**3GPP TSG-RAN WG1 Meeting #101-eR1-200xxxx**

**e-Meeting, May 25th – June 5th, 2020**

**Agenda Item:** 7.2.5.7

**Source:** Moderator (LG Electronics)

**Title:** Summary of [101-e-NR-L1enh-URLLC-IIoTenh-03]

**Document for:** Discussion and decision

# Introduction

According to discussion at the preparation phase, the following email thread is allocated by Chairman for further discussion:

[101-e-NR-L1enh-URLLC-IIoTenh-03] Email discussion on the following issues by 5/29 and corresponding TP (if any) by 6/5 – Duckhyun (LGE)

* 3.3. Unnecessary restriction of at most 1 bit of HARQ-ACK feedback on a PUCCH for single SPS PDSCH configuration for type-2 codebook
* 3.6. HARQ-ACK codebook for SPS PDSCH with PDSCH aggregation

To address the identified issues from companies’ contributions related to the above email thread, the suggestions for the issues are provided in Section 2. [In Section 3, a few open issues identified are listed up so companies are encouraged to provide your input/feedback in the next meeting in order to facilitate the discussion]. In section [4], the outcome from [101-e-NR-L1enh-URLLC-IIoTenh-03] are provided including all the agreements and all the endorsed TPs.

# Email discussions

## Issue 3.3: Unnecessary restriction of at most 1 bit of HARQ-ACK feedback on a PUCCH for single SPS PDSCH configuration for type-2 codebook

Even in case of single SPS configuration in a cell group, it is possible that multiple HARQ-ACK bits are to be transmitted in the same PUCCH considering mixed numerology case (e.g., DL SCS > UL SCS) as raised by ZTE in the last e-meeting. Due to lack of time, there was no chance to discuss if such spec change is also needed for type-2 HARQ-ACK codebook.

For this issue, Following TP and proposals are provided by companies’ contributions.

**<ZTE, [1]>**

|  |
| --- |
| **TS 38.213 v16.1.0****9.1.3.1            Type-2 HARQ-ACK codebook in physical uplink control channel****<**Unchanged text is omitted> for any ~~Set~~ ~~while~~ ~~if a single SPS PDSCH reception is activated for a UE and the UE is configured to receive SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for SPS PDSCH on serving cell~~ ~~= HARQ-ACK information bit associated with the SPS PDSCH reception~~~~end if~~~~;~~~~end while~~If one or multiple SPS PDSCH receptions are activated for a UE and the UE multiplexes corresponding HARQ-ACK information in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.**<**Unchanged text is omitted> |

**<vivo, [2]>**

|  |
| --- |
| ================== Beginning of text proposal 2 ===================**TS 38.213 v16.1.0****9.1.3.1            Type-2 HARQ-ACK codebook in physical uplink control channel** **<**Unchanged text is omitted> for any Set  while if ~~a single SPS PDSCH reception is activated for a UE and~~ the UE is configured to receive a single SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for the SPS PDSCH on serving cell = HARQ-ACK information bit associated with the SPS PDSCH receptionend if;end whileIf multiple SPS PDSCH receptions are activated or there is more than one DL slot for SPS PDSCH receptions on a serving cell and the UE multiplexes corresponding HARQ-ACK information in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.**<**Unchanged text is omitted>================== End of text proposal 2 =================== |

***Proposal 2: Adopt above TP2 in TS 38.213 section 9.1.3.1.***

<Nokia, [4]>

**Proposal 2: Adopt the following text proposal to allow more than 1 bit of SPS PDSCH HARQ-ACK feedback in a Type-2 Codebook when a single SPS PDSCH reception is activated for a UE:**

|  |
| --- |
| **Text proposal to Section 9.1.3.1 in TS 38.213:**9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel**<**Unchanged text is omitted>if a single SPS PDSCH reception is activated for a UE:Set  while Set $N\_{c}^{DL}$ to the number of DL slots with a configured SPS PDSCH reception on serving cell $c$ with HARQ-ACK information multiplexed on the PUCCH Set $n\_{D}=0$ – slot index while $n\_{D}<N\_{c}^{DL}$~~if a single SPS PDSCH reception is activated for a UE and the UE is configured to receive SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for SPS PDSCH on serving cell~~ = HARQ-ACK information bit associated with the SPS PDSCH ~~reception~~ in slot $n\_{D}$ $$n\_{D}=n\_{D}+1$$~~end if~~end while;end whileend ifIf multiple SPS PDSCH receptions are activated for a UE and the UE multiplexes corresponding HARQ-ACK information in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.**<**Unchanged text is omitted> |

**<CATT [5]>**

***Proposal 2: Adopt the text proposal for Type 2 HARQ-ACK codebook generation.***

|  |
| --- |
| -------------------------------------------------- Start of text proposal ------------------------------------------------------9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel<unchanged text omitted>~~Set~~ ~~while~~ ~~if a single SPS PDSCH reception is activated for a UE and the UE is configured to receive SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for SPS PDSCH on serving cell~~ ~~= HARQ-ACK information bit associated with the SPS PDSCH reception~~~~end if~~~~;~~~~end while~~If a UE is configured to receive SPS PDSCH and the UE multiplexes HARQ-ACK information for a single SPS PDSCH reception in the PUCCH in slot $n$, the UE generates 1 bit HARQ-ACK information associated with the SPS PDSCH reception and appends it to the  HARQ-ACK information bits.If ~~multiple SPS PDSCH receptions are activated for a UE~~a UE is configured to receive SPS PDSCH and the UE multiplexes ~~corresponding~~ HARQ-ACK information for multiple SPS PDSCH receptions in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.<unchanged text omitted>----------------------------------------------------- End of text proposal ------------------------------------------------------ |

**<LG, [10]>**

From our understanding, it seems no need to change the specification as the pseudo code in Section 9.1.3.2 only covers the case for 1 bit HARQ-ACK (the case for multiple HARQ-ACK bits is covered by yellow

**<Huawei, HiSilicon, [17]>**

A simple method to overcome this is to revise the restriction and to allow M bits instead of 1 bit to be transmitted in the PUCCH, where M is equal to the number of slots used to transmit the SPS PDSCH.

