**3GPP TSG RAN WG1 Meeting #104-e R1-210xxxx**

**E-meeting, January 25 – February 5, 2021**

**Agenda Item: 8.12.2**

**Source: Moderator (Huawei)**

**Title: FL summary#4 on improving reliability for MBS for RRC\_CONNECTED UEs**

**Document for: Discussion and Decision**

# Introduction

This summary summarizes the contributions submitted in AI 8.12.2 to discuss how to improve the reliability for MBS for RRC\_CONNECTED UEs.

The last meeting agrees to decide in this meeting to support which HARQ-ACK feedback option due to the subsequent design would rely on the supported HARQ-ACK feedback option. Therefore, this issue is suggested to be first top prioritized for this meeting. Meanwhile, to keep discussion in parallel, moderator also suggests keep discussing the relevant issues assuming the corresponding HARQ-ACK feedback option is supported.

This summary includes three high level aspects to address HARQ-ACK feedback, PDSCH repetition, and CSI feedback as in the last meeting. In each of high level issue, a sub-level list of issues are organized.

For each of listed issue, proposal(s) is/are suggested from moderator’s perspective according to the submitted individual company’s proposal(s). Companies are welcome to make comments in the table “collect views”. The proposals may be updated in subsequent rounds according to the comments collected in previous rounds so as to strive to converge to consensus. Note that moderator may only tend to collect concerns when time is right for some specific rounds, for which companies are expected to only provide concerns in the table “collect concerns” if any instead of inputting views again and again to alleviate efforts.

People can use “navigation pane” to quickly overview the organization of the summary and proposal(s) for each issue for discussion and provide views/comments into the table of “collect view”/“collect concerns” under each proposal.

# HARQ-ACK feedback

## HARQ-ACK feedback options

Background

Two high level options ACK/NACK based and NACK-only based HARQ-ACK feedback options were identified in the last meeting and it was agreed to make the decision for this meeting on which option(s) is/are to be supported.

*Agreements:*

*For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support at least one of the following:*

* *ACK/NACK based HARQ-ACK feedback for multicast,*
	+ *From per UE perspective, UE feedback ACK or NACK.*
	+ *From UEs within the group perspective,*
		- *FFS: PUCCH resource configuration for ACK/NACK feedback e.g., shared or separate PUCCH resources.*
	+ *FFS details including conditions for it to be used*
* *NACK-only based HARQ-ACK feedback for multicast,*
	+ *From per UE perspective, UE only feedback NACK.*
	+ *From UEs within the group perspective~~, further down-select between:~~*
		- *FFS: PUCCH resource configuration for NACK only feedback.*
	+ *FFS details including conditions for it to be used*
* *To decide in RAN1#104-e whether or not to support only one or both of the above schemes*
	+ *If both are supported, FFS configuration/selection of ACK/NACK-based and NACK-only based HARQ-ACK feedback*

Submitted Proposals

* (Futurewei) Proposal 1:
	+ Both ACK/NACK based and NACK-only based HARQ-ACK feedback should be supported at least PTM scheme 1.
* (ZTE) Proposal 11:
	+ NR MBS at least supports ACK/NACK feedback.
* (ZTE) Proposal 12:
	+ If both ACK/NACK feedback and NACK only feedback are supported, then configuration of feedback mode should be further studied.
* (OPPO) Proposal 1:
	+ Both ACK/NACK and NACK-only based HARQ feedback mechanisms should be supported for RRC\_CONNECTED UEs receiving multicast.
* (OPPO) Proposal 2:
	+ For ACK/NACK based HARQ-ACK feedback for multicast, both shared and separate PUCCH resources among UEs within the group are supported.
* (OPPO) Proposal 4:
	+ Whether shared or separate PUCCH resources are used can be up to gNB configuration or scheduling.
* (OPPO) Proposal 5:
	+ gNB can indicate whether ACK/NACK or NACK-only HARQ feedback is used by DCI.
* (Huawei) Proposal 1:
	+ ACK/NACK feedback option should be adopted to NR MBS as baseline, and the gNB can configure separate PUCCH resource configuration from that for unicast.
* (Huawei) Proposal 2:
	+ NACK only feedback option could apply as a complementary solution to ACK/NACK feedback mode,
* from UEs within the group perspective, PUCCH resource configuration are shared, and
* from per UE perspective, the PUCCH resource configuration should be separated from that for NR unicast.
* (CATT) Proposal 2:
	+ Rel-16 NR HARQ-ACK feedback mechanism for unicast can be reused by NR MBS as much as possible.
* (CATT) Proposal 5:
	+ For ACK/NACK based HARQ-ACK feedback for multicast, PUCCH resources are configured separate among UEs within the same group
* (CATT)Proposal 8:
	+ NACK-only based HARQ-ACK feedback is supported in MBS, and shared PUCCH resource is supported from the perspective of UEs in the same group.
* (vivo) Proposal 2:
	+ For RRC\_CONNECTED UE,
* NACK only feedback is support for multicast.
* ACK/NACK feedback is not supported for multicast with PTM transmission scheme 1.
* ACK/NACK feedback can be supported for multicast with PTM transmission scheme 2 if PTM transmission scheme 2 is supported for MBS transmission.
* (Nokia) Proposal 3:
	+ If ACK / NACK based HARQ feedback is to be sent by the UEs in response to reception of PTM transmissions, UE-specific PUCCH resources should be allocated for this feedback.
* (Potevio) Proposal 1:
	+ For RRC\_CONNECTED UE, at least for PTM scheme 1, both ACK/NACK based feedback and NACK only based feedback should be supported for multicast.
* (MediaTek) Proposal 1:
	+ support ACK/NACK based HARQ-ACK feedback for Rel-17 NR multicast service.
* (MediaTek) Proposal 2:
	+ From UEs within the group perspective, the PUCCH resource configuration is separate for ACK/NACK based HARQ-ACK feedback.
* (MediaTek) Proposal 3:
	+ support NACK-only based HARQ-ACK feedback for Rel-17 NR multicast service.
* (MediaTek) Proposal 4:
	+ From UEs within the group perspective, the PUCCH resource configuration is shared for NACK-only based HARQ-ACK feedback.
* (MediaTek) Proposal 5:
	+ Network can flexibly choose the HARQ-ACK mode and the HARQ feedback mode can be indicated dynamically by DCI field , e.g., “HARQ feedback option” field.
* (Intel) Proposal 1:
	+ For RRC\_CONNECTED UEs receiving multicast
* Both ACK/NACK based and NACK-only HARQ feedback is supported.
* ACK/NACK based feedback is used for delivery mode with PTP or PTM Scheme 2
* NACK only feedback is used for delivery modes 1 and 2 with PTM Scheme 1
* UEs within a group receiving multicast transmission can be configured with different HARQ feedback modes.
* (Intel) Proposal 3:
	+ For RRC\_CONNECTED UEs, NR MBS supports both ACK/NACK based and NACK-only HARQ feedback. The configuration of ACK/NACK and NACK only mode can be done using the following options
* Option 1: Semi-static RRC configuration of ACK/NACK or NACK only mode
* Option 2: The configured PUCCH resource can contain additional indication that the UE is expected to transmit only NACK on the configured resource
* Option 3: If UE has no dedicated PUCCH resource configuration, the UE uses cell-specific PUCCH resource and is expected to only transmit NACK
* (Google) Proposal 1:
	+ For ACK/NACK based HARQ feedback, support separated PUCCH among UEs, and from the UE perspective, the PUCCH resource configuration is shared with the unicast.
* (Google) Proposal 2:
	+ For NACK-only base HARQ feedback, whether to configure shared or separated PUCCH among UEs can be left for base station implementation.
* (Google) Proposal 3:
	+ For RRC-CONNECTED UE in multicast PTM transmission scheme 1, support ACK/NACK based HARQ feedback as the base line. The NACK-only based HARQ feedback can be supported for UE with lower capability (e.g. Redcap) or for MBS supporting huge number of UE.
* (Lenovo) Proposal 1:
	+ Both Option 1 (NACK-only based HARQ-ACK feedback) and Option 2 (UE-specific ACK/NACK feedback) are supported for PTM scheme 1.
* (Lenovo) Proposal 2:
	+ For NACK-only based HARQ-ACK feedback for PTM scheme 1, a common PUCCH resource for transmitting a NACK sequence is configured to the group of UEs.
* (Lenovo) Proposal 3:
	+ For UE-specific ACK/NACK feedback for PTM scheme 1, UE-specific PUCCH resource is configured to each of the group of UEs.
* (Lenovo) Proposal 4:
	+ Either Option 1 (NACK-only based HARQ-ACK feedback) or Option 2 (UE-specific ACK/NACK feedback) is adopted based on gNB’s scheduling policy and PUCCH resource capacity.
* (Spreadtrum) Proposal 1:
	+ Support both ACK/NACK and NACK-only based feedback schemes.
* (LGE) Proposal 1:
	+ ACK/NACK based HARQ-ACK is supported with UE dedicated PUCCH resource at least for PTP transmission.
* (LGE) Proposal 3:
	+ NACK only based HARQ-ACK is supported at least for PTM scheme 1.
* (ETRI) Proposal 1:
	+ Support both ACK/NACK based HARQ-ACK feedback and NACK-only based HARQ-ACK feedback for multicast.
* (ETRI) Proposal 2:
	+ Support at least RRC configuration for UEs to decide which HARQ-ACK feedback scheme to use.
* (CMCC) Proposal 1:
	+ For PTM transmisison scheme 1, ACK/NACK based HARQ-ACK feedback can be supported only if there is significant performance gain compared with dynamic switch between PTP and PTM .
* (CMCC) Proposal 4:
	+ For PTM transmisison scheme 1, NACK-only based HARQ-ACK feedback can be supported, especially for the case with a large amount of UEs in a MBS group.
* (CMCC) Proposal 8:
	+ For PTM transmission scheme 2, ACK/NACK based HARQ-ACK feedback can be supported.
* (Saumsung) Proposal 1:
	+ HARQ-ACK feedback for MBS PDSCH is only ACK/NACK based.
* (Apple) Proposal 1:
	+ Both ACK/NACK-based and NACK-only HARQ-ACK feedback are supported for MBS.
* (Apple) Proposal 2:
	+ If ACK/NACK based HARQ-ACK feedback is supported, each UE in the group is configured with a dedicated PUCCH resource for MBS service.
* (Convida) Proposal 1:
	+ Only ACK/NACK based HARQ-ACK feedback scheme needs to be supported for MBS.
* (Convida) Proposal 2:
	+ Both legacy ACK-NACK based HARQ feedback scheme and the shared ACK-NACK based HARQ feedback scheme are supported to serve different use cases.
* (Convida) Proposal 3:
	+ HARQ feedback for NR broadcast service to improve the reliability is considered for the UEs in RRC\_CONNECTED state.
* (Qualcomm) Proposal 1:
	+ For RRC\_CONNECTED UEs, support both group NACK and UE-specific ACK/NACK for HARQ feedback.
* Support selection of UE-specific ACK/NACK and NACK-only for different UEs in the same group
* (TD Tech) Proposal 1:
	+ HARQ-ACK feedback with the shared PUCCH resource is supported for the PTM bearer of MBS
* (TD Tech) Proposal 2:
	+ HARQ-ACK feedback with the dedicated PUCCH resource is supported for the PTM bearer of MBS

### 1st round discussion (closed)

FL’s Comments

Companies provided justification for the proposed options, including the targeted use cases, benefits of the proposed option and applicability for the scheduling schemes, etc.

There is a clearly majority support of both options from the submitted proposals. A few companies bind the feedback option to a specific scheduling scheme. Specifically, PTM scheme 1 supports NACK-only solely and ACK/NACK based option is supported for PTP or PTM scheme 2. Some other companies support ACK/NACK based option as baseline or support ACK/NACK based option solely.

It is noted that one company shows NACK-only slightly outperforms ACK/NACK based for PTM 1 in terms of spectrum efficiency via simulations. One another company brings up one implementation issue regarding the threshold uncertainty for gNB detecting the NACK-only, so that it is worried that the practical receiver design that can provide reliable detection for NACK-only HARQ-ACK feedback does not exist.

In addition, regarding the PUCCH resources for UEs among the group, there is also a clearly majority support of separate PUCCH resources for ACK/NACK based HARQ-ACK feedback and shared PUCCH resources for NACK-only based feedback.

Given the above situation, it may be helpful to have more discussion to address the implementation concern regarding the threshold uncertainty for gNB detecting the NACK-only.

FL’s Proposal:

#### Proposal 2.1.1: (HARQ-ACK options)

For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:

* ACK/NACK based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, ACK resources are not shared and NACK resources are not shared.
* FFS: NACK-only based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, NACK resources are shared

