**3GPP TSG RAN WG1 Meeting #104-e R1-200xxxx**

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

**Agenda Item: 8.12.2**

**Source: Moderator (Huawei)**

**Title: FL summary#1 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

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 issue  3. 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

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. |

## 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 ACK/NACK based feedback

Submitted Proposals

* (ZTE) Proposal 1:
  + Regarding ACK/NACK feedback for NR MBS, PUCCH resource is separately configured and determined for each UE in the same MBS group sharing the same K1 and PRI.
* From per UE perspective, PUCCH resource configuration for HARQ-ACK feedback for NR MBS is shared with PUCCH resource configuration for HARQ-ACK feedback for unicast.
* From per UE perspective, PUCCH resource set configuration for HARQ-ACK feedback for NR MBS is shared with PUCCH resource set configuration for HARQ-ACK feedback for unicast.
* (ZTE) Proposal 2:
  + Regarding ACK/NACK feedback for NR MBS, UE determines the PUCCH resource for ACK/NACK feedback for NR MBS based on the last unicast PDCCH if UE receives both unicast and multicast.
* (OPPO) Proposal 3:
  + For ACK/NACK based feedback and NACK only based feedback for multicast, RSRP based PUCCH resource configuration is supported.
* (OPPO) Proposal 7:
  + The following option is supported for PUCCH resource configuration for ACK/NACK based HARQ-ACK feedback:
* Option 1: shared with PUCCH resource configuration for HARQ-ACK feedback for unicast
* (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.
* (CATT) Proposal 1:
  + Different PUCCH format can be configured by gNB to adapt different coverage requirement.
* (CATT) Proposal 6:
  + For PUCCH resource configuration for HARQ-ACK feedback from per UE perspective, shared and separate method can be supported based on configuration.
* (CATT) Proposal 7:
  + For shared PUCCH resource scheme, how to design codebook should be further studied in details.
* (CATT) Proposal 16:
  + For HARQ-ACK feedback mechanism in MBS, the following methods can be considered:
* UE-specific PDCCH to indicate PUCCH resources for common PDSCH.
* Group-common PDCCH to indicate PUCCH resource for common PDSCH.
* Multiple group-common PDCCHs to indicate PUCCH resources for common PDSCH.
* Group-common PDCCH to indicate UE-specific periodic PUCCH resources.
* DCI of UE-specific PDCCH to indicate PUCCH resources for MBS.
* (Nokia) Proposal 4:
  + In case UE-specific PUCCH resources are to be used for PTM ACK / NACK feedback, the PUCCH resource scheduling should as far as possible be based on a group-common PDCCH containing a single PRI, which based on UE-specific configurations of PUCCH resource sets indicates UE-specific PUCCH resources.
* (Nokia) Proposal 5:
  + In case UE-specific PUCCH resources are to be used for PTM ACK / NACK feedback, option 2 (PUCCH resource set separate from PUCCH resource sets for HARQ-ACK feedback for unicast) should be used.
* (Potevio) Proposal 2:
  + For RRC\_CONNECTED UEs, PUCCH resource for ACK/NACK based HARQ-ACK feedback for multicast should be at least shared with PUCCH resource for HARQ-ACK feedback for unicast.
* (Intel) Proposal 4:
  + For ACK/NACK based HARQ feedback, PUCCH resource configuration can be shared with or separate from that of unicast HARQ feedback based on configuration.
* (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.
* (Lenovo) Proposal 8:
  + For PTM transmission scheme 1, from per UE perspective, PUCCH resource configuration for ACK/NACK based feedback can be shared with PUCCH resource configuration for HARQ-ACK feedback for unicast.
* (Spreadtrum) Proposal 2:
  + For ACK/NACK based feedback, Option1 should be supported for PUCCH resource configuration.
* (LGE) Proposal 2:
  + ACK/NACK based PUCCH resource for PTP transmission can be same as the PUCCH resource configuration for HARQ-ACK feedback for unicast.
* (Samsung) Proposal 2:
  + The UE can be optionally provided a separate *PUCCH-Config* for MBS (if the separate *PUCCH-Config* is not provided, the unicast one applies).
* (Qualcomm) Proposal 2:
  + For RRC\_CONNECTED UEs, PUCCH resource allocation for MBS ACK/NACK feedback can be shared or separate from HARQ-ACK feedback for unicast.
* (TD Tech) Proposal 3:
  + Support the code group based ACK-NACK feedback with the shared PUCCH resource for the PTM bearer.
* (TD Tech) Proposal 4:
  + The value of M can be configured, where M is the number of the PUCCHs in the shared PUCCH resource for the PTM bearer. M=1, M=2C -1 or M=2C, C is the number of the code groups of the TB on the PDSCH and C>1.
* (TD Tech) Proposal 5:
  + The shared PUCCH resource for the HARQ-ACK feedback for the PDSCH of the PTM bearer is separated from the PUCCH resource for the HARQ-ACK feedback for a unicast service of UE.
* (TD Tech) Proposal 7:
  + Support the ACK/NACK feedback with the dedicated PUCCH resource for the PTP bearer of MBS. Reuse the ACK/NACK feedback with the dedicated PUCCH resource for a unicast service for NR MBS.
* (Ericsson) Proposal 1:
  + 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 can be either shared with PUCCH resource configuration for HARQ-ACK feedback for unicast, or separate from PUCCH resource configuration for HARQ-ACK feedback for unicast (option 3 from RAN1#103)
* (Ericsson) Proposal 2:
  + To spread the HARQ-ACK in time domain for a group of UE to avoid PUCCH resource limitation, an extra time offset can be configured to each UE in PTM group via RRC signaling. The HARQ ACK feedback delay is then the sum of the PDSCH-to-HARQ\_feedback timing indicator in DCI plus this extra time offset.

#### 1st round discussion

FL’s Comments

From the submitted proposals, the supporting for the options is observed as follows:

* *Option 1: shared with PUCCH resource configuration for HARQ-ACK feedback for unicast*
  + *Support: ZTE, OPPO, Potevio, Google, Lenovo, Spreadtrum, LGE,*
* *Option 2: separate from PUCCH resource configuration for HARQ-ACK feedback for unicast*
  + *Support: Huawei, Nokia, TD Tech,*
* *Option 3: Option 1 or option 2 based on configuration*
  + *Support: CATT, Intel, Samsung, Qualcomm, Ericsson*

The PUCCH resources configured to different UEs in an MBS group need to be orthogonal so that UE specific configuration would be required. Considering UE anyhow will be configured with PUCCH resources for unicast, sharing the PUCCH resources with unicast might be one solution to achieve orthogonal PUCCH resources for UEs within the same group for MBS. However, it does not mean PUCCH resources for MBS have to be the same or shared with PUCCH resources for unicast from a given UE perspective, since the PUCCH resources for MBS will be configured per UE presumably which can be up to gNB configuration to have orthogonal PUCCH resources among UEs within a given group.