***Proposal 1: Do not restrict to at most 1 bit of HARQ-ACK feedback on a PUCCH for single SPS PDSCH configuration for type-2 codebook in mixed numerology case.***

## FL’s suggestion on the issue 3.3

Based on contributions, the problem is valid and all propose solutions seems works. There are two kind of proposed TP. One is to modify current pseudo code for multiple SPS PDSCH occasion. The other is to use pseudo code for multiple SPS configuration also for single configuration. If all given TPs make same results, I would like to take majority view from companies preference.

**TP #1 from [1]**

|  |
| --- |
| **TS 38.213 v16.1.0****9.1.3.1            Type-2 HARQ-ACK codebook in physical uplink control channel****<**Unchanged text is omitted> for any ~~Set~~ ~~while~~ ~~if a single SPS PDSCH reception is activated for a UE and the UE is configured to receive SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for SPS PDSCH on serving cell~~ ~~= HARQ-ACK information bit associated with the SPS PDSCH reception~~~~end if~~~~;~~~~end while~~If one or multiple SPS PDSCH receptions are activated for a UE and the UE multiplexes corresponding HARQ-ACK information in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.**<**Unchanged text is omitted> |

**TP #2 from [2]**

|  |
| --- |
| ================== Beginning of text proposal 2 ===================**TS 38.213 v16.1.0****9.1.3.1            Type-2 HARQ-ACK codebook in physical uplink control channel** **<**Unchanged text is omitted> for any Set  while if ~~a single SPS PDSCH reception is activated for a UE and~~ the UE is configured to receive a single SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for the SPS PDSCH on serving cell = HARQ-ACK information bit associated with the SPS PDSCH receptionend if;end whileIf multiple SPS PDSCH receptions are activated or there is more than one DL slot for SPS PDSCH receptions on a serving cell and the UE multiplexes corresponding HARQ-ACK information in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.**<**Unchanged text is omitted>================== End of text proposal 2 =================== |

**TP #3 from [4]**

|  |
| --- |
| **Text proposal to Section 9.1.3.1 in TS 38.213:**9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel**<**Unchanged text is omitted>if a single SPS PDSCH reception is activated for a UE:Set  while Set $N\_{c}^{DL}$ to the number of DL slots with a configured SPS PDSCH reception on serving cell $c$ with HARQ-ACK information multiplexed on the PUCCH Set $n\_{D}=0$ – slot index while $n\_{D}<N\_{c}^{DL}$~~if a single SPS PDSCH reception is activated for a UE and the UE is configured to receive SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for SPS PDSCH on serving cell~~ = HARQ-ACK information bit associated with the SPS PDSCH ~~reception~~ in slot $n\_{D}$ $$n\_{D}=n\_{D}+1$$~~end if~~end while;end whileend ifIf multiple SPS PDSCH receptions are activated for a UE and the UE multiplexes corresponding HARQ-ACK information in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.**<**Unchanged text is omitted> |

**TP #4 from [5]**

|  |
| --- |
| -------------------------------------------------- Start of text proposal ------------------------------------------------------9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel<unchanged text omitted>~~Set~~ ~~while~~ ~~if a single SPS PDSCH reception is activated for a UE and the UE is configured to receive SPS PDSCH in a slot  for serving cell , where  is the PDSCH-to-HARQ-feedback timing value for SPS PDSCH on serving cell~~ ~~= HARQ-ACK information bit associated with the SPS PDSCH reception~~~~end if~~~~;~~~~end while~~If a UE is configured to receive SPS PDSCH and the UE multiplexes HARQ-ACK information for a single SPS PDSCH reception in the PUCCH in slot $n$, the UE generates 1 bit HARQ-ACK information associated with the SPS PDSCH reception and appends it to the  HARQ-ACK information bits.If ~~multiple SPS PDSCH receptions are activated for a UE~~a UE is configured to receive SPS PDSCH and the UE multiplexes ~~corresponding~~ HARQ-ACK information for multiple SPS PDSCH receptions in the PUCCH in slot $n$, the UE generates the HARQ-ACK information as described in Clause 9.1.2 and appends it to the  HARQ-ACK information bits.<unchanged text omitted>----------------------------------------------------- End of text proposal ------------------------------------------------------ |

**Proposal 1: Down select TP among TP#1-4.**

Companies are encouraged to provide your preference among TPs (or editorial correction if any) on above proposal.