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| CMCC | We support both ACK/NACK based HARQ-ACK feedback and NACK-only based HARQ-ACK feedback.Regarding ACK/NACK based HARQ feedback, the dynamic switch between PTP and PTM for one UE is under discussion in RAN2/3, where the delivery method of initial transmission for one group common PDSCH can be switched between PTP and PTM according to channel conditions. For example, if some cell edge UEs’ channel states become worse, network can switch these cell edge UEs into PTP transmission based on CSI/RSRP report result to improve reliability. Considering the dynamic switch between PTP and PTM can improve the reliability of group-common PDSCH, the performance gain of supporting per-UE PTP transmission for retransmission(s) compared with dynamic switch may be limited. If PTP retransmission method is supported, the ACK/NACK based HARQ-ACK feedback method must be supported as well, but the spec effort of supporting ACK/NACK based HARQ-ACK feedback for PTM scheme 1 is too large, e.g., the discussion of PUCCH resource configuration and UCI multiplexing/prioritization. Therefore, considering the dynamic switch between PTP and PTM will be supported and large spec effort is needed for PTP re-transmission, ACK/NACK based HARQ-ACK feedback can be supported only if there is significant performance gain compared with dynamic switch between PTP and PTM.Regarding NACK-only based HARQ feedback, as in the FL’s summary, **“It is noted that one company shows NACK-only slightly outperforms ACK/NACK based for PTM 1 in terms of spectrum efficiency via simulations.”** , the simulation results seems NACK-only is better than ACK/NACK based HARQ in some cases. In addition, NACK-only based HARQ feedback can reduce PUCCH overhead especially compared with separate PUCCH resource configuration method discuss in section 2.2.1.1. As for the concern about threshold uncertainty, we think NACK-only based HARQ-ACK feedback for MBS is similar to Rel-16 V2X NACK-only based HARQ-ACK feedback, this issue may be not a critical problem.Therefore, it is hard to say which HARQ-ACK feedback method is better, we accept to support both ACK/NACK based and NACK-only based HARQ feedback for MBS.For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:* ACK/NACK based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, ACK resources are not shared and NACK resources are not shared.
* ~~FFS:~~ NACK-only based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, NACK resources are shared
 |
| FUTUREWEI | Proposal 2.1.1: we are OK with the FL proposal |
| Qualcomm | We support the proposal modified by CMCC. |
| MTK | Support deleting the “FFS” in 2nd sub-bullet.For multicast services, considering the feedback resource overhead and different transmission requirement, both the ACK/NACK based HARQ feedback and NACK only feedback should be supported as used in NR V2X groupcast mechanism. For ACK/NACK based HARQ feedback option, each UE has separate feedback resource because gNB can exactly know about UE’s reception status. The purpose of NACK only feedback option is to reduce the PUCCH overhead, all the UEs (actually, the NACK UEs) in one MBS group use the common HARQ feedback resource. Thus, for NACK-only based HARQ feedback option, NACK resources are shared from UEs within the group perspective. |
| OPPO  | Per FL’s summary, majority companies support both ACK/NACK and NACK only feedback, only one company express concern on the NACK-only, we suggest to make NACK-only as working assumption to make progress.  |
| Huawei, HiSilicon | Ok with the proposal but would like also to hear more discussion solving the implementation concern from Samsung.  |
| Samsung | Support the proposal.For NACK-only, there is no functional receiver design. The FFS can be used from supporting companies to provide information for the receiver design and the resulting BLER.The receiver design and the BLER are non-issues/well known for ACK/NACK-based feedback.There are more major problems with NACK-only but, at a minimum, the core problem of NACK-only not being functional has to be addressed first. |
| Lenovo, Motorola Mobility | We support both ACK/NACK based HARQ-ACK feedback and NACK-only based HARQ-ACK feedback.The modification from CMCC is fine with us. |
| Intel | We support both ACK/NACK and NACK-only mode (similar to V2X groupcast case). The modification from CMCC is fine to us.Especially for low QoS delivery supporting both RRC\_IDLE and CONNECTED UEs, NACK-only mode can serve as the baseline scheme.  |
| ETRI | We support both ACK/NACK based and NACK only based HARQ-ACK feedback. The modification from CMCC is fine to us. Considering the case when a number of UEs in the MBS are large, NACK only based method can be useful. |
| LG | We prioritize NACK only based HARQ-ACK feedback. |
| Apple | We support both ACK/NACK based HARQ-ACK feedback and NACK-only based HARQ-ACK feedback. The PUCCH resource overhead is the concern for ACK/NACK based HARQ-ACK feedback, the PUCCH resources for MBS could not be shared in TDM manner as unicast transmission. |
| CATT | We support both ACK/NACK based and NACK-only based feedback mechanism for PTM scheme 1.It is not supposed to combine a feedback scheme and a group scheduling transmission scheme, but naturally, NACK-only feedback mechanism is beneficial for PTM scheme 1 because of shared PUCCH can only consume few resources.* In a system, the probability of receiving ACK is much larger than the probability of receiving NACK, therefore, a very small PUCCH resource set can be configured for a very large group of UEs.
* Besides, DTX, the only concern for NACK-only mechanism is how to differentiate different UEs that are reporting NACK in order to use PTM 2/PTP for retransmissions for specific UEs. gNB can always determine the maximum retransmission number of a TB/service. If there is always NACK on the feedback resources, gNB can determine terminate the retransmissions based on service requirements, e.g. QoS.
* Even for ACK/NACK based feedback, there also has drawback, e.g. large PUCCH resource consumptions if the group is very large.

Therefore, both ACK/NACK and NACK-only can be supported, and gNB can configure either one based on different scenarios/conditions/requirements. |
| ZTE | It seems majority companies suggest to support NACK-only feedback but companies also have concern on its complexity. One compromise proposal would be to support both ACK/NACK and NACK-only feedback but prioritize ACK/NACK feedback.Regarding the sub-bullet of ACK/NACK feedback, it is not clear whether ACK and NACK resources are the same. Thus, we prefer to clarify the proposal as below.For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:* ACK/NACK based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, ACK/NACK resources are not shared ~~and NACK resources are not shared~~.
* ~~FFS:~~ NACK-only based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, NACK resources are shared
* Prioritize ACK/NACK based HARQ-ACK feedback for multicast

*FL response: I worried “ACK/NACK resources are not shared” may cause misleading intention of resources of ACK is not shared with resources for NACK. If it is over-worried, the first suggested change can be fine.*  |
| Spreadtrum | We support both ACK/NACK and NACK-only mode. The modification from CMCC is fine to us. |
| vivo | Our SLS simulation results (coped in following table) show that, from the RU perspective, ACK/NACK based feedback for multicast (e.g. scheme 1 and scheme 2 in the table) is similar to that of NACK only based feedback for multicast (e.g, scheme 3 with dynamic switching between PTP and PTM for initial transmission). Which HARQ-ACK feedback scheme can be supported should be jointly decided with the scheduling scheme, considering specification impact, complexity, etc as the main metric. From our perspective, the most reasonable combination is: **support NACK only feedback for PTM scheme 1 and support ACK/NACK feedback for PTM scheme 2.**Based on that, we suggest the following change for the proposal:For RRC\_CONNECTED UEs receiving multicast, ~~at least for PTM scheme 1~~, ~~support~~ considering the following combinations:* Combination 1: ACK/NACK based HARQ-ACK feedback for multicast for PTM scheme 1
	+ From UEs within the group perspective, ACK resources are not shared and NACK resources are not shared.
* Combination 2: ACK/NACK based HARQ-ACK feedback for multicast for PTM scheme 2 if supported,
	+ From UEs within the group perspective, ACK resources are not shared and NACK resources are not shared.
* ~~FFS:~~ Combination 3: NACK-only based HARQ-ACK feedback for multicast for PTM scheme 1,
	+ From UEs within the group perspective, NACK resources are shared
* Combination 4: NACK-only based HARQ-ACK feedback for multicast for PTM scheme 2 if supported,
	+ From UEs within the group perspective, NACK resources are shared

We support Combination 2 and Combination 3.

|  |  |  |
| --- | --- | --- |
| Scheduling scheme | Cell average spectral efficiency(bps/Hz/TRP) | Resource utilization |
| Scheme 1(ACK/NACK feedback for multicast)Multicast init + unicast ReTx | 1.6191 | 0.4046 |
| Scheme 2(ACK/NACK feedback for multicast)Multicast init + dynamic unicast/multicast ReT | 1.6197 | 0.3989 |
| Scheme 3(NACK only feedback for multicast)Dynamic unicast/multicast for init and ReTx | 1.6177 | 0.3949 |

*FL response: As I responded on GTW session that whether associating the HARQ-ACK option with the scheduling scheme could be separately discussed. Also, what vivo suggested is not the direction agreeable easier than the original one.*  |
| Nokia, NSB | We support both schemes, and so support the intention of the proposal, however;• given there are only 2 companies against NACK-only, we feel the FFS should be removed. Note that our clear preference is for the NACK only scheme and that:1. we have presented results in the past to show that that NACK-only schemes outperform comparable ACK/NACK schemes in terms of overhead, while keeping the same level of SE and PLR. 2. we have analysis (that we can bring to the next meeting if required), that we are confident will show that the threshold detection is not an issue3. we see that ACK/NACK schemes are of limited value in very specific situations, e.g., for small groups of UEs or for individual UEs. |
| Ericsson | We agree |
| Convida | Based on our observation of the inputs above, the benefit of supporting NACK only based scheme is its low overhead. We believe that the shared ACK/NACK also has this merit while it can also address the PDCCH mis-detection issue. However, if the companies’ majority view is to support both ACK-NACK based scheme and NACK only based scheme, we are OK to live with it for sake of progress. |

### 2nd round discussion (closed)

FL’s Comments

Based on the comments on GTW and discussion in the first round, the proposal is updated as follows:

The reasons for updating the proposals as follows are:

There is clearly majority support of both options, but I am also impressed by Samsung’s concern of gNB detection, so I still keep the proposal as support ACK/NACK but FFS NACK-only at this moment. I encourage people can try to directly address the concern and see if we can progress further.

Note that another majority view for ACK/NACK based is that the resources for ACK or for NACK are not shared or are UE-specific, so that Rel-15/Rel-16 HARQ-ACK framework can be the base for further discussion, which are the points the sub-bullet intended to address. To reflect Samsung’ comment that the PUCCH resources should be up to gNB configuration which seems true. However, we should make the point for ACK-NACK that the resources among UEs are orthogonal and the point for NACK-only should be the resources can be shared.

FL’s Proposal:

#### Proposal 2.1.2: (HARQ-ACK options)

For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:

* ACK/NACK based HARQ-ACK feedback for multicast,
	+ It is up to network to configure orthogonal PUCCH resources among UEs within the same group.
* FFS: NACK-only based HARQ-ACK feedback for multicast,
	+ It is up to network to configure the PUCCH resources and the PUCCH resources can be shared among UEs within the same group.

Collect response to address Samsung’s concern and collect other concerns for the proposal if any:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| LG | We think that it is up to network to configure PUCCH resources for both ACK/NACK and NACK only. If configured by the network, the PUCCH resources are orthogonal among UEs i.e. UE specific PUCCH resource for ACK/NACK based HARQ-ACK.In addition, considering Samsung’s concern in 2.2.2, we could support at least PUCCH format 1 for NACK-only feedback.Accordingly, we propose to change to:* ACK/NACK based HARQ-ACK feedback for multicast,
	+ It is up to network to configure the PUCCH resources and the ~~orthogonal~~ PUCCH resources are orthogonal among UEs within the same group.
* ~~FFS:~~ NACK-only based HARQ-ACK feedback for multicast, at least with PUCCH format 1,
	+ It is up to network to configure the PUCCH resources and the PUCCH resources can be shared among UEs within the same group.

*FL’s response: the first change is not necessary but ok to live with it because it is exact the intention of the original wording which does not cause confusion. Second change about PUCCH format 1, I have a specific proposal discussing the PUCCH format, prefer to keep the discussion separate.*  |
| TD Tech, Chengdu TD Tech | We suggest to support the ACK/NACK based HARQ-ACK feedback with the shared PUCCH resources which consists of several PUCCH sequences with format 0. We hope such method can be discussed. Therefore, we hope the current proposal is modified as below.Proposal 2.1.2: (HARQ-ACK options)For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:* ACK/NACK based HARQ-ACK feedback for multicast,
	+ It is up to network to configure orthogonal PUCCH resources among UEs within the same group.
* FFS: NACK-only based HARQ-ACK feedback for multicast,
	+ It is up to network to configure the PUCCH resources and the PUCCH resources can be shared among UEs within the same group.
* FFS: ACK/NACK based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, ACK/NACK resources are shared
	+ The shared ACK/NACK resources consist of (2C-1) PUCCH sequences with format 0. These PUCCH sequences are numbered from 0 to (2C-2).
		- C is the number of the code block groups of a TB on the PDSCH with PTM mode
		- Each UE determines the bit sequence of C bits long：if the c-th CBG of the TB on the PDSCH is decoded correctly/wrongly, the c-th bit of the bit sequence is 1/0.
		- If the decimal value of the bit sequence is X (0<=X< =(2C-2), UE sends the X-th PUCCH sequence to gNB.
		- When C=1, only one PUCCH sequence with format 0 is used to indicate the TB on the PDSCH is NACKed.

*FL’s response: Firstly, if you are talking about UEs in the same group sharing the same PUCCH resource for ACK or NACK, it has been clarified that only a couple of companies proposed it but the majority view is to reuse the current Rel-15/Rel-16 ACK/NACK feedback framework to reduce the spec effort.* *Secondly, we should keep in mind that UE in the consideration should not (or primarily) be the ones which only receives multicast only but not receive unicast. When UE receives both unicast and multicast, ACK/NACK based feedback for multicast is more straightforward to multiplex/prioritize the ACK/NACK feedback for unicast. NACK-only based can also be considered. However, compared with NACK-only, the shared ACK/NACK solution does not have clear benefit because NW still cannot tell which UE feedback the ACK or NACK.* *All in all, as FL, I have no problem to capture this FFS as long as others can be convinced by your suggestion.*  |
| Nokia, NSB | Regarding Samsung’s concerns on a group-common PUCCH for NACK-only HARQ feedback:In R1-2101235 Samsung argued that NACK signals sent by different UEs might superimpose destructively leading to poorer NACK detection performance compared to a single UE sending ACK/NACK feedback, in particular referring to the example of 2 UEs where the aggregated received signal would be smaller than the individual UE’s signal with probability of 50%, based on the assumption that the signals are received with equal amplitude but u.i.i.d. random phase.Our view here is as follows:* We agree with the assumption of u.i.i.d. phases of the different signals.
* The assumption in the document appears to be that fading is **fully** compensated by power control. In our opinion, this is not realistic; power control typically only compensates for pathloss and slow fading, but not fast fading. Hence, some variance / distribution must also be assumed for the amplitude. With this the detrimental effect of superpositions on the distribution of the received sum-signal then turns into a positive effect, i.e., with more UEs transmitting the probability of low sum-signal power decreases (strictly monotonically).

This can be observed in the following figure showing the distribution of the signal power received by the gNB for various numbers of UEs sending simultaneously. (The phases of the individual signals are still assumed to be u.i.i.d. in [0,2π].) Here, we used the simple model of Gaussian i.i.d. signal amplitude per UE with mean zero and variance of 3dB, noting that even for lower variances such as e.g. 0dB results do not change fundamentally. We observe that as far as distribution is concerned, there is no problem with destructive superposition of signals of multiple UEs, i.e., there is no degradation of NACK detection performance to be expected; quite on the contrary, the more UEs there are, the higher the probability that the NACK will not be missed by the gNB due to fast fading.Just as reference here the received power distributions that we would obtain, if we assumed that all UEs have exactly the same amplitude (Samsung’s assumption). Under this assumption, we *would* observe some destructive superposition of signals arriving from different UEs, especially if there are only 2 UEs (with less than 50% probability).In consequence, any detection threshold that would be adequate for a single UE would also be equate for multiple UEs.Another potential, related concern that might be raised against NACK-only on a group-common PUCCH resource is that of timing differences leading to a severely frequency-selective effective channel over which the gNB seems to be receiving the NACK. A quick analysis of this aspect reveals the following: * Timing advance granularity is T\_c = 0.509ns, i.e., we can assume that all UEs’ signals arrive within a window no longer than ~0.509ns.
* If we compute the coherence bandwidth of the effective channel via 2π/(delay spread) and for the sake of simplicity take 'delay spread' = T\_c, then this results in a coherence bandwidth of 125GHz.
* This is only a very quick and not a very accurate computation, but it shows that the minimum coherence bandwidth of the effective channel that would result from this superposition of signals arriving from different UEs with different timings is many orders of magnitude larger than any bandwidth used in the 5G system and does hence not play any role.
* Similarly, T\_c is also very small compared to delay spreads assumed in TR38.901: Table 7.7.3-1. "Example scaling parameters for CDL and TDL models." specifies e.g. 10ns as "very short delay spread" and 30ns as "short delay spread".

