus, Alt. 2D would be interpreted as Alt. 2B subject to 2 CCs. From contributions, we see many details on how to handle K1/PRI and different subcarrier spacing for Alt. 2B, which also covers Alt. 2D. We think it is not necessary to consider Alt. 2D now.Regarding the excluding Alt. 2D, this may not be meaningful. Since Alt. 2D is consist of some points (# of CCs, how to interpret K1/PRI, how to order CCs, what is error case), some of them may need to be considered also for Alt. 2B and additional thing to Alt. 2D also can be considered in the scope of Alt. 2B. We think it is not possible to define what exclusion of Alt.2D means.  |
| Intel | 2C is still preferred for explicit control of the CC switching. |
| Samsung | For Rel-17 carrier switching, the following apply:1. UE needs to have inter-band UL CA capability (very limited applicability to URLLC scenarios, especially ones requiring the smallest latency)
2. PUSCH is not supported
3. Unclear if SR is supported – more important to reduce latency for SR than for HARQ-ACK
4. Commercial UL/DL configurations for inter-band CA can help but only a little

Consequently, if carrier switching is to be supported in Rel-17 URLLC, it will have small usefulness and it should therefore have minimal specification impact, practically no impact on UE procedures (other than for the switching), and should not be a reason to open other discussions.Alt. 2D is just Alt. 2B with some specific restrictions and for one SCell (which is anyway the only meaningful realization as UEs with UL CA capability over more than 2 inter-band CGs is not something to design for in Rel-17) - both rely on new UE procedures. Such procedures will not be as simple as “use the PCell if there is a valid resource on PCell; else, use the SCell” (e.g. the example given in Fig. 13 of [9] does not exist in any current deployment) - they would require additional timeline checks, conditional interpretation of PRI/K1, consideration of different SCS or processing capability on PCell and SCell, conditional deferment for SPS HARQ-ACK based on PUCCH resources on two cells, … We continue to support a completely network-based solution without any new UE procedures/checks/conditions/… To achieve that (and also make carrier switching more meaningful), carrier switching should be applicable to UCI in general and not only to HARQ-ACK – then, all procedures currently applicable on the PCell can remain exactly same on the SCell. |
| Panasonic | Regarding Alt. 2B and 2D, we share a similar view with Nokia.For Alt. 2C, as we mentioned earlier, the singling overhead could be large. In addition, frequent update might be required for the timing table after enabling/disabling a PUCCH carrier. We think that dynamic carrier switching through the DCI along with multiplexing could offer a better performance for SPS. |
| QC2 | @Nokia, Thanks for the technical comments. We’d like to clarify option 2D below and hopefully can remove some of the confusion. First of all, we’d like to emphasize the baseline we use the compare with option 2D is Rel-16. Comparing with Rel-16, option 2D can offer possible PUCCH transmission on SCC when interpretation of K1 on PCC fails. However, Nokia seems comparing option 2D with option 1 (dynamic indication) and trying to find cases where option 2D does not work. While, of course, option 2D is less flexible than option 1. We admit option 1 has more use cases than option 2D, but with the cost of DCI overhead incremental! Now, let’s get into the comments from Nokia one by one. “If on PCell the k1=1 slot is not available for PUCCH, then on Scell I guess slot 1, 2, 3 or 4 should be selected (to not have an additional delay)” – This interpretation of option 2D is not correct. If on PCC k1=1 does not work, then on SCC, only k1=1 is used to see if UE can transmit PUCCH on SCC. It is different from option 2B, in option 2B, by introducing the definition of reference slot, indeed effectively k1=1,2,3,4 are considered on SCC. With option 2D, we don’t define reference slot. UE just try to interpret K1 multiple times on different CCs. “Is there an issue with UE processing time? (e.g. k1=4)” – k1 needs to satisfy the N1 timeline requirement on SCC when interpret it on SCC. If the timeline requirement is not satisfied, SCC cannot be used for PUCCH Tx neither. “For SPS with k1>1 and 1 slot periodicity, there would the out-of-order HARQ operation” – Similar comment as above, if interpretation of K1 on SCC lead to OOO HARQ, SCC can not transmit the PUCCH. “We fail to see the need to define it as a gNB error” – Thanks for the comment. We are OK to not defining it as gNB scheduling error and let UE just drop the PUCCH, as in Rel-16. Again, in terms of flexibility or counting the use case where PUCCH can be transmitted on SCC, option 2D < option 2B < option 2C < option 1. However, considering spec impact and signaling overhead, it is also option 2D< option 2B < option 2C < option 1. So it is just a simple tradeoff between flexibility to put PUCCH on SCC vs spec impact + signaling overhead. We understand Nokia prefer max flexibility from gNB scheduling point of view. However, we prefer smaller signaling overhead and minimum spec impact. @Proponents of option 2C, as we commented already, we think option 2C does not work without defining semi-static rules for reference numerology, reference slot, interpreting K1 based on reference numerology, deciding actual slot in reference slot in case target cell numerology > reference numerology. Can proponents clarify how option 2C work without these rules, especially in case of different numerologies cross CCs?@FL, based on the above, we object option 2C in its current formulation (We added QC in the objecting companies list in the above table). We would be OK to the \***formulation**\* of option 2C (not saying we support option 2C) if the formulation includes the necessary rules as below. **Alt. 2C - PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and certain semi-static rules (at least in case of different numerologies cross the PUCCH cells)**@Sumsung, regarding this “they would require additional timeline checks, conditional interpretation of PRI/K1, consideration of different SCS or processing capability on PCell and SCell, conditional deferment for SPS HARQ-ACK based on PUCCH resources on two cells” – For the additional timeline checks and interpretation of PRI/K1, we admit option 2D needs to do those on UE side, that is why we limit to 2 CCs. But on considerations on different SCS/processing cap, and SPS deferral, aren’t those the same challenges for all the options, even including option 1? |
| Ericsson | To questions that QC1/Q2 in previous update raised in terms of Alt. 2B, I would like to clarify the following:* All these semi-static alternatives are similar. And most probably, for some/many cases if Alt-2C is adopted, the operation would be as Alt-2B/2D. But it doesn’t mean that the design the specification offers should be based on the rule where the same rule can be achieved by NW configuration, if the NW for some/many scenarios prefer that rule.
* Another point that one should consider different users may experience differently. It means that for PUCCH carrier switching, maybe for one UE is better no to do anything and stay on PCell as in Rel-15/16, for another user switch to next SCC and the other user to third. As the NW is complex, it should be left to the NW and choose a framework that allows that, as the opposite.
* On the aspect of reference SCS and interpretation of K1, all the schemes require such attentions, but until the framework is not clear, we can only use examples. For the case you illustrated, one example could be that with RRC configuration, using PCell as reference, configure **the CC index and corresponding number of slot offset.** The rule version of it that you described is to assume first slot. But as explained above, many different UEs are allocated resources on different slots.
 |
| MTK | We support the Option 2C for the configured PUCCH. The simplified scheme in Alt-2D is restrictive as it limits the scheme to two carriers per PUCCH group. We don’t see the need to have the restriction in designing this feature. Also, from UE implementation perspective, the UE needs to attempt a first K1 and PRI interpretation on PCC using the numerology and PUCCH resource configuration on the PCC when transmitting on SCC which comes with extra complexity as the UE needs to do further checking if failing to transmit on PCC and needs to re-interpret again K1 and PRI based on the numerology and PUCCH resource configuration of the SCC. We don’t see this scheme as a “simplified” scheme. As explained by QC, to limit the complexity of the additional timeline checks and interpretation of PRI/K1, the solution was to limit the number of CCs which is not in our view the best design as it restricts the latency and the capacity gain. Regarding Alt 2B we can support it if it has no limit on the number of PUCCH carriers per PUCCH group and if a new priority index is defined per PUCCH carrier (e.g. Primary PUCCH carrier then Secondary PUCCH carrier and so on …) and the order of PUCCH carriers selection is RRC configured by the gNB and not restricted by the specification. Obviously, Option 2C still requires some semi-static rules in addition to the timing pattern, but it doesn’t require multiple interpretation attempts for the dynamically signalled parameters and the PUCCH carrier is known in advance and also doesn’t require restricting the number of CCs.  |
| DOCOMO | We support Alt 2C as our first preference, and Alt 2B without K1 re-interpretation (like Alt 2D) as second preference.We think there are already a lot of comments over Alt 2B and Alt 2C. The main benefit of Alt 2C is PUCCH carrier can be fully under gNB control. And Alt 2C is simpler than Alt 2B due to no need to perform PUCCH carrier searching. So we prefer Alt 2C to Alt 2B.For Alt 2C, as commented by some companies, if different numerologies cross PUCCH cells, semi-static rules need to be discussed to determine the PUCCH reporting slot on Scell. But the rules seem not very complex since the rule is independent from carrier switching. Moreover, whether/what limitation of PUCCH carriers is still under discussion. For Alt 2D, we can understand the benefit is no need to define reference slot. But we share similar concerns as Nokia. * Firstly, since the re-interpretation/re-selection of K1 and PRI is based on the condition whether PUCCH resource on PCell overlaps with non-UL symbol. (“*If the interpreted slot and PUCCH resource on PCC does not conflict with non-UL OFDM symbols (such as DL, SSB, coreset 0), UE transmits PUCCH on PCC; Otherwise, UE moves to the configured only additional SCC.* ”[9]) , Alt 2D has the drawback that K1 interpretation and PUCCH carrier selection is not fully in gNB’s control. Proponents may argue that gNB can control the PUCCH CC by the proper K1 and PRI indication. But at least for SPS HARQ-ACK, there is no dynamic K1 indication. A possible case may be: For one SPS configuration, the K1 value is sometimes interpretated on PCC and sometimes interpretated on candidate SCell. We’re not talking about Alt 2D is less controlled by gNB compared to Alt 1, but it has the risk that fixed K1 value for a SPS configuration may lead to different HARQ-ACK timing offset.
* Secondly, as analysed above, if the PCC and candidate SCell have different numerology, e.g. SCS of PCC is smaller than SCS of candidate SCell may occur. As in the following example, PDSCH#1 and PDSCH#2 are SPS PDSCHs of the same SPS configuration. And the K1 value for the SPS configuration is K1=2. With Alt 2D, for the PDSCH#1, it first interpretates the K=1 on PCell and the determined PUCCH resource on PCell collides with DL symbol. It will then interpretate the K1=2 on candidate SCell and report HARQ-ACK for PDSCH#1 on slot n+2 of candidate Scell. For PDSCH#2, it can successfully interpretating the K1=2 on PCell, and report HARQ-ACK for PDSCH#2 on slot 2n+3 on PCell. It can be observed that HARQ-ACK of the later PDSCH#2 is reported earlier than the earlier PDSCH#1. We think it is an OoO issue.

For QC’s reply [QC2: “For SPS with k1>1 and 1 slot periodicity, there would the out-of-order HARQ operation” – Similar comment as above, if interpretation of K1 on SCC lead to OOO HARQ, SCC can not transmit the PUCCH.], we think it would be very inflexible to determine the K1 considering different numerology relationships of PCC and SCC, and also different collision cases. * Thirdly, timeline may need to be carefully reconsidered for Alt 2D. Even though QC has answered Nokia’s question [QC2:“Is there an issue with UE processing time? (e.g. k1=4)” – k1 needs to satisfy the N1 timeline requirement on SCC when interpret it on SCC. If the timeline requirement is not satisfied, SCC cannot be used for PUCCH Tx neither. ], it may be a little inflexible that gNB needs to consider PCC and SCC to determine a K1 which can satisfy both timelines. And we think possible issue still exists as the following example.
* If not considering the later PDSCH#2, UE interpretates K1=3 for PDSCH#1 on PCell (slot n+3) and the determined resource overlaps with DL symbol. However, if considering a later PDSCH#2, where the DCI of PDSCH#2 fulfils multiplexing timeline (i.e. timeline for multiplexing HARQ-ACK of PDSCH#1 and PDSCH#2 in slot n+3 on PCell is satisfied) and the determined resource for HARQ-ACK of the 2 PDSCHs doesn’t overlap with DL symbol. What CC will the HARQ-ACK of PDSCH#1 be transmitted on?
	+ Will HARQ-ACK of PDSCH#1 be transmitted on candidate SCC? But the PUCCH resource determined on PCC according to Rel-16 rule doesn’t overlap with DL symbol.
	+ Will HARQ-ACK of PDSCH#1 be transmitted on PCC together with HARQ-ACK of PDSCH#2? But the later DCI may be not processed before preparing PUCCH on SCC?
* For cases like this example, if we define some rule that which PDSCHs can be considered together to determine the resource on PCC, it would be very complex and specification impact will be huge.