**Comment:**

|  |  |  |
| --- | --- | --- |
| Company | Preferred TP# | Comment if any |
| QC | TP1 | Seems to be the simplest one |
| Samsung | TP1  |  |
| vivo | TP1 or TP2 | Seems no much difference among the TPs, either TP1 or TP2 is ok since they seem to be simpler. |
| ZTE | TP1 | Actually all the advised TPs are quite understanding the intention, we just want to find a simple way for this. |
| NEC | TP1 |  |
| OPPO | TP1 |  |
| HW/HiSi | TP1 |  |
| CATT | TP4 | TP1 is the simplest one, but if there is only one HARQ-ACK bit corresponding to SPS PDSCH reception, the HARQ-ACK is generated according to clause 9.1.2. However, as we discussed in the last meeting, we have the following agreements. In case there is only one HARQ-ACK bit for SPS PDSCH, whether to include the HARQ-ACK bit in case the SPS PDSCH is cancelled by DCI/dynamic SFI is different for type-1 and type-2 HARQ-ACK codebooks. So we think we cannot simply follow 9.1.2 in this case.Agreements:HARQ-ACK feedback for a SPS PDSCH is included in the HARQ-ACK codebook when the SPS PDSCH is cancelled by DCI/dynamic SFI in which case NACK is generated for the SPS PDSCH.* For type-1 codebook, the main bullet is not applied if only a single HARQ-ACK bit, for an SPS PDSCH, is mapped on a PUCCH; otherwise, the main bullet is applied.
* For type-2 codebook, the main bullet is applied.

In addition, we would like to clarify “SPS PDSCH reception” is not SPS PDSCH configuration. For a same SPS configuration, there can be multiple HARQ-ACK bits corresponding to multiple SPS PDSCH receptions in the same PUCCH. |
| Nokia, NSB | TP#3 or TP#4 | **TP#1 does not keep Rel-15 compatibility** because in Clause 9.1.2 the intention (TP is under discussion in email thread #1) is that for single PDSCH reception the HARQ-ACK bit is not generated if it is cancelled by DCI/dynamic SFI. As a reminder, RAN1#100-bis-e conclusion is that for type-2 codebook, HARQ-ACK feedback for a SPS PDSCH is included in the HARQ-ACK codebook when the SPS PDSCH is cancelled by DCI/dynamic SFI.For TP#2, “or there is more than one DL slot for SPS PDSCH receptions on a serving cell” is not sufficiently accurate in our opinion as it is not referring to a particular PUCCH.  |
| Ericsson | TP3 | We prefer to maintain the pseudo code to clearly define the HARQ-ACK bit order. |

## Issue 3.6 HARQ-ACK codebook for SPS PDSCH with PDSCH aggregation

There were some proposals on HARQ-ACK codebook when PDSCH aggregation is configured for SPS. At least the following aspects are identified to be taken care of:

* For SPS PDSCH with aggregation factor, A/N bit generation is per slot per occasion or within all *pdsch-AggregationFactor* occasions?
* How to assume *pdsch-AggregationFactor* when constructing HARQ-ACK codebook
* HARQ-ACK codebook construction depending on the reception of the last SPS PDSCH (e.g., when only the last SPS PDSCH is cancelled but others are received)

For this issue, Following TP and proposals are provided by companies’ contributions.

**<vivo, [2]>**

***Proposal 5: For type 1 HARQ-ACK codebook, is the maximum of the values of pdsch-AggregationFactor values provided in SPS-Config and PDSCH-Config in the pseudo-code of determining occasions for candidate PDSCH receptions or SPS PDSCH releases.***

***Proposal 6:******Adopt TP3 in TS 38.213 section 9.1.2.1.***

***Proposal 7: For a SPS PDSCH reception ending in slot n, the UE transmits the PUCCH in slot n+k, where reception of the last SPS PDSCH is the PDSCH reception before cancellation.***

**<Ericsson, [3]>**

Proposal 5: For Type-1 codebook, the UE reports HARQ-N/ACK feedback on the placeholder corresponding to last actual transmitted repetition instead of a last configured repetition for a given SPS.

**<Nokia, [4]>**

**Proposal 8: For Type-1 HARQ-ACK codebook, adopt the following text proposal to Section 9.1.2 of TS 38.213 to allow PDSCH aggregation per DL SPS configuration (provided via RRC parameter *pdsch-AggregationFactor* in *sps-Config*).**

|  |
| --- |
| **TP to TS 38.213, Sec. 9.1.2** 9.1.2 Type-1 HARQ-ACK codebook determination<omitted text>For SPS PDSCH reception for which *pdsch-AggregationFactor* is provided in *sps-Config*, $N\_{PDSCH}^{repeat}$ is a value of *pdsch-AggregationFactor* in *sps-Config*. Otherwise, if the UE is provided *pdsch-AggregationFactor* in *pdsch-config* and no entry in *pdsch-TimeDomainAllocationList* includes *RepNumR16* in *PDSCH-TimeDomainResourceAllocation*, $N\_{PDSCH}^{repeat}$ is a value of *pdsch-AggregationFactor* in *pdsch-config*; otherwise $N\_{PDSCH}^{repeat}=1$. The UE reports HARQ-ACK information for a PDSCH reception* from slot $n-N\_{PDSCH}^{repeat}+1$ to slot $n$, if $N\_{PDSCH}^{repeat}>1$, or
* from slot $n-RepNumR16+1$ to slot $n$, if the Time domain resource assignment field in the DCI format scheduling the PDSCH reception indicates an entry in *pdsch-TimeDomainAllocationList* containing *RepNumR16,* or
* in slot $n$, otherwise

only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot $n+k$, where $k$ is a number of slots indicated by the PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format or provided by dl-DataToUL-ACK if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI format. If the UE reports HARQ-ACK information for the PDSCH reception in a slot other than slot $n+k$, the UE sets a value for each corresponding HARQ-ACK information bit to NACK. <omitted text> |