FL’s Proposal:

#### Proposal 2.2.1.1: (PUCCH resources for ACK/NACK based)

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.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Support FL’s proposal. |
| Qualcomm | Ok with the proposal. |
| MTK | We are generally ok with the proposal. |
| OPPO | Support FL’s proposal |
| Huawei, HiSilicon | Ok |
| Samsung | Support the proposal. |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| Intel | OK with the proposal |
| LG | We are fine with this proposal. |
| Apple | We have concerns on fallback operation, i.e., if PUCCH-Config for MBS is not configured. Generally, the PUCCH resource for unicast configured for a UE could be shared with other users by gNB TDM scheduling. For MBS, a group of users will feed back the HARQ-ACK at the same time, which means the PUCCH resource configured for unicast could not be shared. If different PUCCH resource configured for unicast are orthogonal, more PUCCH resources are required and gNB scheduling strategy would be impacted.  *FL response: I can understand the point. I would say it is up to NW configuration, including configuration of UE specific PUCCH and/or configuration of the group multicast. If NW does not configure PUCCH-Config for MBS and applying PUCCH-Config for unicast by default would impliedly mean NW has managed to configure orthogonal PUCCH-config for unicast when grouping UEs together. In the other way around, NW has freedom to configure specific PUCCH-Config for MBS* |
| CATT | OK with the proposal, but need a bit more clarification:   * If a UE is optionally configured a separate *PUCCH-config* for MBS,   + Alt 1: UE can only use this *PUCCH-config* for MBS.   + Alt 2: UE can select to use either *PUCCH-config* for MBS or *PUCCH-config* for unicast.   *FL response: I would say if PUCCH-config for MBS is configured, then UE should use it for MBS HARQ-ACK feedback. However, the MBS HARQ-feedback may be conveyed on the resources of PUCCH-config for unicast ultimately depending on multiplexing/prioritizing PUCCH for unicast, but it should be another separate issue discussed in section 2.3* |
| ZTE | We support Option1.  Based on companies’ positions summarized above, it seems Option1 has the most support. From our perspective, it is not necessary to configure separate PUCCH resource for MBS.  *FL response: note that there are also a lot of support for option 3. It makes sense leave it to gNB configuration.* |
| Spreadtrum | Support the proposal. |
| vivo | The Proposal 2.2.1.1 is option 3, we hesitate to agree on option 3 before see any use cases for configurable. We think option 1 is majority view, we support option 1. |
| Nokia, NSB | The proposal suggested, supports Option 3. We could accept this proposal as a compromise, though we prefer (like Vivo) to keep just Option 1, since it would use PUCCH resources more efficiently and simplify specifications. |
| Ericsson | We agree |
| Convida | We are OK with the proposal |

FL’s Comments

*People are encouraged to check whether happy with FL’s response and at the same time FL does not see the need to update the proposal and it should be stable.*

|  |  |
| --- | --- |
| TD Tech, Chengdu TD Tech | We hope the proposal is modified as below. Proposal 2.2.1.1: (PUCCH resources for ACK/NACK based) 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.   * FFS: For ACK/NACK based feedback with the shared PUCCH resources if supported for RRC\_CONNECTED UEs receiving multicast, UE can be configured with the shared PUCCH resources for multicast which are separate from the PUCCH resource for unicast service.   *FL’s response: see the response to the comment to the “HARQ-ACK options” proposal.* |

### 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

#### 1st round discussion

FL’s Comments

Last meeting has agreed that PUCCH resource configuration for NACK-only based feedback is separate from PUCCH resource configuration for HARQ-ACK feedback for unicast. One FFS is about PUCCH format.

Based the submitted proposals, three companies propose to support PUCCH format 0 for NACK-only and four companies propose both PUCCH format 0 and format 1 could be used for NACK-only based HARQ-ACK feedback.

FL’s Proposal:

#### Proposal 2.2.2.1: (PUCCH format for NACK-only)

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

* FFS whether to support PUCCH format 1.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Support FL’s proposal. We also think PUCCH format 1 can be supported which has a better coverage than PUCCH format 0. |
| Qualcomm | Ok with the proposal. |
| MTK | Support the proposal. |
| OPPO | Support FL’s proposal |
| Huawei, HiSilicon | Ok |
| Samsung | Do not support the proposal.  Setting aside whether NACK-only is supported, the baseline should be PUCCH format 1, not PUCCH format 0.  PUCCH format 0 significantly reduce cells coverage (e.g. ~10 dB). The main applicability for PUCCH format 0 is for FR2 or URLLC – neither are the focus of the MBS WI. |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| Intel | Both PUCCH format 0 and 1 should be supported. Modifications, if any, for NACK-only operation can be FFS. |
| LG | We are fine with this proposal. |
| Apple | Both PUCCH format 0 and 1 can be supported. |
| CATT | OK with the proposal.  We also think PUCCH format 1 can be supported wider coverage and larger distance for those UEs far from gNB. |
| ZTE | Ok with the proposal. |
| Spreadtrum | We are OK with the FL’s proposal. |
| vivo | We also think PUCCH format 1 can be supported which has a better coverage than PUCCH format 0. We prefer to support both. |
| Nokia, NSB | We support the intention of the proposal with PUCCH format 1 supported in addition to PUCCH format 0, however we would like to:   * Agree on Format 1 support now rather than just have it as an FFS. * Add a new FFS: * FFS: Methods to multiple PTM NACK-only feedback with other UCIs on UE-specific PUCCH resources.   *FL response: the FFS I perceive should be issue covered in section 2.3.*  In our Tdoc, we highlight that 1-bit only NACK-only feedback could be very limiting in scenarios where the UE might have a lot of different DL traffic and the UE is limited to sending only 1 PUCCH at a time. We suggest multiple solutions including:  1. Using multiple PUCCHs (format 0) per slot  2. Relying on the sub-slot PUCCH mechanism  3. Using alternative PUCCH formats.  In addition, based on other companies’ proposals, we believe that the understanding of a “separate PUCCH resource configuration for NACK-only based HARQ-ACK” is not clear. Does the previously agreed proposal mean that for NACK-only based feedback, a new PUCCH-config should be introduced to the UE (in addition to the unicast PUCCH-config and possibly sub-slot based PUCCH-config for URLCC PUCCH)?  *FL response: I intended to mean it yes. A new PUCCH-config for NACK-only should be introduced to the UE.* |
| Ericsson | We agree |

#### 2nd round discussion

FL’s Comments

Based on the first round discussion, people may not have concern to support format 0 but some companies clearly expressed format 1 should be supported as well. We can try whether the following updated proposal is agreeable.