To summarize, we think there may be a lot of issues for Alt 2D due to the interpretation of K1 is uncertain. |
| Lenovo, Motorola Mobility | In Alt. 2B, we’d like to point out that semi-static rules to be used for determining a PUCCH carrier can be UE-specifically configured. For example, gNB can configure a UE with a UE-specific selection order of carriers. In this way, network can control PUCCH loads across different carriers and allows a UE to use a carrier optimal for its radio condition and/or traffic. Compared to Alt. 2C, Alt. 2B requires UE to perform PUCCH carrier switching, only if a PUCCH resource on PCell is not available.  |
| Nokia/NSB 2 | Thanks to Qualcomm for the replies. We do understand that Alt. 2D is different (as there is no reference slot or similar defined but the k1is applied directly). But we still think some of the restrictions we pointed out are there inherently in Alt. 2D (the reply just notes, if TX on Scell not possible – then so be it). Thanks for the clarification on the error cases, appreciated! Clearly defining all as error case would prevent the feature to be used by gNB in first place. |

#### General details of PUCCH carrier switching

Based on the feedback received in the 2nd round, it seems that there is a strong majority of companies thinking the PUCCH configuration should be applied per serving cell and UL BWP (see input to questions 3.3.5 and 3.4.4). It seems this could be agreed independently of the discussions of the different alternatives.

Therefore, the following proposal is brought forward:

**Proposal 3.6:** **If PUCCH carrier switching is supported in Rel-17, the PUCCH resource configuration is per UL BWP (i.e. per candidate cell and UL BWP of that specific candidate cell).**

|  |  |
| --- | --- |
| *Support (list of companies)* | QC, vivo, CATT, Nokia/NSB,Xiaomi, APT/FGI, Huawei, HiSilicon, LG, Intel, Samsung, Panasonic, Ericsson, MTK, DOCOMO, NEC, Spreadtrum, WILUS, China Telecom, Lenovo/Motorola Mobility |
| Object(list of companies) |  |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| ZTE | The PUCCH resource set should include all the PUCCH resources which the different CCs belong to the same PUCCH group. Then the selection of target CC for PUCCH transmission and the PUCCH resources can be simultaneously indicated by the PRI field. |
| Ericsson | From our perspective, this is already supported , but it is important to be highlighted. It should be understood that equivalently, for PDSCH-Config, one should be able to configure more than one cell to support this feature. |
| Apple | maxNrofPUCCH-Resources = 128 in Rel-15/16. The memory taken by PUCCH resource configurations should not be too large.  |
|  |  |
|  |  |
|  |  |
|  |  |

#### Further details of Alt. 1 / Dynamic indication

Based on the feedback received in the 2nd round, the following can be noted on the dynamic indication method for Alt. 1 of 2nd round question 3.3.2:

* If all input is counted (i.e. first and 2nd preferences):
	+ 7 companies support Alt. 1 of using the 3bit PRI
	+ 5 companies support Alt. 2 using X>3bit PRI
	+ 17 companies support Alt. 3 of using a dedicated DCI field
* If one would count only first preferences (or without any preference indication), the groups preference seems to be even more clear
	+ 3 companies support Alt. 1 of using the 3bit PRI
	+ 2 companies support Alt. 2 using X>3bit PRI
	+ 17 companies support Alt. 3 of using a dedicated DCI field

Therefore, the following proposal is brought forward:

**Proposal 3.3.1:** **If PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17, the PUCCH cell is dynamically indicated using a dedicated DCI field in the triggering DCI.**

* **FFS details**

|  |  |
| --- | --- |
| *Support (list of companies)* | QC, CATT, Nokia/NSB,Xiaomi, APT/FGI, Huawei, HiSilicon, LG, Samsung, Ericsson, MTK, DOCOMO, NEC, Spreadtrum, WILUS |
| Object(list of companies) | ZTE, Intel, Panasonic, China Telecom |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| ZTE | It is sufficient to reuse the PRI to indicate the PUCCH carrier switching. No need to introduce a new field for indication, the additional overhead of new DCI should be an issue. |
| Intel | Alt.1 and Alt.2 can be merged since the only difference is whether the total number of configurations is increased or not.Alt.1/Alt.2 is more general than Alt.3, and in many cases can result in no additional DCI overhead, as compared to Alt.3. Also, the combinations of CC + PUCCH resource could be optimized considering which type of UCI could be mapped to the switched carrier, and which is not. |
| Samsung | We do not identify any problem with dynamic indication (it is not different than self/cross-carrier scheduling for PUSCH) but it can only be a complementary solution to RRC configuration.Hacks should be avoided in general and in principle – if a new indication/functionality by DCI is introduced, a corresponding field in the DCI should also be introduced. The functionality may not be supported by DCI 0\_0/1\_0 or, if it must be supported, only then a hack can be considered. There is no apparent need to support dynamic carrier indication for fall-back operation. |
| Panasonic | Using a dedicated carrier filed indication entails using the same size for PUCCH resources over all carriers. Using the PRI for determining the carrier allows to define different sizes of PUCCH resources for carriers. |
| Ericsson | We share same view as Samsung. |
| China Telecom | Using PRI enables the flexibility for configuring the number of PUCCH resources in each carrier. |

Similarly, looking at the responses on Question 3.3.3 there seems to be a strong majority of companies thinking that the reference numerology of the k1 interpretation is be based on the dynamically indicated target cell.

Therefore, the following proposal is brought forward:

**Proposal 3.3.1:** **If PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH (i.e. Alt. 1) is supported in Rel-17, the *PDSCH to HARQ-ACK offset k1* is interpreted based on the numerology of the dynamically indicated target PUCCH cell.**

|  |  |
| --- | --- |
| *Support (list of companies)* | QC, CATT, Nokia/NSB, APT/FGI, ZTE, Huawei, HiSilicon, Intel, Samsung, Panasonic, Ericsson, MTK, DOCOMO, NEC, Spreadtrum, WILUS, China Telecom |
| Object(list of companies) |  |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
|  |  |
|  |  |
|  |  |
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|  |  |

### Updated proposals to prepare for May 25th GTW session

The moderator suggests in this intermediate round to focus on things that (in case we get online time) could be discussed today.

Therefore, the focus here is clearly on the overall supporting incl. the supported method(s)/alternative(s). It seems really important to have this agreed in this meeting, to allow working on the details of (and companies preparing their input for) the selected alternative(s) in RAN1#106-e.

Looking at the feedback received so far in round 3, the following can be noted:

* There seems to be good support for the principle of the compromise proposal for supporting both, dynamic indication and semi-static configuration
	+ There has been request to clarify the UE capabilities by several companies– if this is there for each of them and/or only for the combination of them.
* On the ‘semi-static configuration mode’ discussions
	+ For Alt. 2B, 8 companies supporting and 5 companies objecting.
		- The same pros & cons as in previous discussion rounds (incl. from previous meetings) had been mentioned.
	+ For Alt. 2C, 14 companies supporting and 2 companies objecting
		- In addition the same pros & cons mentioned earlier by companies in addition two new aspects had been raised (see next bullets)
		- QC & HW/HiSi pointed out that Alt. 2C cannot be used for initial access or during RRC re-configuration (ambiguity). It is the moderator’s understanding, that the same problem applies to all the discussed PUCCH carrier switching alternatives, as for e.g. initial access the Rel-17 PUCCH carrier switching feature is not yet configured / activated by RRC and therefore cannot be used / applied. The ambiguity issue during RRC configuration applies to all the methods as well (in terms of e.g. applicable CCs, PUCCH config, etc.).
		- QC pointed out, that for different numerologies, there may be still a need for some semi-static rules. *Moderator comment:* This seems to be a valid argument, maybe this could be addressed by having a related FFS (as the different numerology details had not been discussed)
	+ For Alt. 2D, 3 companies supporting and 7 companies subjecting.
		- Some companies mention the restriction to 2 cells me too restricting and they see it as a subset of Alt. 2B.
		- There had been some questions on the k1 usage and error handling, which had been (at least partially) addressed by proponent.

As said above, it would be good have not just the general support but also the supported alternatives agreed in this meeting (to enable completion of the feature in Rel-17). Therefore, the moderator tries to combine the inputs on the Chairman compromise proposal (edits in red) and the preferences on the semi-static configuration towards Alt. 2C (additions in blue) in a single potential agreement.

**Proposal X: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration**

* **Details are FFS (including applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication and/or ~~vs.~~ semi-static configuration ~~will be~~ are subject to separate UE capabilities**
* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS on additional semi-static rules e.g. for support of mixed numerology across PUCCH cells**

**Question: Do you support the proposal (at least in principle)? (please provide your company name in the table below; for further wording suggestions on the proposal and your comments please use the 2nd table)**

|  |  |
| --- | --- |
| ***Support****(list of companies)* | Samsung, ZTE, DOCOMO, CATT, Panasonic, InterDigital, Ericsson, Nokia/NSB, Intel |
| Object (*list of companies*) |  |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| vivo | Although we are not convinced about the usefulness of this feature, we can be compromised to support it with minimal spec impacts and UE implementation efforts. Now we are really concerned about the workload and necessity to support both semi-static and dynamic methods especially the dynamic solution cannot be the completed solution to support configured PUCCH. As commented and shared by some companies, the semi-static method should be the baseline. If both are supported, it is highly likely that neither one can be optimized due to workload/time limitation. Therefore, we suggest following modifications:**Proposal X: Support PUCCH carrier switching at least based on ~~dynamic indication in DCI scheduling a PUCCH and~~ semi-static configuration** * **Details are FFS ~~(including applicability of dynamic and/or semi-static means)~~**
* **Aim for minimum specification impact and UE implementation effort**
* **~~Dynamic indication and/or vs. semi-static configuration will be are subject to separate UE capabilities~~**
* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS on additional semi-static rules e.g. for support of mixed numerology across PUCCH cells**
	+ **FFS** **the maximum number of PUCCH cells**
* **FFS dynamic indication in addition to semi-static configuration**
 |
| CATT | We support the proposal in general, but would like to make the last FFS more generic since it is not clear to us yet whether semi-static rules are needed.* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS on ~~additional semi-static rules e.g. for~~how to support ~~of~~ mixed numerology across PUCCH cells**

We do not agree with the proposal from vivo to make semi-static configuration as the baseline. In general, we do not think we need to select a baseline. Even if we have to, we think dynamic approach should be baseline considering the ambiguity of RRC reconfiguration. |
| Panasonic | Although we are not in favour of semi-static method, we can compromise to support both methods. However, we think dynamic method should be given a higher priority, as it can be applied to both dynamic scheduling and SPS (using multiplexing). |
| Lenovo, Motorola Mobility | As explained in the section “on semi-static configuration..”, Alt 2B allows gNB to control PUCCH loads across different carriers and a UE to use a carrier optimal for its radio condition and/or traffic based on UE-specific selection rule configuration. Also, in Alt2B, UE needs to perform PUCCH carrier switching only when necessary. Thus, we suggest removing the blue texts as shown below:**Proposal X: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration** * **Details are FFS (including applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication and/or ~~vs.~~ semi-static configuration ~~will be~~ are subject to separate UE capabilities**
* **~~The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells~~**
	+ **~~FFS on additional semi-static rules e.g. for support of mixed numerology across PUCCH cells~~**
 |
| Nokia, NSB | We support the proposal with the proposed changes by CATT (i.e. FFS on how to handled mixed SCS case).  |
| QC | We suggest to separate the high level proposal on supporting the feature from the low level proposal on semi-static scheme. We support the high level proposal, without the blue text. On the low level proposal, i.e., the blue text. Like we commented before, by the blue text as it is, the solution is not completed, because it cannot handle different SCS. In other words, option 2C is incomplete. On the other hand, option 2B is a complete solution. It is not fair to select option 2C before completing it while remove the complete solution 2B. We could compromise to option 2C, if option 2C is completed by reformulate it to **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and additional semi-static rules*** + **FFS on ~~additional~~ details of semi-static rules e.g. for support of mixed numerology across PUCCH cells**

As FL also agreed, for option 2C, certain semi-static rules have to be defined in spec to handle different SCS cross CCs. We think the above modification completes option 2C and capture the situation of the discussion more accurately. As for CATT’s modification, it clearly makes option 2B even less complete. So it is not acceptable to us. |

### Proposal for GTW session on May 25th

On the comments above:

@vivo: I do understand, that wants to limit the overall effort of two schemes and prefers semi-static operation only. Just check the reply from Panasonic, from them it is the other way around.