**Proposal 9: For Type-1 HARQ-ACK codebook, the set of MA,c occasions for candidate PDSCH receptions should be determined based on the maximum of the values of *pdsch-AggregationFactor* values, if provided in *sps-Config* and/or *pdsch-Config*, and values of *RepNumR16*, if provided. Adopt the following text proposal to TS 38.213 Section 9.1.2.1:**

|  |
| --- |
| **TP to TS 38.213, Sec. 9.1.2.1** 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channelFor a serving cell , an active DL BWP, and an active UL BWP, as described in Clause 12, the UE determines a set of  occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot . If serving cell  is deactivated, the UE uses as the active DL BWP for determining the set of  occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:<omitted text>e) if *CA-slot-offset* is provided, on $N\_{slot,offset,c}^{DL} $and $μ\_{offset,DL,c}$ for serving cell $c$, or on$N\_{slot,offset}^{UL} $ and $μ\_{offsetUL}$for the cell of PUCCH transmission, as described in [4, TS 38.211].f) on $N\_{PDSCH, max}^{repeat}$, where $N\_{PDSCH, max}^{repeat}$ is the maximum of values of *pdsch-AggregationFactor* if provided in *sps-Config* and/or *pdsch-Config,* and values of *RepNumR16,* if provided.<omitted text>while if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot $\left⌊\left(n\_{U}-K\_{1,k}\right)∙2^{μ\_{DL}-μ\_{UL}}\right⌋+n\_{D}-N\_{PDSCH,max}^{repeat}+1$ to slot , at least one symbol of the PDSCH time resource derived by row  is configured as ULwhere  is the *k*-th slot timing value in set , ;else; end ifend while<omitted text> |

**Proposal 10: When *pdsch-AggregationFactor* > 1 is configured for a SPS configuration, the UE is not expected to be scheduled with another decodable PDSCH that occupies the same bit position as the SPS PDSCH in a Type-1 HARQ-ACK codebook.**

**<CATT, [5]>**

|  |
| --- |
| -------------------------------------------------- Start of text proposal ------------------------------------------------------9.1.2 Type-1 HARQ-ACK codebook determination<unchanged text omitted>Set $N\_{cells}^{DL}$ to the number of serving cells configured to the UESet $N\_{c}^{SPS}$ to the number of SPS PDSCH configuration configured to the UE for serving cell $c$Set $N\_{c}^{DL}$ to the number of DL slots for SPS PDSCH reception on serving cell $c$ with HARQ-ACK information multiplexed on the PUCCHSet $N\_{PDSCH}^{repeat}$ to the number of slots for SPS PDSCH repetition.Set $j=0$ – HARQ-ACK information bit indexSet $c=0$ – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cellwhile $c<N\_{cells}^{DL}$ Set $s=0$ – SPS PDSCH configuration index: lower indexes correspond to lower RRC indexes of corresponding SPS configurations while $s<N\_{c}^{SPS}$Set $n\_{D}=0$ – slot index while $n\_{D}<N\_{c}^{DL}$if {a UE is configured to receive a SPS PDSCH in slot $n\_{D}$ for SPS PDSCH configuration $s$ on serving cell $c$, except that ~~and~~ the SPS PDSCH is not required to be received among overlapping SPS PDSCHs for each slot from slot $n\_{D}-N\_{PDSCH}^{repeat}+1$ to slot $n\_{D}$, if any according to [6, TS 38.214], or based on a UE capability for a number of PDSCH receptions in a slot according to [6, TS 38.214], andHARQ-ACK information for the SPS PDSCH is associated with the PUCCH}$\tilde{o}\_{j}^{ACK}$ = HARQ-ACK information bit for this SPS PDSCH reception $j=j+1$;end if$n\_{D}=n\_{D}+1$;end while$s=s+1$;end while$c=c+1$;end while<unchanged text omitted>----------------------------------------------------- End of text proposal ------------------------------------------------------ |

***Proposal 4: Adopt the text proposal for HARQ-ACK codebook generation in response to SPS PDSCH receptions.***

**<NEC, [6]>**

***Proposal 6****: HARQ-ACK feedback for an SPS PDSCH should be included in a HARQ-ACK codebook even if the last repetition is cancelled but others are received*.

**<Samsung, [8]>**

***Proposal 3: For Type-1 HARQ-ACK codebook, the set of MA,c occasions for candidate PDSCH receptions should be determined based on the maximum of the values of pdsch-AggregationFactor values, if provided in SPS-Config and/or PDSCH-Config and values of RepNumR16, if provided. The following TP should be adopted.***

