**3GPP TSG RAN WG1 #104-e R1-2101833**

**e-Meeting, January 25th – February 5th, 2021**

**Agenda item:** 7.2.11

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** Summary on [104-e-NR-UEFeature-URLLCIIoT-01]

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the following email discussion.

**URLLC/IIoT**

[104-e-NR-UEFeature-URLLCIIoT-01] Email discussion/approval on UE features for NR URLLC and IioT (25th Jan – 29th Jan) – Hiroki (DCM)

* Whether or not to confirm working assumption to add the replicated FGs of 11-2a/c with restriction for non-aligned span case
* Whether or not to add the replicated FGs of 11-2d/e with restriction for non-aligned span case
* Whether/how to clarify the interpretation of FG11-7b/9/9a and FG12-2/2a in case of cross-carrier operation (interpretation 1 or 3)
* Whether/how to clarify the relationship between FG11-4/4a and FG12-1
1. Discussion on Rel-16 NR UE features for URLLC/IioT
	1. Replicated FGs of 11-2a/c[/d/e]

Following proposals are made in contributions.

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| [2] | In RAN1 #103-e, a working assumption was made for introducing new FGs for PDCCH monitoring at least for CA case (i.e., replicated FGs of 11-2a/c) while still open for DC case (i.e., replicated FGs of 11-2[d/e]). After lengthy discussion in several meetings, the working assumption is a good compromise by adding a MO configuration restriction for only non-aligned span case in CA, and therefore should be confirmed.

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| **Work assumption:** * **The replicated FGs of 11-2a/c[d/e] with restriction for non-aligned span case are added to RAN1 UE features list**
	+ **Component 2 of new FGs is below**
		- **UE supports aligned span and non-aligned span**
			* **In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot**
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***Proposal 2:*** *Confirm the working assumption for adding replicated FGs of 11-2a/c with restriction for non-aligned span case.* The current FGs for PDCCH monitoring in NR-DC, i.e., FG 11-2d/11-2e copied as below, includes two cases. One case is there is only one CC per CG and another case is there are more than one CCs per CG. For the former case, there is no need to add above MO configuration restriction since non-aligned span issue only exists for CA. Thus, one way is to split FG 11-2d into two FGs for above two cases separately, and add the MO configuration restriction only for the later case. However, this would fundamentally change current UE capability reporting and thus not backward compatible. Another way is to change the prerequisite of FG 11-2d from ’11-2’ to ’11-2a’. That is, a UE supporting Rel-16 PDCCH monitoring for DC has to support Rel-16 PDCCH monitoring for CA. In this context, the MO configuration restriction for each CG, if applicable, could follow that defined in FG 11-2a. Similarly, the prerequisite of FG 11-2e from ’11-2b’ to ’11-2c’. In our view, changing the prerequisite of FG 11-2d/2e is preferred since no new UE FGs needs to be introduced in NR-DC.

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| 11. NR\_L1enh\_URLLC | 11-2d | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring capability on all the serving cells | 1. Supported combination of (*pdcch-BlindDetectionMCG-UE-r16*, *pdcch-BlindDetectionSCG-UE-r16*)
 | 11-2 | If the UE reports pdcch-BlindDetectionCA-r16, * Candidate values for pdcch-BlindDetectionMCG-UE-r16 is 1 to pdcch-BlindDetectionCA-r16-1
* Candidate values for pdcch-BlindDetectionSCG-UE-r16 is 1 to pdcch-BlindDetectionCA-r16-1
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16 >= pdcch-BlindDetectionCA-r16

Otherwise, if N\_(NR-DC,max,r16)^(DL,cells) is a maximum total number of downlink cells for which the UE is provided monitoringCapabilityConfig-r16 = r16monitoringcapability and the UE is configured on both the MCG and the SCG for NR-DC as indicated in UE-NR-Capability* the value of pdcch-BlindDetectionMCG-UE-r16 or of pdcch-BlindDetectionSCG-UE-r16 is 1,
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16 >= N\_(NR-DC,max,r16)^(DL,cells).
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| 11. NR\_L1enh\_URLLC | 11-2e | Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | 1. Supported combination(s) of (*pdcch-BlindDetectionMCG-UE-r15*, *pdcch-BlindDetectionSCG-UE-r15, pdcch-BlindDetectionMCG-UE-r16*, *pdcch-BlindDetectionSCG-UE-r16*)
 | 11-2b | One combination of (*pdcch-BlindDetectionMCG-UE-r15, pdcch-BlindDetectionSCG-UE-r15, pdcch-BlindDetectionMCG-UE-r16, pdcch-BlindDetectionSCG-UE-r16*) corresponds to one combination of (*pdcch-BlindDetectionCA-r15, pdcch-BlindDetectionCA-r16*)If the UE reports pdcch-BlindDetectionCA-r15, * Candidate values for pdcch-BlindDetectionMCG-UE-r15 is 0 to pdcch-BlindDetectionCA-r15
* Candidate values for pdcch-BlindDetectionSCG-UE-r15 is 0 to pdcch-BlindDetectionCA-r15
* pdcch-BlindDetectionMCG-UE-r15 + pdcch-BlindDetectionSCG-UE-r15>= pdcch-BlindDetectionCA-r15

Otherwise, if N\_(NR-DC,max,r15)^(DL,cells) is a maximum total number of downlink cells for which the UE is provided monitoringCapabilityConfig-r16 = r15monitoringcapability* Candidate values for pdcch-BlindDetectionMCG-UE-r15 is [0, 1, 2]
* Candidate values for pdcch-BlindDetectionSCG-UE-r15 is [0, 1, 2]
* pdcch-BlindDetectionMCG-UE-r15 + pdcch-BlindDetectionSCG-UE-r15 >= N\_(NR-DC,max,r15)^(DL,cells)

If the UE reports pdcch-BlindDetectionCA-r16, * Candidate values for pdcch-BlindDetectionMCG-UE-r16 is 0 to pdcch-BlindDetectionCA-r16
* Candidate values for pdcch-BlindDetectionSCG-UE-r16 is 0 to pdcch-BlindDetectionCA-r16
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16>= pdcch-BlindDetectionCA-r16

Otherwise, if N\_(NR-DC,max,r16)^(DL,cells) is a maximum total number of downlink cells for which the UE is provided monitoringCapabilityConfig-r16 = r16monitoringcapability* Candidate values for pdcch-BlindDetectionMCG-UE-r16 is [0, 1]
* Candidate values for pdcch-BlindDetectionSCG-UE-r16 is [0, 1]
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16 >= N\_(NR-DC,max,r16)^(DL,cells)
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*Proposal 3: Change the prerequisite of FG 11-2d and 11-2e to ’11-2a’ and ’11-2c’ respectively.* |
| [4] | Rel-16 introduces new UE PDCCH monitoring capability on the maximum numbers of blind decodes and non-overlapped CCEs where the limits are defined per span (see 38.213 V16.4.0).When a UE is configured to monitor multiple DL cells with Rel-16 PDCCH monitoring capability for a given (X,Y), if the number of configured DL cells is larger than the UE capability reported value, the total PDCCH monitoring limits are scaled proportionally to the UE reported value. In such case, PDCCH monitoring spans across the concerned DL cells may be determined to be aligned or unaligned and the total limits are applied to a set of spans across the DL cells in a different manner (see 38.213 V16.4.0 section 10.1).In Rel-16, additional UE features (FG 11-2a to FG 11-2e) are introduced for Ues supporting Rel-16 PDCCH monitoring. Later UE feature discussions revolve around whether and how to support Ues with lower complexity for Rel-16 PDCCH monitoring, especially for determining whether the spans across the DL cells are aligned or unaligned in case that the number of configured DL cells is larger than the UE reported value.In RAN1 #103-e [2], the following working assumption was made for potential additional UE features related to Rel-16 PDCCH monitoring.**Work assumption:** * **The replicated FGs of 11-2a/c[d/e] with restriction for non-aligned span case are added to RAN1 UE features list**
	+ **Component 2 of new FGs is below**
		- **UE supports aligned span and non-aligned span**
			* **In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot**

The new UE features are aimed at reducing UE complexity in determining whether the spans across the DL cells are aligned. Since the notion of aligned or unaligned spans are relevant for Rel-16 PDCCH monitoring only when the number of configured DL cells where UE monitors PDCCH is larger than the UE capability reported value, it is reasonable that these new UE features are introduced only for such case.Thus the working assumption above can be confirmed. For CA, the changes described by the WA are realized by introducing two new UE features, e.g., FG 11-2f and 11-2g, which replicate FG 11-2a and 11-2c with the component 2 described for the non-aligned span case. Example of the new UE features FG 11-2f and 11-2g, replicating FG 11-2a and 11-2c are provided in the table below. Note that the UE should report either FG 11-2a/c (i.e., more capable Ues) or FG 11-2f/g (i.e., less capable Ues), but not both.

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| 11. NR\_L1enh\_URLLC | 11-2f | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells and the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value | 1. Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells
	* Candidate value for the component: {2, 3, …, 16}
2. Supported span arrangement for CA
	* Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans}
	* For UE supporting both aligned spans and non-aligned spans,
		1. In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot
 |
| 11. NR\_L1enh\_URLLC | 11-2g | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers and the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value | 1. Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)
	* Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15
	* Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 15
2. Supported span arrangement for CA
	* Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans}
	* For UE supporting both aligned spans and non-aligned spans,
		1. In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot
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For NR-DC, the PDCCH monitoring capability builds on top of the CA monitoring capability (see 38.213 V16.4.0 section 10.1). Thus similar UE features for the case when a UE is configured for NR-DC operation can be considered, i.e., new UE features 11-2h/i replicating FG 11-2d/e with restriction only for the non-aligned span case.1. Confirm the working assumption to introduce new UE features, replicating FG 11-2 a/c/d/e with FG 11-2f/g/h/i with restriction added for the non-aligned span case.
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| [8] | In RAN1#103-e the following working assumption has been agreed on:**Work assumption:** * **The replicated FGs of 11-2a/c[d/e] with restriction for non-aligned span case are added to RAN1 UE features list**
	+ **Component 2 of new FGs is below**
		- **UE supports aligned span and non-aligned span**
			* **In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot**

In general it is OK to confirm the WA, with the following considerations:* There is no need to replicate 11-2d, as it is not directly related to the issue addressed by 11-2a/c
* There is no need to replicate 11-2e, it would be sufficient to modify the pre-requisite to ”one of {11-2b, 11-2x}”, where 11-2x denotes the new replicated FG 11-2b.

**Proposal 3: Confirm the working assumption for replicating FGs of 11-2a/c. Do not replicate FGs for 11-2d/e.**  |
| [9] | The restriction that the same span pattern repeats in every slot for a given CC for Rel-16 PDCCH monitoring capability was discussed in RAN1#103-e meeting. The main concern for such a restriction is that it will introduce serious constraints, i.e. the same location of actual PDCCH monitoring occasions for all the slots. In order to relax the constraints for scheduling, it has been proposed to only introduce this restriction for the non-aligned span case. The working assumption that was reached is as below:

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| Work assumption: * The replicated FGs of 11-2a/c[d/e] with restriction for non-aligned span case are added to RAN1 UE features list
	+ Component 2 of new FGs is below
		- UE supports aligned span and non-aligned span
			* In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot
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We are fine for this working assumption, thus no specification change is needed on the span definition or the method to determine the combination (X, Y). As for FG 11-2d and 11-2e, the restriction is also needed to ease the UE’s implementation for the DC case. However the replicated FGs of 11-2d and FG11-2e is not needed, since the restriction can be achieved by reporting FGs of 11-2d/e together with the new FGs (i.e. the replicated FGs of 11-2a/c with restriction for non-aligned span case), instead of together with FGs of 11-2a/c. **Proposal eURLLC-1: Confirm the following working assumption from RAN1#103-e with modification as following:*** **The replicated FGs of 11-2a/c~~[d/e]~~ with restriction for non-aligned span case are added to RAN1 UE features list**
	+ **Component 2 of new FGs is below**
		- **UE supports aligned span and non-aligned span**
			* **In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot**
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| [13] | At the RAN1#103-e meeting, following working assumption was made [2].