@Len/Moto: I do understand that Len/Moto prefers Alt. 2B, but please also take the companies inputs from the 3rd round above into account.

@QC: Please note, that your suggested edit implies Alt. 2B directly. The same as the my reply to Len/Moto above applies here.

**Proposal X: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration**

* **Details are FFS (including applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication and/or ~~vs.~~ semi-static configuration ~~will be~~ are subject to separate UE capabilities**
* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS ~~on additional semi-static rules e.g. for~~ how to support ~~of~~ mixed numerology across PUCCH cells**

## 4th Round

There had been comments in the GTW session to be not fine with the blue text here (no further discussion was possible in the GTW session due to limited time).

Let’s check maybe the companies opinions on one major thing here, namely if it would be OK in this meeting to only agree on option 1 and one semi-static method (i.e. Proposal X above without the blue paragraph) and keep the decision on which of the Alt. 2B/2C/2D discussed in Sec. 3.4.1.2 for the next meeting.

At least the moderator is a bit worried here, that if the decision on the alternative would be post-poned to the next meeting (… and we again spend much time to decide which of the semi-static alternatives to apply in addition to dynamic switching) that we may risk the completion of the overall feature within Rel-17. This is due to the fact, that already during the discussions here companies were saying we should first agree on the alternatives (before discussing 2nd and 3rd).

So to get the companies opinions, if the semi-static alternative(s) could be potentially still agreed/down-selected in RAN1#106-e or if the decision on the alternative(s) supported should still be in this meeting, the following questions is brought forward.

**Question 3.6: Based on your opinion, should:**

1. **The decision on the supported alternative(s) for PUCCH carrier switching be done still during RAN#105-e (including the specific alternative for ‘semi-static configuration’ for the compromise proposal), to be able to start discussing & agreeing on the related details already in RAN1#106-e; or**
2. **The down-selection of alternatives of the ‘semi-static configuration’ for the compromise proposal can still be done during RAN1#106-e.**

**Please provide your company name in the first table and your explanations / reasons in the second table.**

|  |  |
| --- | --- |
| **A** **– down-selection at this meetingneeded***(list of companies)* | Samsung, DOCOMO, vivo, CATT, Nokia/NSB, OPPO,Xiaomi, Intel, Sony, Huawei, HiSilicon |
| **B - down-selection still possible during RAN1#106-e** (*list of companies*) | ZTE, LG |

**Please provide your reasons why you think down-selection during RAN1#105-e would still be needed (i.e. A) or why you think this is not that urgent and can still be done during RAN1#106-e.**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Samsung | There is nothing to FFS – 3 more e-meetings – decision can be made now (and, otherwise, progress at this meeting is zero). |
| DOCOMO | These alternatives have been discussed in 3 meetings. Companies are aware of pros/cons and specification impact of these alternatives. We think down-selection can be made in this meeting, so that we can have enough time to complete the feature.  |
| vivo | Better to down-select to ensure the minimum spec impacts.  |
| CATT | We share the same view with FL and other companies. |
| QC | We don’t know how to answer the above question. We don’t know why FL insists on doing a hard **down-selection** between option 2B and 2C, while not considering to do a combination of 2B and 2C as we suggested below. Even FL agreed in FL summary that some semi-static rules are needed for option 2C, “QC pointed out, that for different numerologies, there may be still a need for some semi-static rules. *Moderator comment:* This seems to be a valid argument”. Isn’t the following a natural WF? We fail to see the logic to enforce a hard decision between 2B and 2C, when there is a WF available to combine the merit of 2B and 2C.We agree with Samsung that more progress is preferred in this meeting. To us, the following proposal makes more progress than the blue text in proposal X in section 3.4.3, because it decides to support mixed numerology with certain rules, rather than keeping how to support mixed numerology FFS. PS: if “semi-static rules” is a buzzword to some companies, we are OK to use generic wording as “rules in specification” **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and additional rules in specification (to support mixed numerology across PUCCH cells).** * + **~~FFS how to support mixed numerology across PUCCH cells~~**

**FFS details of the rules** |
| Nokia / NSB | Down-selection at this meeting is needed, as mentioned by companies above. We cannot agree to have some generic statement on the support on e.g. ‘semi-static’ and still have the 3 different discussed baseline alternatives open. So from our perspective, if the selection of the semi-static mode (i.e. Alt. 2B/2C/2D) is not part of the overall agreement, we will not be able to agree (will object) to the compromise proposal.  |
| OPPO | We share the same view with FL and other companies. |
| Xiaomi | Better to down-select at this meeting. |
| ZTE | My intention is at least to agree the black part in proposal X. The blue part can be further down select if the controversy can’t be solved. But it will be better if we can finish the down selection in this meeting. |
| Intel | This is just a natural consequence of making little progress in previous meeting, so that we need to make the decision now. |
| NEC | We are fine to down-select at this meeting, but we would like to know how does the semi-static PUCCH carrier switching method Alt.2C work for mixed numerology across PUCCH cells first, then we can compare the specification workloads of Alt.2B and Alt.2C and make the final decision.[Moderator] I cannot speak on behalf of QC here, but I guess QC intention could be when looking at the target carrier, where e.g. one 15kHz PUCCH slots overlaps with four 60kHz sub-slots, to apply a similar (semi-static) rule to define the slot (from the set of 4 slots) for the PUCCH transmission. So a similar procedure could be applied there, but other solutions are not precluded.  |
| NEC | We are fine to down-select at this meeting, but we would like to know how does the semi-static PUCCH carrier switching method Alt.2C work for mixed numerology across PUCCH cells first, then we can compare the specification workloads of Alt.2B and Alt.2C and make the final decision. |
| Huawei, HiSilicon | If possible always good to have more progress. Agree with the FL on the risk for the completion of the overall feature within Rel-17.We are fine with proposal X above with some editorial modification on the FFS as highlight in Red below. The reason is that the original wording looks like the switching is only allowed between the current PUCCH cells defined in Rel-15/16, e.g. PCell and PUCCH-SCell* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS ~~on additional semi-static rules e.g. for~~ how to support PUCCH carrier switching across cells with ~~of~~ mixed numerology ~~across PUCCH cells~~**

In addition, in our understanding, to solve the mixed numerology issue it seems only semi-static rule is possible, therefore the proposed change from Qualcomm is fine to us also, similar do some change on PUCCH cells as highlight in purple below on top of the change from Qualcomm: **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and additional rules in specification (to support PUCCH carrier switching across cells with mixed numerology ~~across PUCCH cells~~).**  |
| LG | Similar to ZTE’s view. Basically, it is better to make a decision as soon as possible and we should aim for that. However, it is not necessary to be subjected.  |

The reason for asking here is, if the compromise proposal (i.e. without any details on the selected semi-static method) would be agreeable or if at the same time we would need to say, which alternative is to be supported. This is just a quick check here to gather companies opinions to see – if the compromise proposal without blue details could be sufficient (for this meeting) or not, i.e.:

**Proposal 3.5: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration**

* **Details are FFS (including semi-static configuration operation, applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication and/or ~~vs.~~ semi-static configuration ~~will be~~ are subject to separate UE capabilities**

If you have any comments on proposal 3.5 itself or any other comments, please provide them below.

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Samsung | Prefer Proposal X from 3.4.3 – no need to re-discuss at the next meeting as there are no FFS regarding the specific choices (Opt. 2B/2D vs. Opt. 2C). It is clear that the overall feature is not of material benefit (few, if any, IIoT UEs will have inter-band CA capability, PUSCH is not supported, existing inter-band TDD configurations do not enable significant latency reductions, R18 is likely to address the latency issue in a comprehensive manner). Even if carrier switching ends up not implemented, the specifications should not be capturing additional UE procedures. RAN1 is still doing maintenance on R16 timelines – adding a cell dimension (with different SCS and potentially different UE processing capabilities) for no reason cannot possibly be acceptable (and that would not be the only impact from Opt. 2B/2D).If a resolution cannot be achieved at this meeting even for that clear topic, essentially zero progress was made and it should be considered to down-scope carrier switching. Based on progress made in the first 3 e-meetings of 2021 and on what remains to be done in R17 URLLC, the next 3 e-meetings are clearly not sufficient even if progress picks up a lot. |
| DOCOMO | We prefer the proposal in section 3.4.3. As commented in last question, we have spent a lot of time discussion these alternatives. It’s better to make a decision in this meeting so that we can complete this feature in Rel-17. |
| vivo | We share views with Samsung about the overall usefulness of the feature. Thanks a lot FL’s efforts for accommodating everyone’s comments here. It is not an easy topic. So we are OK to compromise again, but we prefer proposal X from 3.4.3 with following **modifications:****Proposal X: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration** * **Details are FFS (including applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication and/or ~~vs.~~ semi-static configuration ~~will be~~ are subject to separate UE capabilities**
* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS on additional semi-static rules e.g. for support of mixed numerology across PUCCH cells**
* **FFS the maximum number of PUCCH cells**
* **FFS whether and how to support joint operation of dynamic and semi-static carrier switching for a UE**
 |
| CATT | We prefer proposal in section 3.4.3.  |
| Nokia, NSB | As noted in our reply to Question 3.6 above, we cannot agree to keeping the alternative open for the semi-static operation (would object). But we could be fine with Proposal X from 3.4.3 (as Samsung, DoCoMo & vivo above). We could be fine with the additional FFS points by vivo.  |
| OPPO | Prefer Proposal X from 3.4.3 |
| Xiaomi | Prefer Proposal X from 3.4.3 |
| ZTE | Fine with the proposal. Open to Proposal X. |
| Intel | Support |
| NEC | Fine with the proposal. |
| Huawei, HiSilicon | We are fine with proposal 3.5 here though we prefer proposal X with some editorial modification better. As what we expressed above, we would like to do some editorial modification on the FFS as highlight in Red below in proposal X. The reason is that the original wording looks like the switching is only allowed between the current PUCCH cells defined in Rel-15/16, e.g. PCell and PUCCH-SCell* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS ~~on additional semi-static rules e.g. for~~ how to support PUCCH carrier switching across cells with ~~of~~ mixed numerology ~~across PUCCH cells~~**

For the sake of progress, we are fine with the proposed change from Qualcomm with some editorial modification as we mentioned in the above table also. We are fine with the two additional FFS form Vivo as well if companies feel more comfortable with it, though we really don't want to have too limited scenario for this feature.  |
| LG | As we mentioned before, we are not supportive to make a feature for semi-static PUCCH, especially SPS HARQ-ACK PUCCH. Given majority views from companies and efforts of FL during previous meetings, we can compromise for the sake of progresses.It would be eventually necessary to handle both PUCCH carrier switching and SPS HARQ-ACK deferral. Thus, we would like to add one more FFS point to proposal 3.5 or proposal X. * **FFS whether and how to support joint operation of semi-static carrier switching and SPS HARQ-ACK deferral for HARQ-ACK PUCCH for SPS PDSCH.**

With above FFS bullet, We are slightly prefer to Proposal X.  |

## 5th Round

Based on the feedback on Question 3.6, a strong majority of companies think we have to decide the alternatives to be supported at this meeting - as this had been discussed for several meetings in a row already and we need still time to work on the details of the different alternatives (incl. details for Alt. 1 / dynamic indication). Therefore, also majority companies seem to prefer the earlier suggested ‘proposal X’ from Sec. 3.4.3 over only agreeing the support of semi-static configuration operation without down-selection of the semi-static configuration operation.

QC by email (see inbox, around 10pm UTC 25th May) requested to check a change to the first two bullet points. FL suggests to provide your company input to the 2nd table (comments table), the related proposal there is the first line. Moreover, vivo requested to add two additional FFS to the proposal X (which now named as Proposal 8). Please provide your views if you are fine with the two added FFS points in the 2nd table as comments.