FL’s Proposal:

#### Proposal 2.2.2.2: (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 concerns:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We are fine with this proposal. However, considering Samsung’s concern, we could alternatively agree support of PUCCH format 1 with ‘FFS on PUCCH format 0’.  *FL’s response: FFS PUCCH format 0 may not be agreeable to everybody. We can see more comments.* |
| Nokia, NSB | Support the proposal, but with the additional FFS:  FFS: Methods to increase PUCCH reporting capacity  Note in our Tdoc, we highlight that 1-bit only NACK-only feedback could be very limiting in scenarios where the UE might have a lot of different DL traffic and the UE is limited to sending only 1 PUCCH at a time. We suggest multiple solutions including:  1. Using multiple PUCCHs (format 0) per slot  2. Relying on the sub-slot PUCCH mechanism  3. Using alternative PUCCH formats.  In our view, this is an important issue that needs to be discussed further. |

## 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.

### Priority for MBS and unicast

#### 1st round discussion

FL’s Comments

When UE is configured with separate PUCCH resources for HARQ-ACK feedback for unicast and MBS, respectively, and the PUCCH resources are overlapping in time domain and HARQ-ACK feedback for unicast and MBS are both available for a given time, how UE transmits the HARQ-ACK feedback or the PUCCH needs discussion.

Seven companies submitted proposals for this issue and at least five companies propose to define the priority and four companies propose to support multiplexing the HARQ-ACK feedback for unicast and MBS. One company proposes not supporting PUCCH prioritization for PTM scheme1. In moderator’s understanding, multiplexing/prioritizing will always happen unless UE is allowed to transmit two PUCCH with time resources overlapping which is probably not the case allowed in Rel-17. Therefore, granted that HARQ-ACK feedback for MBS will always be dropped when colliding with HARQ-ACK feedback for unicast, it impliedly means the priority of the feedback for MBS is lower than that for unicast. In addition, the HARQ-ACK feedback for MBS colliding with other UCI is another case for which prioritizing would be impliedly in use.

FL’s Proposal:

#### Proposal 2.3.1.1: (Priority for MBS and unicast)

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

* Option 1: lower than the HARQ-ACK feedback for unicast
* Option 2: configured to be lower or higher than the HARQ-ACK feedback for unicast
* FFS the priority between HARQ-ACK feedback for multicast and other UCI for unicast (SR, CSI)

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | We prefer option 2 which gives gNB more flexibility. In addition, considering the multicast service can also be delivered by PTP transmission mode, it should be treated as the same priority with unicast service. But we think option 2 needs some modification.  In option 2, the priority for HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast can only be configured lower or higher than the HARQ-ACK feedback for unicast, that is PUCCH resources for multicast and unicast HARQ-ACK feedback will never be multiplexed, which is conflict with option 1 in **Proposal 2.4.2.1.**  Therefore, we think the priority for HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast can be configured lower or higher than or equals with the HARQ-ACK feedback for unicast. That is there are 3 cases about the combination of priority of multicast and unicast as this     |  |  |  | | --- | --- | --- | |  | Priority index for multicast | Priority index for unicast | | Higher than the HARQ-ACK feedback for unicast | 1 | 0 | | Lower than the HARQ-ACK feedback for unicast | 0 | 1 | | Equal with the HARQ-ACK feedback for unicast | 0 | 0 | | 1 | 1 |   The priority for HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast is,   * Option 1: lower than the HARQ-ACK feedback for unicast * Option 2: configured to be lower or higher than or equals with the HARQ-ACK feedback for unicast * FFS the priority between HARQ-ACK feedback for multicast and other UCI for unicast (SR, CSI) |
| FUTUREWEI | We are generally OK with the FL proposal as the priority concept should be used for unicast and MBS. More discussion may be needed for Opt 1 versus 2, Opt 1 is easier but Opt 2 could be useful for some traffic. |
| Qualcomm | In Rel16, the ‘priority indicator’ is introduced in DL DCI format 1\_1 and 1\_2 for unicast transmission.  Prefer to defer the proposal after we decide whether DCI format 1\_1 or 1\_2 will be supported for multicast first (in 8.12.1).  *FL response: I think they can be separate somehow. The priority of multicast should not completely depend on whether other DCI formats should be adopted. Instead, it should primarily depend on the use cases.* |
| MTK | We are generally agree with the proposal modified by CMCC. |
| Huawei, HiSilicon | Ok with the update from CMCC. |
| Samsung | Support the proposal.  Proposals 2.3.1.1 and 2.3.2.1 need to be conditioned on this proposal. |
| Lenovo, Motorola Mobility | We are Ok with modified proposal from CMCC. |
| Intel | Support the proposal with modification from CMCC. Agree with Samsung that this should be discussed before proposals 2.3.1.1 and 2.3.2.1  *FL response: I can move this discussion preceding the codebook.* |
| LG | We are fine with this proposal. |
| Apple | We are ok with this proposal. |
| CATT | OK with the proposal, and option 2 is slightly preferred. More discussion with details are further needed for determination. |
| ZTE | Overall, we think it is early to discuss the priority issue at such an early stage. We prefer to defer the discussion.  *FL response: As commented by others, it may also affect the codebook construction. We should strive to find way out instead of twisting all issues together.* |
| Spreadtrum | We are fine with this proposal, and more discussion on the priority issue is needed. |
| vivo | Regarding priority of the HARQ-ACK feedback for unicast, it can be configured or indicated by DCI with low or high priority. Agree with QC’s view, the priority for the HARQ-ACK feedback for multicast can also be indicated directly in DCI.  Based on CMCC’s update, we suggest to further update as:   * Option 1: lower than the HARQ-ACK feedback for unicast * Option 2: configured/indicated to be lower or higher than or equals with the HARQ-ACK feedback for unicast * Option 3: the priority of HARQ-ACK feedback for multicast is configured by RRC or indicated in DCI. * FFS the priority between HARQ-ACK feedback for multicast and other UCI for unicast (SR, CSI)   *FL response: Point of this proposal is the concept of “priority” for multicast. As to the priority is RRC configured or DCI indicated, it could be next step detailed discussion, should not be another option in the same tier.* |
| Nokia, NSB | We prefer option 2 with the modification that equal priority of unicast and multicast feedback should also be supported. Option 1 seems too restrictive.  We also support the FFS. |
| Ericsson | We agree. For Option 2 we propose further that the priority can be set globally for all G-RNTIs or individually for each G-RNTI. |
| Convida | We are generally fine with the proposal with equal priority added to option 2. |