Hence, we can conclude that time of arrival difference between NACK signals arriving from different UEs at the gNB do also not cause problems.Moreover, it should also be noted that the usage of group-common NACK-only feedback at Rel-16 V2X has already been agreed (c.f. TS38.213, TR.37.985) Group-common NACK-only feedback mechanism proposed within the MBS context may follow a similar perspective. |
| Convida | *Reply to FL*: The ACK/NACK scheme with shared resources among the UEs is described as follows: the NW configure two resources, one resource for ACK and the other resource for NACK respectively, where the ACK resource is shared by all the UEs, in addition, the NACK resource is also shared by all the UEs. The benefit of the ACK/NACK scheme with shared resources is not mainly to help the NW to distinguish which UE feedback the ACK or NACK. As a matter of fact, the benefit of such scheme is to solve the PDCCH mis-detection issue caused by the NACK only scheme. When using NACK only scheme, if the PDCCH is missed by the UEs, e.g., due to bad channel condition, the UE will assume no PDSCH transmission is scheduled therefore the UE will not send any feedback. From the gNB side, as it doesn’t receive any NACK, the gNB will assume the PDSCH transmission succeeds, however, the fact is that PDSCH is not successfully delivered. By using the ACK/NACK scheme with shared resources, if the PDCCH is missed by the UEs, gNB will not receive any ACK or NACK due to DTX. In this case, the gNB will be aware that the PDCCH is not detected by the UEs, as the gNB should be receiving either ACK or NACK if the PDCCH is indeed detected by the UEs. In this case, the PDCCH mis-detection issue is solved. In summary, we believe both NACK only scheme and the ACK/NACK scheme with shared resources scheme have the advantage of achieving the low overhead comparing to the legacy ACK/NACK scheme. Comparing between the NACK only scheme and the ACK/NACK scheme with shared resources scheme, the shared ACK/NACK scheme has clear benefit on addressing the PDCCH mis-detection issue while the resource overhead is maintained at low level. Therefore, we agree with Chengdu TD Tech that the ACK/NACK scheme with shared resources scheme should be also considered and captured as the FFS. We propose to modify the current proposal as follow:For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:* ACK/NACK based HARQ-ACK feedback for multicast,
	+ It is up to network to configure orthogonal PUCCH resources among UEs within the same group.
* FFS: NACK-only based HARQ-ACK feedback for multicast,
	+ It is up to network to configure the PUCCH resources and the PUCCH resources can be shared among UEs within the same group.
* FFS: Shared ACK/NACK based HARQ-ACK feedback for multicast,
	+ From UEs within the group perspective, dedicated resources are allocated for ACK and NACK respectively, where the ACK resource(s) are shared and the NACK resource(s) are also shared.
 |
| Samsung | Support the FL proposal. To respond to the comments so far:LGE: The problem is not PUCCH format dependent – it original from several I.I.D random variables with same mean being summed together (shared resource). The nature of the problem is fundamental.TD Tech: PUCCH format 0 cannot possibly be used MBS services – the coverage loss is simply unacceptable. There seems to be a confusion with FR2 or SL where the required SINR conditions, coverage areas/distances, and slot formats are very different than for MBS.Nokia: Regardless of a correct/incorrect assumption of a distribution for the received power, the mean of the distribution should be assumed to be same. Then, statistically, upon adding a small number of variables with random pahses, the result will again be a noise distribution. The result of always getting a better magnitude when superimposing signals with random phases and with a small variance relative to the mean vs. when only one signal is received cannot be explained by theory. Further, for example, when targeting a 10-4 NACK-to-ACK error and having a superposition of 2 signals for which the power difference is small or 0, there is basically a 50% chance that a detection threshold that was set assuming a single signal reception will not be met, DTX will be declared, and a NACK-to-ACK error will occur. A 50% or somewhat smaller chance is much larger than 10-4.Convida: I think what is discussed is different than the comment. However, as also mentioned in our Tdoc, it raises another problem of NACK-only HARQ-ACK - the NACK-to-ACK error when PDCCH is missed. Basically, MBS with NACK-only HARQ-ACK feedback needs to support an error-free PDCCH transmission which is of course unreasonable/impractical. That is another reason why NACK-only HARQ-ACK feedback is pointless.  |
| Qualcomm | We support both ACK/NACK and NACK-only feedback modes. Not sure what is identified specific issue of receiver design for NACK-only. If a UE is capable to handle NACK-only feedback for V2X groupcast, we believe no issue for gNB receiver, which in theory more powerful than UE. If Samsung is worried about the “required SINR conditions, coverage areas/distances,….” of multicast UEs, we can support gNB to configure/select some UEs (e.g., with good SINR/disctance) in the group to use NACK-only and other UEs to use ACK/NACK feedback. Proposal 2.1.2: (HARQ-ACK options)For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:* ACK/NACK based HARQ-ACK feedback for multicast,
	+ It is up to network to configure orthogonal PUCCH resources among UEs within the same group.
* NACK-only based HARQ-ACK feedback for multicast,
	+ It is up to network to configure the PUCCH resources and the PUCCH resources can be shared among UEs within the same group.
* gNB can configure/select ACK/NACK or NACK-only based HARQ-ACK feedback for multicast per UE in the same group.
 |
| Lenovo, Motorola Mobility | We support both ACK/NACK and NACK-only based feedback options.For NACK-only based feedback, regarding DTX problem caused by misdetection of PDCCH, we think it is not an issue when DCI format 1-0 is used as the group-common DCI for PTM scheme 1. It is because DCI format 1-0 is designed with same payload and high reliability. So NACK-only feedback can work properly for PTM scheme 1 with DCI format 1-0 as the group-common DCI.For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support:* ACK/NACK based HARQ-ACK feedback for multicast,
	+ It is up to network to configure orthogonal PUCCH resources among UEs within the same group.
* NACK-only based HARQ-ACK feedback for multicast,
	+ It is up to network to configure the PUCCH resources and the PUCCH resources can be shared among UEs within the same group.
 |
| vivo | If whether associating the HARQ-ACK option with the scheduling scheme could be separately discussed, we would like to delete “at least for PTM scheme 1,” in the main bullet to totally decouple the scheduling scheme and HARQ-ACK option. For NACK only based HARQ-ACK feedback, we are not sure the issue identified by Samsung, it was already supported in V2X. We think the detection at gNB side is not an issue. We also prefer to remove “FFS” for NACK only based HARQ-ACK feedback. |
| CMCC | Support both ACK/NACK based and NACK-only based HARQ-ACK feedback solutions.Agree with Qualcomm’s comment, Rel-16 V2X UE can handle NACK-only feedback, considierng gNB has stronger deomd capaliity than UE, the NACK-only detection is not a cirtical issue.In addition, whether to use ACK/NACK based or NACK-only based can be configured by gNB, we sould not preclude NACK-only option, which can reduce PUCCH resource overhead a lot compared with ACK/NACK option.We are fine with Qualcomm’s version. |
| FUTUREWEI | We are ok with the FL proposal. |
| Intel | We tend to agree with Nokia’s analysis here. While a reasonable UL power control scheme with fractional pathloss compensation should ensure similar receive powers, fast fading plays a non-trivial role and it should be possible to tune the gNB detector for a reasonable DTX-to-NACK probability. However, to address Samsung’s concern that the V2X use case is only meant for short range etc., having a configurable feedback mechanism gives the gNB the flexibility to configure cell-edge UEs in a macro-cell with ACK/NACK feedback if needed. While 100% detection probability of PDCCH is not realistic, it should still be robust enough to support NACK-only feedback especially in broadcast mode when then number of UEs in the group is expected to be large (DTX-NACK ratio should be reasonable). We are ok to support Qualcomm’s version with the added FFS point. Furthermore, we also agree with vivo that the HARQ feedback and scheduling mechanism can be separated for now and we would prefer to delete “at least for PTM Scheme 1” from the main bullet. In our understanding, the main benefit of ACK/NACK based feedback can realized when PTP or PTM Scheme 2 is allowed and UE-specific retransmissions are possible.  |
| OPPO | We share similar view as Convida and TD Tech, we also think that share ACK resource or NACK resource among UEs within the group is beneficial in some cases. We agree with the modified proposal from Convida to add another FFS.  |
| Apple | We support both ACK/NACK based and NACK-only based feedback. We don’t see fundamental difference to support NACK-based feedback for V2X and MBS. |
| Nokia, NSB (2) | We support Qualcomm’s proposal.Regarding ACK/NACK scheme on shared PUCCH resources. Thank you Convida for the detailed explanation. Where we still see a problem with this approach is that it seems to us that the PDCCH mis-detection problem is only solved, if the number of UEs is small. As soon as there is one UE sending ACK, the gNB will not know if another UE missed the PDCCH, will it?Regarding Samsung’s comments above: We think that one must not confuse adding at what level random contributions add up at the receiver. The signals from different UEs are identical, only the channel states, which for a small PUCCH format 0 allocation can be assumed to be more or less constant across the PUCCH format 0 resources, are random and independent per UE. Hence, the channel state becomes noise-like in distribution but still more or less constant across the PUCCH format 0 resources. And the distribution of this channel state improves with increasing number of UEs roughly as indicated by our quick analysis.The situation further described in Samsung’s comments where the signals from 2 UEs cancel each other out, is of course a possibility. But, our analysis shows, that in distribution, and hence in terms of error probability, the probability that this happens is indeed small. One must not disregard that the amplitudes of the different received signals are not likely to be very similar such that the complete cancelation occurs. |
| CATT | Same view with the 1st round of discussion that supporting both ACK/NACK and NACK-only based feedback schemes.ACK/NACK feedback can be used to differentiate different UEs’ feedbacks but requires much PUCCH resources; NACK-only cannot be used to differentiate UEs but requires much less PUCCH resources when the number of UEs is large. To improve the reliability of MBS services, both mechanisms can be supported to adapt different scenarios. Furthermore, the usage of either mechanism is based on configuration, and it is all up to gNB. Rel-16 V2X supports NACK-only feedback in groupcast, so there is no extra effort on the detailed design for MBS. |
| Ericsson | We agree with Proposal 2.1.2 |

FL’s Comments

There is still debating on whether gNB detection is an issue ongoing as well as whether gNB expected with higher capability than UEs can handle the NACK-only detection.

Companies are encouraged to continue the discussion and especially appreciate if Samsung can provide further responses for more discussion.

### Round-3

FL’s Comments

It seems no objection for support of ACK/NACK based option for HARQ-ACK feedback for multicast from the previous rounds of discussion and the debate mainly lies in whether support NACK-only based option. There are also a few (3) companies mentioned to support the ACK/NACK with shared resources scheme and the benefit claimed is lower overhead than the ACK/NACK based and can solve the PDCCH mis-detection issue caused by the NACK only. However, as Nokia also pointed out network is still not aware whether another UE missed the PDCCH as long as one UE feedback the ACK. Therefore, down-selection makes sense to happen between the NACK-only and the ACK/NACK with shared resources, given the situation of no objection to the ACK/NACK based option. Also, NACK-only has clearly majority support over the ACK/NACK with shared resources scheme.

Regarding the NACK-only based option, Nokia provided analysis and simulations to justify gNB detection for the NACK-only option can be manageable. Moreover, there are comments that gNB with higher capability over UE should be able to manage the detection issue since NACK-only has been supported in V2X for which UE is supposed to handle the NACK-only detection. One company also suggested an attempt to alleviate the NACK-only detection concern that network has the full control which option is to be in use.

Now FL wonders whether the following proposal can be agreeable in the group and especially whether Samsung can compromise to it:

FL’s Proposal:

#### Proposal 2.1.3: (HARQ-ACK options)

For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support the following:

* ACK/NACK based HARQ-ACK feedback for multicast,
	+ It is up to network to configure orthogonal PUCCH resources among UEs within the same group.
* ~~FFS:~~ NACK-only based HARQ-ACK feedback for multicast,
	+ It is up to network to configure the PUCCH resources and the PUCCH resources can be shared among UEs within the same group.
* Whether the ACK/NACK based or the NACK-only based HARQ-ACK feedback is to be used up to gNB.
	+ FFS details.

Collect **strong concerns**:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| LG | We support Proposal 2.1.3 |
| Lenovo, Motorola Mobility | We are generally OK with this proposal.For the third bullet, it seems not necessary as anything is up to gNB. I understand this sub-bullet is targeted for the conditions of HARQ-ACK feedback options. Maybe FFS conditions is enough. |
| CATT | We support this proposal 2.1.3. |
| Nokia, NSB | Support the proposal |
| vivo | For the third bullet, we agree with Lenovo, FFS conditions is enough.In addition, we still want to delete “at least for PTM scheme 1” in the main bullet to keep it general, and we can further study the combination between ACK/NACK mode and group scheduling scheme. |
| Samsung | **We cannot agree to NACK-only HARQ-ACK feedback for reasons that include the following:**1. **To support NACK-only without limiting DL coverage and for a ~10-4 NACK-to-ACK error, a gNB needs to set the detection threshold practically at the noise floor – such unnecessary PDCCH/PDSCH retransmissions cannot be justified by any perceivable UL overhead reduction.**
2. **There is no overhead issue with ACK/NACK feedback. It can be configured per UE and the gNB can do so only for UEs with lowest SINR – e.g. for 1 HARQ-ACK bit, 1-2 RBs for PUCCH format 1 are sufficient. Such overhead is trivial compared to unnecessary PDCCH/PDSCH retransmissions.**
3. **Applicability of NACK-only is very limited as, for >1 HARQ-ACK bits expected due to TDD in the NR bands, ACK/NACK is the only option if significant redesigns are not to be done for the PUCCH.**
4. **NACK-only practically requires error free PDCCH receptions (i.e. PDCCH BLER <= 10-5). Similar to unnecessary PDCCH/PDSCH retransmissions, ACK/NACK overhead is trivial in comparison to a CCE aggregation level that is 2x-4x larger than necessary.**
5. **There is no feasible gNB receiver design – once signals with random phases get superimposed, even if they have small differences in power around a nominal value, the result approaches noise. Together with the requirement for a 10-4 NACK-to-ACK error, we don’t see how it is conceivably possible for the gNB to place the detection threshold meaningfully higher than the noise floor (i.e. there is no information from NACK-only).**

**Of course, the above can be addressed/evaluated and the issue can be revisited at the next meeting.** |

## HARQ-ACK feedback resource

Background

From UE perspective, UE is configured with HARQ-ACK PUCCH resources for unicast and also needs HARQ-ACK PUCCH resources for MBS. This issue focuses on the PUCCH configurations for MBS and for unicast and the last meeting agrees the following for ACK/NACK based and NACK-only based options, respectively:

*Agreements:*

*For RRC\_CONNECTED UEs receiving multicast, for ACK/NACK based HARQ-ACK feedback if supported for group-common PDCCH scheduling, PUCCH resource configuration for HARQ-ACK feedback from per UE perspective is, down-select one of the following options:*

* *Option 1: shared with PUCCH resource configuration for HARQ-ACK feedback for unicast*
* *Option 2: separate from PUCCH resource configuration for HARQ-ACK feedback for unicast*
* *Option 3: Option 1 or option 2 based on configuration*

*Agreements:*

*For RRC\_CONNECTED UEs receiving multicast, for NACK-only based HARQ-ACK feedback if supported for group-common PDCCH scheduling, PUCCH resource configuration for HARQ-ACK feedback from per UE perspective is separate from PUCCH resource configuration for HARQ-ACK feedback for unicast.*