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| **Work assumption:** * **The replicated FGs of 11-2a/c[d/e] with restriction for non-aligned span case are added to RAN1 UE features list**
	+ **Component 2 of new FGs is below**
		- **UE supports aligned span and non-aligned span**
			* **In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot**
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Based on that, new FG 11-2f and 11-2g as shown below can be considered as well as potential similar replicated FGs of 11-2d/2e with restriction for non-aligned span case.

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| 11. NR\_L1enh\_URLLC | [11-2f] | [Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case] | 1. Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells
	* Candidate value for the component: {2, 3, …, 16}
2. UE supports aligned span and non-aligned span
	* In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot
 | 11-2 | Yes | N/A |  | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | [11-2g] | [Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case] | 1. Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)
	* Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15
	* Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 15
2. UE supports aligned span and non-aligned span
	* In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot
 | 11-2b | Yes | N/A |  | Per BC | N/A | N/A | N/A | The minimum of the summation of capability on the number of CCs with Rel-15 PDCCH monitoring capability and the capability on the number of CCs with Rel-16 PDCCH monitoring capability is 3 | Optional with capability signalling |

View* We are fine with the working assumption to introduce the replicated FGs of FG 11-2a/2c with the additional component as FG 11-2f/2g. It reduces UE implementation complexity and is less problematic for spec. Regarding whether or not to introduce similar restriction to FG 11-2d/2e, we don’t think it is needed as PDCCH monitoring is performed independently between MCG and SCG.
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Based on the above proposals, following point can be discussed in RAN1#104-e meeting.

**Discussion point #1**

* **Whether or not to confirm working assumption to add the replicated FGs of 11-2a/c with restriction for non-aligned span case**
* **Whether or not to add the replicated FGs of 11-2d/e with restriction for non-aligned span case**

Companies’ views in the contributions can be summarized as below.

* **Confirm working assumption to add the replicated FGs of 11-2a/c with restriction for non-aligned span case**
	+ **Support: ZTE, Ericsson, Nokia/NSB, Huawei/HiSi, DOCOMO**
	+ **Not support:**
* **Add the replicated FGs of 11-2d/e with restriction for non-aligned span case**
	+ **Support: Ericsson**
	+ **Not support: ZTE, Nokia/NSB, Huawei/HiSi, DOCOMO**
		- **Change the prerequisite of 11-2d/e: ZTE (from 11-2 to 11-2a and from 11-2b to 11-2c), Nokia/NSB (from 11-2b to one of {11-2b, 11-2x}), Huawei/HiSi (from 11-2 to 11-2f and from 11-2b to 11-2g)**

Based on above, following two FL proposals can be made.

### **FL proposal 1:**

* **Confirm the working assumption to add the replicated FGs of 11-2a/c with restriction for non-aligned span case as below.**

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| 11. NR\_L1enh\_URLLC | 11-2f | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case | 1. Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells
	* Candidate value for the component: {2, 3, …, 16}
2. UE supports aligned span and non-aligned span
	* In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot
 | 11-2 | Yes | N/A |  | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-2g | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case | 1. Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)
	* Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15
	* Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 15
2. UE supports aligned span and non-aligned span
	* In case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot
 | 11-2b | Yes | N/A |  | Per BC | N/A | N/A | N/A | The minimum of the summation of capability on the number of CCs with Rel-15 PDCCH monitoring capability and the capability on the number of CCs with Rel-16 PDCCH monitoring capability is 3 | Optional with capability signalling |

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

 Cannot accept the proposal:

|  |  |
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| Company | Comment |
| DOCOMO | We agree with the proposal |
| ZTE | Support the proposal.  |
| Vivo | We agree with FL’s proposal. |
| Nokia, NSB | We support the FL proposal |
| Huawei, HiSilicon  | Support the FL proposal 1.  |
| Qualcomm | Agree.  |
| Intel | Fine with FL proposal |
| Moderator (NTT DOCOMO) | Thanks for the feedbacks.Based on the feedbacks so far, it seems all companies are fine with the FL proposal 1.So, let’s try to make it agreement in the GTW session on Tuesday. |
| Samsung | We support the proposal. |
| Apple | Support |
| Ericsson | Agree |

### **FL proposal 2:**

* **Update the prerequisite FG of 11-2d/2e as below.**
	+ **For 11-2d, ‘11-2’ is changed to:**
		- **Alt.1: ’11-2a’**
		- **Alt.2: ’11-2f’**
		- **Alt.3: not changed**
	+ **For 11-2e, ‘11-2b’ is changed to:**
		- **Alt.1: ’11-2c’**
		- **Alt.2: ’11-2g’**
		- **Alt.3: ‘one of {11-2b, 11-2x}’**
		- **Alt.4: not changed**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

 Cannot accept the proposal:

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| Company | Comment |
| DOCOMO | For 11-2d, ‘one of {11-2, 11-2f}’ should be better to let UE also support the case where there is only one CC per CG in NR-DC. For 11-2e, Alt.3 (i.e. ‘one of {11-2b, 11-2g}’) is preferred with the same reason for 11-2d. |
| ZTE | For 11-2d, it should be reported with 11-2a to determine the span arrangement (component 2 of 11-2a) for each CG. Then, the prerequisite of 11-2d should be changed to 11-2a. If a UE doesn’t report 11-2f, the restriction for non-aligned span case will not be applied, otherwise the restriction will be applied for 11-2d. That is, 11-2f doesn’t have to be the prerequisite of 11-2d. Similarly, the prerequisite of 11-2e should be changed to 11-2c. Thus, we prefer Alt 1 for both 11-2d and 11-2e. *2. Supported span arrangement for CA**Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans}* |
| vivo | Prefer Alt.1 for both 11-2d and 11-2e.  |
| Nokia, NSB | Actually, assuming 11-2f/g as proposed above, we don’t see a need for updating the pre-requisites of 11-2d or 11-2e, given that 11-2f/g do not make 11-2/2b obsolete, but rather complement them. |
| Huawei, HiSilicon  | Update the pre-requiste may work, but it will introduce restriction, e.g. even if UE only supports 1 carrier per CG UE needs to report FG 11-2f which is actually not necessary. Our original thinking is that there is no need to update the pre-requiste, and if UE reports FG 11-2f, then the corresponding restriction will be applied to FG 11-2d also. Note that in reality when UE needs to do PDCCH monitoring scaling for NR-DC, then UE should need to report FG 11-2a or FG 11-2f also since in this case the number of DL carriers that the UE can support is already larger than 2. In addition, if a UE reports FG 11-2a or FG11-2f, then the corresponding definition of FG 11-2a of FG 11-2f should be applied to FG 11-2d also, e.g. pdcch-BlindDetectionCA-r16 and/or the restriction on the non-aligned span case. Therefore, some alternative for further discussion can be below:1. No change of pre-requiste for both FG 11-2d and FG 11-2e;2. For FG 11-2d, add a note “If a UE supports FG 11-2a or FG 11-2f, then the capability defined by FG 11-2a or FG 11-2f is applied to FG 11-2d”.3. For FG 11-2e, add a note “If a UE supports FG 11-2c or FG 11-2g, then the capability defined by FG 11-2c or FG 11-2g is applied to FG 11-2d”.  |
| Qualcomm | Agree with Nokia and HW. Adding the notes as proposed above could be a way forward.  |
| Intel | Support views from Nokia, HW, QC. We are also fine to clarify using notes on the applicability of the capability in these FGs to FG 11-2d. |
| Moderator (NTT DOCOMO) | Thanks for the feedbacks.Based on the feedbacks so far, we can focus on following two alternatives.* **Alt.1:**
	+ **For FG 11-2d, ‘11-2’ is changed to ’11-2a’**
	+ **For FG 11-2e, ‘11-2b’ is changed to ’11-2c’**
* **Alt.2:**
	+ **No change of pre-requiste for both FG 11-2d and FG 11-2e;**
	+ **For FG 11-2d, add a note “If a UE supports FG 11-2a or FG 11-2f, then the capability defined by FG 11-2a or FG 11-2f is applied to FG 11-2d”.**
	+ **For FG 11-2e, add a note “If a UE supports FG 11-2c or FG 11-2g, then the capability defined by FG 11-2c or FG 11-2g is applied to FG 11-2e”.**
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| Ericsson | Support Alt 2. Agree with Nokia/HW/QC/Intel view.  |

### **Updated FL proposal 2:**

* **Adopt one of following alternatives**
	+ **Alt.1:**
		- **For FG 11-2d, ‘11-2’ is changed to ’11-2a’**
		- **For FG 11-2e, ‘11-2b’ is changed to ’11-2c’**
	+ **Alt.2:**
		- **No change of pre-requiste for both FG 11-2d and FG 11-2e;**
		- **For FG 11-2d, add a note “If a UE supports FG 11-2a or FG 11-2f, then the capability defined by FG 11-2a or FG 11-2f is applied to FG 11-2d”.**
		- **For FG 11-2e, add a note “If a UE supports FG 11-2c or FG 11-2g, then the capability defined by FG 11-2c or FG 11-2g is applied to FG 11-2e”.**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

 Cannot accept the proposal:

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | We support no change to pre-requisite. |
| Apple | Alt. 2 |
|  |  |

* 1. Interpretation of FG11-7b/9/9a and FG12-2/2a in case of cross-carrier operation

Following proposals are made in contributions.