#### 2nd round discussion

FL’s Comments

The first round discussion shows majority support of the proposal and some companies expressed option 2 as preferred option, so let’s try option 2 in this round, if many concerns received, we can step back to keep two options open then.

FL’s Proposal:

#### Proposal 2.3.1.2: (Priority for MBS and unicast)

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

* ~~Option 1: lower than the HARQ-ACK feedback for unicast~~
* Option 2: ~~configured/indicated to be~~ lower, higher than or equal to the HARQ-ACK feedback for unicast
  + FFS how to reflect the priority in specification.
* FFS the priority between HARQ-ACK feedback for multicast and other UCI for unicast (SR, CSI) or PUSCH for unicast.

Collect concerns:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We are generally fine with this proposal. Regarding ‘equal to’ in Option 2, we wonder if we need explicit indication/configuration to ‘equal to’. Instead, gNB can optionally configure/indicate lower or higher. No configuration/indication means ‘equal to’ and how to prioritize can be left to UE implementation.  Option 2 can be changed to:   * Option 2: optionally configured/indicated to be lower or higher than ~~or equal to~~ the HARQ-ACK feedback for unicast * If the priority is not configured/indicated, how to prioritize is left to UE implementation. * FFS the priority between HARQ-ACK feedback for multicast and other UCI for unicast (SR, CSI) or PUSCH for unicast.   *FL’s response: The point of this proposal is priority of multicast vs. unicast, how the priorities is configured/indicated/default can be FFS. I can update the proposal accordingly.* |
| Nokia, NSB | Support the LG proposal |
| Convida | Agree with the FL. The signaling detail is already included in the FFS. We don’t support to modify the proposal as suggested by LG. |

### Multiplexing/prioritizing

#### 1st round discussion

FL’s Comments

When UE is configured with separate PUCCH resources for HARQ-ACK feedback for unicast and MBS, respectively, and the PUCCH resources are overlapping in time domain and HARQ-ACK feedback for unicast and MBS are both available for a given time, how UE transmits the HARQ-ACK feedback or the PUCCH needs discussion.

Seven companies submitted proposals for this issue and at least five companies propose to define the priority and four companies propose to support multiplexing the HARQ-ACK feedback for unicast and MBS. One company proposes not supporting PUCCH prioritization for PTM scheme1. In moderator’s understanding, multiplexing/prioritizing will always happen unless UE is allowed to transmit two PUCCH with time resources overlapping which is probably not the case allowed in Rel-17. Therefore, granted that HARQ-ACK feedback for MBS will always be dropped when colliding with HARQ-ACK feedback for unicast, it impliedly means the priority of the feedback for MBS is lower than that for unicast. In addition, the HARQ-ACK feedback for MBS colliding with other UCI is another case for which prioritizing would be impliedly in use.

FL’s Proposal:

#### Proposal 2.3.2.1: (multiplexing/prioritizing)

For the cases of HARQ-ACK feedback is available for multicast and unicast and the PUCCH resources for multicast and unicast are overlapping, for determining the PUCCH resource:

* Option 1: multiplexing is applied for the same priority and prioritizing is applied for different priorities.
* Option 2: HARQ-ACK feedback for multicast is always dropped.
* FFS the case of HARQ-ACK feedback for multicast and other UCI for unicast.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | We prefer option 1, which the HARQ-ACK feedback for multicast and unicast can be multiplexed in the same PUCCH to guarantee the transmission of HARQ-ACK feedback.  In addition, as the comments in Proposal 2.3.1.1, option 2 with some modification in Proposal 2.3.1.1 is the baseline to support option 1 in Proposal 2.4.2.1. |
| FUTUREWEI | We are generally OK though there could be refinement based on the discussion of the last proposal. |
| Qualcomm | Prefer to defer the discussion of Proposal 2.4.1.1 and 2.4.2.1. |
| MTK | We are generally fine with the proposal. |
| OPPO | We are OK with the proposal |
| Huawei, HiSilicon | Ok with the proposal. |
| Samsung | Support option 1 - doesn’t make sense to drop HARQ-ACK for MBS because, for the NR bands (mostly TDD), the result will practically be always dropping.  However, multiplexing should be based on gNB configuration. |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| Intel | Support only Option 1. Option 2 does not make sense to us since, based on outcome of Proposal 2.4.1.1, some priority rule will be decided. One option is conclude that discussion in its entirety and then proceed to discuss this proposal. |
| LG | We are fine with this proposal. |
| Apple | We are ok with this proposal. |
| CATT | OK with the main bullet, and option 1 is reasonable.  Option 2 can lead to degradation of MBS services performance, and we never know how important for MBS service sometime is prioritized other than unicast. Furthermore, a dropping mechanism can be discussed based on some conditions/scenarios. |
| ZTE | Similar view as Qualcomm. |
| Spreadtrum | We support Option 1. Multiplexing between multicast and unicast on a same PUCCH resource should be supported. |
| vivo | Similar view as Qualcomm. |
| Nokia, NSB | We prefer Option 1. We are unsure if the FL with this proposal is suggesting both options are supported or if this is intended to be a down-selection between the 2 options. We would prefer to attempt to down-select if possible (our preference is Option 1).  *FL response: The intention is for down-selection.* |
| Ericsson | We can remove this proposal, as it is covered by 2.3 (multiplexing) and 2.4.1.1 (prioritization).  *FL response: I’m confused. It is right the proposals discussed in multiplexing or prioritizing….* |
| Convida | We are generally fine with the proposal. We think option 2 is not reasonable since it doesn’t make sense to always drop MBS. Also, we wonder if the intention of this proposal is to preclude all the other solutions if any? |

#### 2nd round discussion

FL’s Comments

Based on the discussion in the first round, majority is fine with the proposal and some companies expressed the preference to option 1. We can try option 1 in this round of discussion. If many technical concerns are received for support of option 1, we can step back to keep two options open and down-select it later.