* *FFS PUCCH format*

### For NACK-only based feedback

Submitted Proposals

* (ZTE) Proposal 7:
	+ If NACK only feedback is supported for MBS,
* PUCCH resource configuration per MBS service is supported.
* PUCCH format 0 is supported for NACK only feedback.
* PUCCH format 0 supports PUCCH repetition.
* (OPPO) Proposal 8:
	+ PUCCH format 0 can be used for the NACK-only feedback. FFS other PUCCH formats which can improve the coverage and capacity.
* (Huawei) Proposal 2:
	+ NACK only feedback option could apply as a complementary solution to ACK/NACK feedback mode,
* from UEs within the group perspective, PUCCH resource configuration are shared, and
* from per UE perspective, the PUCCH resource configuration should be separated from that for NR unicast.
* (CATT) Proposal 9:
	+ PUCCH format 0/1 can be configured by gNB to be used for NACK-only feedback for MBS.
* (CATT) Proposal 10:
	+ NACK-only based feedback framework is designed based on Rel-15 NR ACK/NACK-based feedback mechanism by considering PRI, DCI CCE index and k1 to indicate PUCCH resources.
* (CATT) Proposal 11:
	+ When configuring PUCCH resource set for NACK-only feedback in MBS, 8-32 PUCCH resources can be supported based on configuration.
* (CATT) Proposal 12:
	+ The PUCCH resource set can be used by all the MBS services using NACK-only based feedback mechanism.
* (Intel) Proposal 6:
	+ For NACK-only feedback, PUCCH formats 0 and 1 are supported.
* (Lenovo) Proposal 7:
	+ For PTM transmission scheme 1, from per UE perspective, PUCCH resource configuration for NACK-only based feedback should be separate from PUCCH resource configuration for HARQ-ACK feedback for unicast.
* (LGE) Proposal 4:
	+ NACK only based HARQ-ACK is transmitted on group common PUCCH resource.
* (LGE) Proposal 6:
	+ Support PUCCH format 0 and 1 for NACK based HARQ feedback.
* (CMCC) Proposal 5:
	+ PUCCH format 0 or PUCCH format 1 could be used for NACK-only based HARQ-ACK feedback.
* (Ericsson) Proposal 4:
	+ PUCCH format 0 can be used for semistatic codebook.as a basis for NACK-only signaling

#### Round-4

FL’s Comments

Qualcomm and Samsung expressed the comment on the FFS. If company worry about the coverage of PUCCH format 0, PUCCH format 1 can also be configured by network. Since some companies prefer to keep this FFS and others prefer to delete it, it is mentioned by a few company and it is FFS anyway so I deleted it for now for this round and suggest company should not spend too much time debating whether this FFS is kept or deleted.

FL’s Proposal:

#### Proposal 2.2.1.1: (PUCCH format for NACK-only)

For NACK-only based feedback if supported for RRC\_CONNECTED UEs receiving multicast, support PUCCH format 0 and PUCCH format 1.

Collect **strong** **concerns**:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| ZTE | Our preference would be to add this FFS point. But if majority companies prefer not to touch this part for now, we can live with it. |
| CATT | We support this proposal 2.2.1.1.Deleting the FFS sub-bullet does not preclude further contribution/discussion about the repetition mechanism. Keeping the FFS may focus companies to further study/discuss about the design/details/benefit on this item. Some other companies already expressed the concerns on further study this repetition mechanism. It would be better and clearer to have the main bullet only as agreement for progress. |
| Nokia, NSB | Support the proposal. |
| vivo | Support the proposal. |

## UCI multiplexing/prioritization

Background

This was not discussed in the last meeting. Current specification supports two types of HARQ-ACK feedback corresponding to different priorities. The HARQ-ACK feedback with the same priority will be multiplexed and with different priorities will be prioritized.

When discussing the HARQ-ACK feedback for multicast, some relevant issues need to be discussed. For example, whether MBS is one priority or can be more than one priority; what the priority is between unicast and MBS; is it multiplexing or prioritizing between feedback for unicast and MBS when determining the feedback resources.

Submitted Proposals

* (ZTE) Proposal 5:
	+ Regarding ACK/NACK feedback for NR MBS for UEs receiving both unicast and MBS service, the existing multiplexing methods can be reused between PUCCH for unicast and PUCCH for MBS.
* (ZTE) Proposal 8:
	+ If the NACK only feedback mode is supported, RAN1 further discusses the multiplexing method for scenarios where NACK only PUCCHs overlap.
* (ZTE) Proposal 9:
	+ If the NACK only feedback mode is supported, RAN1 further discusses the multiplexing method for scenarios where NACK only PUCCH and other PUCCH/PUSCH overlap.
* (OPPO) Proposal 6:
	+ Multiplexing HARQ-ACK information for unicast and multicast in a single feedback channel should be supported.
* (Huawei) Proposal 8:
	+ Support defining at least two priorities for MBS.
* (Huawei) Proposal 9:
	+ The intra-UE HARQ-ACK feedback multiplexing and prioritization between unicast and MBS should be supported.
* (Nokia) Proposal 6:
	+ If for a UE a scheduled group-common PUCCH resource for PTM NACK-only feedback overlaps in time with a UE-specific PUCCH resource for other UCIs, this UE should multiplex the PTM HARQ feedback with the other UCIs on the UE-specific PUCCH resource.
* (Nokia) Proposal 7:
	+ The PUCCH resource set for NACK-only feedback should be defined inside the existing PUCCH Config structures, but not interfere with the existing UCI-size based PUCCH resource set selection for UE-specific PUCCH resources.
* (Nokia) Proposal 9:
	+ As in Rel-16 framework, there are two priorities defined also for multicast, i.e., low-priority for eMBB and high-priority for URLLC transmissions that can be indicated by the DCI, and those priorities are equal to their unicast counterparts, i.e., low-priority unicast eMBB transmission has the same priority with low-priority multicast eMBB transmission.
* (Nokia) Proposal 10:
	+ In case the HARQ-ACK feedback of low-priority transmission is scheduled to be sent at the same time instance with the feedback of high-priority transmission, the low-priority feedback is dropped. In case the HARQ-ACK feedback of the transmissions with the same priority are scheduled to be sent at the same time instance, they are multiplexed according to the procedures defined by this document.
* (Nokia) Proposal 13:
	+ When group-common NACK-only HARQ-ACK feedback is used as the HARQ-ACK scheme, in case the UE has UE-specific HARQ-ACK resource for unicast services along with group-common NACK-only resource for PTM, the UE utilizes the UE-specific PUCCH resource by constructing separate HARQ-ACK sub-codebooks, as if ACK / NACK based approach is being used for PTM.
* (Nokia) Proposal 19:
	+ Rel-15/16 handling rules should be followed for multiplexing / prioritization of HARQ-ACK with other UL transmissions.
* (Intel) Proposal 5:
	+ When a PUCCH resource carrying HARQ ACK for MBS overlaps in time domain with a PUCCH resource carrying other UCI types, priority order for PUCCH dropping can be defined where HARQ-ACK feedback of unicast transmission > HARQ-ACK feedback of MBS transmission > SR > CSI report
* (CMCC) Proposal 2:
	+ If ACK/NACK based HARQ-ACK feedback is supported for PTM transmision scheme 1, PUCCH prioritization should not be supported.
* (CMCC) Proposal 6:
	+ If there is a collision between NACK-only feedback PUCCH for MBS and other UCI, NACK-only feedback PUCCH can be dropped to solve the multiplexing issue.
* (Samsung) Proposal 5:
	+ Support multiplexing, prioritization, and undefined UE behavior when a PUCCH with HARQ-ACK for MBS PDSCH overlaps in time with a unicast PUCCH or PUSCH following corresponding Rel-16 mechanisms.

### Multiplexing/prioritizing

#### Round-4

FL’s Comments

This issue was discussed on GTW session and comments received are primarily the conditions for using this rule. The intention of the proposal was to reuse the rule which is normally used in URLLC instead of listing all complicated different conditions. For example, whether the PUCCH resources are overlapping or whether UE is configured to transmit sub-slot based PUCCH or is configured to transmit slot based PUCCH but only one PUCCH carrying HARQ-ACK is transmitted per slot. What if UE is configured to transmit two slot based PUCCH without PUCCH overlapped in time domain, etc.

According to mechanism introduced by URLLC, if UE is configured with sub-slot PUCCH, for the same sub-slot PUCCH indicated by k1 in the DCIs scheduling PDSCH, when determining the sub-slot based PUCCH resources, support multiplexing for the same priority and support prioritizing for different priorities. When UE is not configured with sub-slot based PUCCH, there could be two case. Case 1, if UE supports to transmit **two** slot based PUCCHs without overlapping in time domain for HARQ-ACK, for each slot based PUCCH transmission, support multiplexing for the same priority and support prioritizing for different priorities. Case 2, for UE transmits **one** slot based PUCCH for HARQ-ACK, regardless the PUCCH resources for multicast and unicast are overlapping or not in the same slot, support multiplexing for the same priority and support prioritizing for different priorities.

The proposal is updated as follows accordingly.

FL’s Proposal:

#### Proposal 2.3.1.1: (multiplexing/prioritizing)

For the cases of HARQ-ACK feedback (at least for ACK/NACK based feedback) is available for multicast and unicast, for determining the PUCCH resource,

* if UE is configured with sub-slot based PUCCH, for determining sub-slot PUCCH resources, support multiplexing for the same priority and support prioritizing for different priorities.
* if UE is **NOT** configured with sub-slot based PUCCH,
	+ for UE supports to transmit **two** slot based PUCCHs without overlapping in time domain for HARQ-ACK, for each slot based PUCCH transmission, support multiplexing for the same priority and support prioritizing for different priorities.
	+ for UE transmits **one** slot based PUCCH for HARQ-ACK, regardless the PUCCH resources for multicast and unicast are overlapping or not in the same slot, support multiplexing for the same priority and support prioritizing for different priorities.

Collect comments:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| Lenovo, Motorola Mobility | I understand the main motivation of this proposal is to multiplex the HARQ-ACK feedback for multicast and unicast in same PUCCH when the corresponding PUCCHs are overlapped in symbol level or non-overlapped in same slot. However, the latest proposal seemingly includes many conditions.1. For sub-slot based PUCCH, should both PUCCH be overlapped in symbol level then support multiplexing in one PUCCH?
2. We are not sure about the conditions of “for UE supports to transmit **two** slot based PUCCHs without overlapping in time domain for HARQ-ACK”. Are you referring to two PUCCHs in two slots?
3. What does “one slot based PUCCH” mean in the last bullet?
 |
| LG | We think that “for determining sub-slot PUCCH resources” is not clear and can be aligned with “not configured” case. We could also clarify two slot based PUCCHs and one slot based PUCCH as follows:* *if UE is configured with sub-slot based PUCCH, for each sub-slot based PUCCH transmission ~~determining sub-slot PUCCH resources~~, support multiplexing for the same priority and support prioritizing for different priorities.*
* *if UE is* ***NOT*** *configured with sub-slot based PUCCH,*
	+ *for UE supporting~~s~~ ~~to transmit~~ transmission of up to* ***two*** *slot based PUCCHs without overlapping in time domain for HARQ-ACK in a slot, for each slot based PUCCH transmission, support multiplexing for the same priority and support prioritizing for different priorities.*
	+ *for UE supporting ~~transmits~~ transmission of at most* ***one*** *slot based PUCCH for HARQ-ACK in a slot, regardless the PUCCH resources for multicast and unicast are overlapping or not in the same slot, support multiplexing for the same priority and support prioritizing for different priorities.*

Except the concerned part, we are generally fine with this proposal. |
| **ZTE** | It seems the current proposal is not very clear. Regarding the following “for UE supports to transmit two slot based PUCCHs without overlapping in time domain for HARQ-ACK”, based on our understanding, Rel15/16 UE does NOT support two slot-based PUCCHs in one slot. Not sure whether the intention is to increase the UE capability here or do we miss anything?In our view, multiplexing is performed for PUCCHs carrying HARQ-ACK in the same slot no matter whether they are overlapped or not. Prioritization is performed only if PUCCHs of different priority carrying HARQ-ACK are overlapped with other.From our point of view, we would propose the following.*For the cases of HARQ-ACK feedback (at least for ACK/NACK based feedback) is available for multicast and unicast, for determining the PUCCH resource,* * *if UE is configured with sub-slot based PUCCH, for determining sub-slot PUCCH resources,*
	+ *Support multiplexing for the same priority for PUCCH transmissions in the same sub-slot*
	+ *Support prioritizing for different priorities that are overlapping.*
* *if UE is* ***NOT*** *configured with sub-slot based PUCCH, for determining sub-slot PUCCH resources,*
	+ *Support multiplexing for the same priority for PUCCH transmissions in the same slot*
	+ *Support prioritizing for different priorities that are overlapping*
 |
| CATT | Thanks moderator for the great effort on this proposal.The updated proposal above brings more unclear part compared with the previous FL proposal during GTW. It is because the above proposal is based on the condition whether sub-slot based PUCCH is configured or not, which is not quite the intention of this proposal. I would like to suggest using the previous FL proposal as starting point for this round of discussion, because it has clearer discussion direction. Furthermore, the sub-slot configuration can also be added as an condition in the proposal.Proposal:For the cases of HARQ-ACK feedback (at least for ACK/NACK based feedback) is available for multicast and unicast and the PUCCH resources for multicast and unicast are overlapping, for determining the PUCCH resource:* Multiplexing/prioritization can be used
	+ FFS: Details of how multiplexing/prioritization are done
* FFS: The case of HARQ-ACK feedback for multicast and other UCI for unicast.
* FFS: The cases of overlapping, e.g. symbol-level, slot-level.
* FFS: The cases that sub-slot based PUCCH is configured or not.
* FFS: ~~how to determine the PUCCH resource~~ the case for NACK-only based feedback if supported ~~for the cases stated in the main bullet~~.
 |
| Nokia, NSB | We do not support the proposal. We do not see a point in separating the discussion for sub-slot/slot configurations. Any rule in slot based configuration should apply also to sub-slot based configuration, but in sub-slot scale rather than slot scale (as stated in TS 38.213). In order to determine some rules for the UEs sending more than 1 PUCCHs in a (sub-)slot, first we need to discuss and agree on the upper limit of number of PUCCHs including HARQ-ACK sent by the UE in the same (sub-)slot. We would like to keep the previous proposal with modifications:Proposal x: (multiplexing/prioritizing)For the cases of HARQ-ACK feedback is scheduled for multicast and unicast in the PUCCH resources that are overlapping in time, for determining the PUCCH resource:* Multiplexing is applied for the same priority and prioritizing is applied for different priorities.
* FFS the case of HARQ-ACK feedback for multicast and other UCI for unicast.
* FFS the case of HARQ-ACK feedback for multicast and multicast if supported.
 |
| **vivo** | The current proposal is not very clear. Firstly, some clarifications for the current spec1. In Rel-15, PUCCH has no PHY priority, no sub-slot configuration either. A UE can only transmit at most one PUCCH with HARQ-ACK in a slot. For PDSCHs indicated to transmit HARQ-ACK in the same slot via k1, UE constructs one HARQ-ACK codebook to feed back HARQ-ACK for these PDSCHs, and determines one PUCCH resource based on PRI indication in the last DCI.
2. In Rel-16, HARQ-ACK for PDSCH can be indicated/configured as low priority or high priority. Sub-slot can be configured.
	1. If sub-slot is not configured, a UE can transmit at most **one PUCCH with HARQ-ACK in a slot per priority index**.
	2. If sub-slot is configured, a UE can transmit at most **one PUCCH with HARQ-ACK in a sub-slot per priority index**.
	3. HARQ-ACK for a PDSCH can be indicated/configured with low priority or high priority, UE constructs HARQ-ACK codebook and determines PUCCH resource per priority. If the PUCCH resource for low priority HARQ-ACK and PUCCCH resource for high priority HARQ-ACK are overlapped in time-domain (symbol-level), then prioritization is applied.
3. In Rel-16, M-TRP feature is introduced, and the HARQ-ACK feedback mode (i.e., *ackNACKFeedbackMode-r1*6) can be configured as joint or separate. **When *ackNACKFeedbackMode-r1*6 = separate, a UE can transmit two PUCCHs with HARQ-ACK in a slot** (when sub-slot is not configured).