|  |
| --- |
| **TS 38.213**9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channelFor a serving cell , an active DL BWP, and an active UL BWP, as described in Clause 12, the UE determines a set of  occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot . If serving cell  is deactivated, the UE uses as the active DL BWP for determining the set of  occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:a) on a set of slot timing values  associated with the active UL BWPa) If the UE is configured to monitor PDCCH for DCI format 1\_0 and is not configured to monitor PDCCH for DCI format 1\_1 on serving cell ,  is provided by the slot timing values {1, 2, 3, 4, 5, 6, 7, 8} for DCI format 1\_0b) If the UE is configured to monitor PDCCH for DCI format 1\_1 for serving cell ,  is provided by *dl-DataToUL-ACK* for DCI format 1\_1b) on a set of row indexes  of a table that is provided either by a first set of row indexes of a table that is provided by *pdsch-TimeDomainAllocationList* in *pdsch-ConfigCommon* or by Default PDSCH time domain resource allocation A [6, TS 38.214], or by the union of the first set of row indexes and a second set of row indexes, if provided by *pdsch-TimeDomainAllocationList* in *pdsch-Config*, associated with the active DL BWP and defining respective sets of slot offsets , start and length indicators *SLIV*, and PDSCH mapping types for PDSCH reception as described in [6, TS 38.214]c) on the ratio  between the downlink SCS configuration  and the uplink SCS configuration  provided by *subcarrierSpacing* in *BWP-Downlink* and *BWP-Uplink* for the active DL BWP and the active UL BWP, respectivelyd) if provided, on *tdd-UL-DL-ConfigurationCommon* and *tdd-UL-DL-ConfigurationDedicated* as described in Clause 11.1 e) if *CA-slot-offset* is provided, on $N\_{slot,offset,c}^{DL} $and $μ\_{offset,DL,c}$ for serving cell $c$, or on$N\_{slot,offset}^{UL} $ and $μ\_{offsetUL}$for the cell of PUCCH transmission, as described in [4, TS 38.211].f) on $N\_{PDSCH, max}^{repeat} $, where $N\_{PDSCH, max}^{repeat} $ is the maximum of values of *pdsch-AggregationFactor,* if provided in *SPS-Config* and/or *PDSCH-Config,* and values of *RepNumR16,* if provided.If a UE- is not provided *CORESETPoolIndex* or is provided *CORESETPoolIndex* with a value of 0 for first CORESETs on active DL BWPs of serving cells, and- is provided *CORESETPoolIndex* with a value of 1 for second CORESETs on active DL BWPs of the serving cells, and- is provided *ACKNACKFeedbackMode* = *JointFeedback*where - a serving cell is placed in a first set $S\_{0}$ of $N\_{cells}^{DL,0}$ serving cells if the serving cell includes a first CORESET, and- a serving cell is placed in a second set $S\_{1}$ of $N\_{cells}^{DL,1}$ serving cells if the serving cell includes a second CORESET, and- serving cells are placed in a set according to an ascending order of a serving cell indexthe UE generates a Type-1 HARQ-ACK codebook for the set $S\_{0}$ and the set $S\_{1}$ of serving cells separately by setting $N\_{cells}^{DL}=N\_{cells}^{DL,0}$ and $N\_{cells}^{DL}=N\_{cells}^{DL,1}$ in the following pseudo-code. The UE concatenates the HARQ-ACK codebook generated for the set $S\_{0}$ followed by the HARQ-ACK codebook generated for the set $S\_{1}$ to obtain a total number of  HARQ-ACK information bits..For the set of slot timing values, the UE determines a set of  occasions for candidate PDSCH receptions or SPS PDSCH releases according to the following pseudo-code. A location in the Type-1 HARQ-ACK codebook for HARQ-ACK information corresponding to a single SPS PDSCH release is same as for a corresponding SPS PDSCH reception. A location in the Type-1 HARQ-ACK codebook for HARQ-ACK information corresponding to multiple SPS PDSCH releases by a single DCI format is same as for a corresponding SPS PDSCH reception with the lowest SPS configuration index among the multiple SPS PDSCH releases.Set  - index of occasion for candidate PDSCH reception or SPS PDSCH releaseSet Set Set  to the cardinality of set Set *k* =0 – index of slot timing values , in descending order of the slot timing values, in set  for serving cell If a UE is not provided *CA-slot-offset* for any serving cell of PDSCH receptions and for the serving cell of corresponding PUCCH transmission with HARQ-ACK informationwhile  if  Set  – index of a DL slot within an UL slotwhile  Set  to the set of rowsSet  to the cardinality of Set  – index of row in set if slot  starts at a same time as or after a slot for an active DL BWP change on serving cell  or an active UL BWP change on the PCell and slot  is before the slot for the active DL BWP change on serving cell  or the active UL BWP change on the PCell $n\_{D}=n\_{D}+1$; else while if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot $\left⌊\left(n\_{U}-K\_{1,k}\right)∙2^{μ\_{DL}-μ\_{UL}}\right⌋+n\_{D}-N\_{PDSCH}^{repeat}+1$ $\left⌊\left(n\_{U}-K\_{1,k}\right)∙2^{μ\_{DL}-μ\_{UL}}\right⌋+n\_{D}-N\_{PDSCH,max}^{repeat}+1$ to slot , at least one symbol of the PDSCH time resource derived by row  is configured as ULwhere  is the *k*-th slot timing value in set , ;else; end ifend while… |

***Proposal 4: For Type-2 HARQ-ACK codebook, monitoring occasions for PDCCH on an active DL BWP of a serving cell should be determined by all the values of pdsch-AggregationFactor, when provided in both SPS-Config and PDSCH-Config. The following TP should be adopted.***

|  |
| --- |
| **TS 38.213**9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channelA UE determines monitoring occasions for PDCCH with DCI format scheduling PDSCH receptions or SPS PDSCH release on an active DL BWP of a serving cell , as described in Clause 10.1, and for which the UE transmits HARQ-ACK information in a same PUCCH in slot  based on- PDSCH-to-HARQ\_feedback timing indicator field values for PUCCH transmission with HARQ-ACK information in slot  in response to PDSCH receptions or SPS PDSCH release- slot offsets  [6, TS 38.214] provided by time domain resource assignment field in a DCI format scheduling PDSCH receptions or SPS PDSCH release and by values of *pdsch-AggregationFactor*, when provided in *SPS-Config* and *PDSCH-Config*. … |

