3GPP TSG RAN WG1 #98bis **R1-1910225**
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Title: **UL inter-UE Tx prioritization for URLLC**
Agenda Item: **7.2.6.5**
Document for: **Discussion and Decision**

1. Introduction

In RAN1 #97 and #98 meeting, following agreements regarding UL inter-UE Tx prioritization for URLLC [1][2]. In this contribution, we discuss the design of UL cancelation mechanisms and enhanced UL power control scheme. For UL cancellation, signalling design and related UE behaviours for monitoring and cancellation will be studied. Besides, regarding enhanced UL power control scheme, power control parameter determination, whether to increase TPC step/range will be discussed.

Agreements:
- Reuse the existing methods for search space configuration to support UL CI monitoring
  - FFS possible restrictions
  - Note: this means both symbol level and slot level monitoring periodicities are possible from specification perspective

Agreements:
- The UE DCI size budget is not increased by UL CI monitoring
- Further discuss methods to reduce the UE monitoring for UL CI, e.g.
  - The number of aggregation levels and/or candidates for the UL CI monitoring should be limited
  - Conditions for eMBB UE UL CI monitoring:
    - For UL transmission with associated PDCCH,
      - Option 1: UE starts UL CI monitoring after the PDCCH is decoded
      - Option 2: UE monitors UL CI at least at the latest monitoring occasion ending no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.
    - For UL transmission without associated PDCCH, UE monitors UL CI at least at the latest monitoring occasion that ends no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.
    - Other conditions?
  - Others?
- FFS the enhancement of UE capability (number of non-overlapping CCE and/or blind decodes) for UL CI monitoring

Agreements:
- Upon detecting an UL cancelation indication, for the transmission of UL signal/channels, "stop with resuming" is not supported
  - Except:
    - SRS can still be transmitted on the non-cancelled symbols (conditioned on if SRS can be pre-empted)
    - FFS for the PUSCH repetition (Rel-15 & Rel-16) case
    - FFS for the PUCCH repetition case (conditioned on if PUCCH can be pre-empted)
  - FFS whether another PUSCH can be scheduled in non-pre-empted resource
  - FFS impact (e.g. phase continuity issue) to a different carrier due to UL cancelation

Agreements:
- The following UL channel/signals can be cancelled by UL cancelation indication
  - PUSCH (including DG-, CG- and SP-)
  - FFS for SRS
  - FFS for PUCCH
    - Option 1: PUCCH (all types) can be cancelled
    - Option 2: Some PUCCH can be cancelled, e.g. PUCCH carrying CSI
    - Option 3: PUCCH cannot be cancelled
  - FFS for PRACH (preamble and/or MSG 3 PUSCH)

Agreements:
- The UE processing time requirement for UL cancelation indication based on N2 defined in Rel-15 UE cap#2 is supported

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- FFS whether the processing time requirement for UL cancelation indication larger than N2 as defined in Rel-15 UE cap#2 can also be supported as an UE capability
- FFS whether the processing time requirement for UL cancelation indication shorter than N2 as defined in Rel-15 UE cap#2 as can also be supported an UE capability

Agreements:

- For a DG-PUSCH, an open-loop parameter set indicated to the UE by scheduling DCI using a separate field than SRI is supported.
  - FFS number of bits for the indication

2. UL cancelation mechanisms

2.1. UE related behaviors for UL cancellation indication

2.1.1. UE monitoring behavior

Considering the scheduling of URLLC traffic and latency requirement, the monitoring periodicity can be 2, 4, 7 or 14 symbols as starting point. If mini-slot level monitoring periodicity is adopted, the blind decoding may be increased. To limit the blind decoding for UL cancellation indication, the monitoring behaviours, e.g. monitoring occasion and number for blind decoding, should be configurable. Besides, it is important to restrict mini-slot level monitoring is only applied for UL cancellation indication for eMBB UE, to avoid large power consumption for PDCCH monitoring.

Proposal 1: For eMBB UE supporting UL cancellation,

- **Monitoring periodicity can be 2, 4, 7 or 14, 28 symbols as starting point**

There was discussion on methods to reduce UE monitoring for UL CI in the last meeting. Following conditions were discussed.

- Conditions for eMBB UE UL CI monitoring:
  - For UL transmission with associated PDCCH,
    - Option 1: UE starts UL CI monitoring after the PDCCH is decoded
    - Option 2: UE monitors UL CI at least at the latest monitoring occasion ending no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.
  - For UL transmission without associated PDCCH, UE monitors UL CI at least at the latest monitoring occasion that ends no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.