Now, **for unicast and multicast HARQ-ACK feedback, we should first discuss how many PUCCHs with HARQ-ACK in a slot/sub-slot can be transmitted**. Then,* If only one PUCCH with HARQ-ACK can be transmitted in a slot, once a UE is scheduled to transmit HARQ-ACK for unicast and multicast in the same slot, UE need to do multiplexing/prioritization in the slot. UE does not need to construct codebook or determine PUCCH resource separately for unicast and multicast before multiplexing/prioritization.
* If two PUCCHs with HARQ-ACK can be transmitted in a slot, when UE is scheduled to transmit HARQ-ACK for unicast and multicast in the same slot, UE needs to determine PUCCH resource separately for unicast and multicast. Then, if the PUCCH resource for unicast HARQ-ACK and PUCCH resource for multicast are overlapped in time domain (symbol-level), then UE needs to do multiplexing/prioritization. Otherwise, UE just transmits the two non-overlapped PUCCH respectively.

We want to make sure that we are on the same page for UE procedure to do multiplexing/prioritization. |
| **Samsung** | **No need at this time to consider sub-slots for MBS/unicast HARQ-ACK multiplexing. If that is to be supported for Rel-17 MBS, progress in Rel-17 URLLC is first needed. The remaining of the proposal can be simplified as follows:**1. **Define a UE capability for transmission of 2 non-overlapping PUCCHs with unicast HARQ-ACK and multicast HARQ-ACK, respectively, in a slot.**
2. **Support multiplexing of unicast and multicast HARQ-ACK in a PUCCH when the corresponding PUCCH resources overlap in time in a slot.**
 |

## HARQ-ACK codebook

Background

For ACK/NACK based feedback if supported, last meeting agreed to support both Type-1 and Type-2 codebooks and FFS others.

*Agreements:*

*For ACK/NACK based HARQ-ACK feedback if supported, both Type-1 and Type-2 HARQ-ACK codebook are supported for RRC\_CONNECTED UEs receiving multicast,*

* *FFS details of HARQ-ACK codebook design.*
* *FFS whether enhanced Type-2 and/or Type-3 HARQ-ACK codebook is supported or not.*

Submitted Proposals

*The proposals are maybe applicable to both Type-1 and Type-2 HARQ-ACK codebook are listed here:*

* (vivo) Proposal 6:
	+ Regarding HARQ-ACK for multicast PDSCH, the followings need to be discussed/decided.
* Aggregated HARQ-ACK feedback, i.e., 1-bit HARQ-ACK for multiple PDSCHs can be considered
* In case of simultaneous multicast and unicast traffic for the same UE, whether HARQ-ACK for multicast PDSCH and unicast PDSCH can be multiplexed in one HARQ-ACK CB
* (Nokia) Proposal 11:
	+ The UE constructs separate HARQ-ACK sub-codebooks using Rel-15/16 mechanisms for each MBS service and one sub-codebook for unicast services.
* (Nokia) Proposal 12:
	+ The UE concatenates the constructed sub-codebooks and sends them in the same PUCCH resource in case their HARQ-ACK feedback is scheduled for the same time instance (slot or sub-slot).
* (Nokia) Proposal 14:
	+ The PHY identification of PDSCH HARQ-ACK to MBS sub-codebook mapping is the group-common RNTI value.
* (Nokia) Proposal 15:
	+ The UE maps the PDSCH HARQ-ACK of unicast services scrambled with a UE-specific RNTI to the unicast sub-codebook.
* (Nokia) Proposal 16:
	+ Further study is to be conducted on the mechanisms of concatenation of HARQ-ACK sub-codebooks.
* (Nokia) Proposal 17:
	+ In a resource limited system, construction of semi-static HARQ-ACK sub-codebooks per PTM service can be avoided. Instead, for the FDM-ed PDSCH occasions, one unified bit can be included in the HARQ-ACK codebook that is to be constructed using the Rel-15/16 methods.
* (Intel) Proposal 8:
	+ Further study the following options for MBS HARQ codebook design
* Joint codebook with unicast
* Separate HARQ codebook for NR MBS
* (Lenovo) Proposal 10:
	+ HARQ-ACK feedback for PDSCHs scheduled by UE-specific DCI is multiplexed in one sub-codebook and HARQ-ACK feedback for PDSCHs scheduled by the group-common DCI is multiplexed in another sub-codebook.
* (Samsung) Proposal 4:
	+ A UE separately determines Type-2 HARQ-ACK codebooks for MBS and unicast receptions. A UE jointly or separately determines Type-1 HARQ-ACK codebook(s) for MBS and unicast receptions when the UE multiplexes or does not multiplex, respectively, the Type-1 HARQ-ACK codebook(s) in a same PUCCH/PUSCH.
* (Qualcomm) Proposal 4:
	+ Support multiplexing of UE-specific ACK/NACK for unicast and multicast transmission based on UE capability.
* FFS: Type 1, 2, 3 HARQ-ACK codebook for multiplexing unicast and multicast feedback
* (Ericsson) Proposal 7:
	+ The UE does not expect to transmit HARQ feedback in the same slot for PTM and PTP, and PTP and PTM do not share a common codebook. When the UE receives PTM and PTP so that the HARQ feedback is in the same slot for PTM and PTP, the UE applies a rule to drop either PTM or PTP HARQ feedback.
* FFS dropping rule

### Type-1 HARQ codebook

Submitted Proposals

* (ZTE) Proposal 3:
	+ Regarding ACK/NACK feedback for NR MBS for UEs only receiving MBS service, consider the following mechanisms.
* For the Type-1 HARQ-ACK codebook, existing mechanisms can be reused.
* For the Type-2 HARQ-ACK codebook, UE generates one sub-codebook per MBS service and concatenates all the sub-codebooks together.
* (ZTE) Proposal 4:
	+ Regarding ACK/NACK feedback for NR MBS for UEs receiving both unicast and MBS service.
* For Type-1 HARQ-ACK codebook, UE constructs a HARQ-ACK codebook according to the union of the PDSCH TDRA sets of the unicast service and the MBS service.
* For Type-2 HARQ-ACK codebook, UE generates sub-codebook for unicast and MBS service separately and concatenates the sub-codebooks together.
* (Huawei) Proposal 3:
	+ Type-1 HARQ-ACK codebook construction for FDM-ed PDSCH for MBS can refer to the mechanism supported by mTRP. It can also be further optimized to reduce the overhead.
* (CATT) Proposal 14:
	+ Joint codebook determination is considered when Type-1 codebook is used for both MBS and unicast.
* (Nokia) Proposal 18:
	+ Further study is to be conducted on the mechanisms of including one unified bit for the FDM-ed PDSCH occasions to the semi-static HARQ-ACK codebook.
* (vivo) Proposal 3:
	+ For ACK/NACK based HARQ-ACK feedback if supported, for type 1 HARQ-ACK codebook for RRC\_CONNECTED UEs receiving multicast.
* Reuse the existing mechanism to construct a HARQ-ACK codebook for multicast PDSCHs.
* If UE configured to receive multiple FDM PDSCHs in a slot, UE constructs a HARQ-ACK codebook for these multiple PDSCHs separately and then concatenate the codebooks together.
* (Ericsson) Proposal 3:
	+ For NACK-only transmission of HARQ feedback for group scheduling, a semi-static codebook is supported and dynamic codebook is not supported.

#### Round-3

FL’s Comments

Based on the comments received on GTW session, if separate TDRA tables are configured for unicast and multicast, constructing a Type-1 codebook based on the union of TDRA sets at least for the same priority is supported.

The proposal is updated as follows.

FL’s Proposal:

#### Proposal 2.4.1.1: (Type-1 HARQ-ACK codebook)

For ACK/NACK based feedback if supported for multicast, construction of Type-1 HARQ-ACK feedback based on the union of the PDSCH TDRA sets of the unicast service and the multicast service (if they are separately configured), at least of the same priority, is supported

* FFS details of Type-1 codebook construction for FDM-ed unicast and multicast.
* FFS details of Type-1 codebook construction for FDM-ed multicast and multicast if supported.
* FFS: whether/how to optimize the Type-1 codebook construction to reduce the HARQ-ACK feedback payload size.

Collect comments:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| LG | We are fine with this proposal. |
| Lenovo, Motorola Mobility | We are OK with this proposal. |
| ZTE | OK |
| CATT | OK with this proposal.As we asked for clarification during GTW, the “union” in the main bullet means that the HARQ-ACK codebook (Type-1) is jointly generated for both unicast service and multicast service on a PUCCH resource. |
| Nokia, NSB | We support the proposal if the proposal covers the following:We believe that by using the current schemes of semi-static codebook construction, separate HARQ-ACK bits cannot be included in the semi-static codebook corresponding to the FDM-ed unicast and multicast transmissions. Therefore, as in case of Type-2 codebook, the UE should be able to construct separate sub-codebooks and concatenate them (one for unicast services, one per multicast service). Can we get a confirmation that the body of the proposal does not preclude this? Otherwise, we do not support the proposal, because of the aforementioned problem. |
| vivo | Fine with the proposal in general. We think the taking union operation is only needed for the case that unicast PDSCH and multicast PDSCH are TDMed in a slot/in different slots. We also want to clarify the application of the proposal. As comment for proposal 2.3.1.1, UE procedure may be related with the number of PUCCHs a UE can transmit in a slot. For example,* Case 1: If only one PUCCH with HARQ-ACK can be transmitted in a slot, once a UE is scheduled to transmit HARQ-ACK for unicast and multicast in the same slot, UE need to do multiplexing/prioritization in the slot. UE does not need to construct codebook or determine PUCCH resource separately for unicast and multicast before multiplexing/prioritization.
* Case 2: If two PUCCHs with HARQ-ACK can be transmitted in a slot, when UE is scheduled to transmit HARQ-ACK for unicast and multicast in the same slot, UE needs to determine PUCCH resource separately for unicast and multicast. Then, if the PUCCH resource for unicast HARQ-ACK and PUCCH resource for multicast are overlapped in time domain (symbol-level), then UE needs to do multiplexing/prioritization. Otherwise, UE just transmits the two non-overlapped PUCCH respectively.

For case 1, we think there is no problem to apply this proposal. But for case 2, since UE needs to construct HARQ-ACK codebook and determine PUCCH resource separately before multiplexing (step 1). then if we adopt this proposal, that means, when the PUCCH resources for unicast HARQ-ACK and multicast HARQ-ACK are overlapped in time domain, UE needs to run pseudo-code again (using the union of the TDRA table) to re-construct the HARQ-ACK codebook for unicast and multicast. But if we just concatenate the two HARQ-ACK codebooks resulting in step 1, it would be simpler for the UE to implement multiplexing.We want to make sure the proposal covers the above case 1 and case 2? or it can be for case 1 only and we discuss further for case 2. |
| Samsung | OK with the proposal. |

### Enh Type-2 / Type 3 HARQ codebook (pending)

Submitted Proposals

* (Huawei) Proposal 5:
	+ Do not support enhanced type-2 nor type-3 HARQ-ACK codebook for MBS.
* (CATT) Proposal 13:
	+ Rel-17 MBS HARQ-ACK codebook does not support enhanced Type-2 or Type-2 HARQ-ACK codebook.
* (vivo) Proposal 5:
	+ For ACK/NACK based HARQ-ACK feedback if supported, support enhanced type 2 and type 3 HARQ-ACK codebook for RRC\_CONNECTED Ues receiving multicast.
* Whether HARQ-ACK for multicast PDSCH and unicast PDSCH be multiplexed in one HARQ-ACK codebook or not
* (Nokia) Proposal 8:
	+ Enhanced Type-2 and Type-3 HARQ-ACK codebooks that target LBT failure problems for Rel-16 Unlicensed Band are not needed for PTM.
* (Intel) Proposal 9:
	+ For NR MBS, Type 3 HARQ Codebook is not supported.
* (CMCC) Proposal 3:
	+ Enhanced Type-2 and Type-3 HARQ-ACK codebook are not supported for ACK/NACK based HARQ-ACK feedback if supported.
* (Qualcomm) Proposal 3:
	+ For RRC\_CONNECTED Ues, also support Type 3 HARQ-ACK codebook for multicast ACK/NACK based HARQ-ACK feedback.
* (Ericsson) Proposal 8:
	+ Type 2 or Type 3 HARQ-ACK codebooks are not supported for PTM

#### 1st round discussion

FL’s Comments

This question is whether to support enhanced Type-2 and Type-3 HARQ-ACK codebook.

The proponents argue that the MBS transmission in unlicensed band is within the scope of the WI.

One more argument is that gNB can trigger UE to feedback type 3 HARQ-ACK codebook to get the information of PDSCH reception states in a period and use this information for link adaption, or gNB can group multicast PDSCH as group 0 and unicast PDSCH as group 1, and then gNB can trigger UE to feedback HARQ-ACK for multicast PDSCH by UE-specific PDCCH, which can solve the issue that group common PDCCH can’t indicate UE-specific PUCCH resource with one PRI.