**<Spreadtrum, [9]>**

**Proposal 7. For SPS PDSCH with aggregation factor, A/N bit generation is within all pdsch-AggregationFactor occasions.**

**Proposal 8. When constructing HARQ-ACK codebook, pdsch-AggregationFactor is the maximum value among the values of pdsch-AggregationFactor from PDSCH-config and SPS-config which SPS PDSCH reception with HARQ-ACK information multiplexed on the PUCCH**

**Proposal 9. When at least one SPS PDSCH is received, the HARQ-ACK can be in the HARQ-ACK codebook.**

**<oppo, [10]>**

**Proposal 3: A/N bit generation is per periodicity.**

**Proposal 4: Maximum value of *pdsch-AggregationFactor* for multiple SPS configurations with the same priority is applied for Type 1 HARQ-ACK codebook construction.**

**Proposal 5: The slot/sub-slot to transmit HARQ-ACK depends on the reception of the last SPS PDSCH repetition after semi-static cancellation of SPS PDSCH repetition.**

**< NTT DOCOMO, INC., [15]>**

**Proposal 2:**

* *If a UE is provided multiple PDSCH aggregation factor values by pdsch-AggregationFactor in SPS-Config and/or PDSCH-Config, the Type-1 HARQ-ACK codebook is determined based on the maximum of the multiple PDSCH aggregation factor values.*

**<** **Qualcomm Incorporated, [16]>**

**Proposal 9:** $N\_{PDSCH}^{repeat}$ **is always defined as 1 and A/N bit position for each PDSCH with repetitions is tied with the last actual PDSCH reception.**

**Proposal 10: If Proposal 5 is adopted, UE does not expect to be configured with a set of slot timing values K1 that for a given PDSCH with *pdsch-AggregationFactor* >1, none of actual receptions is received within the set of *nD* slots.**

**< Huawei, HiSilicon, [17]>**

***Proposal 3:******HARQ-ACK feedback for a SPS PDSCH should also be included in the HARQ-ACK codebook, if the last SPS PDSCH repetition is not received but other SPS PDSCH repetitions within same repetition are received****.*

## FL’s suggestion on the issue 3.6

Based on contributions, there seems two majority views as following.

* For SPS PDSCH with aggregation factor, UE generates one A/N bit for all *pdsch-AggregationFactor* occasions
* Assume maximum value of *pdsch-AggregationFactor* when constructing HARQ-ACK codebook

And, following are controversial, so that we need to discuss further.

* HARQ-ACK timing determination among *pdsch-AggregationFactor* occasions (e.g., when only the last SPS PDSCH is cancelled but others are received)

Main discussion point is which last SPS PDSCH occasion between actual and configured is. Since pdsch-AggregationFactor is already supported in Rel-15, this is not a new issue. In the perspective of FL, we should consider backward compatibility at this last stage. Based on the specification and contributions, currently PUCCH resource for PDSCH aggregation is determined by last configured SPS PDSCH reception without changing by SFI. So, I would like to suggest to consider below proposal with backward compatibility issue.

Regardless of my proposal, companies are encouraged to provide your preference between actual and configured transmission, detailed reason to support and differences from Rel-15.

In those point of view, please consider following:

**Proposed Conclusion: For SPS PDSCH with aggregation factor, UE generates one A/N bit for all pdsch-AggregationFactor occasions same as Rel-15**