FL’s Proposal:

#### Proposal 2.3.2.2: (multiplexing/prioritizing)

For the cases of HARQ-ACK feedback is available for multicast and unicast and the PUCCH resources for multicast and unicast are overlapping, for determining the PUCCH resource:

* Option 1: multiplexing is applied for the same priority and prioritizing is applied for different priorities.
* ~~Option 2: HARQ-ACK feedback for multicast is always dropped.~~
* FFS the case of HARQ-ACK feedback for multicast and other UCI for unicast.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We are fine with this proposal. But, it is also fine to keep Option 2, e.g. if multicast priority is not configured/indicated. |
| Nokia, NSB | Support the Proposal |
| Convida | We are fine with the proposal |

## 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.

#### 1st round discussion

FL’s Comments

There are two cases for Type-1 HARQ-ACK codebook construction. One case is that UE receives multicast only but may receive multiple multicast and the other case is that UE receives both unicast and multicast. The proposal aims to focus on the codebook construction for unicast and multicast because whether/how UE supports multiple multicast services is still under discussion in AI 8.12.1.

It is moderator’s understanding that, if UE is separately configured with *PUCCH-Config* for multicast from that for unicast, it is nature for UE to generate separate HARQ-codebook and use the indicated PUCCH resources for HARQ-ACK feedback. When the feedback for multicast collides with that for unicast, UCI multiplexing/prioritizing will be applied, which will be discussed in section 2.3.

The proposal in this section applies to the case that when a single *PUCCH-Config* is configured for both unicast and multicast sharing for HARQ-ACK feedback.

FL’s Proposal:

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

For the case of shared *PUCCH-Config* for both unicast and multicast and for ACK/NACK based feedback if supported for multicast, Type-1 HARQ-ACK feedback is constructed based on the union of the PDSCH TDRA sets of the unicast service and the MBS service

* FFS FDM-ed unicast and multicast.
* FFS FDM-ed multicast and multicast.
* FFS whether/how Type-1 HARQ-ACK feedback is constructed for NACK-only based feedback for multicast.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Support FL’s proposal.  But one thing we want to clarify, we have agreed to support FDM and TDM multiplexing of one multicast PDSCH and one unicast PDSCH in one slot in AI 8.12.1, but whether to support Case 1~5 is still under discussion. Is the main bullet in this proposal only considers the TDM multiplexing of one multicast PDSCH and one unicast PDSCH in one slot case?  *FL response: The main bullet intended to cover both FDM-ed unicast and multicast the case agreed earlier and cases of TDM-ed unicast and multicast (at least for cases 1~3). The proposal is quite generic and inclusive and should be applicable to the cases whatever agreed later on. I may need to clarify the meaning of the FFS which was actually intended to say the details of Type-1 codebook construction for FDM-ed unicast and multicast.* |
| Qualcomm | Basically fine with the proposal  Minor comment: ‘MBS service’ should be ‘multicast service’ in the main bullet. |
| MTK | Support the proposal. The FDM-ed HARQ-ACK codebook can be postpone until it has a clear conclusion whether to support these cases in AI 8.12.1.  *FL response: FDM-ed unicast and multicast has been agreed. FDM-ed multicast and multicast can be discussed further in AI 8.12.1.* |
| Huawei, HiSilicon | Ok with the proposal. The proposal can cover TDM cases in case 1~3 and also cover the case agreed earlier on on FDMed unicast and multicast. FDM-ed multicast and multicast can be FFS depending on the progress in AI 8.12.1. |
| Samsung | OK in principle but requires further discussion (also together with proposal 2.4.1.1).  It is understood that MBS and unicast are assumed to have same priority, TRP, and slot duration.  We do not support the multiplexing to be default UE behavior, even for shared PUCCH resources – should be controlled by gNB/RRC as for Rel-16 multi-TRP or URLLC - Type-1 codebook size is large and applying union of TDRA tables will of course make it larger.  *FL response: if the same priority and same PUCCH resources configuration for both unicast and multicast, multiplexing seems nature or straightforward, which is the basic rule discussed in URLLC with regard to the same priority. Anyhow, suggestion on how modifying the proposal is welcome. Would adding a FFS “FFS: whether/how to optimizing the Type-1 codebook construction to reduce the HARQ-ACK feedback payload size” solve your concern?* |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| LG | We are fine with this proposal. |
| CATT | OK with the main bullet.  For the 3rd sub-bullet of FFS on codebook for NACK-only, the intention is not quite clear to us and further clarification is needed.  *FL response: regarding the 3rd sub-bullet, I guess we don’t need it because it was agreed that the PUCCH resource configuration should be separate from PUCCH configuration for unicast.* |
| ZTE | Ok with the proposal. |
| Spreadtrum | We are fine with this proposal in principle. The details need further study |
| vivo | From our understanding, shared *PUCCH-Config* doesn’t mean the HARQ-ACK for unicast and multicast should be multiplexed in one HARQ-ACK codebook. This should be FFS.  *FL response: multiplexing for shared resource is straightforward. Can vivo clarify what else solution vivo is thinking?*  For multiplexing HARQ-ACK for unicast and multicast in one HARQ-ACK codebook, this proposal is for the case that unicast PDSCH and multicast PDSCH are TDMed and the TDRA for unicast and multicast are separately configured, otherwise, there may be no need to take union operation.  *FL response: Separate TDRA is assumed and this assumption seems straightforward. If an agreement for this is needed, it should be discussed in AI 8.12.1.* |
| Nokia, NSB | We generally support the proposal, but we believe that the main bullet in this proposal only considers the TDM multiplexing of one multicast PDSCH and one unicast PDSCH in one slot. However, FDM multiplexing of unicast and multicast PDSCH is also agreed, and current mechanisms of Type-1 codebook construction is not feasible in case of FDM-ed PDSCH of different services. For that we propose 2 options:  - 1 sub-codebook for unicast services and 1 sub-codebook per multicast service is produced following the current mechanisms. Those codebooks are concatenated in case their HARQ-ACK feedback is scheduled for the same time instance.  - One HARQ-ACK bit is included in the HARQ-ACK codebook for the FDM-ed time instances. Details are FFS.  *FL response: The intension was to cover both at least TDM and FDM-ed unicast and multicast. The FFS would be updated to clarify or reflect it.*  Regarding the third FFS, our perspective is: 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 multicast, 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 multicast.  *FL response: As responded, NACK-only feedback should be configured with specific resources separate from that for unicast. The scheme you are talking about seems one solution for multiplexing/prioritizing NACK-only and HARQ-ACK feedback for unicast which is covered by section 2.3* |
| Ericsson | We agree with the proposal in principle, but we think it could be expanded further, as support of a common code-book is de-facto agreed already if proposal 2.2.1.1 is agreed (if unicast and multicast have a common PUCCH config, they must have a common HARQ codebook)  For Type-I codebook for NACK-only, the following variants are FFS, where the first 2 are mutually exclusive, the other 2 can be combined with either of the first 2:   * Use multiple PUCCH resources in the same slot, M=2^N-1 PUCCH resources for N HARQ processes, each UE transmits on one of the resources according to the subset of HARQ processes for which the UE needs to signal NACK. * Use multiple PUCCH resources in the same slot, where each PUCCH resource represents one HARQ process and the UE needs to transmit multiple NACK signals, one on each PUCCH resource corresponding to a HARQ process for which the UE has to signal a NACK. * Use the PUCCH format 0 phase rotations as dimension in addition to OFDM-symbol and PRB, i.e associate each rotation with a HARQ process. * Associate each NACK signal with a set of HARQ processes, where multple UEs use the same PUCCH resource for the NACK-only signal relating to the same subset of HARQ processes, and the subset size may reduce to 1. A UE transmits the NACK signal if at least one process of the associated subset of HARQ processes has a decoding failure and the gNB accordingly retransmits the transport blocks of all HARQ processes of the subset.   *FL response: As responded, NACK-only feedback should be configured with specific resources separate from that for unicast. So whether a common codebook is constructed for NACK-only depends on whether multiplexing them in one PUCCH resource when NACK-only PUCCH resources collides with PUCCH resources for unicast which will be discussed in section 2.3* |
| Convida | We are generally OK with the principle. The details need further study |