|  |  |
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| [2] | Ambiguity issue in case of cross-carrier operation was discussed for FG11-9/9a and FG12-2/2a in the RAN1 #103-e meeting. However, no consensus was reached on adopting Interpretation 1 (based on the support of this capability for the band of the scheduled/triggered/indicated cell only) or Interpretation 3 (based on the support of this capability for both the band of the scheduled/triggered/indicated cell and the band of the scheduling/triggering/indicating cell). For FG11-9/9a and FG12-2/2a, UE may need to receive regular DCI format with some repurposed fields in one carrier and activate/release CG PUSCH/SPS PDSCH in another carrier. These two FGs are more related to configured grant transmission/activation/deactivation in the scheduled/triggered/indicated cell. In this case, Interpretation#1 would make more sense for them. Furthermore, if we adopt Interpretation#3, in order to support cross-carrier activate/deactivate CG PUSCH/SPS PDSCH, both the scheduling cell and the scheduled cell need to support multiple CG/SPS configurations, which is too restrictive. Several companies argued that the situation here is similar to cross-carrier operation for FG *crossCarrierScheduling-SameSCS*, for which Interpretation 3 is adopted. However, the reason is that *crossCarrierScheduling-SameSCS* was originally agreed as per BC UE reporting in RAN1, while it changed to per UE in RAN2 incautiously. Using Interpretation 3 is kind of back to per BC reporting to align with RAN1’s original intention. However, it seems not the case for FG11-9/9a and FG12-2/2a. Based on above, Interpretation 1 is preferred for cross-carrier operation for FG11-9/9a and FG12-2/2a.***Proposal 4:*** *Regarding the interpretation of UE capabilities in case of cross-carrier operation, RAN1 clarifies that support of the following UE capability is based on the support of this capability for the band of the scheduled/triggered/indicated cell only.** + *FG11-9, FG11-9a, FG12-2 and FG12-2a.*
 |
| [4] | In RAN1#103e, it was agreed that for FG 11-7a (UL cancelation scheme for cross-carrier), the interpretation of UE capabilities in case of cross-carrier operation is according to Interpretation 3, i.e., based on the support of this capability for both the band of the scheduled/triggered/indicated cell and the band of the scheduling/triggering/indicating cell.Interpretation for several other features was discussed without reaching conclusion, including FG 11-7b/9/9a and 12-2a.* 11-7b Independent cancellation of the overlapping PUSCHs in an intra-band UL CA
* 11-9 Multiple active configured grant configurations for a BWP of a serving cell
* 11-9a Joint release in a DCI for two or more configured grant Type 2 configurations for a given BWP of a serving cell
* 12-2a Joint release in a DCI for two or more SPS configurations for a given BWP of a serving cell

For these feature groups, the UE receives the DCI in the scheduling/triggering/indicating cell, and performs the described procedure in the scheduled/triggered/indicated cell. No special operations is required in the scheduling/triggering/indicating cell, and DCI is simply received as usual. Thus, for these feature groups, interpretation 1 should be applied, i.e., * ***Interpretation 1****: Support of this UE capability is based on the support of this capability for the band of the scheduled/triggered/indicated cell only.*
1. For FG 11-7b/9/9a and 12-2: the interpretation of these UE capabilities in case of cross-carrier operation are based on the support of this capability for the band of the scheduled/triggered/indicated cell only.
 |
| [13] | At the RAN1#103-e meeting, the interpretation of UE capabilities FG11-9/9a and FG12-2/2a in case of cross-carrier operation was extensively discussed. However, there was no consensus on Interpretation 1 or Interpretation 3 for FG11-9/9a, 12-2/2a in the last meeting [2].

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| *Interpretation 1:** *Regarding the interpretation of UE capabilities in case of cross-carrier operation, RAN1 clarifies that support of the following UE capability is based on the support of this capability for the band of the scheduled/triggered/indicated cell only.*

*Interpretation 3:** *Regarding the interpretation of UE capabilities in case of cross-carrier operation, RAN1 clarifies that support of the following UE capability is based on both the support of this capability for the band of the scheduled/triggered/indicated cell and the support of this capability for the band of the scheduling/triggering/indicating cell.*
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| 11. NR\_L1enh\_URLLC | 11-9 | Multiple active configured grant configurations for a BWP of a serving cell | 1. Supports up to 12 configured/active configured grant configurations in a BWP of a serving cell.

• Separate RRC parameters for different configured grant configurations• Separate activation for different configured grant Type 2 configurations• Separate release for different configured grant Type 2 configurations1. Supported maximum number of configured/active configured grant configurations in a BWP of a serving cell

Candidate values for component 2: {1, 2, 4, 8, 12}1. Supported maximum number of configured/active configured grant configurations across all serving cells

Candidate values for component 3: {2, …, 32} | One of {5-19, 5-20} | Yes | N/A |  | Per band | N/A | N/A | N/A | For component 3: Total number in FR1 is not greater than X value reported for FR1. Total number in FR2 is not greater than X value reported for FR2.Total number across FR1 and FR2 is not greater than the larger of the FR1 and FR2 values | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-9a | Joint release in a DCI for two or more configured grant Type 2 configurations for a given BWP of a serving cell | 1. M<=4 bits indication in the Release DCI is used for indicating which CG configuration(s) is/are released, where the association between each state indicated by the indication and the CG configuration(s) is

• Up to 2^M states are higher layer configurable, where each of the state can be mapped to a single or multiple CG configurations to be released• In case of no higher layer configured state(s), separate release is used where the release corresponds to the CG configuration index indicated by the indication | 11-9 | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 12. NR\_IIOT | 12-2 | Multiple SPS configurations | 1. Support of up to 8 configured SPS configurations in a BWP of a serving cell and up to 32 configured SPS configurations in a cell group, including separate RRC parameters and separate activation/release for different SPS configurations
2. The max number of active SPS configurations in a BWP of a serving cell
3. The max number of active SPS configurations across all serving cells
4. The related HARQ-ACK enhancements to support multiple active SPS configurations
 | 5-18 DL SPS  | Yes | N/A |  | Per band | N/A | N/A | N/A | Component-2, candidate value set is {1, 2, …, 8}Component-3, candidate value set is {2, …, 32} | Optional with capability signaling |
| 12. NR\_IIOT | 12-2a | Joint release in a DCI for two or more SPS configurations for a given BWP of a serving cell | 1. M<=4 bits indication in the Release DCI is used for indicating which SPS configuration(s) is/are released, where the association between each state indicated by the indication and the SPS configuration(s) is

• Up to 2^M states are higher layer configurable, where each of the state can be mapped to a single or multiple SPS configurations to be released• In case of no higher layer configured state(s), separate release is used where the release corresponds to the SPS configuration index indicated by the indication1. The related HARQ-ACK enhancements to support joint release
 | 12-2  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |

View* As the activation/release of CG type2 and SPS are the features mainly performed on the schedulded carrier, we think Interpretation 1 is the appropriate one for FG11-9/9a and 12-2/2a.
 |

Based on the above proposals, following point can be discussed in RAN1#104-e meeting.

**Discussion point #2**

* **Whether/how to clarify the interpretation of FG11-7b/9/9a and FG12-2/2a in case of cross-carrier operation (interpretation 1 or 3)**

Companies’ views in the contributions can be summarized as below.

* **Interpretation 1 for 11-9/9a and 12-2/2a: ZTE, Ericsson, DOCOMO**
	+ **Interpretation 1 also for 11-7b: Ericcson**
		- **At the last meeting, majority companies considered that there is no ambiguity on 11-7b since the reporting is per band and 11-7b is only for intra-band case.**
* **Interpretation 3 for 11-9/9a and 12-2/2a:**

Based on above, following FL proposal can be made.

### **FL proposal 3:**

* **Regarding the interpretation of UE capabilities in case of cross-carrier operation, RAN1 clarifies that support of the following UE capability is based on the support of this capability for the band of the scheduled/triggered/indicated cell only (Interpretation 1).**
	+ **FG11-9/9a. 12-2/2a**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

 Cannot accept the proposal:

|  |  |
| --- | --- |
| Company | Comment |
| DOCOMO | We agree with the proposal |
| ZTE | Support the proposal.  |
| Vivo | We agree with FL’s proposal. |
| Huawei, HiSilicon | Agree with the FL proposal 3  |
| Qualcomm | We do not support. Given that both the scheduled and scheduling cells are involved, interpretation #3 should be used.  |
| Intel | Fine with FL’s proposal 3. |
| Moderator (NTT DOCOMO) | Thanks for the feedbacks.Based on the feedbacks so far, all companies except one company are fine with FL proposal 3.Since this issue (i.e., interpretation 1 or 3) has been discussed in previous meetings, I think we have to make a decision now without consuming the time to have repeated discussion.So, let’s try to make it agreement in the GTW session on Tuesday. |
| Apple | We could be fine with interpretation 1. However, we would like to first clarify:1. For 11-9, how to interpret component 3 “Supported maximum number of configured/active configured grant configurations across all serving cells” when the value is reported per-band? Should the total number be no greater than the minimum value reported across all the bands? We have similar question for 12-2 component 3.
2. For 11-9, how to interpret the note “For component 3: Total number in FR1 is not greater than X value reported for FR1. Total number in FR2 is not greater than X value reported for FR2.Total number across FR1 and FR2 is not greater than the larger of the FR1 and FR2 values”? Depending on the clarification, we may need a similar note for 12-2 also.
 |
| Ericsson | Support FL proposal 3. Also, Apple’s questions are not relevant to the interpretation question addressed by Proposal 3. |

* 1. Relationship between FG11-4/4a and FG12-1

Following proposals are made in contributions.

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| [2] | The relationship between FG11-4 and FG12-1 was discussed in the last meeting, with concerning FG11-4 is incomplete since component 7) requires the timeline defined by component 4) and component 5) in FG12-1. In addition, there is overlapping part between the two FGs on handling of collision of UL channles/signals with different priority levels.

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| 11. NR\_L1enh\_URLLC | 11-4 | Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook (i.e. slot-based + slot-based, or slot-based + sub-slot based) simultaneously constructed for supporting HARQ-ACK codebooks with different priorities at a UE  | 1. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed with the restriction up to one sub-slot based HARQ-ACK codebook.
2. Supports separate PUCCH configuration for different HARQ-ACK codebooks
3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.
4. Supports a DCI format (from the formats 1\_1/1\_2) scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_1/1\_1 is configured or only DCI format 0\_2/1\_2 is configured per BWP
5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and ‘codeBlockGroupTransmission” for different HARQ-ACK codebooks.
6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot

Candidate values for the component 6 of FG11-4 is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration.1. Support intra-UE multiplexing/prioritization of UL overlapping channels/signals with two priority levels for HARQ-ACK
 | If a UE reports both 11-3 and 11-4, it can support two slot-based HARQ-ACK codebooks, and one slot-based and one-sub-slot-based HARQ-ACK codebooks. If a UE reports 11-4 but not 11-3, it can only support two slot-based HARQ-ACK codebooks.The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBsComponent 6 is applied to the sub-slot HARQ-ACK codebook. It is assumed that only 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook.* Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases.

For component 6, maximum of 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook. Thus value reported for component 6 has no meaning for “slot-based + slot based”. |
| 12. NR\_IIOT | 12-1 | UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer | Support intra-UE multiplexing/prioritization of overlapping PUCCH/PUCCH and PUCCH/PUSCH with two priority levels in physical layer (PHY)1. Configuration of PHY priority level for CG PUSCH and SR, and dynamic indication of priority level for dynamic PUSCH with a single DCI format
2. Multiplexing/prioritization between UL channels/signals with the same PHY priority level
3. Prioritization between UL channels/signals with different PHY priority levels
4. Additional number of symbols (d1) needed beyond the PUSCH preparation time for cancelling a low priority UL transmission.
5. Additional number of symbols (d2) needed beyond the PUSCH preparation time for scheduling a high priority UL transmission that cancels a low priority UL transmission
 | Candidate value set for component 4: {0, 1, 2}Candidate value set for component 5: {0, 1, 2}The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4x should be further discussed. |

To solve the issues, three alternatives was discussed as follows. All three alternatives need to change component 7) of FG11-4 from the overlapping case with two priority levels to the case with same priority level. In such case, no addition timeline requirement is needed for component 7) and the overlapping with FG12-1 for the case with two priority levels can be solved. However, it will overlap with component 2) of FG12-1 instead. Thus, a clean way is to directly remove component 7) of FG11-4. By this way, if a UE supports FG11-4 while not FG12-1, it only supports HARQ-ACK codebooks with different priorities while the two codebooks cannot be overlapped. All multiplexing or prioritization behaviors can be covered by FG12-1. Given anyway the change could be NBC, we prefer not to disable current FGs and introduce new FGs.