* + **No spec changed is needed.**

**Comment:**

|  |  |
| --- | --- |
| Company | Comment if any |
| QC | Do not agree. First the statement “UE generates one A/N bit for all pdsch-AggregationFactor occasions same as Rel-15” is not correct, since Rel-15 specification is not that way. Second, in Rel-15, for each PDSCH occasion within a slot, a bit is generated in the codebook even if that occasion is dropped due to U conflict, if there is at least one occasion within the last $N\_{PDSCH}^{repeat}$-1 occasions that has no U conflict. This means a big unnecessary overhead in codebook size, which is magnified if we go with maximum of $N\_{PDSCH}^{repeat}$ configurations, as shown in our contribution. A solution to this problem is to generate a bit per occasion only if that occasion is not dropped due to U conflict, without looking back to its $N\_{PDSCH}^{repeat}$-1 previous occasions, i.e. when codebook construction always assume $N\_{PDSCH}^{repeat}=1$. This is also aligned with the agreement RAN1 made in 100b-e meeting, that decision is made per occasion not within bundle of occasions.   |
| Samsung | AgreeIn Rel-15, for Type-1 HARQ-ACK codebook, “If the UE is provided *pdsch-AggregationFactor*,  is a value of *pdsch-AggregationFactor*; otherwise, . The UE reports HARQ-ACK information for a PDSCH reception from slot  to slot  only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot ,” It is quite clear that UE only reports one HARQ-ACK bit for all the PDSCH repetitions. Since all the repetitions are considered as one PDSCH reception, there is only one HARQ-ACK bit.  |
| vivo | Do not agree. Agree with QC that the first the statement “UE generates one A/N bit for all pdsch-AggregationFactor occasions same as Rel-15” is not correct. From our understanding, in Rel-15, for type 2 CB, UE generates one A/N bit for all pdsch-AggregationFactor occasions; For type 1 CB, UE may generate multiple A/N bits (one valid A/N relative to the last repetition occasion, for other occasions, the HARQ-ACK can be set NACK) for the PDSCH with pdsch-AggregationFactor repetitions, it depends on how many occasions are included in the MA,c occasions. |
| ZTE | Agree, the proposed conclusion is the simple way. |
| NEC | Agree. One HARQ-ACK bit for all the repetitions is consistent with Rel-15 as explained by Samsung. |
| OPPO | Agree the intention of proposal and follow Rel-15 behavior.However, for type 1 HARQ-ACK codebook, A/N bit mapping is determined by MA,c occasions and K sets. So more than one A/N bits for SPS-PDSCH repetition may be included in one HARQ-ACK codebook. But A/N bit value in target PUCCH slot n+k is determined by final reception result for total SPS-PDSCH reception. A/N bit value in other PUCCH slot covering SPS-PDSCH slots is set NACK. |
| HW/HiSi | Do not agree in general. An A/N-bit does not need to be generated for all pdsch-AggregationFactor occasions. It is enough to generate an A/N –bit for the last repetition that is received, as illustrated in the figure below. Only an A/N bit for the orange SPS in slot 2 needs to be generated and one A/N for the green SPS in slot 3. One A/N bit should be generated for each SPS configuration and included in the same codebook. If they need to be transmitted simultaneously. In the example below, 1 bit for SPS index 1 and one bit for SPS index 2 would be transmitted in the same PUCCH.  |
| CATT | We are not quite clear about the intention of the proposal. |
| Nokia, NSB | **Agree with main bullet, but not with sub-bullet that no on specs change is needed**. Main bullet: As Samsung and Vivo mentioned, in Rel-15 the UE generates only one A/N bit relative to the last repetition occasion. This is, in our understanding, what the main bullet of the proposed conclusion tries to express.However, we disagree on sub-bullet with the “No spec changed is needed”. As we highlighted in our TDoc [4], in current Rel-16 specifications $N\_{PDSCH}^{repeat}$ is set to 1 when *RepNumR16* is provided. In our view, *RepNumR16* should work independently of *pdsch-AggregationFactor* provided in *sps-Config* and thus the following change is proposed to TS 38.213, Sec. 9.1.2:For SPS PDSCH reception for which *pdsch-AggregationFactor* is provided in *sps-Config*, $N\_{PDSCH}^{repeat}$ is a value of *pdsch-AggregationFactor* in *sps-Config*. Otherwise, if the UE is provided *pdsch-AggregationFactor* in *pdsch-config* and no entry in *pdsch-TimeDomainAllocationList* includes *RepNumR16* in *PDSCH-TimeDomainResourceAllocation*, $N\_{PDSCH}^{repeat}$ is a value of *pdsch-AggregationFactor* in *pdsch-config*; otherwise $N\_{PDSCH}^{repeat}=1$. The UE reports HARQ-ACK information for a PDSCH reception |
| Ericsson | Agree with proposed conclusion |

**Proposal 2: For Type-1 HARQ-ACK codebook, the set of MA,c occasions for candidate PDSCH receptions should be determined based on the maximum of the values of pdsch-AggregationFactor values, if provided in SPS-Config and/or PDSCH-Config and values of RepNumR16, if provided.**

**Comment:**

|  |  |
| --- | --- |
| Company | Comment if any |
| QC | Do not agree. This increases codebook size unnecessarily, as explained under proposal 1, and also illustrated in our contribution.  |
| Samsung | AgreeRel-15 Type-1 HARQ-ACK codebook includes all the possible candidates for PDSCH receptions to ensure the size and order of HARQ-ACK codebook. Same principle should be followed in Rel-16 with minimum modifications. |
| vivo | Do not agree. In case of RepNumR16 is provided, it has been discussed in MIMO session in RAN1 100e meeting, and it was agreed that $N\_{PDSCH}^{repeat}=1$ to reduce the codebook size. Proposal 2 will revert MIMO’s agreements. We think the set of MA,c occasions for candidate PDSCH receptions should be determined based on the maximum of the values of pdsch-AggregationFactor values, provided in SPS-Config and/or PDSCH-Config if RepNumR16 is not provided, otherwise it is 1. |
| ZTE | Agree the proposal 2, only minor specification impact. |
| OPPO | Agree with intention of proposal 2. Considering that HARQ-ACK codebook is constructed per priority level, It seems reasonable to restrict “pdsch-AggregationFactor values” to “pdsch-AggregationFactor values **corresponding to PDSCHs with the same priority”**  |
| HW/HiSi | Do not agree. This would make the size of the codebook too large, which is not needed. It is enough to use one A/N bit for a SPS configuration. The A/N bits corresponds to last received PDSCH from the PDSCH repetitions. |
| CATT | In our understanding, even if RepNumR16 is provided, the number of repetition for SPS follows pdsch-AggregationFactor in SPS-Config and in this case we should not assume $N\_{PDSCH}^{repeat}=1$. We can further discuss how to resolve the discrepancy between different WIs. |
| Nokia, NSB | Agree. With respect to the comment from Vivo, it is problematic to operate with $N\_{PDSCH}^{repeat}=1$ and *pdsch-AggregationFactor* >1 (in *sps-Config*) simultaneously because that may result in not having a A/N bit for the SPS PDSCH in a Type-1 codebook if the last SPS PDSCH of the *pdsch-AggregationFactor* occasions is dropped due to semi-static UL symbols. |
| Ericsson | Do not agree.Each PDSCH (dynamic or SPS) has its own number of repetitions. One PDSCH reception (including all of its repetitions) corresponds to one A/N bit. We do not see any reason to use max to determine MA,C |

**Proposal 3: For a SPS PDSCH reception, the UE transmits the PUCCH in slot n+k:**

* + **Slot n is determined by the last configured SPS PDSCH occasion (i.e., before cancellation)**
	+ **Where 𝑘 is a number of slots indicated by the PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format or provided by dl-DataToUL-ACK if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI format.**