**Proposal 3.8: Support PUCCH carrier switching based on dynamic indication in DCI scheduling a PUCCH and semi-static configuration**

* **Details are FFS (including applicability of dynamic and/or semi-static means)**
* **Aim for minimum specification impact**
* **Dynamic indication and/or ~~vs.~~ semi-static configuration ~~will be~~ are subject to separate UE capabilities**
* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS ~~on additional semi-static rules e.g. for~~ how to support ~~of~~ mixed numerology across PUCCH cells**
* **FFS the maximum number of PUCCH cells**
* **FFS whether and how to support joint operation of dynamic and semi-static carrier switching for a UE**

|  |  |
| --- | --- |
| *Support (list of companies)* | Ericsson, Panasonic, LG(with additional FFS bullet), Sony, InterDigital, ZTE, Samsung, Nokia/NSB, Intel, Huawei, HiSilicon, OPPO, DOCOMO, CATT, Spreadtrum, WILUS, APT/FGI |
| Object(list of companies) |  |

**In case you object to the proposal or have any editorial suggestions please provide your reasons below in the table (i.e. your views on the suggested change to the blue bullets below by QC, and/or if the two additional FFS points by vivo in magenta above would be acceptable to you).**

|  |  |
| --- | --- |
| *Company* | *Additional comments* |
| Moderator | QC suggested the following changes to the blue bullets on top of ‘Proposal X’ from Sec. 3.4.3. * **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and additional semi-static rules**
	+ **FFS on ~~additional~~ details of semi-static rules e.g. for support of mixed numerology across PUCCH cells**

**Please check also check the moderator replies to QC from the RAN reflector (reply 9am UTC May 26th). Please also share your views on this suggestion.**  |
| Ericsson | We support FL proposal and we agree that it would be unfortunate not to agree to this proposal.With respect to the question above by moderator on changes suggested by QC, we do not support these changes and prefer FL version.The reason is that in our understanding FL proposal is a balanced approach:* It still leaves the door open unde under following FFS to discuss even semi-static rule based approach for support of mixed SCS.
	+ **FFS ~~on additional semi-static rules e.g. for~~ how to support ~~of~~ mixed numerology across PUCCH cells**
* While QC not only proposal imposes semi-static rule which is objected by many companies, specially NW vendors in the main bullet, but also implies that the support of mix numerologies would be based on semi-static rules.

Therefore, we think FL proposal is balanced and reflects better the situation. |
| LG | As we mentioned before, we are not supportive to make a feature for semi-static PUCCH, especially SPS HARQ-ACK PUCCH. Given majority views from companies and efforts of FL during previous meetings, we can compromise for the sake of progresses.It would be eventually necessary to handle both PUCCH carrier switching and SPS HARQ-ACK deferral. Thus, we would like to add one more FFS point to the proposal. * **FFS whether and how to support joint operation of semi-static carrier switching and SPS HARQ-ACK deferral for HARQ-ACK PUCCH for SPS PDSCH.**

As an editorial, If I recall correctly, some contribution propose to perform PUCCH carrier switching only within CCs having same numerology. It would be clearer to add “whether”* + **FFS whether/how to support mixed numerology across PUCCH cells**
 |
| Nokia/NSB | Support the proposal. * We are fine with magenta sub-bullets in the proposal (originally by vivo)
* We agree with Ericsson that the current FFS on how to operate mixed SCS leaves the door open to any solutions there (and should be generic enough)
* We could be fine with addition the ‘whether’ for the blue FFS point as suggested by LGE above.
 |
| Ericson2 | We are NOT fine at all with addition the ‘whether’ for the blue FFS point as suggested by LGE above.In UL CA typical configurations, the SCS of PUCCH cells are different. By this addition, the feature will not be useful at all and not worth the effort. |
| Huawei, HiSilicon | 1. We would like to do some editorial modification on the FFS as highlight in Red below. The reason is that the original wording looks like the switching is only allowed between the current PUCCH cells defined in Rel-15/16, e.g. PCell and PUCCH-SCell
* **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
	+ **FFS ~~on additional semi-static rules e.g. for~~ how to support PUCCH carrier switching across cells with ~~of~~ mixed numerology ~~across PUCCH cells~~**
1. For the sake of progress, we are fine with the proposed change from Qualcomm with some editorial modification as highlight in purple below also.

**The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and additional rules in specification (to support PUCCH carrier switching across cells with mixed numerology ~~across PUCCH cells~~).**1. We don't agree with adding “whether” as LG proposed, because it is too restricted.
 |
| vivo | We are fine with the proposal 3.8.About LG’s FFS on handling both PUCCH carrier switching and SPS HARQ-ACK deferral, we wondered why only semi-static carrier switching is listed, the joint operation of dynamic carrier switching and SPS HARQ-ACK deferral is not supported? * **FFS whether and how to support joint operation of semi-static carrier switching and SPS HARQ-ACK deferral for HARQ-ACK PUCCH for SPS PDSCH.**
 |
| QC | We are fine with HW’s medication on top of QC’s proposal, i.e., the following**The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and additional rules in specification (to support PUCCH carrier switching across cells with mixed numerology ~~across PUCCH cells~~).**Or the version suggested by Aris in the email discussion. **The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and supports PUCCH carrier switching across cells with different numerologies.****FFS whether additional rules are needed to support PUCCH carrier switching across cells with different numerologies.** |
| DOCOMO | Support the proposal. We share the same view with Ericsson and Nokia that the current FFS leave the door open for certain rule (if needed) for different numerology across CCs.LGE’s additional FFS is also fine for us. But we don’t agree with Huawei’s comment to remove the “whether” in the FFS. |
| CATT | We are fine with the update proposed by Aris in the email reflector.**The semi-static PUCCH carrier switching configuration operation is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells and supports PUCCH carrier switching across cells with different numerologies.*** **FFS whether additional rules are needed to support PUCCH carrier switching across cells with different numerologies**
 |
| NEC | We are fine with the proposal.We agree to add the LGE’s FFS to handle both PUCCH carrier switching and SPS HARQ-ACK deferral. |
| Spreadtrum | Fine with the proposal. We also agree with QC or Aris’s version.  |
| WILUS | We are fine with the proposal. Regarding interaction on dynamic PUCCH carrier switching and SPS HARQ-ACK deferral, we need to discuss further. So, we are fine with LG’s additional FFS. Regarding support of mixed numerologies, we share the same view with Ericsson that different UL SCSs seems to be a typical UL CA case in real deployments so that we need to support mixed numerology case.  |
| APT/FGI | We are fine with QC’s proposal, and we don’t agree with LG’s suggestion to add ‘whether’ in FFS. Since restriction on PUCCH cell carrier switching between cells with same numerology is not a result we want to see, we suggest that further discussing **how to** support mixed numerology instead of whether to support mixed numerology.  |

# References

1. R1-2104217 HARQ-ACK Enhancements for IIoT/URLLC Ericsson
2. R1-2104262 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon
3. R1-2104309 HARQ-ACK Feedback Enhancements for URLLC/IIoT Nokia, Nokia Shanghai Bell
4. R1-2104326 Discussion on HARQ-ACK enhancements for eURLLC ZTE
5. R1-2104353 HARQ-ACK enahncements for Rel-17 URLLC vivo
6. R1-2104420 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications
7. R1-2104512 UE feedback enhancements for HARQ-ACK CATT
8. R1-2104604 Discussion on UE feeback enhancements for HARQ-ACK CMCC
9. R1-2104663 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated
10. R1-2104802 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO
11. R1-2104854 Discussion on two aspects of UE HARQ-ACK feedback enhancements China Telecom
12. R1-2104899 On dynamic carrier switching and dropped HARQ feedback retransmission Intel Corporation
13. R1-2105097 Views on eIIoT/URLLC HARQ feedback enhancements Apple
14. R1-2105160 Retransmission of dropped HARQ-ACK for URLLC Sony
15. R1-2105188 Discussion on UE feedback enhancements for HARQ-ACK PANASONIC R&D Center Germany
16. R1-2105212 UE feedback enhancements for HARQ-ACK ETRI
17. R1-2105258 UE feedback enhancements for HARQ-ACK NEC
18. R1-2105302 HARQ-ACK Reporting Enhancements for URLLC Samsung
19. R1-2105399 HARQ feedback enhancements for IIoT and URLLC InterDigital, Inc.
20. R1-2105425 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics
21. R1-2105631 UE feedback enhancements for HARQ-ACK Sharp
22. R1-2105693 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.
23. R1-2105732 On UE feedback enhancements for HARQ-ACK MediaTek Inc.
24. R1-2105750 UE feedback enhancements for HARQ-ACK CAICT
25. R1-2105766 HARQ-ACK feedback enhancement for IIoT/URLLC Lenovo, Motorola Mobility
26. R1-2105819 Discussion on UE feedback enhancements for HARQ-ACK Asia Pacific Telecom, FGI
27. R1-2105872 Discussion on HARQ-ACK enhancement for URLLC/IIoT WILUS Inc.

# Appendix A: RAN1 agreements on HARQ-ACK feedback enhancements for NR Rel-17 URLLC/IIoT

**RAN1#102-e (Aug. 2020)**

Agreements:

Support Rel-17 enhancements to avoid SPS HARQ-ACK dropping for TDD due to PUCCH collision with at least one DL or flexible symbol.

* This topic is to be considered as high priority
* FFS detailed solution(s)

Agreements:

* Simultaneous PUSCH / PUCCH within a cell group (of Sec. 6.13 of R1-2007216) and enhanced (sub-slot) HARQ-ACK multiplexing on PUSCH (of Sec. 4.3 of R1-2007216) can be further discussed as part of AI 8.3.3 in this WI (but not as part of AI 8.3.1.1).

Agreements:

Study further at least the following schemes:

* SPS HARQ skipping for ‘skipped’ SPS PDSCH
* PUCCH repetition enhancements (at least for HARQ-ACK), e.g., sub-slot based, etc.
* Retransmission of cancelled HARQ
* SPS HARQ payload size reduction and / or skipping for ‘non-skipped’SPS PDSCH
* Type 1 HARQ codebook based on sub-slot PUCCH config
* PUCCH carrier switching for HARQ feedback

**RAN1#103-e (Oct/Nov. 2020)**

Agreements: To address the issue of SPS HARQ-ACK dropping for TDD systems, focus on the following two options:

* Option 1: Deferring HARQ-ACK until a next (e.g., first) available PUCCH
	+ FFS: Details including the definition of a next (e.g, first) available PUCCH, CB construction / multiplexing
* Option 2: Dynamic triggering of a one-shot / Type-3 CB type of re-transmission
	+ FFS: Details on triggering and/or CB construction (incl. potential Type-3 CB optimizations) / multiplexing

**Agreements: In the studies on PUCCH carrier switching for HARQ-ACK, PUCCH carrier switching for different cells operated is considered only for cells that are part of the active UL CA configuration.**

**Agreements: For the studies on SPS HARQ skipping for skipped SPS PDSCH, the further discussions should focus on the following reduced sets methods:**

* **‘NACK skipping’ for (skipped) SPS PDSCH (Alt. 1)**
	+ **FFS: details including at least when to skip the HARQ-ACK as well as NACK skipping configuration details (per SPS or group of SPS configurations etc.)**
	+ Note: this alternative assumes inherently no identification of a skipped SPS PDSCH by the UE
* **Dynamic indication of skipped SPS PDSCH occasions (Alt. 3)**
	+ **FFS: details including dynamic indication methods such as e.g. DCI, MAC CE, specific DM-RS instead of SPS DM-RS, …**

**Agreements:** For the studies on SPS HARQ payload size reduction (of non-skipped SPS PDSCH), the further discussions should focus on the following reduced sets of methods:

1. ACK skipping (NACK-only) (Alt. 1)
	1. FFS: Details
2. NACK skipping (ACK-only) (Alt. 2)
	1. FFS: Details
3. HARQ bundling / compression (Alt. 3)
	1. FFS: Details including HARQ bundling / compression window, bundling / compression technique
4. HARQ-ACK disabling /skipping for certain SPS configurations (Alt. 4)
	1. The skipping / disabling is higher-layer configured per SPS configuration
	2. FFS: HARQ-ACK skipping behaviour for Type 1 CB

**RAN#89 (Dec. 2020) – see agreed conclusion from** [RP-202872](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Docs/RP-202872.zip)

**RAN conclusion on IIoT scope:**

* For handling of the PUCCH repetitions it is proposed to proceed as follows:
1. RAN1 to continue discussion on PUCCH repetition, whether to specify or not, in the IIoT/URLLC WI for single TRP.
	1. The following items are not within scope of the continued discussions in the IIoT/URLLC WI:
		1. DMRS-less PUCCH with UCI payload up to 11 bits
		2. PUSCH-repetition-Type-B like PUCCH repetition
		3. DMRS bundling across PUCCH repetitions
2. PUCCH repetition issues with multi-TRP to be handled in Fe-MIMO WI.
* For the UE CSI/HARQ-ACK feedback enhancements in the IIoT/URLLC WI, RAN1 work to continue the discussions. Status to be checked in March if any RAN level guidance needed.
	+ RAN1 to continue discussion on A-CSI on PUCCH, whether to specify or not.