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| Alt.1:* Add 3 new FGs as below
	+ New FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”
	+ New FG12-1 with removing components 3/4/5
	+ New FG (12-1b) for UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer
* Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)
* Need to update dependency with other FGs

Alt.2: * Add two new FGs as below
	+ FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”
	+ FG12-1 to cover all cancellation scenarios
* Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)

Alt.3: No additional new FGs* + Redefine component 7 of FG11-4 as: Support intra-UE multiplexing/prioritization of UL overlapping channels/signals of the same priority level
 |

***Proposal 5:*** *Remove component 7) of FG11-4 and remove the following note of FG12-1.* *‘The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4x should be further discussed.* |
| [4] | For the support of intra-UE multiplexing/prioritization of overlapping UL signals/channels, a question was raised that this is described fully in FG 12-1, and also mentioned in component 7 of 11-4 for HARQ-ACK. However, FG 11-4 component 7 does not contain necessary components for multiplexing/prioritization (e.g., additional number of symbols d1, d2 as described in component 4) and 5) of FG 12-1). Thus, clarification is needed to sort out intra-UE multiplexing/prioritization among FG 12-1, 11-4, 11-4a.It is noted that 11-4 component 7 does not exist in 11-4a, although 11-4 and 11-4a are parallel features on HARQ-ACK codebooks. Thus it is better that 11-4 component 7 is deleted to align with 11-4a. Then the intra-UE multiplexing/prioritization of UL channels/signals is handled by 12-1 only, including the case involving two HARQ-ACK codebooks with two priority levels (related to 11-4, 11-4a).In summary the following is proposed to sort out the support of intra-UE multiplexing/prioritization:1. Resolve the relationship between FG 12-1 and 11-4/4a with the following: (a) Add one new FG, which mirrors FG11-4 but with component 7 removed; (b) FG12-1 is understood to cover all cancellation scenarios, including the cases involving two HARQ-ACK codebooks with two priority levels (see FG 11-4/4a); (c) Ask RAN2 to disable the existing FG11-4 (e.g., by setting dummy bit).

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| 11. NR\_L1enh\_URLLC | 11-4 | Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook (i.e. slot-based + slot-based, or slot-based + sub-slot based) simultaneously constructed for supporting HARQ-ACK codebooks with different priorities at a UE  | 1. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed with the restriction up to one sub-slot based HARQ-ACK codebook.
2. Supports separate PUCCH configuration for different HARQ-ACK codebooks
3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.
4. Supports a DCI format (from the formats 1\_1/1\_2) scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_1/1\_1 is configured or only DCI format 0\_2/1\_2 is configured per BWP
5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and ‘codeBlockGroupTransmission” for different HARQ-ACK codebooks.
6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot

Candidate values for the component 6 of FG11-4 is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration.1. Support intra-UE multiplexing/prioritization of UL overlapping channels/signals with two priority levels for HARQ-ACK
 |
| 11. NR\_L1enh\_URLLC | 11-4a | Two subslot based HARQ-ACK codebooks simultaneously constructed for supporting HARQ-ACK codebooks with different priorities at a UE  | 1. Supports two subslot based HARQ-ACK codebooks with different priorities to be simultaneously constructed.
2. Supports separate PUCCH configuration for different HARQ-ACK codebooks
3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.
4. Supports a DCI format (from the formats /1\_1/1\_2) scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_1/1\_1 is configured or only DCI format 0\_2/1\_2 is configured in USS per BWP
5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and ‘codeBlockGroupTransmission” for different HARQ-ACK codebooks.
6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot
7. Candidate values for the component 6 of FG11-4a is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration.
 |
| 12. NR\_IIOT | 12-1 | UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer | Support intra-UE multiplexing/prioritization of overlapping PUCCH/PUCCH and PUCCH/PUSCH with two priority levels in physical layer (PHY)1. Configuration of PHY priority level for CG PUSCH and SR, and dynamic indication of priority level for dynamic PUSCH with a single DCI format
2. Multiplexing/prioritization between UL channels/signals with the same PHY priority level
3. Prioritization between UL channels/signals with different PHY priority levels
4. Additional number of symbols (d1) needed beyond the PUSCH preparation time for cancelling a low priority UL transmission.
5. Additional number of symbols (d2) needed beyond the PUSCH preparation time for scheduling a high priority UL transmission that cancels a low priority UL transmission
 |

 |
| [6] | Currently, FG #12-1 has the following note: * “*The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4x should be further discussed.*”

For convenience, the components for the involved FG are reproduced below. **FG 11-4: Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook (i.e. slot-based + slot-based, or slot-based + sub-slot based) simultaneously constructed for supporting HARQ-ACK codebooks with different priorities at a UE**1. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed with the restriction up to one sub-slot based HARQ-ACK codebook.
2. Supports separate PUCCH configuration for different HARQ-ACK codebooks
3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.
4. Supports a DCI format (from the formats 1\_1/1\_2) scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_1/1\_1 is configured or only DCI format 0\_2/1\_2 is configured per BWP
5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and ‘codeBlockGroupTransmission” for different HARQ-ACK codebooks.
6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot
7. Candidate values for the component 6 of FG11-4 is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration.
8. Support intra-UE multiplexing/prioritization of UL overlapping channels/signals with two priority levels for HARQ-ACK

**FG 12-1: UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer**Support intra-UE multiplexing/prioritization of overlapping PUCCH/PUCCH and PUCCH/PUSCH with two priority levels in physical layer (PHY)1. Configuration of PHY priority level for CG PUSCH and SR, and dynamic indication of priority level for dynamic PUSCH with a single DCI format
2. Multiplexing/prioritization between UL channels/signals with the same PHY priority level
3. Prioritization between UL channels/signals with different PHY priority levels
4. Additional number of symbols (d1) needed beyond the PUSCH preparation time for cancelling a low priority UL transmission.
5. Additional number of symbols (d2) needed beyond the PUSCH preparation time for scheduling a high priority UL transmission that cancels a low priority UL transmission

Towards resolving the above, RAN1 discussed various options during RAN1 #103-e meeting, with the following options being identified towards the end of the meeting, without a conclusion. Note that the component numbers are adjusted from the summary in [3] considering the latest UE features list.**Alt. 1*** Add 3 new FGs as below
	+ New FG11-4 with modifying component **8** as “Note: Support handling of UL overlapping channels/signals of the same priority level”
	+ New FG12-1 with removing components 3/4/5
	+ New FG (12-1b) for UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer
* Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)
* Need to update dependency with other FGs

**Alt. 2*** Add two new FGs as below
	+ FG11-4 with modifying component **8** as “Note: Support handling of UL overlapping channels/signals of the same priority level”
	+ FG12-1 to cover all cancellation scenarios
* Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)

**Alt. 3*** No additional new FGs
	+ Redefine component **8** of FG11-4 as: Support intra-UE multiplexing/prioritization of UL overlapping channels/signals of the same priority level

Comparing the options, it is observed that Alt. 1 and Alt. 2 are somewhat equivalent in terms of overall coupling of the features of simultaneous multiple HARQ-ACK CB support and the features related to handling of prioritization involving HARQ-ACK and those involving other UL channels/signals. Even for Alt. 1, in order to support scenarios with overlaps of physical channels requiring mux/prioritization, the UE needs to support both 11-4 and 12-1. Thus, mux/prioritization support would require support of both 11-4 and 12-1 (and certainly, the newly proposed 12-1b), and this coupling seems like that for Alt. 2. Compared to Alt. 2, Alt. 1 introduces further bifurcation of FG 12-1 into two FGs. Given the effective equivalence, Alt. 2 is certainly preferable to Alt. 1. However, considering the late stage in Rel-16 maintenance, it may be desirable to avoid introducing new FGs now. Instead, Alt. 3 could also work as long as it is clarified that FG 12-1 would be expected to cover all cancelation cases. Alt. 2 and Alt. 3 are similar with differences in the exact implementation to update component 8 of FG 11-4. In this regard, it could even be considered to be left up to RAN2 on the best approach to realize the update to component 8 of FG 11-4.***Proposal 1:**** ***To resolve the existing ambiguity and coupling between FGs 11-4 and 12-1, delete the existing note “****The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4x should be further discussed****” from FG 11-4 and adopt one of Alt. 2’ or Alt. 3’ as below:***
	+ ***Alt. 2’:***
		- ***Add two new FGs as below***
			* ***FG11-4 with modifying component 8 as “Note: Support handling of UL overlapping channels/signals of the same priority level”***
			* ***New version of FG 12-1 such that FG 12-1 covers all intra-UE prioritization cases (including PUCCH with HARQ-ACK).***
		- ***Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)***
	+ ***Alt. 3’:***
		- ***No additional new FGs***
			* ***Redefine component 8 of FG11-4 as: Support intra-UE multiplexing/prioritization of UL overlapping channels/signals of the same priority level.***
			* ***Clarify that FG 12-1 covers all intra-UE prioritization cases, including PUCCH with HARQ-ACK, e.g., via a note if not as a new component.***
 |
| [9] | The relationship between FG 11-4 and FG 12-1 was discussed in RAN1#103-e meeting. Three alternatives were given as following, but consensus could be reached during the meeting.

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| Alt.1: * **Add 3 new FGs as below**
	+ **New FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
	+ **New FG12-1 with removing components 3/4/5**
	+ **New FG (12-1b) for UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer**
* **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**
* **Need to update dependency with other FGs**

Alt.2: * **Add two new FGs as below**
	+ **FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
	+ **FG12-1 to cover all cancellation scenarios**
* **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**

Alt.3: * **No additional new FGs**
	+ **Redefine component 7 of FG11-4 as: Support intra-UE multiplexing/prioritization of UL overlapping channels/signals of the same priority level**
 |

Among the three alternatives, we slightly prefer Alt. 1. Firstly, with Alt.1, the original intention to separate the support of two priorities for DL and UL is still kept compared to all other 2 alternatives. Secondly, by using FG 12-1b as the common FG for the support of UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels, only one set of d1 and d2 is reported by the UE. Furthermore, even without FG12-1b, it is still meaningful to support either the new FG11-4 or the new FG 12-1. For example, for new FG11-4, we have agreed to have separate RRC configuration for high priority HARQ-ACK codebook and low priority HARQ-ACK codebook, which can enable a better transmission of high priority HARQ-ACK. For Alt 2 and Alt 3, FG 12-1 covers all cancellation cases, which cannot meet the original intention to separate the support of two priorities for DL and UL.If we go with Alt.1, the update on the FGs can be found in Annex 3. As for the dependency on with other FGs, since the existing FG11-4 and FG 12-1 will be set to dummy bit, the new FG11-4 and FG12-1 will replace the existing FG11-4 and FG 12-1. Therefore, there is no need to update the dependency with other FGs if there are any other FGs with FG 11-4 or FG 12-1 as the pre-requisite.**Proposal eURLLC-2: Adopt modified Alt 1 as following:*** **Add 3 new FGs as below**
	+ **New FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
	+ **New FG12-1 with removing components 3/4/5**
	+ **New FG (12-1b) for UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer**
* **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**
* **~~Need to update dependency with other FGs~~**
 |
| [11] | In RAN1 #103e, the relationship between FG 11-4 and 12-1 was discussed. Since FG 12-1 was supposed to cover all cancellation scenarios, to define the relation in an easy way, component 7 of FG 11-4 can be removed. RAN1 then needs to clarify that all cancellation scenarios including PUCCH and PUCCH collisions as well as PUCCH and PUSCH collisions are reported under FG 12-1 by a UE.  |
| [13] | At the RAN1#103-e meeting, following proposal regarding the relationship between FG12-1 and the feature of up to two HARQ-ACK codebooks of 11-4/4x was extensively discussed. However, there was no consensus on the proposal in the last meeting [2].