The following situation is observed from the submitted proposals:

*Enhanced Type-2 HARQ-ACK codebook:*

* *Support: vivo*
* *Not support: Huawei, CATT, Nokia, CMCC, Ericsson*

*Type-3 HARQ-ACK codebook:*

* *Support: vivo, Qualcomm*
* *Not support: Huawei, CATT, Nokia, Intel, CMCC, Ericsson*

FL’s Proposal:

#### Proposal 2.4.3.1: (Enh Type-2 and Type-3 HARQ-ACK codebook)

For ACK/NACK based feedback for RRC\_CONNECTED Ues receiving multicast, not support

* Enhanced Type-2 HARQ-ACK codebook.
* Type-3 HARQ-ACK codebook.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| CMCC | Support FL’s proposal. |
| Qualcomm | Object to the proposal.We checked the reason mentioned by companies who do not support the enhanced Type 2 and Type 3 for multicast, that those codebooks are too complicated for multicast in licensed band. But during RANP discussion, it was clarified the MBS in unlicensed band is not precluded. At least for that case, enhanced Type 2 and Type 3 can be used for multicast feedback. Also, we see the benefits in licensed band to get unicast and multicast in limited PUCCH resource triggered for a UE. At least for ACK/NACK feedback, the enhanced Type 2 and Type 3 can be configured on UE-specific PUCCH.  |
| Huawei, HiSilicon | Ok with the proposal. At least enh Type-2 /Type-3 should be low prioritized and would like to hear more views.  |
| Samsung | Support the proposal. It is incorrect to say that enhanced Type-2/Type-3 are supported on licensed spectrum. The condition for such support is that the gNB/UE support NR-U – N/A for Rel-17 NTN. Also, on licensed spectrum, Type-3 is always worse than Type-2 (and Type-1/Type-2 are mandatory while enhanced Type-2/Type-3 are optional). |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| Intel | OK with the proposal. Type 3 being a one shot feedback would lead to unnecessary overhead when the number of HARQ processes for MBS is small (expected behaviour) |
| LG | We are fine with this proposal. |
| CATT | Support FL’s proposal. |
| ZTE | Ok with the proposal. If companies have strong concern on this proposal, maybe we can revisit this proposal once type1 and type2 HARQ-ACK codebook are finalized. |
| Spreadtrum | We are fine with the proposal. |
| vivo | Not support the proposal.Some clarifications:1. According to the WID, MBS in unlicensed band is not precluded
2. According to the Rel-16 UE feature discussion, enhanced type 2 and type 3 can also be applied to licensed band.

For type 3 codebook, it is one simple and effective way to get the HARQ-ACK information of scheduled PDSCHs (which may be blocked by other channels with higher priority or DL symbols). If PTM scheme 2 is used for MBS scheduling, all legacy HARQ-ACK codebook types can be directly reused and should not be precluded. |
| Nokia, NSB | Support FL Proposal |
| Ericsson | We agree |

FL’s Comments

From the first round discussion, the following situation is unchanged:

*Enhanced Type-2 HARQ-ACK codebook:*

* *Support: vivo*
* *Not support: Huawei, CATT, Nokia, CMCC, Ericsson, Lenovo, Motorola Mobility*

*Type-3 HARQ-ACK codebook:*

* *Support: vivo, Qualcomm*
* *Not support: Huawei, CATT, Nokia, Intel, CMCC, Ericsson, Lenovo, Motorola Mobility*

FL has no idea on how to proceed, any suggestion that could be agreeable to the entire group is welcome. Any more views/debating if any can proceed by expanding the table in the first round discussion.

[Samsung]: The above two codebooks were designed for operation with shared spectrum (NR-U). They both are optional UE features. They both are worse than the Type-2 HARQ-ACK codebook (mandatory UE feature, also relies on DCI detection) in non-shared spectrum and they will remain so no matter what optimization is done to them. There is no need to spend time on those codebooks.

[QC]: not sure we understand the reason why enhanced Type-2 and Type-3 are worse than the Type-2 HARQ-ACK codebook. We believe different types of codebook are beneficial for different scenarios. The enhanced Type-2 and Type-3 are even further supported for licsened band in Rel-16. The HARQ ACK/ACK feedback for multicast can be per UE configured and we are discussing the multiplexing between multicast and unicast as well. So it is immature to agree with the FL’s proposal.

[Ericsson] For the sake of moving forward, we suggest the use of Type 2 and Type 3 HARQ-ACK codebooks are not discarded but kept for FFS and treated with low priority for now.

[Lenovo, Motorola Mobility]: our views added above.

## Enable/disable HARQ-ACK feedback

Background

*Agreements:*

*Enabling/disabling HARQ-ACK feedback for MBS is supported, further down-select between:*

* *Option 1: DCI*
* *Option 2: RRC configures enabling/disabling*
* *Option 3: RRC configures the enabling/ disabling function and DCI indicates enabling /disabling*
* *FFS: Option 4: MAC-CE indicates enabling/disabling*
* *FFS: Option 5: RRC configures the enabling/ disabling function and MAC-CE indicates enabling /disabling*

Submitted Proposals

* (Futurewei) Proposal 2:
	+ Support option 3 where RRC configures the enabling/ disabling function and DCI indicates enabling /disabling.
* (ZTE) Proposal 10:
	+ Regarding enabling/disabling HARQ-ACK feedback for MBS, option 1, 2 and 4 are supported together.
* Option 1: DCI
* Option 2: RRC configures enabling/disabling
* Option 4: MAC-CE indicates enabling/disabling
* (OPPO) Proposal 9:
	+ DCI based enable/disable HARQ feedback is preferred.
* (Huawei) Proposal 7:
	+ Support that disabling and enabling HARQ feedback is indicated by DCI, and the function of enabling/disabling HARQ-ACK feedback can be RRC configured.
* (CATT) Proposal 3:
	+ Option 1 (DCI-based) and Option 3 (RRC configuration and DCI indication-based) are supported for enabling/disabling HARQ-ACK feedback for MBS.
* (CATT) Proposal 4:
	+ It is up to gNB to determine which mechanism is used for a MBS service, and all UEs in the same group should use the same HARQ-ACK feedback enabling/disabling mechanism.
* (vivo) Proposal 1:
	+ HARQ-ACK feedback for multicast should be RRC configurable.
* (Nokia) Proposal 25:
	+ RRC based enabling/disabling of HARQ-ACK feedback is used for MBS.
* (MediaTek) Proposal 6:
	+ NR multicast HARQ-ACK disable/enable indicator can be defined in DCI.
* (Intel) Proposal 2:
	+ For NR MBS, HARQ feedback should be configurable i.e., it can be enabled or disabled. The following options can be considered for such configuration
* Semi-static configuration through RRC signaling
* Dynamic indication using a single bit in the scheduling DCI for the groupcast transmission
* (Lenovo) Proposal 5:
	+ A non-numerical value is configured in the K1 set and HARQ-ACK feedback for MBS can be enabled or disabled by DCI.
* (LGE) Proposal 7:
	+ Support Option 1 or 3 for enabling/disabling HARQ-ACK feedback.
* (CMCC) Proposal 7:
	+ “Option 1: DCI” and “Option 3: RRC configures the enabling/ disabling function and DCI indicates enabling /disabling” can be supported for enabling/disabling HARQ-ACK feedback for MBS.
* (Samsung) Proposal 3:
	+ Support HARQ-ACK feedback enabling/disabling by UE-specific RRC configuration. Consider further whether to complement the RRC configuration by DCI indication.
* (Apple) Proposal 3:
	+ Enabling/disabling HARQ-ACK feedback and repetition number are dynamic indicated via DCI or MAC CE.
* (Convida) Proposal 4:
	+ For MBS HARQ-ACK feedback enabling/disabling, option 3 (i.e., RRC configures the enabling/ disabling function and DCI indicates enabling /disabling) is supported.
* (Qualcomm) Proposal 5:
	+ For RRC\_CONNECTED Ues, HARQ-ACK feedback can be enabled/disabled at least by RRC signaling.
* The configuration of HARQ-ACK feedback can be configured for a given G-RNTI (corresponding to a service) or for a UE receiving a service.
* FFS: by DCI or MAC-CE
* (Ericsson) Proposal 5:
	+ Enabling/disabling HARQ-ACK feedback for MBS is supported by either RRC configuration or MAC CE ignaling (option 2 and 4).
* (Ericsson) Proposal 6:
	+ In the case of MAC CE, shall include the PUCCH resource indicator so that the UE knows which PUCCH resource to use.

### Round-4

FL’s Comments

*Option 3: LG, Convida, Samsung, Lenovo, CMCC, FutureWei, OPPO, Apple, Spreadtrum, CATT,*

*Nokia, Qualcomm, vivo, and Ericsson would like to support option 2 additionally.*

From the last round discussion, majority (at least 10 companies) support DCI indicating enabling/disabling which is configured by RRC, i.e., if RRC signalling configures the function, DCI indicates (explicitly or implicitly) whether HARQ-ACK feedback is enabled/disabled. If RRC signalling does not configure the function, DCI does not indicate enabling/disabling the feedback. Four companies proposed to support option 2 additionally.

There is also comment to FFS MAC-CE and NACK-only. Since majority is supporting DCI indicating enabling/disabling, MAC-CE would not be necessarily needed. It may not be a good idea to bind the enabling/disabling discussion to the HARQ-ACK feedback options especially when HARQ-ACK feedback options is still pending.

Not sure whether the proponent of option 3 will have concern to support option 2 additionally, I would try the following proposal to support both or defer this discussion to the next meeting given the relation of this proposal and the indication of HARQ-ACK feedback option (if both are supported) is not clear to everybody.

FL’s Proposal:

#### Proposal 2.5.1: (enable/disabling HARQ-ACK feedback)

For enabling/disabling HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast for at least PTM scheme 1, support both:

* Option 3: RRC signalling configures the enabling/ disabling function of DCI indicating the enabling /disabling HARQ-ACK feedback.
	+ If RRC signalling configures the function, DCI indicates (explicitly or implicitly) whether HARQ-ACK feedback is enabled/disabled
		- FFS details on RRC signalling and DCI indicating.
	+ If RRC signalling does not configure the function, DCI does not indicate enabling/disabling the feedback.
		- FFS whether enabling or disabling the feedback is the default mode.
* Option 2: RRC indicates enabling/disabling.

Collect **strong concerns**:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| LG | We support Option 3. We do not support Option 2. We do not understand additional benefit of agreeing Option 2 as well as Option 3. |
| Lenovo, Motorola Mobility | We support Option 3. Option 2 can’t support dynamic enabling /disabling. |
| ZTE | We can compromise to support both Option2 and Option3. However, from our perspective, supporting both Option2 and Option3 essentially equals to our previous proposal of the updated Option3. But anyway, the signaling design can be up to RAN2, it should be clear that it is not precluded to combine Option2 and Option3 in one RRC parameter. Thus, we would propose to add the following note.Note: It is up to RAN2 how to design the RRC signaling for Option2 and Option3 |
| CATT | We support Option 3.Further clarification on Option 3:* RRC signalling configures the function: it means the RRC configuration step is using **explicit signalling configuration**, rather than **implicit method** by configuring the PUCCH resource or not.

Please correct me if my understanding is the right way. Thanks. |
| Nokia, NSB | We are ok with the proposal.However, we believe that Option 3 is not needed, since UE-level enabling/disabling HARQ-ACK is needed, but that cannot be utilized using a group-common DCI without introducing further mechanisms. In addition, our simulation results have shown that DCI level dynamicity is not needed, rather semi-static configuration via RRC is enough. Therefore, we should not be consuming precious PHY level signalling if not needed. We would like to hear the use cases from the companies that support Option 3. |
| vivo | We are fine with the proposal. We share view with Nokia. The motivation to support group-common DCI based dynamic indication is not clear to us. |
| Samsung | It would be simpler to just agree on RRC configuration with optional enabling/disabling by DCI. It is unclear whether something different is intended by the two options.Option 3 is nice for the NW to have and should be optional for the NW to implement and for the UE to support. We have a different understanding of option 3 than Nokia and Vivo. With option 3, enabling/disabling is still UE-specific – for UEs that were configured to report HARQ-ACK based on indication by DCI. But a default UE behavior needs to be defined if the RRC is not provided (e.g. UE reports HARQ-ACK “as usual”). |

## Retransmission (pending)

Background

Agreements:

From the perspective of RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1 initial transmission, retransmission supports, for the purpose of down-selection, options are:

* Option 1: group-common PDCCH scheduled group-common PDSCH
* Option 2: UE-specific PDCCH scheduled PDSCH
	+ Alt 1: PDSCH is UE-specific PDSCH
	+ Alt 2: PDSCH is group-common PDSCH
* Option 3: both option 1 and option 2
* FFS other options
* FFS CBG based retransmission

Submitted Proposals

* (Futurewei) Proposal 4:
	+ Select option 3 for the type of retransmission supported.
* (ZTE) Proposal 6:
	+ Both PTM-based and PTP-based retransmissions can be considered for NR MBS.
	+ CBG-based transmission is not supported for NR MBS.
* (OPPO) Proposal 11:
	+ From the perspective of RRC\_CONNECTED UEs receiving multicast, if the initial transmission is based on PTM scheme 1, re-transmission based on PTP should be supported.
* (Huawei) Proposal 6:
	+ Support both PTP and PTM 1 for MBS retransmission scheduling for the ACK/NACK feedback option, and support only PTM 1 for MBS retransmission scheduling with NACK only feedback option.
* (CATT) Proposal 19:
	+ When PTM scheme 1 is used as initial transmission, retransmission scheme supports PTM scheme 1 and PTP.
* (CATT) Proposal 20:
	+ CBG based PTP retransmission can be supported in multicast retransmission when a UE is configured with CBG transmission for unicast.
* (Nokia) Proposal 1:
	+ Retransmissions are made using the PTM scheme that is used for the corresponding initial transmission, i.e., when initial transmission is made using PTM scheme 1, corresponding retransmissions are made using PTM scheme 1; when initial transmission is made using PTM scheme 2, corresponding retransmissions are made using PTM scheme 2.
* (Nokia) Proposal 2:
	+ CBG-based (re-)transmissions are not supported for PTM (re-)transmissions.
* (MediaTek) Proposal 7:
	+ The PTP mechanism can be supported for multicast service retransmission.
* (Intel) Proposal 10:
	+ For ACK/NACK based HARQ operation, support UE specific CBG based retransmission. Other advanced retransmission schemes are not precluded.
* (Lenovo) Proposal 6:
	+ When PTM transmission scheme 1 is used in initial transmission, with UE-specific ACK/NACK feedback, both PTM transmission scheme 1 and PTP are supported as retransmission scheme.
* (Spreadtrum) Proposal4:
	+ De-prioritize the discussion on CBG based retransmission.
* (Samsung) Proposal 7:
	+ No restriction is introduced for the DCI formats that can schedule a TB reception for a HARQ process to a UE - both a DCI format in a group-common PDCCH and a DCI format in UE-specific PDCCH can be used.
* (Convida) Proposal 5:
	+ For retransmission, option 3 (i.e., both option 1 and option 2) is supported.
* (TD Tech) Proposal 6:
	+ For the PDSCH of the PTM bearer, the PTM transmission scheme 1 is used for the initial transmission and the retransmission. The code group based retransmission can be supported by PTM transmission scheme 1.
* (Ericsson) Proposal 10:
	+ The discussion for retransmission support is moved to agenda 8.12.1

### Retransmission schemes

#### 1st round discussion

FL’s Comments

In AI 8.12.1, last meeting agreed PTM scheme 1 is supported for retransmission if the initial transmission is PTM scheme 1.

*Agreements****:*** *For RRC\_CONNECTED UEs, if initial transmission for multicast is based on PTM transmission scheme 1, at least support retransmission(s) can use PTM transmission scheme 1.*

* *FFS: whether to support PTP transmission for retransmission(s).*
* *FFS: whether to support PTM transmission scheme 2 for retransmission(s).*
* *FFS: How to indicate the association between PTM scheme 1 and PTP transmitting the same TB.*
* *FFS: If multiple retransmission schemes are supported, then can different retransmission schemes be supported simultaneously for different UEs in the same group?*

AI 8.12.1 will continue discussion of scheduling schemes including initial retransmission and retransmission. This discussion in AI 8.12.2 will focus on what retransmission scheme will be supported for a specific HARQ-ACK feedback option.