**RAN1#104-e (Jan/Feb. 2021)**

Agreements:

* Support deferring SPS HARQ-ACK dropped due to TDD specific collisions until a next available PUCCH in Rel-17 based on semi-static configuration of slot format
	+ FFS: Details (including possible conditions for such a deferring, whether or not to consider semi-statically configured flexible symbols for PUCCH availability, etc.)
	+ Aim for minimal standardization efforts and UE complexity in implementation

Agreements:

Further down-select between the following two options for SPS HARQ-ACK deferral:

* Option 1: Joint RRC configuration of the SPS HARQ-ACK deferral per PUCCH cell group
	+ *Note: any SPS HARQ-ACK within a PUCCH cell group in principle is subject to deferral*
* Option 2: The SPS HARQ-ACK deferral is configured per SPS configuration
	+ *Note: part of sps-config, only HARQ-ACK of SPS PDSCH configurations configured for deferral is in principle subject to deferral*

Agreements: Support sub-slot based PUCCH repetition for HARQ-ACK based on the Rel-16 PUCCH procedure for slot-based PUCCH applied to sub-slot based PUCCH

* Note: the intention is to take the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately, without further optimization unless necessary
* FFS whether or not there is any restriction for the applicability of sub-slot based PUCCH repetition for HARQ-ACK
* Dynamic repetition indication is supported also for sub-slot based PUCCH in Rel-17
	+ FFS: if the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or if changes are needed

Agreements: Support PUCCH repetition for PUCCH formats 0 and 2 at least for sub-slot based PUCCH repetition.

* FFS: Support for slot-based PUCCH repetition

Agreements: Rel-16 UCI multiplexing  / PUCCH overriding rules are reused for deferred SPS HARQ-ACK in the target slot, if applicable.

Agreements: For SPS HARQ-ACK, the deferral from the initial slot/sub-slot determined by *k1* in the activation DCI to the target slot/sub-slot determined by *k1*+ *k1def*, the UE will check the validity of a target slot/sub-slot evaluating from one slot/sub-slot to the next sub/sub-slot (i.e. in principle *k1def* granularity is 1 slot/sub-slot)

* FFS: if there is a limit on the minimum deferral considered the required UE processing (*k1def* ≥0)
* FFS: if there is a limit on the maximum deferral

Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the initial slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.

Agreements: **For further study on** **whether and how to support** **PUCCH carrier switching** **in a PUCCH group, focus on the following three alternatives:**

* **Alt. 1: PUCCH carrier switching is based dynamic indication in DCI**
* **Alt. 2B: PUCCH carrier switching is based on certain (semi-static) rules**
* **Alt. 2C: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells**
* Note: In above alternatives, it is assumed that HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group, can be sent on a PUCCH onan Scellalso instead ofonly onPcell/PScell/PUCCH-SCellin the same PUCCH group, as opposed to Rel-16 where HARQ-ACK corresponding to PDSCH received on a Pcell/PScell or an Scell in a PUCCH group can only be sent on Pcell/PScell/PUCCH-SCell in the same PUCCH group.
* ***Note: Realistic deployment scenarios including TDD configurations should be considered for the study***

**RAN1#104b-e (April 2021)**

Agreements: For SPS HARQ-ACK deferral, for the determination of valid symbols in the target slot/sub-slot a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as ‘invalid’ or ‘no symbols for UL transmission’.

Agreements: For SPS HARQ-ACK deferral, support a limit on the maximum deferral of SPS HARQ in terms of *k1def* or *k1*+ *k1def*

* + FFS: limitation given by a maximum value of *k1def* or a maximum of *k1eff* =*k1*+ *k1def*
	+ FFS how the limitation is determined (e.g. by K1 set(s) or RRC configured limit)

Agreements: For SPS HARQ-ACK deferral, there is no lower limit defined for *k1def*

**Conclusion:**

No support for dynamic indication of skipped SPS PDSCH occasions in Rel-17 as part of this WI.

Agreement: Restrict the further discussions on the initial slot handling for SPS HARQ-ACK deferral to the identified alternatives Alt. 1, Alt. 1A and 2.

Agreement: For SPS HARQ-ACK deferral, the limit on the maximum deferral of SPS HARQ is defined in terms of *k1eff =k1*+ *k1def.*

Working assumption: To handle the collision for the same HARQ process due to deferred SPS HARQ-ACK the following behaviour is to be specified:

* In case the UE receives PDSCH of a certain HARQ Process ID, the deferred SPS HARQ bit(s) for this HARQ Process ID are dropped.

Agreement: For SPS HARQ-ACK deferral, the initial HARQ-ACK transmission occasion is considered to determine the out-of-order HARQ condition

Agreement: Support Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration in Rel-17.

* The properties of the Type-1 HARQ-ACK codebook for sub-slot PUCCH at least includes that a PDSCH TDRA is associated with a UL /PUCCH sub-slot if the end of the PDSCH overlaps with the associated sub-slot determined by a k1 in the set of sub-slot timing values K1.
* FFS: whether the PDSCH TDRA grouping is performed per DL slot or sub-slot
	+ Decide between PDSCH TDRA grouping per DL slot and sub-slot during RAN1#105-e

# Appendix B: Summary of companies’ proposals

In here, the proposals and some example figures are collected for easier referencing.

### R1-2104217 HARQ-ACK Enhancements for IIoT/URLLC Ericsson

**Observation 1 Type-3 HARQ-ACK codebook is not yet supported together with the 2-level PHY priority.**

**Observation 2 The usefulness of PUCCH carrier switching highly depends on the underlying conditions to support the feature.**

**Observation 3 Support that HARQ-ACK corresponding to PDSCH received on a Pcell/PScell in a PUCCH group, can be sent on a PUCCH on an Scell in the same PUCCH group.**

**Observation 4 Operation of PUCCH carrier switching in a PUCCH group should not be conditioned on the numerologies in the PUCCH group, such that UL SCS can be same or larger/smaller than DL SCS.**

**Observation 5 Operation of PUCCH carrier switching in a PUCCH group should be under gNB control.**

**Observation 6 Operation of PUCCH carrier switching should be based on extension of existing PUCCH related procedures to more carriers in the PUCCH group.**

**Observation 7 If the gNB indicates a cell for PUCCH by DCI, other factors such as UCI multiplexing or PUCCH resource or payload size, etc. should not result in further changes of the cell for PUCCH.**

**Observation 8 Discussion are needed to understand joint operation of PUCCH carrier switching and simultaneous PUCCH/PUSCH transmission, as well as extension of simultaneous UL transmissions to simultaneous PUCCHs transmission on multiple carriers.**

Based on the discussion in the previous sections we propose the following:

**Proposal 1 Discussions on Type-3 HARQ-ACK codebook should prioritize “enabling” the feature for two-level priority transmission, rather than “enhancement of the codebook size”.**

**Proposal 2 Support triggering Type 3 HARQ-ACK codebook by DCI format 1\_2 with or without scheduling a PDSCH.**

**Proposal 3 Support priority indication in a DCI that triggers a Type 3 HARQ-ACK codebook.**

**Proposal 4 An indicated priority in a DCI that triggers a Type-3 HARQ-ACK codebook, determines the associated PUCCH\_Config for the corresponding PUCCH carrying the Type-3 HARQ-ACK codebook.**

**Proposal 5 A Type 3 HARQ-ACK codebook can include both HP and LP HARQ-ACK bit.**

**Proposal 6 For construction of a Type-3 HARQ-ACK codebook, activated cells are considered rather than configured cells.**

**Proposal 7 Support PUCCH carrier switching in a PUCCH group based on at least the following conditions:**

**• HARQ-ACK corresponding to PDSCH received on a Pcell/PScell in the PUCCH group, can be sent on a PUCCH on an Scell in the same PUCCH group.**

**• No restriction to the relation between the numerologies in the PUCCH group**

**• The PUCCH cell index in the PUCCH group is indicated by DCI and/or determined based on a configured pattern.**

**Proposal 8 Design of PUCCH carrier switching should be based on extension of existing PUCCH related procedures. An indicated PUCCH carrier for a UCI transmission should not be changed further for the UCI transmission.**

**Proposal 9 Discuss joint operation of PUCCH carrier switching and simultaneous PUCCH/PUSCH transmission, and the extension of UL transmissions to simultaneous PUCCHs transmission.**

### R1-2104262 UE feedback enhancements for HARQ-ACK Huawei, HiSilicon

***Proposal 1: Support PUCCH carrier switching in Rel-17.***

***Proposal 2：Dynamic PUCCH carrier switching with the DCI to indicate the carrier for PUCCH transmission should be supported in Rel-17 for HARQ-ACK feedback.***

* ***A predefined rule can be used for further determining the carrier for PUCCH transmission in case of SPS PDSCH HARQ-ACK feedback.***

***Proposal 3：If Type 3 CB(s) with smaller size (compared to Rel-16) is to be supported in Rel-17,***

* ***The codebook size is determined by RRC configuration.***
* ***The codebook construction uses HARQ processes as a bases.***

### R1-2104309 HARQ-ACK Feedback Enhancements for URLLC/IIoT Nokia, Nokia Shanghai Bell

The discussions **in Sec. 2 on retransmissions of dropped HARQ-ACK** can be summarized in the following related observations and proposals:

***Observation 2.1: In case that HARQ ACK multiplexed on PUSCH is dropped, triggering retransmission of dropped HARQ-ACK via DCI scheduling UL grant and/or via semi-static configuration at least for CG PUSCH could decrease the downlink control overhead.***

**Proposal 2.1: Support enhanced Type 3 CB(s) with smaller size (compared to Rel-16)**

* *Definition of enhanced Type 3 CB:*
	+ - *The codebook size of a single triggered enhanced Type 3 HARQ-ACK codebook is ~~not flexible, but~~ at least determined by RRC configuration*
		- *The codebook construction uses HARQ processes as a basis (i.e. ordered according to HARQ-IDs and serving cells)*

**Proposal 2.2: For Type 3 codebook enhancements for URLLC, RAN 1 to consider**

* **Limiting the enhanced Type 3 CB to RRC configured subsets of HARQ processes / IDs or serving cells**
* **Support dynamic indication of the RRC configured Type 3 CB subset from multiple enhanced Type 3 CB alternatives only by a triggering DCI that does not schedule PDSCH. For a triggering DCI also scheduling PDSCH, only a fixed single RRC configured enhanced Type 3 CB can be triggered.**
* **Including the support for Type 3 CB triggering using DCI format 1\_2.**
* **Triggering DCI including a PHY priority indication for the PUCCH carrying the Type-3 CB.**

**Proposal 2.3: On one-shot HARQ-ACK codebook re-transmission on PUCCH and/or PUSCH:**

* **Support one-shot HARQ-ACK codebook re-transmission on PUCCH with a dynamic indication of the timing of the HARQ-ACK CB (of a specific PUCCH occasion) to be re-transmitted.**
* **Support dynamic triggering the retransmission of dropped HARQ-ACK on PUSCH via DCI scheduling the PUSCH retransmission.**
* **Further study autonomous HARQ-ACK re-transmission on PUSCH with a scheduled PUSCH re-transmission and via semi-static configuration for autonomous CG PUSCH re-transmission.**

The discussions **in Sec. 3 on dynamic PUCCH carrier switching** can be summarized in the following related observations and proposals:

***Observation 3.1: Changes of the PUCCH cell within a PUCCH repetition bundle with different associated SCS would require specific handling for all PUCCH switching alternatives.***

***Observation 3.2: Mixed numerology of PUCCH carriers for PUCCH carrier switching creates at least the following complications:***

* ***For Alt. 1, the multiplexing of SPS HARQ-ACK and DG PDSCH HARQ-ACK in terms of k1 definition (i.e. Type 1 CB) and related multiplexing. Overlapping PUCCHs for DG HARQ-ACK on lower SCS Scell with SPS HARQ-ACK on higher SCS PCell would require special handling.***
* ***For. Alt. 2B, the PUCCH slot/sub-slot selection for higher SCS cells, multiplexing handling for lower SCS cells as well as overall PUCCH carrier selection depending on the SCS of different PUCCH carriers. Multiple overlapping PUCCHs of different SCS PUCCH cells originating from different PUCCH slots/sub-slots of the target cell would need to be specifically handled.***
* ***For. Alt. 1A, the complications of both Alt. 1 and Alt. 2B apply.***
* ***For Alt. 2C, at least some rules for the PUCCH slot/sub-slot selection for higher SCS cells (as for Alt. 2B) would be needed.***