**Comment:**

|  |  |
| --- | --- |
| Company | Comment if any |
| QC | Not sure what “before cancellation” means. Regarding the PUCCH determination to report HARQ-ACK for each PDSCH, it is determined based on Rel-15 procedure that is (38.213, 9.1.2)The UE reports HARQ-ACK information for a PDSCH reception- from slot $n-N\_{PDSCH}^{repeat}+1$ to slot $n$, if PDSCH is configured with $N\_{PDSCH}^{repeat}>1$, or - from slot $n-RepNumR16+1$ to slot $n$, if the Time domain resource assignment field in the DCI format scheduling the PDSCH reception indicates an entry in *pdsch-TimeDomainAllocationList* containing *RepNumR16,* or - in slot $n$, otherwise only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot $n+k$, where $k$ is a number of slots indicated by the PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI format. If the UE reports HARQ-ACK information for the PDSCH reception in a slot other than slot $n+k$, the UE sets a value for each corresponding HARQ-ACK information bit to NACK. |
| Samsung | This proposal is the Rel-15 behavior, no additional spec impact is expected.  |
| vivo | Agree in principle. This proposal seems for clarification and no spec change is needed. As QC’s comment, the current spec is very clear. |
| ZTE | Agree |
| NEC | Agree with this proposal |
| OPPO | Do not agree. In Rel-15, only dynamic SFI/DCI can cancel SPS-PDSCH transmission. However, in Rel-16, multiple SPS-PDSCH overlapping can also lead to SPS-PDSCH transmission cancellation. So, HARQ-ACK timing determination needs take multiple SPS-PDSCH overlapping case into account.For cancellation due to dynamic SFI/DCI, it is not feasible to determine HARQ-ACK timing based on actual SPS-PDSCH due to actual SPS-PDSCH is determined dynamically and there may not enough time update HARQ-ACK codebook in updated uplink slot. For cancellation due to semi-static SPS-PDSCH overlapping, there is no timeline issue and HARQ-ACK timing is still determined semi-statically. And it also provides HARQ-ACK feedback opportunity to avoid unnecessary retransmission scheduling. So it is preferred that*Slot n is determined by the last configured SPS PDSCH occasion* ***after semi-static cancellation of SPS PDSCH repetition*** |
| HW/HiSi | Agree |
| CATT | Although we agree with the proposal, we are not clear about the intention of the proposal. |
| Nokia, NSB | Agree with Samsung and Vivo: This proposal is the Rel-15 behavior, no additional spec impact is expected. |
| Ericsson | The proposal repeats the existing specification. It seems sufficient to state “reuse Rel-15 procedure”. Also, this avoids the need to explain that ‘slot’ should be interpreted as 7-symbol or 2-symbol sub-slot, if the relevant RRC parameter is configured. |

# Open issues to be discussed

For section 3, it is recommended for companies to take into account the issues carefully and to come back with sufficiently specific options/preference/suggestions to the next meeting so that we can complete RAN1 works on the relevant functionalities with respect to specification.

# Final outcome from [101-e-NR-L1enh-URLLC-IIoTenh-03]

# References

1. R1-2003323, Remaining issues on SPS enhancements, ZTE
2. R1-2003393, Other issues for URLLC, vivo
3. R1-2003445, Remaining Issue of Other Enhancements for NR URLLC/IIoT, Ericsson
4. R1-2003582, Maintenance of Rel-16 URLLC/IIoT SPS enhancements, Nokia, Nokia Shanghai Bell
5. R1-2003625, Remaining issues on IIoT, CATT
6. R1-2003710, Remaining issues on DL SPS enhancement for URLLC, NEC
7. R1-2003741, Corrections for DL SPS and intra-UE prioritization involving CG PUSCH, Intel Corporation
8. R1-2003869, Remaining issues for Others, Samsung
9. R1-2003982, Remaining issues on enhanced DL SPS for IIoT, Spreadtrum Communications
10. R1-2004034, Remaining issues of other aspects for URLLC/IIOT, LG Electronics
11. R1-2004120, DL SPS enhancement, OPPO
12. R1-2004125, Remaining issues on intra-UE prioritization for URLLC, MediaTek Inc.
13. R1-2004184, Discussion on RAN2 LS on Intra-UE Prioritization, Sony
14. R1-2004227, Remaining Issues in eURLLC/IIoT, Apple
15. R1-2004394, Remaining issues for SPS enhancement for Rel-16 URLLC, NTT DOCOMO, INC
16. R1-2004461, Remaining issues on uplink collision handling and SPS for URLLC, Qualcomm Incorporated
17. R1-2004611, Corrections on other aspects for URLLC/IIOT enhancements, Huawei, HiSilicon
18. R1-2003347, Discussion on Intra-UE Prioritization, vivo
19. R1-2003583, Discussion on RAN2 LS on Intra-UE Prioritization, Nokia, Nokia Shanghai Bell
20. R1-2004433, Discussion on Intra-UE prioritization, Qualcomm Incorporated
21. R1-2003345, Draft reply LS on Intra-UE Prioritization, ZTE
22. R1-2003348, Draft reply LS on Intra-UE Prioritization, vivo
23. R1-2003584, [Draft] Reply LS on Intra-UE Prioritization, Nokia
24. R1-2003589, Draft LS reply on Intra-UE Prioritization, CATT
25. R1-2004124, [Draft] Rely LS on Intra UE prioritization, OPPO