|  |
| --- |
| **Proposal:*** **The note “The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4x should be further discussed” is removed from FG12-1**

Alt.1: Huawei, HiSi, MTK, Apple* **Add 3 new FGs as below**
	+ **New FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
	+ **New FG12-1 with removing components 3/4/5**
	+ **New FG (12-1b) for UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer**
* **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**
* **Need to update dependency with other FGs**

Alt.2: Intel, Ericsson, Qualcomm* **Add two new FGs as below**
	+ **FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
	+ **FG12-1 to cover all cancellation scenarios**
* **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**

Alt.3: DCM, Nokia, NSB* **No additional new FGs**
	+ **Redefine component 7 of FG11-4 as: Support intra-UE multiplexing/prioritization of UL overlapping channels/signals of the same priority level**
 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 11. NR\_L1enh\_URLLC | 11-4 | Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook (i.e. slot-based + slot-based, or slot-based + sub-slot based) simultaneously constructed for supporting HARQ-ACK codebooks with different priorities at a UE  | 1. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed with the restriction up to one sub-slot based HARQ-ACK codebook.
2. Supports separate PUCCH configuration for different HARQ-ACK codebooks
3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.
4. Supports a DCI format (from the formats 1\_1/1\_2) scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_1/1\_1 is configured or only DCI format 0\_2/1\_2 is configured per BWP
5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and ‘codeBlockGroupTransmission” for different HARQ-ACK codebooks.
6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot

Candidate values for the component 6 of FG11-4 is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration.1. Support intra-UE multiplexing/prioritization of UL overlapping channels/signals with two priority levels for HARQ-ACK
 |  | Yes | N/A |  | Per FSPer FS is selected because in bands or BCs with large number of carriers or large BW, the UE’s procesing power is spent on PDCCH/PDSCH decoding, and hence in some cases the support of the new codebook or some codebook configurations may not be possible | N/A | N/A | N/A  | If a UE reports both 11-3 and 11-4, it can support two slot-based HARQ-ACK codebooks, and one slot-based and one-sub-slot-based HARQ-ACK codebooks. If a UE reports 11-4 but not 11-3, it can only support two slot-based HARQ-ACK codebooks.The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBsComponent 6 is applied to the sub-slot HARQ-ACK codebook. It is assumed that only 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook.* Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases.
* For component 6, maximum of 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook. Thus value reported for component 6 has no meaning for “slot-based + slot based”.
 | Optional with capability signalling |
| 12. NR\_IIOT | 12-1 | UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer | Support intra-UE multiplexing/prioritization of overlapping PUCCH/PUCCH and PUCCH/PUSCH with two priority levels in physical layer (PHY)1. Configuration of PHY priority level for CG PUSCH and SR, and dynamic indication of priority level for dynamic PUSCH with a single DCI format
2. Multiplexing/prioritization between UL channels/signals with the same PHY priority level
3. Prioritization between UL channels/signals with different PHY priority levels
4. Additional number of symbols (d1) needed beyond the PUSCH preparation time for cancelling a low priority UL transmission.
5. Additional number of symbols (d2) needed beyond the PUSCH preparation time for scheduling a high priority UL transmission that cancels a low priority UL transmission
 |  | Yes | N/A |  | Per FSPer FS is selected because this FG involves various kinds of prioritization/cancellation/multiplexing, it is very processing intensive, and hence it is important to have finer granularity so that the UE does not have to under-report based on the worst band/band combination | N/A | N/A | N/A | Candidate value set for component 4: {0, 1, 2}Candidate value set for component 5: {0, 1, 2}The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4xshould be further discussed. | Optional with capability signaling |

View* As current FG11-4 is not complete, we are fine with either way as long as the issue is fixed. We think either way can fix the issue and slightly prefer Alt.3 as no additional new FGs are necessary assuming FG12-1 covers all cancellation scenarios
 |

Based on the above proposals, following point can be discussed in RAN1#104-e meeting.

**Discussion point #3**

* **Whether/how to clarify the relationship between FG11-4/4a and FG12-1**

Companies’ views in the contributions can be summarized as below.

* **Alt.1’: Huawei/HiSi**
	+ **Add 3 new FGs as below**
		- **New FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
		- **New FG12-1 with removing components 3/4/5**
		- **New FG (12-1b) for UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer**
	+ **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**
* **Alt.2: Intel (note that component number 7 is correct and no need to update it to 8)**
	+ **Add two new FGs as below**
		- **FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
		- **FG12-1 to cover all cancellation scenarios**
	+ **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**
* **Alt.3: Intel, DOCOMO**
	+ **No additional new FGs**
	+ **Redefine component 7 of FG11-4 as: Support intra-UE multiplexing/prioritization of UL overlapping channels/signals of the same priority level**
* **Alt.4: ZTE, Qualcomm**
	+ **Remove component 7) of FG11-4 and clarify that all cancellation scenarios including PUCCH and PUCCH collisions as well as PUCCH and PUSCH collisions are reported under FG 12-1 by a UE**
* **Alt.4’: Ericsson**
	+ **Resolve the relationship between FG 12-1 and 11-4/4a with the following:**
		- **(a) Add one new FG, which mirrors FG11-4 but with component 7 removed;**
		- **(b) FG12-1 is understood to cover all cancellation scenarios, including the cases involving two HARQ-ACK codebooks with two priority levels (see FG 11-4/4a);**
		- **(c) Ask RAN2 to disable the existing FG11-4 (e.g., by setting dummy bit).**

Based on above, following FL proposal can be made.

### **FL proposal 4:**

* **Remove the note of FG12-1‘The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4x should be further discussed.’, and adopt one of the following alternatives**
	+ **Alt.1’:**
		- **Add 3 new FGs as below**
			* **New FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
			* **New FG12-1 with removing components 3/4/5**
			* **New FG (12-1b) for UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer**
		- **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**
	+ **Alt.2:**
		- **Add two new FGs as below**
			* **FG11-4 with modifying component 7 as “Note: Support handling of UL overlapping channels/signals of the same priority level”**
			* **FG12-1 to cover all cancellation scenarios**
		- **Ask RAN2 to disable current FG11-4/12-1 (e.g., by setting dummy bit)**
	+ **Alt.3:**
		- **No additional new FGs**
		- **Redefine component 7 of FG11-4 as: Support intra-UE multiplexing/prioritization of UL overlapping channels/signals of the same priority level**
	+ **Alt.4:**
		- **Remove component 7) of FG11-4 and clarify that all cancellation scenarios including PUCCH and PUCCH collisions as well as PUCCH and PUSCH collisions are reported under FG 12-1 by a UE**
	+ **Alt.4’:**
		- **Resolve the relationship between FG 12-1 and 11-4/4a with the following:**
			* **(a) Add one new FG, which mirrors FG11-4 but with component 7 removed;**
			* **(b) FG12-1 is understood to cover all cancellation scenarios, including the cases involving two HARQ-ACK codebooks with two priority levels (see FG 11-4/4a);**
			* **(c) Ask RAN2 to disable the existing FG11-4 (e.g., by setting dummy bit).**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

 Cannot accept the proposal:

|  |  |
| --- | --- |
| Company | Comment |
| DOCOMO | As commented in our contribution, we are fine with either way as long as the issue of incomplete FG11-4 is fixed. We think either way can fix the issue and slightly prefer Alt.3 or Alt. 4 as no additional new FGs are necessary assuming FG12-1 covers all cancellation scenarios |
| ZTE | We prefer Alt 4, and would be also ok with Alt 4’. If we keep component 7) of 11-4, it needs additional timeline as defined in 12-1. If we change component 7) of 11-4 to the case with same priority level, it will overlap with component 2) of FG12-1. Thus, we suggest to delete component 7 directly, and leave multiplexing or prioritization behaviors can be covered by FG12-1. By this way, if a UE supports FG11-4 while not FG12-1, it only supports HARQ-ACK codebooks with different priorities while the two codebooks cannot be overlapped. In addition, according to TS 38.213, it seems only d1 is introduced as additional preparation time for scheduling high priority UL transmission.*where* *- the overlapping is applicable before or after resolving overlapping among channels of larger priority index, if any, as described in Clauses 9.2.5 and 9.2.6**- the UE expects that the transmission of the first PUCCH or the first PUSCH, respectively, would not start before* $T\_{proc,2}+d\_{1}$ *after a last symbol of the corresponding PDCCH reception**-* $T\_{proc,2} $*is the PUSCH preparation time for a corresponding UE processing capability assuming* $d\_{2,1}=0$ *[6, TS 38.214], based on* $μ$ *and* $N\_{2}$ *as subsequently defined in this Clause, and* $d\_{1}$ *is determined by a reported UE capability*Thus, component 4) and 5) of 12-1 should be changed as follows. 4)Additional number of symbols (d1) needed beyond the PUSCH preparation time for ~~cancelling a low priority UL transmission~~ scheduling a high priority UL transmission that cancels a low priority UL transmission. ~~5)Additional number of symbols (d2) needed beyond the PUSCH preparation time for scheduling a high priority UL transmission that cancels a low priority UL transmission~~  |
| vivo | We prefer Alt.4’.  |
| Nokia, NSB | We prefer alt. 3, but alt.4 would be OK as well. In general we agree with DCM that it is preferable to avoid introduction of new FGs due to this issue. |
| Huawei, HiSilicon  | We still slightly prefer Alt. 1’, since it is complete and clean. Firstly, with Alt.1, the original intention to separate the support of two priorities for DL and UL is still kept compared to all other 4 alternatives. Secondly, by using FG 12-1b as the common FG for the support of UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels, only one set of d1 and d2 is reported by the UE. Furthermore, even without FG12-1b, it is still meaningful to support either the new FG11-4 or the new FG 12-1. For example, for new FG11-4, we have agreed to have separate RRC configuration for high priority HARQ-ACK codebook and low priority HARQ-ACK codebook, which can enable a better transmission of high priority HARQ-ACK. Alt 2 cannot meet the original intention to separate the support of two priorities for DL and UL. In addition, the current FG 12-1 is not able to cover all the scenarios since it doesn’t include d2 for PDSCH processing timeline. Alt.3, since component 7 is redefined it is impossible to avoid introducing new FGs in my understanding,since the current FG 11-4 is already there, RAN2 needs to dummy the current FG11-4 and add a new FG for it also, similar as what Alt.1’ does. In addition, it cannot meet the original intention to separate the support of two priorities for DL and UL.Alt.4 cannot meet the original intention to separate the support of two priorities for DL and UL. In addition, the alternative is not complete, since both the current FG11-4 and 12-1 needs to be changed thus similar as Alt.1’ new FGs needs to be introduced also.Alt.4’ cannot meet the original intention to separate the support of two priorities for DL and UL. In addition, for FG 11-4 we cannot just simply remove component 7 since something needed for same priority. The current FG 12-1 cannot cover all cases since d2 for PDSCH processing timeline is missing.  |
| Intel | Same view as DCM and Nokia. We prefer not introducing new FGs for this now. We can accept either Alt 3 or 4. Alt. 4 works fine as well since removing component 7 (in our tdoc mistakenly referred to as component 8) does not cause any issue (handling of overlapping channels w/ same priority is already covered in core specs).Regarding the observation that additional processing time margins are currently not perfectly described since they mention PUSCH processing, in our view, the applicability in case of PDSCH processing and HARQ-ACK feedback can be extended in FG 12-1 by generalizing the applicability of ‘d1’. We do not see any major compatibility issue with this generalization (just as we consider the update to component 7 of 11-4 not necessitating new FG). However, if these small adjustments are considered NBC, then we would be left with Alt. 2. Considering the need to generalize the processing time margins, we would think the impact to FG 12-1 (in terms of how it shows up on TS 38.306) would be more than FG 11-4. Thus, not sure if Alt 4’ offers any increased clarity beyond Alt. 3. Lastly, as indicted in our tdoc, we are still not convinced how Alt. 1 does much better than Alt. 2.  |
| Moderator (NTT DOCOMO) | Thanks for the feedbacks.Based on the feedbacks so far, following is the situation.-Alt.1’: HW/HiSi-Alt.3: DCM, Nokia/NSB, Intel-Alt.4: DCM, Nokia/NSB, Intel, ZTE-Alt.4’: vivo, ZTEAlthough there are still different views among companies, this issue has been discussed in previous meetings and I think we should make a decision without consuming long time for further discussion based on ‘preference’ of each company.So, my suggestion as moderator is to focus on Alt.4 and to discuss whether Alt.4 has any essential problem. |