#### 2nd round discussion

FL’s Comments

As responded to the received comments, the intention of the proposal is to cover both FDM-ed unicast and multicast the case agreed earlier and cases of TDM-ed unicast and multicast (at least for cases 1~3). The proposal was formulated to be quite generic and inclusive so as to be applicable to the cases whatever agreed later on.

The first two FFS are updated to more accurately reflect the original intension of covering the cases of FDM-ed but the details are FFS.

The 3rd FFS “FFS whether/how Type-1 HARQ-ACK feedback is constructed for NACK-only based feedback for multicast” is deleted because NACK-only feedback should be configured with specific resources separate from that for unicast as agreed in the last meeting. Whether a common codebook is constructed for NACK-only depends on whether multiplexing them in one PUCCH resource when NACK-only PUCCH resources collides with PUCCH resources for unicast which will be discussed in section 2.3. Instead, one FFS is added “FFS whether/how Type-2 HARQ-ACK feedback is constructed for NACK-only based feedback for multicast” to try to address the comment from Samsung.

FL’s Proposal:

#### Proposal 2.4.1.2: (Type-1 HARQ-ACK codebook)

For the case of shared *PUCCH-Config* for both unicast and multicast and for ACK/NACK based feedback if supported for multicast, Type-1 HARQ-ACK feedback is constructed based on the union of the PDSCH TDRA sets of the unicast service and the multicast service

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

Collect comments:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We are fine with this proposal. |
| Nokia, NSB | Support the proposal |

### Type-2 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 4:
  + The Type-2 HARQ-ACK codebook for unicast and MBS should be separately constructed.
* (CATT) Proposal 15:
  + The current multiplex mechanism (i.e. concatenates the TB-based HARQ-ACK codebook followed by the CBG-based HARQ-ACK codebook) can be reused for MBS and unicast codebook determination.
* (vivo) Proposal 4:
  + For ACK/NACK based HARQ-ACK feedback if supported, for type 2 HARQ-ACK codebook for RRC\_CONNECTED Ues receiving multicast.
* Reuse the existing mechanism to construct a HARQ-ACK codebook for multicast PDSCHs.
* If UE is configured with multiple g-RNTIs or UE is configured with simultaneous unicast PDSCH reception,
  + - * If PTM transmission scheme 1 is used for group-common PDSCH, separate DAI counting for different g-RNTIs or g-RNTI and c-RNTI is used.
* If PTM transmission scheme 2 is used for group-common PDSCH, the existing mechanism can be reused to construct a HARQ-ACK codebook for different PDSCHs.
* (Lenovo) Proposal 9:
  + From a UE’s perspective, DAI is counted separately for multicast and unicast.

#### 1st round discussion

FL’s Comments

There are two cases for Type-1 HARQ-ACK codebook construction. One case is that UE receives multicast only but may receive multiple multicast and the other case is that UE receives both unicast and multicast. The proposal aims to focus on the codebook construction for unicast and multicast because whether/how UE supports multiple multicast services is still under discussion in AI 8.12.1.

It is moderator’s understanding that, if UE is separately configured with *PUCCH-Config* for multicast from that for unicast, it is nature for UE to generate separate HARQ-codebook and use the indicated PUCCH resources for HARQ-ACK feedback. When the feedback for multicast collides with that for unicast, UCI multiplexing/prioritizing will be applied, which will be discussed in section 2.3.

The proposal in this section applies to the case that when a single *PUCCH-Config* is configured for both unicast and multicast sharing for HARQ-ACK feedback.