**Proposal 3.1: Limit the further discussions on the potential support of PUCCH carrier switching in Rel-17 to the case of same numerology (i.e. SCS) of the involved PUCCH candidate cells.**

**Proposal 3.2: If PUCCH carrier switching is to be supported, the PUCCH carrier switching should be limited to HARQ-ACK and SR only (i.e. PUCCH carrier switching for CSI is not to be supported).**

***Observation 3.3: PUCCH carrier switching for SR would be simple with Alt. 2C, could require common PUCCH configurations for PUCCH cells with Alt. 1A and 2B, and is possible only in presence of dynamically scheduled PUCCH with Alt. 1.***

***Observation 3.4: Alt. 1A and 2B are complex to specify and implement as well as complex to operate from gNB perspective as there is little to no control over the PUCCH carrier selection.***

**Proposal 3.3: Exclude Alt. 1A and 2B from the studies on PUCCH carrier switching for HARQ-ACK feedback and focus the further discussions on the remaining Alt. 1 (dynamic indication in DCI) and Alt. 2C (RRC configured PUCCH cell timing pattern).**

* **Nokia has a slight preference towards Alt. 2C due to the lower DL control signaling overhead and better handling for configured PUCCH (for SPS HARQ-ACK and/or SR).**

### R1-2104326 Discussion on HARQ-ACK enhancements for eURLLC ZTE

***Proposal 1:*** *The standardization work for retransmission of the low-priority HARQ-ACK codebook should be considered first.*

* *The similar principle could be applied for high priority HARQ-ACK retransmission if it does not require a lot of extra standardization work compared to low priority HARQ-ACK retransmission.*

***Proposal 2:*** *The cancelled HARQ-ACK codebook should be triggered for transmission as early as possible after the conflict is determined, for example, the earliest trigger is started after the PDCCH corresponding to the high-priority PUCCH.*

***Proposal 3:*** *RAN1 should consider the method of constructing the type 3 codebook based on the priority indication if the type 3 like codebook is supported for retransmission of the cancelled HARQ-ACK.*

***Observation:*** *Compared with Alt. 3/Alt. 4(DCI scheduling PUSCH or PUCCH to carry dropped HARQ), in order to support Alt. 2 (Type 3 CB), more issues need to be solved, which significantly increases the standardization work load.*

***Proposal 4:*** *For the retransmission of the dropped HARQ-ACK codebook, Alt. 3/Alt. 4 should be supported.*

* *Alt. 3: DCI scheduling PUSCH to carry dropped HARQ-ACK codebook.*
* *Alt. 4: DCI scheduling PUCCH to carry dropped HARQ-ACK codebook.*

***Proposal 5:*** *Dynamic PUCCH carrier switching should be supported in HARQ-ACK enhancement in Rel-17 URLLC.*

***Proposal 6:*** *For dynamic PUCCH carrier switching in the PUCCH cell group, dynamic indication in DCI should be supported.*

* *PRI is used to instruct PUCCH carrier switching from an extended PUCCH resource set, which can include PUCCH resources of different UL CCs in the PUCCH cell group.*

***Proposal 7:*** *The PUCCH resource and PUCCH carrier are always determined using k1 and PRI from the DCI according to the SCS corresponding to each carrier in a PUCCH cell group.*

***Proposal 8:*** *Configure a cell set to support PUCCH carrier switching among cells in the cell set.*

***Proposal 9:*** *In Rel-17, PUCCH carrier switching should be supported first for scheduled PUCCH with HARQ-ACK and the discussion for configured PUCCH should be postponed.*

### R1-2104353 HARQ-ACK enahncements for Rel-17 URLLC vivo

**Proposal 1: Unified method(s) is supported for retransmission of cancelled HARQ-ACK for low priority and high priority.**

**Proposal 2: HARQ-ACK retransmission mechanisms introduced in NR-U Rel-16 should be a starting point, and there is no need to introduce additional ones.**

**Proposal 3: Support the retransmission of cancelled HARQ-ACK by enhancing the Type-3 codebook.**

**Proposal 4: Support the retransmission of cancelled HARQ-ACK by Type-2 codebook with clarification that PDSCH grouping is within each priority with maximum two PDSCH groups per priority.**

**Observation 1: The plan for realistic deployment scenarios including TDD configurations for PUCCH carrier switching have not been identified.**

**Observation 2: Compared to existing mechanisms, e.g. configuring the balanced DL-UL or UL heavy TDD carrier as the PUCCH carrier, configuring two PUCCH cell groups, or multiplexing the UCI on PUSCH in SCell, etc., the additional performance benefits by PUCCH carrier switching have not been identified.**

**Observation 3: To support PUCCH carrier switching, a lot of issues need to be addressed and large specification efforts are expected.**

**Proposal 5: Do not support PUCCH carrier switching for HARQ-ACK for URLLC Rel-17.**

### R1-2104420 Discussion on HARQ-ACK feedback enhancements for Rel-17 URLLC Spreadtrum Communications

**Proposal 1. For SPS HARQ-ACK deferral, a maximum deferring value can be configured by RRC signalling. If the RRC signalling does not exist, the maximum value of K1 set can be used as ae maximum deferring value.**

**Proposal 2. To handle Initial slot issue for SPS HARQ-ACK deferral, Alt. 2 is supported.**

**Proposal 3. For all the other configured PUCCH resources, a default rule can be used to choose one resource, e.g., the one with small resource index or the one with earliest starting symbol.**

**Proposal 4. The SPS HARQ-ACK deferral is configured per SPS configuration**

**Proposal 5. Support slot-based PUCCH repetition for PUCCH formats 0 and 2.**

**Proposal 6. Support enhancement type3 codebook for retransmission of cancelled HARQ.**

**Proposal 7. Regarding how to how to indicate an enhanced Type 3 CB to the UE, using dynamic indication in the DCI is supported (Option 3).**

**Proposal 8. With respect to the enhanced Type 3 CB triggering DCI issue, Option 1 (triggering DCI can scheduled PDSCH at the same time) is supported as a baseline.**

**Proposal 9. If a DCI is received to trigger type 3 codebook transmission, all configured HARQ-ACK process should be included regardless of the previous priorities.**

**Proposal 10. NACK skipping should be supported, and it can be applied by both skipped and non-skipped SPS PDSCH.**

**Proposal 11. NACK skipping scheme can be configured by higher layer signalling for all configured SPSs.**

**Proposal 12. ACK skipping scheme can be considered for SPS HARQ payload size reduction of non-skipped SPS PDSCH.**

**Proposal 13. For Type-1 HARQ-ACK codebook for sub-slot based PUCCH configuration, support PDSCH TDRA grouping per sub-slot.**

### R1-2104512 UE feedback enhancements for HARQ-ACK CATT

***Proposal 1: Enhanced Type-3 codebook which includes HARQ-ACKs for HARQ processes of SPS PDSCHs only is supported.***

***Proposal 2: Type-3 codebook and enhanced Type-3 codebook are distinguished by RRC configuration only.***

***Proposal 3: The PHY priority indicated in triggering DCI is used to determine the priority of the PUCCH resource used for the enhance Type-3 codebook and the enhanced Type-3 codebook is constructed independently from the PHY priority indication.***

***Proposal 4: An additional DCI field can be added in DCI format 1\_2 to trigger (enhanced) Type-3 codebook.***

***Proposal 5: If one-shot triggering of dropped HARQ-ACK is supported, the offset between the slot for triggering DCI and slot for dropped HARQ-ACK can be indicated by the triggering DCI to identify which ‘dropped HARQ-ACK’ should be re-transmitted.***

***Proposal 6: PUCCH carrier switching based on dynamic indication in DCI is supported.***

* ***The transmission carrier of dynamic HARQ-ACK is indicated by DCI corresponding to the dynamic HARQ-ACK;***
* ***SPS HARQ-ACK can be multiplexed with dynamic HARQ-ACK in the same slot if dynamic HARQ-ACK is indicated to be transmitted on the switched cell and the other configured PUCCH resources can be dropped if they are in the same slot with the switched dynamic HARQ-ACK;***
	+ ***For the case of different numerologies, the slot based the smallest SCS can be used as the reference slot.***

### R1-2104604 Discussion on UE feeback enhancements for HARQ-ACK CMCC

**Proposal 1: support PUCCH carrier switching in Rel-17.**

**Proposal 2: PUCCH carrier switching is based on dynamic indication in DCI.**

**Proposal 3: PUCCH carrier switching is based on RRC configured PUCCH cell timing pattern of applicable PUCCH cells, as a complementary method.**

### R1-2104663 HARQ-ACK enhancement for IOT and URLLC Qualcomm Incorporated

In summary, we make the following observations for HARQ-ACK feedback enhancement for Rel-17 IOT and URLLC.

***Observation 1: The scenario of cancelling PUSCH and piggybacked HARQ bits is a strong case in URLLC scenarios.***

***Observation 2: The scenario of the UE internally dropping/cancelling LP PUCCH due to own HP PUCCH although theoretically possible should not be the driver for the work for cancelled/dropped HARQ bits in URLLC.***

***Observation 3: The work in specifying solutions for the scenario of SPS PUCCH HARQ bits colliding with DL symbols was initiated without any direct reference to any URLLC/IIOT scenario among the ones of TS 22.104.***

***Observation 4: The work in specifying modifications of Type 1 CB HARQ so as to support the feature of cancelled HARQ bits will be high.***

***Observation 5: The work in specifying modifications of Type 2 CB HARQ so as to support the feature of cancelled HARQ bits will be high.***

***Observation 6: PUCCH carrier switch for HARQ-ACK is beneficial to reduce HARQ-ACK feedback latency, especially for inter-band CA with unaligned SFN, which is already supported and standardized in Rel-16.***

In summary, we make the following proposals for HARQ-ACK feedback enhancement for Rel-17 IOT and URLLC.

***Proposal 1: Support enhancement for cancelled HARQ in URLLC; retransmission of cancelled HARQ bits constitutes solid use cases in IIOT scenarios.***

***Proposal 2: The main solution for (re)transmission of cancelled HARQ bits should be a network controlled mechanism. The network should indicate to the UE***

* ***the HARQ feedback bits for requested HARQ processes***
* ***the PUCCH resource used to carry the HARQ feedback bits for requested HARQ processes.***

***Proposal 3: Support transmission of canceled HARQ via 1-shot enhanced Type 3 CB. Rel. 17 Enhanced Type 3 CB, although different from Rel. 16 Type 3 CB, is constructed with the same principle where the Rel. 17 enhancement lies in the flexibility/reconfiguration of the Type 3 CB size and its contents:***

* ***Type 3 CB size per CC and number of reported CCs reconfigurable per CC***
* ***Type 3 CB HARQ bits only for indicated HARQ processes per CC.***

***Proposal 4: Rel. 17 Enhanced Type 3 CB does not require support of Rel. 16 Type 3 CB and both features can be activated/deactivated separately. An extra bit on the DCI (different from*** *pdsch-HARQ-ACK-OneShotFeedback****) activates/deactivates the Rel. 17 Enhanced Type 3 CB.***

***Proposal 5: Request for Rel. 17 Enhanced Type 3 CB issued via DCI 1\_1 (similar to Release 16 CB) via appropriate setting of the “Release 17 OneShotFeedback”. Request for:***

***Option 1: A/N bits for HARQ Process IDs indicated in the DCI***

***Option 2: A/N bits within a pre-determined time duration, td, with a starting point in time t0, e.g. t0: X sub(slots) prior to DCI.***

***Proposal 6: Enhanced Type 3 CB consisted of either***

***Option 1 (corresponding to Option 1 of proposal 5): (Latest) Bit per requested HARQ Process ID***

***Option 2 (corresponding to Option 2 of proposal 5): Bits per requested HARQ Process IDs within indicated time window.***