### **Updated FL proposal 4:**

* **Remove the note of FG12-1‘The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4x should be further discussed.’, and adopt one of the following alternatives**
	+ **Remove component 7) of FG11-4 and clarify that all cancellation scenarios including PUCCH and PUCCH collisions as well as PUCCH and PUSCH collisions are reported under FG 12-1 by a UE**

Companies are encouraged to check above FL proposal and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

 Cannot accept the proposal:

|  |  |
| --- | --- |
| Company | Comment |
| Apple | Similar to Huawei, we also prefer Alt 1’ because it is the cleanest solution.Regarding the updated proposal, we wonder what FG11-4 by itself means after component 7) is removed. Does it mean it supports two HARQ-ACK codebooks only when the high priority HARQ-ACK PUCCH does not overlap with any low priority channel? |
| Ericsson | We can support Updated FL proposal 4 (i.e., Alt 4). Intention of Alt 4’ is the same as Alt 4. |
|  |  |

1. Conclusion

TBD

Reference

[1] R1-2009585 Updated RAN1 UE features list for Rel-16 NR Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2100094 Discussion on NR Rel-16 UE Features ZTE

[3] R1-2100140 Correction for V2X UE feature list OPPO

[4] R1-2100522 Remaining details of Rel-16 NR UE features Ericsson

[5] R1-2100554 Discussion on NR Rel-16 UE features LG Electronics

[6] R1-2100635 Remaining issue on UE features Intel Corporation

[7] R1-2101184 On NR Rel.16 UE features Samsung

[8] R1-2101249 Updates on NR UE Features Nokia, Nokia Shanghai Bell

[9] R1-2101273 Remaining details of Rel-16 NR UE features Huawei, HiSilicon

[10] R1-2101342 Discussions on NR Rel-16 UE features Apple

[11] R1-2101444 Discussion on NR Rel-16 UE features Qualcomm Incorporated

[12] R1-2101517 Correction on half-DuplexTDD-CA-SameSCS-r16 CATT

[13] R1-2101587 Remaining issues on Rel-16 NR UE features NTT DOCOMO, INC.

[14] R1-2101685 Remaining issues on Rel-16 eMIMO UE features vivo

Appendix: NR UE features list for NR URLLC/IIoT in [1]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 11. NR\_L1enh\_URLLC | 11-1 | Monitoring DCI format 1\_2 and DCI format 0\_2 | 1. Supports monitoring DCI format 1\_2 for DL scheduling
2. Supports monitoring DCI format 0\_2 for UL scheduling
 |  | Yes | N/A |  | Per UE | No | No | N/A  |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-1a | Monitoring both DCI format 0\_1/1\_1 and DCI format 0\_2/1\_2 in the same search space  | 1. Supports monitoring both DCI format 0\_1/1\_1 and DCI format 0\_2/1\_2 in the same search space
 | 11-1 | Yes | N/A |  | Per UE | No | No | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-1b | Type 1 HARQ-ACK codebook support for relative TDRA for DL | 1. Support Type 1 HARQ-ACK codebook for TDRA using the starting symbol of the PDCCH monitoring occasion in which the DL assignment is detected as the reference of the SLIV
 | 11-1 | Yes | N/A |  | Per UE | No | YesNote: Differentiation is from the perspective of the scheduled carrier | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-2 | Rel-16 PDCCH monitoring capability  | 1. Supported combination(s) of (X, Y, μ). For each reported combination, the UE supports the limit C on the maximum number of non-overlapped CCEs for channel estimation per PDCCH monitoring span and the limit M on the maximum number of monitored PDCCH candidates per PDCCH monitoring span
2. Maximum number of DL and UL unicast DCI formats in a span

For the set of monitoring occasions which are within the same span:* Processing one unicast DCI scheduling DL and one unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for FDD
* Processing one unicast DCI scheduling DL and two unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for TDD
* Processing two unicast DCI scheduling DL and one unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for TDD
 |  | Yes | N/A |  | Per FS for component 1Note: Indicating support of this capability in a band in a BC implies that only rel-16 monitoring can be configured in a CA configuration for the BC if the CA configuration includes the band and if rel-16 monitoring is configured for the band | N/A | N/A | N/A | This capability is signaled for SCS 15 kHz and 30 kHz. For μ=0 and 1, candidate value set for (X, Y, μ): {(7, 3, μ), (4, 3, μ), (2, 2, μ)}For component 1, a list of separate UE capabilities (X, Y, μ)for processing capability #1;For component 1, a list of separate UE capabilities (X, Y, μ)for processing capability #2; | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-2a | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells | 1. Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells
	* Candidate value for the component: {2, 3, …, 16}
2. Supported span arrangement for CA
	* Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans}
 | 11-2 | Yes | N/A |  | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-2b | Mix of Rel. 16 PDCCH monitoring capability and Rel. 15 PDCCH monitoring capability on different carriers | 1. Support Rel-15 monitoring capability and Rel-16 monitoring capability on different serving cells
 | 11-2 | Yes | N/A |  | Per FSNote: Per FS is selected because same type with 3-5b is preferred | N/A | N/A | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-2c | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | 1. Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)
	* Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15
	* Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 15
2. Supported span arrangement for CA
	* Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans}
 | 11-2b | Yes | N/A |  | Per BC | N/A | N/A | N/A | The minimum of the summation of capability on the number of CCs with Rel-15 PDCCH monitoring capability and the capability on the number of CCs with Rel-16 PDCCH monitoring capability is 3 | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-2d | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring capability on all the serving cells | 1. Supported combination of (*pdcch-BlindDetectionMCG-UE-r16*, *pdcch-BlindDetectionSCG-UE-r16*)
 | 11-2 | Yes | N/A |  | Per BC | N/A | N/A | N/A | If the UE reports pdcch-BlindDetectionCA-r16, * Candidate values for pdcch-BlindDetectionMCG-UE-r16 is 1 to pdcch-BlindDetectionCA-r16-1
* Candidate values for pdcch-BlindDetectionSCG-UE-r16 is 1 to pdcch-BlindDetectionCA-r16-1
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16 >= pdcch-BlindDetectionCA-r16

Otherwise, if N\_(NR-DC,max,r16)^(DL,cells) is a maximum total number of downlink cells for which the UE is provided monitoringCapabilityConfig-r16 = r16monitoringcapability and the UE is configured on both the MCG and the SCG for NR-DC as indicated in UE-NR-Capability* the value of pdcch-BlindDetectionMCG-UE-r16 or of pdcch-BlindDetectionSCG-UE-r16 is 1,
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16 >= N\_(NR-DC,max,r16)^(DL,cells).
 | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-2e | Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | 1. Supported combination(s) of (*pdcch-BlindDetectionMCG-UE-r15*, *pdcch-BlindDetectionSCG-UE-r15, pdcch-BlindDetectionMCG-UE-r16*, *pdcch-BlindDetectionSCG-UE-r16*)
 | 11-2b | Yes | N/A |  | Per BC | N/A | N/A | N/A | One combination of (*pdcch-BlindDetectionMCG-UE-r15, pdcch-BlindDetectionSCG-UE-r15, pdcch-BlindDetectionMCG-UE-r16, pdcch-BlindDetectionSCG-UE-r16*) corresponds to one combination of (*pdcch-BlindDetectionCA-r15, pdcch-BlindDetectionCA-r16*)If the UE reports pdcch-BlindDetectionCA-r15, * Candidate values for pdcch-BlindDetectionMCG-UE-r15 is 0 to pdcch-BlindDetectionCA-r15
* Candidate values for pdcch-BlindDetectionSCG-UE-r15 is 0 to pdcch-BlindDetectionCA-r15
* pdcch-BlindDetectionMCG-UE-r15 + pdcch-BlindDetectionSCG-UE-r15>= pdcch-BlindDetectionCA-r15

Otherwise, if N\_(NR-DC,max,r15)^(DL,cells) is a maximum total number of downlink cells for which the UE is provided monitoringCapabilityConfig-r16 = r15monitoringcapability* Candidate values for pdcch-BlindDetectionMCG-UE-r15 is [0, 1, 2]
* Candidate values for pdcch-BlindDetectionSCG-UE-r15 is [0, 1, 2]
* pdcch-BlindDetectionMCG-UE-r15 + pdcch-BlindDetectionSCG-UE-r15 >= N\_(NR-DC,max,r15)^(DL,cells)

If the UE reports pdcch-BlindDetectionCA-r16, * Candidate values for pdcch-BlindDetectionMCG-UE-r16 is 0 to pdcch-BlindDetectionCA-r16
* Candidate values for pdcch-BlindDetectionSCG-UE-r16 is 0 to pdcch-BlindDetectionCA-r16
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16>= pdcch-BlindDetectionCA-r16

Otherwise, if N\_(NR-DC,max,r16)^(DL,cells) is a maximum total number of downlink cells for which the UE is provided monitoringCapabilityConfig-r16 = r16monitoringcapability* Candidate values for pdcch-BlindDetectionMCG-UE-r16 is [0, 1]
* Candidate values for pdcch-BlindDetectionSCG-UE-r16 is [0, 1]
* pdcch-BlindDetectionMCG-UE-r16 + pdcch-BlindDetectionSCG-UE-r16 >= N\_(NR-DC,max,r16)^(DL,cells)
 | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-3 | More than one PUCCH for HARQ-ACK transmission within a slot | 1. Supports sub-slot based HARQ-ACK feedback procedure.