FL’s Proposal:

#### Proposal 2.4.2.1: (Type-2 HARQ-ACK codebook)

For the case of shared *PUCCH-Config* for both unicast and multicast and for ACK/NACK based feedback if supported for multicast, for Type-2 HARQ-ACK feedback construction,

* DAI for unicast and DAI for multicast are separately counted.
* Type-2 HARQ-ACK codebook for unicast and multicast are concatenated.
* FFS whether to support concatenating more than one Type-2 HARQ-ACK codebook for multicast.
* FFS whether/how Type-2 HARQ-ACK feedback is constructed for NACK-only based feedback for multicast.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Support the FL’s proposal. |
| Qualcomm | Looks ok |
| Huawei, HiSilicon | ok |
| Samsung | Support the first sub-bullet.  Same comments as for Type-1 apply for the second sub-bullet (e.g. assumption for same TRP/priority/slot duration and concatenation is controlled by gNB, not default UE behavior). |
| Lenovo, Motorola Mobility | We are Ok with this proposal. |
| CATT | OK with this proposal. |
| ZTE | Ok with the proposal. |
| Spreadtrum | We are fine with the proposal. |
| vivo | Same as comments for type 1 codebook, from our understanding, shared *PUCCH-Config* doesn’t mean the HARQ-ACK for unicast and multicast should be multiplexed in one HARQ-ACK codebook. This should be FFS.  If PTM scheme 2 is supported, there is no issue to be solved, and legacy DAI counting can be reused.  If PTM scheme 1 is used, separate DAI counting is needed.  *FL response: proposal will be updated it is for PTM scheme 1.* |
| Nokia, NSB | We support the proposal, especially the FFSs and the explicit mentioning that unicast DAI and multicast DAI are counted separately. We would also like to add the following sub-bullet:   * FFS whether/how to construct and concatenate separate sub-codebooks for multicast and unicast   Regarding the second FFS, our perspective is: 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 multicast, 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 multicast. |
| Ericsson | We agree, except the FFS for NACK: we disagree to keep this FFS (should be dropped), since we propose that dynamic codebook is not supported for NACK only. |
| Convida | We are Ok with this proposal. |

#### 2nd round discussion

FL’s Comments

The original 2nd FFS “• FFS whether/how Type-2 HARQ-ACK feedback is constructed for NACK-only based feedback for multicast” is deleted because NACK-only feedback should be configured with specific resources separate from that for unicast as agreed in the last meeting. Whether a common codebook is constructed for NACK-only depends on whether multiplexing them in one PUCCH resource when NACK-only PUCCH resources collides with PUCCH resources for unicast which will be discussed in section 2.3.

The proposal is updated as follows to reflect the comments in the first round discussion:

FL’s Proposal:

#### Proposal 2.4.2.2: (Type-2 HARQ-ACK codebook)

For the case of shared *PUCCH-Config* for both unicast and multicast and 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.
* Type-2 HARQ-ACK codebook for unicast and multicast are concatenated.
  + FFS details on concatenating the codebooks.
* FFS whether to support concatenating more than one Type-2 HARQ-ACK codebook for multicast.

Collect comments:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia, NSB | Support the Proposal |

### Enh Type-2 / Type 3 HARQ codebook

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*

*Type-3 HARQ-ACK codebook:*

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

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.

## 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.

### 1st round discussion

FL’s Comments

The advantage of option 1 is the network can indicate whether feedback for a particular transmission is needed. The drawback is the overhead in the DCI when the feedback control does not change frequently. The advantage of option 2 is when conditions do not change much, a semi-static configuration avoid the overhead in the DCI.

From the submitted proposals, to moderator’s understanding of the proposals, option 3 is a good tradeoff between overhead and the flexibility of this functionality, i.e., RRC configures whether DCI indicates the HARQ-ACK feedback enabling/disabling, which seems the majority proposal.

FL’s Proposal:

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

For enabling/disabling HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast, support

* Option 3: RRC configures the enabling/ disabling function and DCI indicates enabling /disabling

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Support FL’s proposal. |
| FUTUREWEI | Support FL’s proposal. |
| Qualcomm | We prefer Option 2 as the baseline, FFS dynamic signalling by DCI or MAC-CE. |
| MTK | Support the proposal. |
| OPPO | Support FL’s proposal. |
| Huawei, HiSilicon | Ok with the proposal. |
| Samsung | Support the proposal with one clarification – the RRC is UE-specific, not UE-common (SIB).  *FL’s response: UE-specific is explicitly straightforward since this discussion is for UE connected UE receiving multicast.* |
| Lenovo, Motorola Mobility | We think the proposal is not quite clear.  If RRC configures the enabling or disabling, why is DCI required for indicating enabling and disabling again?  *FL’s response: as stated in option 3, RRC configures the functionality, i.e., whether DCI includes the bit of indicating enabling/disabling.* |
| Intel | OK with the proposal.  We can also accept option 2 given that DCI format is not decided yet and this may incur additional DCI overhead. Also, if RRC enables configurability to ON, default mode can be HARQ ON if not indicated otherwise dynamically. |
| LG | We are fine with this proposal. |
| Apple | As the DCI format for MSB is not decided yet, it’s open for dynamic indication by DCI or MAC CE.  RRC configures the enabling/ disabling function, FFS dynamic indication via DCI or MAC CE. |
| CATT | OK with the proposal.  For option 3, one of the benefits is that the DCI size can be different when RRC configures to enable or disable HARQ-ACK feedback function. When RRC configures it disable, a small DCI size can be applied. |
| ZTE | Our first preference is to support Option1, 2 4 at the same time and network can choose the option by implementation.  If majority companies prefer to support Option 3, it is ok to go with Option3. Our understanding of Option3 is that network can configure {enabling, disabling, enabling+disabling} via RRC parameter.  If “enabling” or “disenabling” is configured, no DCI is needed.  If “enabling+disabling”, then DCI is used to indicate enabling /disabling.\  We suggest the following proposal.  For enabling/disabling HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast, support   * Option 3: RRC configures the enabling/ disabling function and DCI indicates enabling /disabling   + Network configures {enabling, disabling, enabling+disabling} via RRC parameter, only if “enabling+disabling” is configured, DCI is used to indicate enabling /disabling.   *FL’s response: I doubt it is the common understanding among people who are ok with option 3. But the original proposal can be improved.* |
| Spreadtrum | Fine with the proposal. |
| vivo | Not support the proposal. We think option 2 should be the baseline. Does option 3 mean introducing a new field in the scheduling DCI? If so, if DCI 1-0 is reused to schedule MBS, then how to indicate enabling /disabling?  *FL’s response: It should be easily to be understood that only the DCI formats whose fields that can be configured can support this functionality.* |
| Nokia, NSB | In our view, using the DCI for indication is a not necessary and wasteful, however we could proceed with a modified version of this proposal that also supported option 2. We feel that the additional RRC signalling is relatively trivial but the saving in DCI overhead is high.  For enabling/disabling HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast, support either  • Option 2: RRC indicates enabling/disabling  • Option 3: RRC configures the enabling/ disabling function and DCI indicates enabling /disabling |
| Ericsson | We disagree.  In our view, for the enabling /disabling to be useful, it should be UE specific, which is impossible via a DCI carried by group-common PDCCH. This can be useful if all UEs are in the same condition and can all benefit to switch from enable to disable. But in general not all UEs will benefit from enabling or disabling HARQ feedback. Thus in our view, RRC and MAC-CE indication provide a better trade-off of flexibility. |
| Convida | We are fine with the proposal. The signaling details can be FFS. |