***Proposal 7: Only one Enhanced Type 3 CB size should be supported at a given time.***

***Proposal 8: Do not support request for retransmission of cancelled HARQ bits via PUSCH allocation.***

***Proposal 9: Do not support introduction of priority indication in the enhanced Type 3 CB.***

***Proposal 10: Request for Enhanced Type 3 CB can be issued as a response to***

***A) SPS PUCCH HARQ collision with DL symbols or with semi-static SSB symbols***

***B) Canceled HARQ bits***

***C) Both SPS PUCCH HARQ and Canceled HARQ bits***

***In case A, only HARQ Processes associated with SPS PDSCH are requested by the gNB and reported by the UE.***

***In cases B and C, HARQ processes associated with both SPS and DG PDSCHs are requested by the gNB and reported by the UE***

***An identifier in the DCI 1\_1 indicates the case for which Rel. 17 Enhanced Type 3 CB is issued.***

***Proposal 11: Support automatic transmission of cancelled HARQ ACK info at retransmission of PUSCH cancelled by DCI 2\_4.***

***Provided that DCI 0\_x indicates same NDI and HARQ Process ID for both cancelled and retransmitted PUSCH.***

***In case canceled UCI contains CSI, SR and HARQ payload, only HARQ payload is automatically transmitted.***

***No support for new UCI multiplexed in the retransmitted PUSCH.***

***Proposal 12: Do not support partial automatic (re)transmission of cancelled HARQ bits.***

***Proposal 13: Support joint configuration of Enhanced Type 3 CB and automatic reTx of canceled HARQ bits.***

***Proposal 14: Upon joint configuration of i) automatic transmission of cancelled HARQ bits and of ii) enhanced Type 3 CB, canceled HARQ bits transmission occurs with earliest opportunity - either with automatic retransmission via PUSCH, or via Enhanced Type 3 CB.***

***Proposal 15: With PUCCH carrier switch, similar to Rel-15, the slot to transmit HARQ-ACK follows the K1 indicated in DCI, and the granularity of K1 follows the numerology of PCC.***

***Proposal 16: With PUCCH carrier switch, the following static rule is applied to determine the CC to transmit HARQ-ACK, in a given slot.***

* ***The lowest indexed CC which has enough UL OFDM symbols to accommodate the HARQ-ACK PUCCH resource is selected to transmit the HARQ-ACK.***

***Proposal 17: PUCCH carrier switch is supported for UL CA with different SCS cross CCs. Within the reference slot (based on PCC numerology) indicated by K1, if multiple actual slots on a determined CC can be used to transmit the PUCCH, the earliest slot is selected.***

***Proposal 18: PUCCH carrier switch is configured by RRC per CC.***

***Proposal 19: With PUCCH carrier switch, do not support PUCCH resource sharing between dynamic PUCCH resource (indicated by PRI in DCI) and configured PUCCH resource (by RRC).***

***Proposal 20: With PUCCH carrier switch, the PUCCH resources are configured per CC.***

***Proposal 21: If enabled (by RRC configuration), PUCCH carrier switch is perform by UE before UCI multiplexing procedure or PUCCH/PUSCH simultaneous transmission.***

***Proposal 22: Simplify the PUCCH carrier switch by restricting to only one additional SCC to transmit PUCCH. UE interpret the K1 and PRI (or RRC configured PUCCH resource indicator for SPS A/N) twice, once for PCC and once for a configured PUCCH allowed SCC. Between the two interpretations, the interpretation for PCC takes precedence.***

### R1-2104802 HARQ-ACK enhancements for Rel-17 URLLC/IIoT OPPO

***Proposal 1: The following enhancements can be supported to reduce the payload of Type 3 HARQ-ACK codebook:***

* ***Multiple subsets of cells can be semi-statically configured by high layer signaling, and DCI indicates one subset for HARQ-ACK feedback.***
* ***Enhanced Type 3 CB includes the HARQ-ACKs corresponding to the DL HARQs within a predefined window which references to the reception of DCI.***

***Proposal 2: One-shot triggering of dropped HARQ-ACK should be supported.***

***Proposal 3: Dynamic indication of the PUCCH occasion that is to be retransmitted should be supported.***

***Proposal 4: If PUCCH carrier switching is to be supported, only a simple solution to determine PUCCH carrier can be considered.***

### R1-2104854 Discussion on two aspects of UE HARQ-ACK feedback enhancements China Telecom

**Proposal 1: PUCCH carrier switching for HARQ feedback is supported in Rel-17 URLLC.**

**Proposal 2: If DCI indicating the PUCCH carrier for HARQ-ACK transmission is supported in Rel-17,**

* **The reference SCS of PDSCH to HARQ-ACK offset K1 is the SCS of the indicated target carrier.**
* **RRC signal could configure different K1 sets for carrier with different SCS. The number of K1 values in the K1 sets should be the same.**
* **When the HARQ-ACK codebook only contains the SPS HARQ-ACK feedback, PDSCH MAC CE indicating the PUCCH carrier for HARQ-ACK can be considered if there is ACK in the codebook, PUCCH is dropped if all of the HARQ-ACK for these SPS PDSCH are NACK.**

**Proposal 3: If PUCCH carrier switching based on certain rules is supported in Rel-17,**

* **On the original carrier, a collision with semi-static DL symbols, SSB and CORESET#0 is regarded as needing carrier switching.**
* **For searching of the target carrier, firstly consider the carrier with PUCCH resource consisted of only semi-static UL symbols. If no target carrier is found, then semi-static flexible symbol can be used as the valid PUCCH resource.**
* **The carrier with larger SCS is ordered with priority.**
* **On the target carrier, available PUCCH resource is searched in the slot(s)/sub-slot(s) overlapped with the slot/sub-slot determined by K1 on the original PUCCH carrier.**

**Proposal 4: If PUCCH carrier switching based on RRC configured PUCCH cell timing pattern is supported in Rel-17,**

* **RRC configures a time unit and a period with the smallest SCS of the candidate PUCCH carriers as the reference SCS. The carrier configured for the time unit containing the slot/sub-slot determined by K1 is used for PUCCH transmission.**

**Proposal 5: Support enhanced Type 3 CB with reduced size. The enhanced Type 3 CB has a single size such as only include HARQ-ACK for active carriers in the PUCCH group and active SPS configurations, and is enabled by RRC.**

**Proposal 6: Support DCI format 1\_2 to trigger Type 3 HARQ-ACK CB transmission.**

### R1-2104899 On dynamic carrier switching and dropped HARQ feedback retransmission Intel Corporation

**Proposal 1-1**

* *Support enhanced Type 3 CB with a smaller size comparing to Release 16 Type 3 CB*
	+ *Switching between Release 16 and Release 17 Type 3 CBs is based on RRC configuration*

**Proposal 1-2**

* *Support triggering of enhanced Type 3 CB transmission by both*
	+ *DCI scheduling other PDSCH*
	+ *DCI not scheduling other PDSCH*

**Proposal 1-3**

* *Support combination of RRC configuration and triggering DCI content for constructing enhanced Type 3 CB, i.e. support multiple Type 3 CB sizes*
	+ *The different CB sizes are resulted from different assumption on*
		- *cells to be reported*
		- *SPS-only or all HARQ processes*
		- *priority*
		- *etc.*

**Proposal 1-4**

* *Support enhanced Type 3 CB construction from a subset of HARQ processes based dynamic indication in DCI triggering the enhanced Type 3 CB*
	+ *The sub-set may comprise of the HARQ processes belonging to one or both priorities, if priority field in DCI is present, FFS details*

**Proposal 1-5**

* *If supported, the one-shot triggering of dropped HARQ feedback retransmission is indicated in the DCI scheduling PDSCH for which UCI carrying HARQ feedback may be subject to dropping*
	+ *A substitute PUCCH resource is provided together with the original PUCCH resource, and is used whenever the original PUCCH resource is dropped, FFS details*

**Proposal 2-1**

* *If dynamic PUCCH carrier switching is supported, for PUCCH carrying HARQ feedback for SPS PDSCH, support RRC configuration of a time pattern indicating which carrier is used for PUCCH mapping when SPS PDSCH is received in that time slot indicated by the pattern*

**Proposal 2-2**

* *If dynamic PUCCH carrier switching is supported, for PUCCH carrying HARQ feedback for dynamic PDSCH, down select between*
	+ *(1st preference) Dynamic indication of PUCCH carrier in DCI*
	+ *(2nd preference) RRC configuration of a time pattern indicating which carrier is used for PUCCH mapping when a DCI is received in that time slot indicated by the pattern*

**Proposal 2-3**

* *If dynamic PUCCH carrier switching is supported, allow different sub-carrier spacing between PUCCH cells which are subject to switching, FFS details*

### R1-2105097 Views on eIIoT/URLLC HARQ feedback enhancements Apple

**Proposal 2-1: to control feedback overhead, the presence of NDI and utilization of CBG based feedback can be separately configured for code states in the “priority indicator”.**

**Proposal 2-2: to control feedback overhead, HARQ process IDs can be grouped, one group is associated with the high priority, another is associated with the low priority.**

**Proposal 3: study the UE behavior when SPS HARQ skipping and HARQ retransmission are both enabled.**

**Proposal 4: dynamic PUCCH carrier switching is excluded from further consideration.**

### R1-2105160 Retransmission of dropped HARQ-ACK for URLLC Sony

**Observation 1: Since the size of Type 3 HARQ-ACK Codebook is semi-static, any enhancement made to Type 3 HARQ-ACK Codebook for overhead reduction can never be as effective as a new HARQ-ACK codebook that retransmits only dropped HARQ-ACK.**

We therefore propose the following:

**Proposal 1: Do not support enhancements for Type 3 HARQ-ACK Codebook.**

**Proposal 2: Consider introducing one shot trigger for Type 3 Codebook in DCI Format 1\_2.**

**Proposal 3: Consider a new “one-shot trigger” to trigger a new Type 4 HARQ-ACK Codebook to retransmit only dropped HARQ-ACK(s), where this “one-shot trigger” can be transmitted using a DL Grant that can schedule a PUCCH without a PDSCH and/or an UL Grant that can schedule a PUSCH without any uplink data.**

**Proposal 4: Further consider the following 3 options on the definition of “dropped HARQ-ACK” under the context of HARQ-ACK retransmission:**

* **Option 1: the last dropped PUCCH occasion is to be re-transmitted**
* **Option 2: dynamic indication of the PUCCH occasion that is to be re-transmitted**
* **Option 3: based on a timing window of the PUCCH occasion(s) that is/are to be re-transmitted**

### R1-2105188 Discussion on UE feedback enhancements for HARQ-ACK PANASONIC R&D Center Germany

**Proposal 1: Consider only Alt. 1 for dynamic PUCCH carrier switching in Rel. 17.**

**Proposal 2: PUCCH carrier should be identified through the PRI filed. To enlarge PRI field should be considered. Proposal 3: A gNB should restrict the dynamic DCIs to point to the same PUCCH carrier for a given codebook construction.**

**Proposal 4: Support different SCSs for PUCCH carriers within a PUCCH cell group.**

**Proposal 5: The SCS of the target PUCCH carrier is considered for determining the timing of the PUCCH resource.**

**Proposal 6: To support PUCCH carriers with different SCSs, the RRC signaling is used with one of the following options.**

* **Option 1: A set of offset values are defined for different SCSs**
* **Option 2: Different sets of k1 values are defined for different SCSs**
* **Option 3: Different sets of k1 values are defined for different PUCCH carriers**

**Proposal 7: If retransmission of cancelled HARQ is supported, reuse the HARQ feedback based on Type-3 HARQ-ACK codebook.**

**Proposal 8: The codebook size of triggered Type-3 HARQ-ACK codebook should be determined by RRC configuration and activation.**

### R1-2105212 UE feedback enhancements for HARQ-ACK ETRI

Regarding PUCCH carrier switching,

**Proposal 1: If PUCCH carrier switching is supported, then the RRC configured approach is adopted, and further consider dynamic switching is discussed.**

**Proposal 2: Any UCI type can support the PUCCH carrier switching if supported.**

Regarding Type-3 HARQ-ACK codebook,

**Proposal 3: The size of the enhanced Type-3 HARQ-ACK codebook can be determined by at least activation/release DCI.**

**Proposal 4: The size of the enhanced Type-3 HARQ-ACK codebook can be determined by at least activated serving cells.**

**Proposal 5: The reference time to derive HARQ-ACK codebook is introduced in terms of a (sub) slot, where the HARQ-ACK of relevant HARQ processes are involved.**

**Proposal 6: If M=2 type-3 HARQ-ACK codebooks are enabled, then the distinct RNTI can be used to generate a legacy one or an enhancement one.**

### R1-2105258 UE feedback enhancements for HARQ-ACK NEC

**Proposal 1:**

* *Support more than one enhanced Type-3 HARQ-ACK codebook in Rel-17.*

**Proposal 2:**

* *Support dynamic triggering of a Type-3 CB of HARQ-ACK re-transmission for SPS PDSCH due to collision between PUCCH resource and invalid symbol.*
	+ *Following options can be considered to reduce the Type-3 HARQ-ACK codebook size:*
		- *Alt.1: The requested HARQ-ACK codebook contains the number of all DL HARQ processes for all the configured/activated SPS configuration(s) in the configured CC(s).*
		- *Alt.2: The requested HARQ-ACK codebook contains only the number of DL HARQ processes for the indicated SPS configuration(s) in the configured CC(s).*
		- *Alt.3: The requested HARQ-ACK codebook contains a set of DL HARQ processes for the configured/activated SPS configuration(s) in the configured CC(s).*

**Proposal 3:**

* *Further study the PUCCH resource determination for the triggered Type-3 HARQ-ACK codebook for SPS PDSCH only if supported.*

**Proposal 4：**

* *Support PUCCH carrier switching for HARQ-ACK feedback in Rel-17.*
	+ *A predefined rule can be used for determining the UL carrier for PUCCH transmission.*

**Proposal 5：**

* *Further study the PUCCH power control if PUCCH carrier switching for HARQ-ACK is supported.*

### R1-2105302 HARQ-ACK Reporting Enhancements for URLLC Samsung

This contribution considered aspects related to retransmission of HARQ-ACK information and to cell switching for UL transmissions and proposes the following.