FL’s Proposal:

#### Proposal 2.6.1.1: (retransmission schemes)

For retransmission schemes for RRC\_CONNECTED UE receiving multicast,

* for ACK/NACK based HARQ-ACK feedback if supported, support PTP and PTM scheme 1;
* for NACK-only based HARQ-ACK feedback if supported, support PTM scheme 1.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| CMCC | Not support.Considering most companies have discussed this issue in the Tdocs in AI 8.12.1, we find 12 companies propose to support PTP for retransmission and 6 companies propose to also support PTM transmission scheme 2 for retransmission. Therefore, we suggest to discuss this issue in AI 8.12.1. |
| Qualcomm | Fine with the proposal. |
| MTK | Support the proposal. |
| OPPO | We can wait the agreement for re-transmission schemes discussed in AI 8.12.1. Then we can discuss the HARQ feedback based on that.  |
| Huawei, HiSilicon |  Ok with the proposal. The discussion can be separate or isolated from AI 8.12.1 as Chairman suggested in the first meeting from different angle. For example, retransmission in AI 8.12.2 can be discussed in association with a specific HARQ-ACK feedback option.  |
| Samsung | Support the proposal. There is no reason to restrict the RNTI that can be used to schedule a PDSCH (also not done in Rel-15).  |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| Intel | We think for ACK/NACK based feedback mode PTM scheme 2 should also be listed in the options since neither PTP nor PTM Scheme 2 are agreed yet.  |
| LG | We prioritize NACK only based HARQ-ACK feedback for PTM scheme 1 |
| Apple | We are ok with this proposal. |
| CATT | We are generally OK with the direction and discussion on this proposal, but maybe we can wait until the Tx and re-Tx schemes are determined in 8.12.1.Furthermore, as Intel mentioned, we also think that PTM scheme 2 should be listed in the first sub-bullet. |
| ZTE | We are fine with the proposal, and also okay to discuss this issue in AI 8.12.1. |
| Spreadtrum | We prefer to discussion this issue after the discussion on retransmission scheme in AI 8.12.1. |
| vivo | The retransmission scheme may be dependent on the initial transmission scheme, we suggest to discuss this issue in AI 8.12.1. |
| Nokia, NSB | As per our Tdoc, we show that PTP retransmissions will incur significant overhead compared to PTM, since on average 30% of the UEs (based on our simulation assumptions) in the PTM group would need PTP based retransmissions to be scheduled on distinct physical resources.We would prefer a revised proposal where the PTP is left as an FFS until we see more evidence/reasons to justify its inclusion.For retransmission schemes for RRC\_CONNECTED UE receiving multicast, • for ACK/NACK based HARQ-ACK feedback if supported, support PTM scheme 1* FFS If PTP based retransmissions are also supported.

• for NACK-only based HARQ-ACK feedback if supported, support PTM scheme 1.  |
| Ericsson | We agree |
| Convida  | We also think that PTM scheme 2 should be listed. We are OK to discuss this issue in AI 8.12.1. |

FL’s Comments

There are some comments to list PTM scheme 2 into the proposal, which is still being discussed in AI 8.12.1. FL would suggest we can hold it on for a while and see if more progress can go on in AI 8.12.1.

### CBG based retransmission

#### 1st round discussion

FL’s Comments

Five companies submitted proposals regarding CBG based retransmission for multicast. Two companies support it, two companies don’t support it, and the other company propose to deprioritize it. The opponent of this proposal argues that UEs in an MBS group may have different CBGs that need to be retransmitted. In the end, the base station may transmit all CBGs in one TB.

Given this situation, moderator suggests FFS CBG based retransmission.

FL’s Proposal:

#### Proposal 2.6.2.1: (CBG based retransmission)

FFS on whether support CBG based retransmission for RRC\_CONNECTED UE receiving multicast.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| CMCC | Support FL’s proposal. |
| FUTUREWEI | We are OK to deprioritize CBG discussion |
| Qualcomm | Agree to further study CBG configuration for multicast. |
| MTK | CBG based retransmission is more complicated for multicast HARQ transmission considering so many Ues in one MBS group. We suggest not to discuss it in Rel-17 MBS. |
| OPPO | Agree with FUTUREWEI to deprioritize this.  |
| Huawei, HiSilicon |  ok |
| Samsung | Can be deprioritized.  |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| Intel  | OK with FFS |
| LG | We propose to deprioritize CBG based retransmission for MBS |
| Apple | Agree to deprioritize. |
| CATT | OK with the proposal, and deprioritized this discussion. |
| ZTE | Fine with the proposal.  |
| vivo | Ok with FFS |
| Nokia, NSB | We don’t support this proposal for the reason below, but can leave this deprioritized and/or FFSFrom our analysis error events in different CBs are heavily correlated considering that CBs are mapped to resources first in frequency and then in time direction. Thus, only in case of mixed UL-DL slots and different mixed slot formats in different cells, would CBG-based (re-)transmissions provide practical benefits to the system performance. Therefore, we believe that CBG-based retransmissions should not be specified for PTM |
| Ericsson | We agree |
| Convida | We are OK with FFS.  |

FL’s Comments

No update to the proposal.

# PDSCH repetition

Background

*Agreements:*

*For slot-level repetition for group-common PDSCH of RRC\_CONNECTED UEs, for indicating the repetition number, further down-select among:*

* *Opt 1: by DCI*
* *Opt 2: by RRC*
* *Opt 3: by RRC+DCI*
* *FFS: Opt 4: by MAC-CE*
* *FFS: Opt 5: by RRC+MAC-CE*
* *FFS details for each option.*
* *FFS further enhancements for configuration of slot-level repetition*

Submitted Proposals

* (Futurewei) Proposal 3:
	+ Support either Opt 1 or Opt 3 for indicating the number of repetitions.
* (ZTE) Proposal 13:
	+ For slot-level repetition for group-common PDSCH of RRC\_CONNECTED UEs, the repetition number is configured via RRC.
* (ZTE) Proposal 14:
	+ Slot-level repetition of group-common PDSCH is also supported for UEs in RRC\_IDLE/INACTIVE states.
* (OPPO) Proposal 10:
	+ Repetition number indicated in RRC signalling is preferred.
* (Huawei) Proposal 10:
	+ RRC configuration and DCI indicating can be used for NR MBS PDSCH repetition indication.
* (vivo) Proposal 1:
	+ For PDSCH repetition of group-common PDSCH,
* NR Rel-15/16 existing options (i.e., RRC or DCI) for indicating the repetition number should be adopted.
* The PDSCH repetition numbers for different MBS services should be separately configured.
* (Nokia) Proposal 20:
	+ For slot-level repetition of group-common PDSCH of RRC\_CONNECTED UEs, for indicating the repetition number, RRC signalling is used.
* (Nokia) Proposal 21:
	+ Different repetition numbers can be configured for each PTM service.
* (Intel) Proposal 12:
	+ NR MBS supports dynamic indication of number of repetitions for PDSCH transmissions with slot-based repetitions and the configuration is provided as part of the TDRA table through UE-specific RRC signaling.
* (Lenovo) Proposal 11:
	+ The number of transmission repetitions for MBS PDSCH is configured by RRC signaling.
* (Spreadtrum) Proposal3:
	+ For indicating the MBS PDSCH repetition number, support Opt 2 and Opt 3.
* (LGE) Proposal 8:
	+ Support Option 1 or 3 for repetitions of group common PDSCH.
* (CMCC) Proposal 9:
	+ For slot-level repetition for group-common PDSCH for NR MBS, the repetition number can be indicated by RRC and DCI, and no additional enhancements are needed.
* (Samsung) Proposal 6:
	+ For slot-level repetitions of a MBS PDSCH transmission, a 2-bit field in the DCI format is used to indicate 1, 2, 4, or 8 repetitions.
* (Apple) Proposal 3:
	+ Enabling/disabling HARQ-ACK feedback and repetition number are dynamic indicated via DCI or MAC CE.
* (Qualcomm) Proposal 6:
	+ Support independent repetition configuration for GC-PDSCH with different G-RNTIs.
* (Qualcomm) Proposal 7:
	+ Support independent repetition configuration for dynamic GC-PDSCH and SPS GC-PDSCH.
* (Qualcomm) Proposal 8:
	+ Support semi-static and dynamic slot-level repetition for GC-PDSCH by using existing schemes for unicast PDSCH repetition indication.
* Semi-static and dynamic repetitions for GC-PDSCH are not simultaneously configured for the GC-PDSCH associated with same G-RNTI
* (Ericsson) Proposal 9:
	+ Options 2&3 are already supported by specifications while option 4 is considered for FFS.

### Round-4

FL’s Comments

Based on the refinement from Futurewei and Qualcomm, the proposal is updated as following.

As to the comment from ZTE that “the last bullet is not aligned with the current specification (copied below)”, what you cited from spec is for PUSCH repetition. What I proposed is for PDSCH repetition, and the proposal is aligned with spec regarding PDSCH repetition introduced in MTRP.

From TS 38.214:

“If a UE is configured with higher layer parameter *repetitionNumber* or if the UE is configured by *repetitionScheme* set to one of 'fdmSchemeA', 'fdmSchemeB' and 'tdmSchemeA', the UE does not expect to be configured with *pdsch-AggregationFactor.*”

FL’s Proposal:

#### Proposal 3.1.1: (PDSCH repetition)

For slot-level repetition for group-common PDSCH for RRC\_CONNECTED UEs receiving multicast,

* (Config A) UE can be optionally configured with *pdsch-AggregationFactor*.
* (Config B) UE can be optionally configured with TDRA table with *repetitionNumber* as part of the TDRA table.
* If UE is configured with Config B, UE does not expect to be configured with Config A for the same group-common PDSCH.

Collect **strong concerns**:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| Lenovo, Motorola Mobility | Does this proposal support both RRC configured repetition and DCI based repetition? |
| ZTE | Thank you FL for the clarification. We are fine with the above proposal with your clarification. |
| CATT | The intention of this proposal was to discuss about the indication method on PDSCH repetition. The current wording seems like the indication discussion is skipped and RRC configuration (Opt. 2) rather than RRC+DCI (Opt. 3) is applied.It would be better to be clarified which indication option is selected before we go further on the configuration part. |
| Nokia, NSB | Support the proposal. |
| vivo | Fine with the proposal. |
| Samsung | OK with the proposal. |

# CSI feedback (pending)

Background

Agreements:

FFS whether CSI feedback enhancement is needed for MBS, including but not limited:

* New CQI measurement
* New CSI report formats
* Targeted BLER
* CSI-RS configuration
* A-CSI-RS transmission triggering
* SRS configuration

Submitted Proposals

* (ZTE) Proposal 15:
	+ UE supports reporting multiple candidate {CQI, PMI, RI} sets in one CSI report for MBS.
* (ZTE) Proposal 16:
	+ RAN1 further discusses the issues on CSI subband determination for MBS transmission.
* If common frequency resource is defined as an MBS frequency region within the unicast BWP, mechanism to align different UE’s CSI subband size is needed.
* If common frequency resource is defined as an MBS BWP, no additional mechanism is needed (i.e., just reusing the previous MBS mechanism).
* (Huawei) Proposal 11:
	+ CSI feedback mechanism used in NR unicast can be applied to NR MBS without any enhancements.
* (CATT) Proposal 21:
	+ CSI feedback enhancement for MBS can be further studied and discussed but with low priority.
* (Nokia) Proposal 22:
	+ When using NACK-only based HARQ feedback along with CSI reporting, CQI measurements are done based on actual (time-averaged) BLER measurements at the UEs, rather than (instantaneous) CSI-RS based measurements.
* (Nokia) Proposal 23:
	+ New compact CSI report formats are defined for multicast transmission, where only a CQI or CQI along with an RI can be reported, and these formats are used in CSI reporting when NACK-only based HARQ feedback on group-common PUCCH resources is used.
* (Nokia) Proposal 24:
	+ The configuration for CQI reporting for PTM is extended to include not only the reliability target but also the number of HARQ transmissions per transport block after which the reliability target should be met.
* (Intel) Proposal 11:
	+ No further enhancements to NR CSI feedback mechanism is needed for NR MBS
* (CMCC) Proposal 10:
	+ CSI feedback mechanism in Rel-15/16 can be used for NR MBS, and no additional enhancements are needed.
* (Samsung) Proposal 8:
	+ Support CSI-RS triggering by the DCI format scheduling MBS PDSCH or by a GC-DCI format.
* (Samsung) Proposal 9:
	+ Support configuration of multiple *CSI-ReportConfig* for MBS to a UE.
* (Qualcomm) Proposal 9:
	+ For RRC\_CONNNECTED UES, configure the CSI-RS resource per MBS BWP.
* CSI-RS bandwidth is limited within the MBS BWP.
* CSI-RS power is associated with GC-PDSCH power.
* (Qualcomm) Proposal 10:
	+ Support GC-PDCCH to trigger A-CSI-RS transmission in MBS BWP.
* (Qualcomm) Proposal 11:
	+ For RRC\_CONNECTED UEs, support beam management for multicast assisted by unicast connection.
* (Qualcomm) Proposal 12:
	+ Consider SRS configuration for CSI measurement of multicast transmission in MBS BWP.
* (Ericsson) Proposal 11:
	+ The existing Rel. 15/16 framework of periodic CSI feedback is reused for multicast/PTM with no further additions.
* FFS use of periodic or aperiodic CSI feedback for PTM.

## 1st round discussion

FL’s Comments

Nine companies submitted proposals for this issue. Four companies propose no further enhancement is needed for multicast or the discussion can be low prioritized. There are other proposals regarding detailed enhancement for CSI feedback, including defining new CSI for multicast, new CSI reports or configuration of the reports for multicast, CSI report triggering, beam management, etc.

Before diving into details, maybe the first issue can be aligned within the group is whether additional specific CSI reporting configuration is needed for multicast when people proposing no enhancement or the current CSI feedback framework can be reused for multicast.