• A UL slot consists of a number of sub-slots. No more than one transmitted PUCCH carrying HARQ-ACKs starts in a sub-slot.• At least one sub-slot configuration for PUCCH can be UE specifically configured to a UE. • Supports a single configuration for PUCCH resource for all sub-slots in a slot. The starting symbol of a PUCCH resource is defined with respect to the first symbol of sub-slot. Any sub-slot PUCCH resource is not across sub-slot boundaries. 1. Supported sub-slot configuration
 |  | Yes | N/A |  | Per FSPer FS is selected because in bands or BCs with large number of carriers or large BW, the UE’s processing power is spent on PDCCH/PDSCH decoding, and hence in some cases the support of the new codebook or some codebook configurations may not be possible | N/A | N/A | N/A  | Candidate value set for component 2:{ 7-symbol\*2, 2-symbol\*7 and 7-symbol\*2} for NCP or { 6-symbol\*2, 2-symbol\*6 and 6-symbol\*2} for ECPThe number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBsA UE supporting 11-3 is also expected to support FGs 4-1, 4-3, 4-4, 4-5, and 4-19 with a “slot” being replaced by a sub-slot of length 2 or 7 symbols for NCP and (2 and 6 symbols for ECP) for the PUCCH formats that can be accommodated in the corresponding sub-slot durations | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-3c | 2 PUCCH of format 0 or 2 for a single 7\*2-symbol subslot based HARQ-ACK codebook  | 1) 2 PUCCH format 0/2 in different symbols and once per subslot for HARQ-ACK, 2) 2 PUCCH format 0 in different symbols and once per subslot for SR  | 11-3 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For ECP, “7” is replaced by “6” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-3d | 2 PUCCH of format 0 or 2 for a single 2\*7-symbol subslot based HARQ-ACK codebook  | 1) 2 PUCCH format 0/2 in different symbols and once per subslot for HARQ-ACK, 2) 2 PUCCH format 0 in different symbols and once per subslot for SR   | 11-3 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-3e | 1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3 or 4 in the same subslot for a single 2\*7-symbol HARQ-ACK codebooks  | If the UE supports a 2\*7-symbol subslot HARQ-ACK codebook, the UE also supports:1) 1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3 and 4 in the same subslot | 11-3 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-3f | 2 PUCCH transmissions in the same subslot for a single 2\*7-symbol HARQ-ACK codebooks which are not covered by 11-3d and 11-3e  | If the UE supports a 2\*7-symbol subslot HARQ-ACK codebook, the UE also supports:2 PUCCH transmissions in the same subslot for a single 2\*7-symbol HARQ-ACK codebooks which are not covered by 11-3d and 11-3e  | 11-3 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-3g | SR/HARQ-ACK multiplexing once per subslot using a PUCCH (or HARQ-ACK piggybacked on a PUSCH) when SR/HARQ-ACK are supposed to be sent with different starting symbols in a subslot | If a UE supports a subslot based HARQ-ACK codebook, the UE also supports:Overlapping PUCCH resources with different starting symbols in a subslot | 11-3 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4 | Two HARQ-ACK codebooks with up to one sub-slot based HARQ-ACK codebook (i.e. slot-based + slot-based, or slot-based + sub-slot based) simultaneously constructed for supporting HARQ-ACK codebooks with different priorities at a UE  | 1. Supports two HARQ-ACK codebooks with different priorities to be simultaneously constructed with the restriction up to one sub-slot based HARQ-ACK codebook.
2. Supports separate PUCCH configuration for different HARQ-ACK codebooks
3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.
4. Supports a DCI format (from the formats 1\_1/1\_2) scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_1/1\_1 is configured or only DCI format 0\_2/1\_2 is configured per BWP
5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and ‘codeBlockGroupTransmission” for different HARQ-ACK codebooks.
6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot

Candidate values for the component 6 of FG11-4 is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration.1. Support intra-UE multiplexing/prioritization of UL overlapping channels/signals with two priority levels for HARQ-ACK
 |  | Yes | N/A |  | Per FSPer FS is selected because in bands or BCs with large number of carriers or large BW, the UE’s procesing power is spent on PDCCH/PDSCH decoding, and hence in some cases the support of the new codebook or some codebook configurations may not be possible | N/A | N/A | N/A  | If a UE reports both 11-3 and 11-4, it can support two slot-based HARQ-ACK codebooks, and one slot-based and one-sub-slot-based HARQ-ACK codebooks. If a UE reports 11-4 but not 11-3, it can only support two slot-based HARQ-ACK codebooks.The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBsComponent 6 is applied to the sub-slot HARQ-ACK codebook. It is assumed that only 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook.* Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases.
* For component 6, maximum of 1 actual PUCCH transmission for HARQ-ACK within a slot for slot-based HARQ-ACK codebook. Thus value reported for component 6 has no meaning for “slot-based + slot based”.
 | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4a | Two subslot based HARQ-ACK codebooks simultaneously constructed for supporting HARQ-ACK codebooks with different priorities at a UE  | 1. Supports two subslot based HARQ-ACK codebooks with different priorities to be simultaneously constructed.
2. Supports separate PUCCH configuration for different HARQ-ACK codebooks
3. Supports 2-level priority of HARQ-ACK for dynamically scheduled PDSCH and SPS PDSCH.
4. Supports a DCI format (from the formats /1\_1/1\_2) scheduling PDSCH with different HARQ-ACK priorities when only DCI format 0\_1/1\_1 is configured or only DCI format 0\_2/1\_2 is configured in USS per BWP
5. Supports separate configuration of parameters PDSCH-HARQ-ACK-Codebook, UCI-OnPUSCH and ‘codeBlockGroupTransmission” for different HARQ-ACK codebooks.
6. Supported maximum number of actual PUCCH transmissions for HARQ-ACK within a slot

Candidate values for the component 6 of FG11-4a is: For NCP, {4, 5, 6, 7} for 2-symbol\*7 sub-slot configuration; For ECP, the candidate value is {4,5,6} for 2-symbol\*6 sub-slot configuration. | 11-3 and 11-4 | Yes | N/A |  | Per FSPer FS is selected because in bands or BCs with large number of carriers or large BW, the UE’s procesing power is spent on PDCCH/PDSCH decoding, and hence in some cases the support of the new codebook or some codebook configurations may not be possible | N/A | N/A | N/A | The number of PUCCHs for CSI reporting per slot is not impacted compared with Rel-15 by introducing the new HARQ-ACK CBsComponent 6 is applied to the two sub-slot HARQ-ACK codebooks, respectively.* Component 6 is reported for 2-symbol\*7 sub-slot configuration. For 7-symbol\*2 sub-slot configuration, the value of component 6 is {2} for both NCP and ECP cases.
 | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4b | DL priority indication in DCI with mixed DCI formats | 1. Support of priority indicator field configured in DCI formats 1\_1 and 1\_2 in a BWP when configured to monitor both DCI formats 1\_1 and 1\_2 in the BWP
 | 11-1, 11-4 | Yes | N/A |  | Per UE | No | No | N/A  |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4c | 2 PUCCH of format 0 or 2 for two HARQ-ACK codebooks with one 7\*2-symbol sub-slot based HARQ-ACK codebook | If the UE supports a 7\*2-symbol subslot HARQ codebook, the UE also supports:1) 2 PUCCH format 0/2 in different symbols and once per subslot for HARQ-ACK, 2) 2 PUCCH format 0 in different symbols and once per subslot for SR  | 11-4 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting. For slot based + slot based case, the capability for each HARQ-ACK codebook is subjected to the capability reported by FG 4-2For ECP, “7” is replaced by “6” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4d | 2 PUCCH of format 0 or 2 in consecutive symbols for two HARQ-ACK codebooks with one 2\*7-symbol sub-slot based HARQ-ACK codebook | If the UE supports a 2\*7-symbol subslot HARQ codebook, the UE also supports:1) 2 PUCCH format 0/2 in different symbols and once per subslot for HARQ-ACK, 2) 2 PUCCH format 0 in different symbols and once per subslot for SR   | 11-4 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For slot based + slot based case, the capability for each HARQ-ACK codebook is subjected to the capability reported by FG 4-2For ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4e | 2 PUCCH of format 0 or 2 for two subslot based HARQ-ACK codebooks  | If the UE supports two subslot HARQ codebooks, the UE also supports:1) 2 PUCCH format 0/2 in different symbols and once per subslot per codebook for HARQ-ACK, 2) 2 PUCCH format 0 in different symbols and once per subslot per priority for SR   | 11-4a | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting. | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4f | 1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3 or 4 in the same subslot for HARQ-ACK codebooks with one 2\*7-symbol subslot based HARQ-ACK codebook  | If the UE supports a 2\*7-symbol subslot HARQ-ACK codebook, the UE also supports:1) 1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3 and 4 in the same subslot of the codebook | 11-4 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For slot based + slot based case, the capability for each HARQ-ACK codebook is subjected to the capability reported by FG 4-22For ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4g | 1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3 or 4 in the same subslot for two subslot based HARQ-ACK codebooks  | If the UE supports two subslot HARQ-ACK codebooks both configured with 2\*7-symbols, the UE also supports:1) 1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3 and 4 in the same subslot of a codebook | 11-4a | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4h | 2 PUCCH transmissions in the same subslot for two HARQ-ACK codebooks with one 2\*7-symbol subslot which are not covered by 11-4c and 11-4e  | If the UE supports two HARQ-ACK codebooks with one subslot based codebook with 2\*7-symbol configuration, the UE also supports:1) 2PUCCH transmissions in the same subslot of the codebook which are not covered by 11-4c and 11-4e | 11-4 | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For slot based + slot based case, the capability for each HARQ-ACK codebook is subjected to the capability reported by FG 4-22aFor ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-4i | 2 PUCCH transmissions in the same subslot for two subslot based HARQ-ACK codebooks which are not covered by 11-4d and 11-4f  | If the UE supports two HARQ-ACK codebooks both with 2\*7-symbol configuration, the UE also supports:1) 2PUCCH transmissions in the same subslot of a codebook which are not covered by 11-4d and 11-4f | 11-4a | Yes | N/A |  | Per FSPer FS is selected because the processing power the UE has to spend on preparing PUCCH has a relation with PDSCH processing power and that is related to number of carriers on which the UE has to process PDSCH | N/A | N/A | N/A | This FG covers any PUCCH transmission and not only those for HARQ-ACK reporting.For ECP, “7 symbols” is replaced by “6 symbols” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-5 | PUSCH repetition Type B | 1. For a transport block, one dynamic UL grant or one configured grant schedules two or more PUSCH repetitions that can be in one slot, or across slot boundary in consecutive available slots.
2. Dynamic indication of the nominal number of repetitions in the DCI scheduling dynamic PUSCH.
3. The time window within which valid symbols are used for transmission is L\*K, starting from the first symbol indicated by the SLIV in TDRA field.
4. PUSCH repetition type B is supported for DCI format 0\_1 and DCI format 0\_2 (for DG and type 2 CG).
5. S and L are separately indicated (4-bit for S and 4-bit for L). L <= 14.
6. Handling of interaction with DL/UL directions depending on whether dynamic SFI is configured or not, including both cases with and without higher layer parameter InvalidSymbolPattern configured
7. Supported maximum number of PUSCH transmissions within a slot for all TB(s), where each actual repetition for PUSCH repetition type B is counted as 1 PUSCH transmission, separately reported for UE processing capability 1 and for UE processing capability 2 if UE supports both processing capabilities

Note: Number of TBs are based on reported Rel-15 capability on number of TBs, and reported value for component 7 cannot be smaller than the reported value of the number of TBs1. Supported PUSCH hopping scheme
 |  | Yes | N/A |  | Per FSNote: Per FS is selected to follow Rel-15 reporting type for number of TBs to be supported | N/A | N/A | N/A | Candidate value for component 7: {2, 3, 4, 7, 8, 12}Candidate value for component 8: {Inter-slot hopping, Inter-repetition hopping, both Inter-slot hopping and Inter-repetition hopping}PUSCH repetition type B with configured grant is applied only if UE reports the support of FG 5-19 or FG 5-20, and subjected to the capability of FG 5-19 and FG 5-20The case that both dynamic SFI and InvalidSymbolPattern are configured is applied only if UE reports the support of FG3-6 | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-6 | PUSCH repetition Type A | 1. PUSCH transmission with Rel-15 behavior with or without slot aggregation.