**Proposal 1: Support triggering retransmission of a dropped HARQ-ACK codebook.**

**Proposal 2: Support cell switching for a PUCCH transmission based on (a) DCI indication and (b) a timing pattern provided by higher layers.**

**Proposal 3: Support cell switching at least for HP PUCCH with HARQ-ACK or SR.**

In addition, the following are observed.

**Observation 1**: Modifications of the Rel-16 Type-3 HARQ-ACK codebook are neither relevant nor necessary to support retransmission of HARQ-ACK information for Rel-17 URLLC.

**Observation 2**: Modifications of the Rel-16 Type-3 HARQ-ACK codebook are not likely to offer meaningful functional enhancements over the Rel-16 Type-3 HARQ-ACK codebook and would always be worse than retransmitting only the intended/dropped HARQ-ACK information.

**Observation 3**: Triggering HARQ-ACK retransmission in a PUCCH or PUSCH has minimal specification impact and practically no impact on UE complexity.

**Observation 4**: The enhanced Type-2 HARQ-ACK codebook is less flexible than retransmitting dropped HARQ-ACK information and is not generally feasible for non-shared spectrum operation in Rel-17 without additional enhancements.

**Observation 5**: Alternatives relying on a predetermined rule to determine a cell of PUCCH transmission have large specification and network/UE implementation impacts and can lead to problematic functionality.

**Observation 6**: Alternatives relying on the network to determine the cell of PUCCH transmission minimize specification impact and UE complexity while allowing full flexibility to the network and improving overall functionality.

### R1-2105399 HARQ feedback enhancements for IIoT and URLLC InterDigital, Inc.

**Proposal 1: The UE can retransmit a cancelled HARQ using Type 3 HARQ CB.**

**Proposal 2: Support enhanced Type 3 HARQ CB containing the same priority ACK/NACK feedback.**

**Proposal 3: The DCI triggering enhanced Type 3 CB can indicate the priority of the Type 3 HARQ CB.**

**Proposal 4: The PUCCH carrier switching is based on dynamic indication using the scheduling DCI.**

### R1-2105425 Discussion on UE feedback enhancement for HARQ-ACK LG Electronics

Proposal 1: If there is a consensus that dynamic PUCCH carrier switching is necessary, PUCCH carrier switching based on dynamic indication in DCI can be supported

* To indicate switched carrier, a DCI field is added to DL scheduling DCI.
* If there are overlapping PUCCHs with the PUCCH indicated with carrier indication, overlapping PUCCHs are multiplexed and transmitted in switched PUCCH carrier by the indication.

Proposal 2: For HARQ-ACK PUCCH for SPS PDSCH itself, dynamic PUCCH carrier switching is not supported.

* Carrier indication in activation DCI is ignored for SPS PDSCH without corresponding DCI

Proposal 3: For dynamic PUCCH carrier switching from source carrier to target carrier, target carrier should be same or higher SCS than of source carrier.

Proposal 4: Support enhanced type-3 HARQ-ACK codebook with reduced HARQ-ACK payload size for re-transmission of cancelled HARQ-ACK if necessary.

Proposal 5: For construction of the enhanced type-3 HARQ-ACK codebook with reduced HARQ-ACK payload size, following options can be considered:

* Option 1: type-3 HARQ-ACK codebook with subset of entire HARQ processes.
	+ Multiple subset of HARQ processes can be configured by RRC signaling.
	+ A subset of HARQ processes can be indicated in a DCI triggering type-3 HARQ-ACK codebook for HARQ-ACK codebook construction.
* Option 2: type-3 HARQ-ACK codebook with HARQ processes used in SPS PDSCH reception.

Proposal 6: For triggering method enhanced type-3 HARQ-ACK codebook with reduced HARQ-ACK payload size, following options can be considered on the top of current framework. :

* + Option 1: triggering DCI indicates a subset of HARQ processes for the HARQ-ACK codebook. Existing DCI field (e.g., One-shot HARQ-ACK request field) can be re-used or extended for indicating a subset of HARQ process.
	+ Option 2: RNTI scrambling CRC of DCI format can indicates how to construct type-3 HARQ-ACK codebook.

Proposal 7: For type-3 HARQ-ACK codebook only for SPS PDSCH, priority handling can be considered.

### R1-2105631 UE feedback enhancements for HARQ-ACK Sharp

**Proposal 1:**

* Rather than discussing on optimizations such as smaller codebook size, clarify the necessary modifications on Type-3 HARQ-ACK codebook for adoption in Rel-17 URLLC operation first, e.g., handling of different priorities.

### R1-2105693 Discussion on HARQ-ACK feedback enhancements for Rel.17 URLLC NTT DOCOMO, INC.

**Proposal 1: If DCI 1\_1 can be simultaneously configured with one-shot HARQ-ACK feedback and priority indicator field existing in DCI 1\_1, type 3 HARQ-ACK CB consists of all HARQ process IDs regardless of priority indicated for each HARQ-ACK bit. The priority of the HARQ-ACK PUCCH is determined by physical priority indicator in the triggering DCI.**

**Proposal 2: Support enhanced Type 3 CB(s) with smaller size,**

* **Option 1: HARQ-ACK information in the enhanced type 3 CB is determined based on RRC configured sub-set of HARQ processes and/or serving cells.**
* **Option 2: HARQ-ACK information in the enhanced type 3 CB is determined based on time window indicated by the triggering DCI.**

**Proposal 3: If enhanced type 3 CB with only HARQ-ACKs in a time window is not supported, support triggering HARQ-ACKs in a time window to be retransmitted on PUCCH.**

**Proposal 4: Support Alt 2B or Alt 2C for PUCCH carrier switching, at least for HARQ-ACK PUCCH.**

* **Same SCS candidate PUCCH Scells as SCS of PCell/PSCell/PUCCH-Scell is preferred.**
* **Same number of PUCCH-configs among candidate PUCCH Scells and PCell/PSCell/PUCCH-Scell is expected.**

### R1-2105732 On UE feedback enhancements for HARQ-ACK MediaTek Inc.

***Observation 1: Dynamic cross-carrier PUCCH allows for up to 30% latency reduction.***

***Observation 2: Dynamic cross-carrier PUCCH doubles the network capacity and reduces the resource utilization compared to the Carrier Aggregation baseline operation.***

1. ***Support dynamic cross-carrier PUCCH for Carrier Aggregation.***
2. ***All DCIs pointing to the same PUCCH carry the same PUCCH carrier index, hence no overriding and no risk if one DCI is missed.***
3. ***Selection between Option-1 and Option-2 for the PUCCH configuration:***
* ***Option 1: A PUCCH configuration per PUCCH carrier.***
* ***Option 2: Define two levels of PUCCH configuration, “per PUCCH group” and “per PUCCH carrier”.***
1. ***Each cell carrying PUCCH has its own TPC configuration (PUCCH-PowerControl) and has its own TPC loop. When switching the PUCCH carrier, UE changes the power control parameters to use the ones associated to the new PUCCH carrier.***
2. ***Support retransmission of cancelled low priority and high priority HARQ.***
3. ***Support reusing the existing Rel-16 Type 3 HARQ-ACK codebook.***
4. ***Support the use of DCI scheduling new PUCCH / PUSCH resource for HARQ re-transmission / One-shot triggering of dropped HARQ-ACK.***

### R1-2105750 UE feedback enhancements for HARQ-ACK CAICT

In this contribution, we discussed more aspects about PUCCH carrier switching for HARQ feedback in Rel.17 URLLC. The following proposals are reached:

**Proposal 1: Support PUCCH carrier switching for HARQ feedback.**

**Proposal 2: To exclude Alt. 1A for further study.**

**Proposal 3: For Alt.1, PUCCH switching for SPS HARQ-ACK is achieved by dynamic PUCCH/PUSCH scheduling in another cell.**

**Proposal 4: For dynamic PUCCH carrier switching, implicit indication through PRI is used.**

**Proposal 5: Configure independent candidate K1 values for different SCSs.**

**Proposal 6: Alt. 2B is based on more consensus in terms of SPS HARQ-ACK deferral.**

**Proposal 7: Support Alt. 1 at this time.**

### R1-2105766 HARQ-ACK feedback enhancement for IIoT/URLLC Lenovo, Motorola Mobility

**Proposal 1: Support autonomous one-shot HARQ-ACK re-transmission for all or a subset of HARQ processes in a CG-PUSCH resource, where the CG-PUSCH is available in an earlier slot/sub-slot than a slot/sub-slot with the earliest available PUCCH resource for HARQ-ACK.**

**Observation 1: Configuring a UE with multiple PUCCH carriers and allowing the UE to dynamically switch across the configured PUCCH carriers can provide the UE with more HARQ-ACK transmission opportunities under dynamic TDD operation.**

**Observation 2: UE should be able to perform dynamic PUCCH carrier switching without dynamic indication to enhance HARQ-ACK feedback consisting of only SPS PDSCH HARQ-ACK bits.**

**Proposal 2: Support dynamic PUCCH carrier switching based on semi-static rules (Alt 2B).**

### R1-2105819 Discussion on UE feedback enhancements for HARQ-ACK Asia Pacific Telecom, FGI

**Proposal 1 Support triggering a Type-3 HARQ-ACK codebook by DCI format 1\_1 and DCI format 1\_2.**

**Proposal 2 When the priority indicator indicates low priority and high priority, a PUCCH resource for the Type-3 HARQ-ACK codebook should be selected based on the payload size of the Type-3 HARQ-ACK codebook and the PRI in the triggering DCI, from the PUCCH resources configured in the first PUCCH-Config and in the second PUCCH-Config, respectively.**

**Proposal 3 A list of pdsch-HARQ-ACK-OneShotFeedbackCBG-r16 is used to indicate the presence of CBG HARQ-ACK bits in the Type-3 HARQ-ACK codebooks triggered by DCI formats indicating low priority and high priority.**

**Proposal 4 A list of pdsch-HARQ-ACK-OneShotFeedbackNDI-r16 is used to indicate the presence of NDI bits in the Type-3 HARQ-ACK codebooks triggered by DCI formats indicating low priority and high priority.**

**Proposal 5 For PUCCH carrier switching, support of Alt.1A is preferred.**

### R1-2105872 Discussion on HARQ-ACK enhancement for URLLC/IIoT WILUS Inc.

**Proposal 1: Support one-shot triggering of enhanced Type-3 HARQ-ACK CB.**

** Further discuss how to configure/indicate HARQ process numbers.**

**Proposal 2: One-shot HARQ-ACK codebook is used for retransmission of cancelled HARQ-ACK information and the following aspects should be further enhanced.**

** Determination of Type-3 HARQ-ACK CB priority, Support of DCI format 1\_2 triggering Type-3 HARQ-ACK CB, and inclusion of HARQ-ACK associated with SPS release DCI.**

**Proposal 3: If dynamic PUCCH carrier switching is supported, Alt 2C is preferred in terms of PUCCH carrier ambiguity.**