### 2nd round discussion

FL’s Comments

There is comment that the wording of option 3 is not perfectly understandable without ambiguity. The proposal is updated based the majority view as follows:

FL’s Proposal:

#### Proposal 2.5.2: (enable/disabling HARQ-ACK feedback)

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

* 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 whether HARQ-ACK feedback is enabled/disabled ( via, e.g., 1 bit in DCI, value 1 represents enabling the feedback and value 0 represents disabling the feedback, or an existing field in DCI to indicate enabling/disabling implicitly.)
  + 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.
    - FFS whether UEs in the same group can having different default mode for PTM scheme 1.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We are fine with this proposal. |
| Nokia, NSB | Do not support the proposal.  Multiple companies mentioned that RRC should enable/disable the HARQ-ACK feedback and this is not reflected in the proposal. We support the proposal from ZTE, where RRC can enable/disable HARQ-ACK feedback, and RRC can configure enable/disable functionality so that DCI method is used.  In addition to the fact from our simulation results on RAN1-103e meeting that semi-static enabling/disabling is enough for multicast and DCI based method is not needed, DCI can only enable/disable HARQ-ACK for all the UEs in the multicast group. Rather, UE-wise enabling/disabling of HARQ-ACK is needed, which can be achieved with RRC.  We suggest the following proposal.  For enabling/disabling HARQ-ACK feedback for RRC\_CONNECTED UE receiving multicast for at least PTM scheme 1, support   * 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 whether HARQ-ACK feedback is enabled/disabled ( via, e.g., 1 bit in DCI, value 1 represents enabling the feedback and value 0 represents disabling the feedback, or an existing field in DCI to indicate enabling/disabling implicitly.)   + 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.     - FFS whether UEs in the same group can having different default mode for PTM scheme 1. * Option 2: RRC indicates enabling/disabling. |
| Convida | We are fine with the proposal. We don’t support the proposal from ZTE that the NW configures three status. We think two status are enough, i.e., the NW only configures {enabling, disabling} through RRC signaling. |

## Retransmission

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 FFS  From 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.

## 1st round discussion

FL’s Comments

From the submitted proposals, RRC configuring the repetition numbers and DCI indicating a specific number seems the majority view, which has also been supported in current specifications, i.e., the slot-based repetition number is configured as part of TDRA table and DCI dynamically indicates the time domain scheduling including the repetition number.

FL’s Proposal:

#### Proposal 3.1: (PDSCH repetition)

For slot-level repetition for group-common PDSCH for RRC\_CONNECTED UEs receiving multicast, for indicating the repetition number, support:

* Opt 3: by RRC+DCI
* Slot-based repetition is configured by RRC as part of TDRA table.

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Support FL’s proposal, indication method of current spec is enough. |
| FUTUREWEI | Support FL’s proposal |
| Qualcomm | We support Option 2 and Option 3, which reuses the way of unicast PDSCH repetition indication. |
| MTK | Support the proposal. |
| OPPO | Support FL’s proposal |
| Huawei, HiSilicon | Ok with the proposal. We also noted that Rel-15 supports aggregation and Rel-16 extended the support to RRC configuring the TDRA table and DCI indicating the index of the table. Regarding the common from Qualcomm, if support both option 2 and option 3, I wonder whether it would end up with option 3 eventually. |
| Samsung | Can discuss further – will be good to have a same design for RRC IDLE/INACTIVE and RRC CONNECTED. |
| Lenovo, Motorola Mobility | For multicast transmission, we think option 2 using RRC signaling is enough and can be baseline solution since it is defined in Rel-15. There is no strong motivation to use RRC+DCI as defined in Rel-16 URLLC. |
| Intel | OK with proposal since this is already supported in specification for mTRP. Similar design can also be supported for IDLE UEs with TDRA table configured via SIB and indicated dynamically through DCI. |
| LG | We are fine with this proposal. |
| CATT | OK with the proposal. |
| ZTE | We think option 2 is enough.  It is unnecessary for indicating dynamically as some scheduling configuration for the group-common PDSCH (e.g., MCS, resource size, etc.) are updated very slowly considering that the PDSCH scheduling should be more conservative in order to accommodate multiple UEs in the same group. Then, determining a repetition number semi-statically is sufficient from this perspective. So indicating the repetition number by RRC signaling is preferred. |
| Spreadtrum | Support both Option2 and Option3. We share the same view as QC. |
| vivo | Same view as QC. We prefer to reuse Rel-15 RRC based option or Rel-16 TDRA based option. |
| Nokia, NSB | Similar view to ZTE  Do not support the proposal given from our analysis we could not find regular scenarios that justified DCI based indication. However, we could support it, if it is made clear that RRC configuration (opt 2) is supported.  Based on our reading of the companies’ positions (at least 8 companies in favour of RRC signalling), and also our own analysis, RRC signalling (Opt 2) is sufficient. |
| Ericsson | We support the FL proposal, and would like to add option 4 (MAC CE) as FFS. |

## 2nd round discussion

FL’s Comments

Based on the comments received and the majority views and given RRC configuring aggregation factor in Rel-15 and repetition number configured as part of TDRA in Rel-16 have been supported, the proposal is updated as follows to have it up to network configuration.

FL’s Proposal:

#### Proposal 3.1: (PDSCH repetition)

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

* UE can be optionally configured with *pdsch-AggregationFactor*.
* 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.
  + Config A represents “optionally configured with *pdsch-AggregationFactor*”
  + Config B represents “optionally configured with TDRA table with *repetitionNumber* as part of the TDRA table”

Collect views:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We are fine with this proposal. |
| Nokia, NSB | We are fine with this proposal. |

# CSI feedback

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. |

# 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

## Proposals for GTW

# References

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# 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.