• With slot aggregation, the number of repetitions can be dynamically indicated (as agreed for Rel-16).• When dynamically indicated, the number of repetitions is jointly coded with SLIV in TDRA table, by adding an additional column for the number of repetitions in the TDRA table. | One of {5-16, 5-17] | Yes | N/A |  | Per UE | No | No | N/A | Note: RAN1 agreed it should be possible to separately indicate support of this FG based on whether the UE is operated with or without shared spectrum access. It is left to RAN2 how to implement this while leaving the type as “per UE” | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-7 | UL cancelation scheme for self-carrier | 1. Supports group common DCI (i.e. DCI format 2\_4) for cancelation indication on the same DL CC as that scheduling PUSCH or SRS
2. UL cancelation for PUSCH
* Cancellation is applied to each PUSCH repetition individually in case of PUSCH repetitions
1. UL cancelation for SRS symbols that overlap with the cancelled symbols
 |  | Yes | N/A |  | Per FSPer FS is selected because the FG is very demanding in UE processing, considering that this can be a UE with processing capability 1 but required to be able to cancel according to processing capability 2, and hence it is important to take into account the BC information for dimensioning purpose | N/A | N/A | N/A  | More than one monitoring occasion for DCI format 2\_4 per slot is applied only if the UE reports to support FG 3-5 or FG 3-5a or FG 3-5b or 11-2 or 11-2a | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-7a | UL cancelation scheme for cross-carrier | 1. Supports group common DCI (i.e. DCI format 2\_4) for cancelation indication on a different DL CC than that scheduling PUSCH or SRS
2. UL cancelation for PUSCH
* Cancellation is applied to each PUSCH repetition individually in case of PUSCH repetitions
1. UL cancelation for SRS symbols that overlap with the cancelled symbols
 |  | Yes | N/A |  | Per FSPer FS is selected because the FG is very demanding in UE processing, considering that this can be a UE with processing capability 1 but required to be able to cancel according to processing capability 2, and hence it is important to take into account the BC information for dimensioning purpose | N/A | N/A | N/A  | More than one monitoring occasion for DCI format 2\_4 per slot is applied only if the UE reports to support FG 3-5 or FG 3-5a or FG 3-5b or 11-2 or 11-2aRegarding the interpretation of UE capabilities in case of cross-carrier operation, support of 11-7a is based on the support of this capability for both the band of the scheduled/triggered/indicated cell and the band of the scheduling/triggering/indicating cell | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-7b | Independent cancellation of the overlapping PUSCHs in an intra-band UL CA | 1. For a UE indicating the capability of pa-PhaseDiscontinuityImpacts, and if the PUSCH on at least one serving cell is cancelled, the UE may cancel the (repetition of the) PUSCHs transmission on all other intra-band serving cell(s). The cancellation of the (repetition of the) PUSCH transmission on the set of intra-band serving cell(s) includes all symbols from the earliest symbol that is overlapping with the first cancelled symbol of the PUSCH on the serving cell for which the DCI format 2\_4 is applicable to.
 | 6-23, 11-7  | Yes | N/A |  | Per band | N/A | N/A | N/A | If UE indicates 6-23 but does not support this FG, UE is not expected to be scheduled simultaneous PUSCHs on multiple carriers but receiving UL CI only for subset of carriers in intra-band carriers | Optional with capability signaling |
| 11. NR\_L1enh\_URLLC | 11-8 | Enhanced UL power control scheme | 1. For DG-PUSCH, one bit (separately from SRI) in UL grant is used to indicate the P0 value if SRI is present in the UL grant, and 1 or 2 bits is used to indicate the P0 value if SRI is not present in the UL grant
 |  | Yes | N/A |  | Per UE | No | YesNote: Differentiation is from the perspective of the scheduled carrier | N/A |  | Optional with capability signaling |
| 11. NR\_L1enh\_URLLC | 11-9 | Multiple active configured grant configurations for a BWP of a serving cell | 1. Supports up to 12 configured/active configured grant configurations in a BWP of a serving cell.

• Separate RRC parameters for different configured grant configurations• Separate activation for different configured grant Type 2 configurations• Separate release for different configured grant Type 2 configurations1. Supported maximum number of configured/active configured grant configurations in a BWP of a serving cell

Candidate values for component 2: {1, 2, 4, 8, 12}1. Supported maximum number of configured/active configured grant configurations across all serving cells

Candidate values for component 3: {2, …, 32} | One of {5-19, 5-20} | Yes | N/A |  | Per band | N/A | N/A | N/A | For component 3: Total number in FR1 is not greater than X value reported for FR1. Total number in FR2 is not greater than X value reported for FR2.Total number across FR1 and FR2 is not greater than the larger of the FR1 and FR2 values | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-9a | Joint release in a DCI for two or more configured grant Type 2 configurations for a given BWP of a serving cell | 1. M<=4 bits indication in the Release DCI is used for indicating which CG configuration(s) is/are released, where the association between each state indicated by the indication and the CG configuration(s) is

• Up to 2^M states are higher layer configurable, where each of the state can be mapped to a single or multiple CG configurations to be released• In case of no higher layer configured state(s), separate release is used where the release corresponds to the CG configuration index indicated by the indication | 11-9 | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-10  | Type 2 configured grant release by DCI format 0\_1  | 1. Support of type 2 configured grant release by DCI format 0\_1
 | 5-20 | Yes | N/A |  | Per UE | No | No | N/A  | A UE supporting this feature and 11-1 (DCI format 0\_2/1\_2) shall also support 11-11 (Type 2 configured grant release by DCI format 0\_2). | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-11  | Type 2 configured grant release by DCI format 0\_2 | 1. Support of type 2 configured grant release by DCI format 0\_2
 | 5-20, 11-1 | Yes | N/A |  | Per UE | No | No | N/A  | A UE supporting this feature shall also support 11-10 (Type 2 configured grant release by DCI format 0\_1). | Optional with capability signalling |
| 11. NR\_L1enh\_URLLC | 11-12  | CBG-based re-transmission for UL using CBGTI with only in-order CBG-based re-transmission(s) for cancelled initial PUSCH transmission | 1. Support of CBG-based PUSCH re-transmission(s) of a TB using CGBTI in case the initial PUSCH transmission was not cancelled due to gNB scheduling/indication/configuration. 2. Support of CBG-based PUSCH re-transmission(s) of a TB using CGBTI in case the initial PUSCH transmission was cancelled due to gNB scheduling/indication/configuration and the following condition is satisfied: the UE is scheduled for a re-transmission of a CBG #N in a given TB when CBG #N-1 has been transmitted before or is scheduled in the same UL grant that includes CBG#N. |  | Yes | N/A |   | Per UE | No | No | N/A |  | Optional with capability signaling  |

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 12. NR\_IIOT | 12-1 | UL intra-UE multiplexing/prioritization of overlapping channel/signals with two priority levels in physical layer | Support intra-UE multiplexing/prioritization of overlapping PUCCH/PUCCH and PUCCH/PUSCH with two priority levels in physical layer (PHY)1. Configuration of PHY priority level for CG PUSCH and SR, and dynamic indication of priority level for dynamic PUSCH with a single DCI format
2. Multiplexing/prioritization between UL channels/signals with the same PHY priority level
3. Prioritization between UL channels/signals with different PHY priority levels
4. Additional number of symbols (d1) needed beyond the PUSCH preparation time for cancelling a low priority UL transmission.
5. Additional number of symbols (d2) needed beyond the PUSCH preparation time for scheduling a high priority UL transmission that cancels a low priority UL transmission
 |  | Yes | N/A |  | Per FSPer FS is selected because this FG involves various kinds of prioritization/cancellation/multiplexing, it is very processing intensive, and hence it is important to have finer granularity so that the UE does not have to under-report based on the worst band/band combination | N/A | N/A | N/A | Candidate value set for component 4: {0, 1, 2}Candidate value set for component 5: {0, 1, 2}The relationship between this feature and the feature of up to two HARQ-ACK codebooks of 11-4 and 11-4xshould be further discussed. | Optional with capability signaling |
| 12. NR\_IIOT | 12-1a | UL priority indication in DCI with mixed DCI formats | Support of priority indicator field configured in DCI formats 0\_1 and 0\_2 in a BWP when configured to monitor both DCI formats 0\_1 and 0\_2 in the BWP | 12-1 and 11-1 | Yes | N/A |  | Per UE | No | No | N/A  |  | Optional with capability signalling |
| 12. NR\_IIOT | 12-2 | Multiple SPS configurations | 1. Support of up to 8 configured SPS configurations in a BWP of a serving cell and up to 32 configured SPS configurations in a cell group, including separate RRC parameters and separate activation/release for different SPS configurations
2. The max number of active SPS configurations in a BWP of a serving cell
3. The max number of active SPS configurations across all serving cells
4. The related HARQ-ACK enhancements to support multiple active SPS configurations
 | 5-18 DL SPS  | Yes | N/A |  | Per band | N/A | N/A | N/A | Component-2, candidate value set is {1, 2, …, 8}Component-3, candidate value set is {2, …, 32} | Optional with capability signaling |
| 12. NR\_IIOT | 12-2a | Joint release in a DCI for two or more SPS configurations for a given BWP of a serving cell | 1. M<=4 bits indication in the Release DCI is used for indicating which SPS configuration(s) is/are released, where the association between each state indicated by the indication and the SPS configuration(s) is

• Up to 2^M states are higher layer configurable, where each of the state can be mapped to a single or multiple SPS configurations to be released• In case of no higher layer configured state(s), separate release is used where the release corresponds to the SPS configuration index indicated by the indication1. The related HARQ-ACK enhancements to support joint release
 | 12-2  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |
| 12. NR\_IIOT | 12-3 | SPS release by DCI format 1\_1 | Support of SPS release by DCI format 1\_1 | 5-18 DL SPS | Yes | N/A |  | Per UE | No | No | N/A |  | Optional with capability signaling |
| 12. NR\_IIOT | 12-3a | SPS release by DCI format 1\_2 | Support of SPS release by DCI format 1\_2 | 5-18 DL SPS and 11-1  | Yes | N/A |  | Per UE | No | No | N/A |  | Optional with capability signaling |
| 12. NR\_IIOT | 12-5 | Configuration of aggregation factor per SPS configuration | Support of configurable PDSCH aggregation factor ({1, 2, 4, 8}) per DL SPS configuration | 5-18 DL SPS | Yes | N/A |  | Per UE | No | Yes | N/A |  | Optional with capability signaling |
| 12. NR\_IIOT | 12-6  | Support of SPS periodicity shorter than 10 ms | Support of SPS periodicity shorter than 10 ms | 5-18 DL SPS | Yes | N/A |  | Per UE | No | Yes | N/A  |  | Optional with capability signalling |