FL’s Proposal:

#### Proposal 4.1: (CSI for multicast)

For RRC\_CONNECTED UE receiving multicast, whether UE needs CSI feedback configuration for multicast specifically,

* Option 1: Yes.
* Option 2: No.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| CMCC | We prefer option 2, it is network’s implementation to configure a proper CSI measurement and report configuration for UE to reflect the CSI of multicast transmission, but doesn’t need define specific CSI feedback configuration for multicast. |
| Qualcomm | We prefer Option 1.The multicast beam will be different from unicast beam. The CSI-RS resource(s) for multicast measurement should be common to the group of UEs configured with same MBS common frequency resource. If the UE-specific CSI-RS is configured out of MBS common frequency resource, different power relative to PDSCH DMRS, or different UL grant to trigger A-CSI-RS, it leads to separate CSI-RS required per UE, wasting the network spectrum efficiency.  |
| OPPO | Option 2 is preferred. |
| Huawei, HiSilicon | Reading comment from Qualcomm, actually I was thinking unicast needs more for CSI feedback in which case UE will be configured with CSI measurement for unicast dedicated BWP anyway, regardless whether the CSI-RS is within or out of the common frequency resources. On top of that, configuring additional CSI-RS for multicast would be instead degrading NW SE.  |
| Samsung | Support Option 1.Option 2 does not work in several cases such as if different BLERs are targeted for MBS and unicast, or if different frequency regions are used, etc. *FL’s response: the common frequency resources is confined within unicast BWP,UE for unicast CSI measurement can be configured with a report to correspond to the common resources even if the CSI is different between unicast and multicast.*  |
| Lenovo, Motorola Mobility | Option 2 is preferred. |
| Intel | We support Option 2 with the understanding that if MBS frequency resource is contained within the unicast BWP, the CSI report for the unicast BWP suffices.  |
| LG | We prefer Option 2. |
| Apple | Option 2 is preferred. Don’t see the strong motivation to introduce MSB specific CSI feedback configuration. |
| CATT | Option 2. |
| ZTE | We prefer Option 1. The current CSI reporting mechanism and reporting quantity are designed for unicast transmission, there may be some enhancement room for multicast transmission, which is targeting a group of UEs instead of single UE. The link adaptation for MBS transmission should take into account the requirements of a group of UEs. Therefore, each UE can be required to feedback multiple candidate {CQI, PMI, RI} sets, such as the optimal {CQI, PMI, RI} set and suboptimal {CQI, PMI, RI} set. So that gNB can learn more comprehensive channel status information of each UE in the group of UEs. Based on such information, gNB can schedule the MBS PDSCH with a more appropriate applicable MCS and precoding.Subband size is another problem to be considered in CSI feedback used for MBS transmission. The bandwidth of common frequency resource for MBS may be smaller than a unicast BWP, so the subband size suitable for the common frequency resource may be different from the subband size suitable for the unicast BWP. In order to schedule a group of UEs on the common frequency resource, the gNB should be reported the CSI feedback with aligned subband size from different UEs. Therefore, in order to get CSI feedback that is applied in MBS transmission link adaptation, the subband size should be common for common frequency resource for MBS transmission for all UEs. *FL’s response: UE can be configured with multiple CSI reports, and one or more than one reports can be targeted to serve multicast but the configuration framework for unicast can be unchanged.*  |
| Spreadtrum | We prefer Option 2 |
| vivo | Option 2 is slightly preferred. we can see more companies’ views. |
| Nokia, NSB | We prefer Option 1 |
| Ericsson | We think the Proposal needs to be reformulated. With the existing CSI framework, a UE may be configured with multiple CSI reports, which are generally applicable and therefore independent from unicast vs multicast. A subset of configured CSI reports may be used with multicast, but these are not logically tied to multicast, but general. We therefore do not think there is any need for a dedicated unicast or multicast CSI configurations and we think the required functionality exists already with the existing CSI framework, so no extension is needed.*FL’s response: I agree with what you explained and I hope people should be on the same page. However, the attempt of the proposal is trying to exploit the essence of discussion when commenting “yes” or “no” to whether CSI enhancement is needed.*  |

## 2nd round discussion

FL’s Comments

The following summarized the status after the first round discussion

*For RRC\_CONNECTED UE receiving multicast, whether UE needs CSI feedback configuration for multicast specifically,*

* *Option 1: Yes.*
	+ *Support: Qualcomm, Samsung, ZTE, Nokia,*
* *Option 2: No.*
	+ *Support: CMCC, OPPO, Lenovo, Intel, LG, CATT, Spreadtrum, vivo, Ericsson. Huawei*

Given this situation, I would suggest tying the following updated proposal. If not agreeable, we can step back to have this issue FFS.

FL’s Proposal:

#### Proposal 4.1: (CSI for multicast)

For RRC\_CONNECTED UE receiving multicast, whether UE needs CSI feedback configuration for multicast specifically,

* ~~Option 1: Yes.~~
	+ ~~FFS spec impact.~~
* Option 2: No.
	+ No enhancement to the current CSI reporting procedure.

Collect concerns:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| LG | We are fine with removal of Option 1. |
| Nokia, NSB | Do not support.We have provided technical reasoning for necessary enhancements in unicast CSI feedback mechanism in our contribution to RAN1-103e and RAN1-104e meetings, along with simulation results. We ask companies who are against enhancements to either present technical reasons/evidence why they are against and/or question the extensive analysis we present in our contributions. |
| Samsung | At least the triggering mechanism should be kept for further discussion. It should not be expected that all UEs have UL traffic or that the network will transmit UL grants just to get a CSI report.  |
| Qualcomm | Not agree.The CSI-RS for the same UE group should be common for multicast. The configuration and triggering schemes should be futher considered. |
| ZTE | Not agree.From our perspective, the reporting mechanism can be further considered. We don’t see the need to preclude any potential enhancements for CSI for MBS in such a early stage. |
| CATT | Support this proposal. |
| Ericsson |  |

# Other miscellaneous proposals

Submitted Proposals

* (OPPO) Proposal 12:
	+ For a UE receiving group-common PDSCH transmitted with PTM scheme 1 a TPC-PUCCH-RNTI different from that for unicast should be configured.
* (CATT) Proposal 17:
	+ To support multi-beam transmission in MBS, gNB can transmit same MBS data on all SSB beams.
* (CATT) Proposal 18:
	+ UE can receive MBS data from neighbor SSB-beam, and the soft-combination is used to improve the reliability of MBS receptions.
* (MediaTek) Proposal 8:
	+ The total HARQ process number (e.g., 16) is unchanged for UE receiving unicast and multicast service.
* (MediaTek) Proposal 9:
	+ Independent HARQ process is allocated at gNB to PTM and PTP for downlink multicast transmission.
* (MediaTek) Proposal 1:
	+ A combined HARQ process is allocated at UE to receive the data from both PTM and PTP HARQ process.
* (Intel) Proposal 7:
	+ For NR MBS, no additional HARQ processes are defined and MBS shares HARQ process ID with unicast i.e., the total of 16 HARQ processes is unchanged.
* (LGE) Proposal 5:
	+ Different group common PUCCH resources can be related to different RS e.g. in terms of PRB and/or sequence for PUCCH.
* (Apple) Proposal 4:
	+ To enhance the MBS reception reliability, the following schemes can be considered for RRC\_CONNECTED UEs
* Frequency hopping
* Cross-slot channel estimation
* Enhanced CSI report

FL’s Comments

The proposals listed in this section are either interested by very few company, or should be discussed in AI 8.12.1 in moderator’s judgement. Moderator does not plan to come up with proposals for initial rounds of discussion and see the discussing situation later on to decide whether to proceed.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments**  |
| LG | Regarding CATT’s proposals, we think that gNB can transmit same MBS data on all SSB beams for broadcast and selective SSB beams for multicast based on HARQ-ACK feedback.  |
| CATT | Thanks LG for mentioning this proposal.It is beneficial for gNB transmitting the same MBS data on all beams for reception UEs to do combination which can improve the reliability. |
| Ericsson | We agree |
| Nokia, NSB | Regarding CATT’s proposal, we think that different redundancy versions might be used on the different SSBs to enhance soft-combining gain for UEs receiving multiple beams. |

# Summary

# References

1. R1-2100049 Discussion on improving reliability for RRC\_CONNECTED UEs FUTUREWEI
2. [R1-2100107](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100107.zip) Discussion on mechanisms to Improve Reliability for RRC\_CONNECTED UEs ZTE
3. [R1-2100145](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100145.zip) UL feedback for RRC-CONNECTED UEs in MBMS OPPO
4. [R1-2100190](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100190.zip) Mechanisms to improve reliability for RRC\_CONNECTED UEs Huawei, HiSilicon
5. [R1-2100355](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100355.zip) Discussion on reliability improvement mechanism for RRC\_CONNECTED UEs in MBS CATT
6. [R1-2100470](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100470.zip) Discussion on mechanisms to improve reliability for RRC\_CONNECTED UEs vivo
7. [R1-2100511](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100511.zip) Reliability Improvements for RRC\_CONNECTED UEs Nokia, Nokia Shanghai Bell
8. [R1-2100557](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100557.zip) Reliability improvement for RRC\_CONNECTED UEs in MBS Potevio Company Limited
9. [R1-2100614](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100614.zip) Discussion on HARQ operation for NR MBS reliable transmission MediaTek Inc.
10. [R1-2100675](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100675.zip) Mechanisms to Improve Reliability of NR-MBS for RRC\_CONNECTED UEs Intel Corporation
11. [R1-2100699](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100699.zip) Views on retransmission procedure for NR MBS Google Inc.
12. [R1-2100769](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100769.zip) Discussion on reliability improvement for RRC-CONNECTED UEs Lenovo, Motorola Mobility
13. [R1-2100806](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100806.zip) Mechanisms to improve reliability for RRC\_CONNECTED UEs Spreadtrum Communications
14. [R1-2100907](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100907.zip) Mechanisms to improve reliability of Broadcast/Multicast service LG Electronics
15. [R1-2100957](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100957.zip) Discussion on mechanisms to improve reliability for RRC\_CONNECTED UEs ETRI
16. [R1-2101064](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101064.zip) Discussion on reliability improvement CMCC
17. [R1-2101235](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101235.zip) On mechanisms to improve reliability for RRC\_CONNECTED UEs Samsung
18. [R1-2101360](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101360.zip) Discussion on MBS reliability improvement for RRC\_connected UEs Apple
19. [R1-2101425](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101425.zip) On reliability enhancement for NR multicast and broadcast Convida Wireless
20. [R1-2101488](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101488.zip) Views on UE feedback for Multicast RRC\_CONNECTED UEs Qualcomm Incorporated
21. [R1-2101637](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101637.zip) Study on the reliability for RRC\_CONNECTED UEs CHENGDU TD TECH LTD.
22. [R1-2101727](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101727.zip) Discussion on reliability mechanisms for NR MBS Ericsson

# Appendix Agreements summary for AI 8.12.2

## 102e

Agreements:

For RRC\_CONNECTED UEs, HARQ-ACK feedback is supported for multicast and no additional evaluation is needed to justify this.

* + FFS: The detailed HARQ-ACK feedback solutions, e.g., ACK/NACK based, NACK-only based.
	+ FFS: HARQ-ACK feedback can be optionally disabled and/or enabled.

Agreements:

* For RRC\_CONNECTED UEs, at least support slot-level repetition for group-common PDSCH.
	+ FFS: whether enhancement is needed

Agreements:

* For RRC\_CONNECTED UEs, existing CSI feedback can be used for multicast transmission.
	+ FFS: whether enhancement is needed

## 103e

Agreements:

For RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1, support at least one of the following:

* ACK/NACK based HARQ-ACK feedback for multicast,
	+ From per UE perspective, UE feedback ACK or NACK.
	+ From UEs within the group perspective,
		- FFS: PUCCH resource configuration for ACK/NACK feedback e.g., shared or separate PUCCH resources.
	+ FFS details including conditions for it to be used
* NACK-only based HARQ-ACK feedback for multicast,
	+ From per UE perspective, UE only feedback NACK.
	+ From UEs within the group perspective~~, further down-select between:~~
		- FFS: PUCCH resource configuration for NACK only feedback.
	+ FFS details including conditions for it to be used
* To decide in RAN1#104-e whether or not to support only one or both of the above schemes
	+ If both are supported, FFS configuration/selection of ACK/NACK-based and NACK-only based HARQ-ACK feedback

Agreements:

For RRC\_CONNECTED UEs receiving multicast, for ACK/NACK based HARQ-ACK feedback if supported for group-common PDCCH scheduling, PUCCH resource configuration for HARQ-ACK feedback from per UE perspective is, down-select one of the following options:

* Option 1: shared with PUCCH resource configuration for HARQ-ACK feedback for unicast
* Option 2: separate from PUCCH resource configuration for HARQ-ACK feedback for unicast
* Option 3: Option 1 or option 2 based on configuration

Agreements:

For RRC\_CONNECTED UEs receiving multicast, for NACK-only based HARQ-ACK feedback if supported for group-common PDCCH scheduling, PUCCH resource configuration for HARQ-ACK feedback from per UE perspective is separate from PUCCH resource configuration for HARQ-ACK feedback for unicast.

* FFS PUCCH format

Agreements:

Enabling/disabling HARQ-ACK feedback for MBS is supported, further down-select between:

* Option 1: DCI
* Option 2: RRC configures enabling/disabling
* Option 3: RRC configures the enabling/ disabling function and DCI indicates enabling /disabling
* FFS: Option 4: MAC-CE indicates enabling/disabling
* FFS: Option 5: RRC configures the enabling/ disabling function and MAC-CE indicates enabling /disabling

Agreements:

For slot-level repetition for group-common PDSCH of RRC\_CONNECTED UEs, for indicating the repetition number, further down-select among:

* Opt 1: by DCI
* Opt 2: by RRC
* Opt 3: by RRC+DCI
* FFS: Opt 4: by MAC-CE
* FFS: Opt 5: by RRC+MAC-CE
* FFS details for each option.
* FFS further enhancements for configuration of slot-level repetition

Agreements:

From the perspective of RRC\_CONNECTED UEs receiving multicast, at least for PTM scheme 1 initial transmission, retransmission supports, for the purpose of down-selection, options are:

* Option 1: group-common PDCCH scheduled group-common PDSCH
* Option 2: UE-specific PDCCH scheduled PDSCH
	+ Alt 1: PDSCH is UE-specific PDSCH
	+ Alt 2: PDSCH is group-common PDSCH
* Option 3: both option 1 and option 2
* FFS other options
* FFS CBG based retransmission

Agreements:

FFS whether CSI feedback enhancement is needed for MBS, including but not limited:

* New CQI measurement
* New CSI report formats
* Targeted BLER
* CSI-RS configuration
* A-CSI-RS transmission triggering
* SRS configuration

Agreements:

For ACK/NACK based HARQ-ACK feedback if supported, both Type-1 and Type-2 HARQ-ACK codebook are supported for RRC\_CONNECTED UEs receiving multicast,

* FFS details of HARQ-ACK codebook design.
* FFS whether enhanced Type-2 and/or Type-3 HARQ-ACK codebook is supported or not.

Agreement:

For ACK/NACK based feedback if supported for RRC\_CONNECTED UEs receiving multicast, UE can be optionally configured a separate *PUCCH-Config* for multicast. Otherwise, *PUCCH-Config* for unicast applies.

Agreement:

The priority for HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast can be,

* Lower, higher than or equal to the HARQ-ACK feedback for unicast
	+ FFS: How to reflect the priority in specification, e.g., whether it is configured or indicated to the UE
	+ FFS: The total number of priorities across multicast and unicast
* FFS the priority between HARQ-ACK feedback for multicast and other UCI for unicast (SR, CSI) or PUSCH for unicast.

Agreement:

For ACK/NACK based feedback if supported for multicast, for Type-2 HARQ-ACK feedback construction for PTM scheme 1,

* DAI for unicast and DAI for multicast are separately counted.
* Concatenation of Type-2 HARQ-ACK codebook for unicast and multicast is supported.
	+ FFS details on concatenating the codebooks.
* FFS whether to support concatenating more than one Type-2 HARQ-ACK codebook for multicast.