For UL transmission with associated PDCCH, two options were proposed.

- Option 1

Regarding option 1, the key issue is how to determine the timing when a PDCCH is decoded. A decoded PDCCH means UE knows in what time and frequency resource it is scheduled a UL transmission.

To facilitate the monitoring behaviour of option 1, a definition of PDCCH decoding time could be needed, which is not defined in current specification. In principle, if PDCCH decoding time is to be defined, there are some aspects that need to take into account as follows.

- SCS
- Number of CCE/BD
- Duration of CORESET
- Bandwidth of CORESET
- Whether wideband/narrow DMRS is adopted

Note that PDSCH processing timeline, i.e. N1, is specified in Rel.15, which includes PDCCH decoding, PDSCH processing, and PUCCH preparation. If only PDCCH decoding is considered, partition of PDSCH processing time N1 of Capability #1 could be considered, e.g. 1/2 of N1, as PDCCH decoding time.

- Option 2

Regarding option 2, UE needs to obtain the time domain resource of the scheduled UL transmission before determining the monitoring for UL CI. Hence, the PDCCH should be decoded as the condition in option 1.

Although PDCCH decoding time is not necessary to be defined, the drawback of option 2 is that UE needs to buffer the received DL signal from the timing of PDCCH detection to the timing of X symbols before start of UL transmission..

Above all, if the PDCCH decoding time considering the worst case can be specified, one alternative is that UE monitors UL CI from the timing of PDCCH decoded to the X symbols before the start of UL transmission. There is specification impact for such alternative. Another alternative is UE buffers PDCCH in each monitoring occasion for UL CI. If a PDCCH for grant is detected and decoded, UE starts to decode UL CI. Since UE needs to buffer DL reception frequently, there may be no specification impact for this alternative.

Proposal 2: For UL transmission with associated PDCCH, following conditions for eMBB UE UL CI monitoring are considered.

- **Alt.1: If the PDCCH decoding time is specified, UE monitors UL CI from the timing of PDCCH decoded to the X symbols before the start of UL transmission.**
- **Alt. 2: If the PDCCH decoding time is not specified, UE monitors UL CI at least at the latest monitoring occasion ending no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.**
    - **UE buffers PDCCH in each monitoring occasion for UL CI. If a PDCCH for grant is decoded, UE starts to decode the PDCCH for UL CI at the latest monitoring occasion ending no later than X symbols before the start of the UL transmission.**

For UL transmission without associated PDCCH, the time resource for a UL transmission is deterministic. Hence, it is not necessary to involve with PDCCH decoding time when determining the monitoring of UL CI. As discussed in the last meeting, UE monitors UL CI at least at the latest monitoring occasion that ends no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.

Proposal 3: For UL transmission without associated PDCCH, UE monitors UL CI at least at the latest monitoring occasion that ends no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.

2.1.2. UE cancellation behavior

If a DCI for UL CI is detected, it is agreed that UE stops without resuming a PUSCH that is overlapped with the resources indicated by the UL CI. This is because there could be phase contiguity issue.

In case of SRS, PUSCH with repetitions and PUCCH with repetitions cases, further discussion on the UE cancellation behavior is needed.

- **<u>SRS</u>**

In Rel.15, a SRS can be transmitted in a set of contiguous symbols with duration of 1, 2, or 4, which are located in the last 6 symbols of a slot. A ZC sequence is used for SRS transmission. When partial SRS transmission in the pre-empted symbols is cancelled, SRS on the remaining non-pre-empted symbols can be transmitted.

Proposal 4: If SRS can be cancelled by UL CI, SRS can be transmitted on the non-pre-empted symbols.

- **<u>PUSCH with repetition</u>**

PUSCH repetitions in slot-level and mini-slot level are to be specified in Rel.16. In case a PUSCH repetition overlapping with a URLLC transmission, the PUSCH repetition can be cancelled by the UL CI. The motivation is the same as the case where PUSCH without repetition is overlapping with URLLC transmission and the PUSCH is cancelled to ensure URLLC performance.

If PUSCH with repetitions are overlapped with URLLC transmission, the repetition that collides with URLLC transmission is cancelled, if the cancellation timeline is satisfied. Regarding PUSCH repetitions of Rel.16, a PUSCH repetition could a nominal repetition or an actual repetition after segmentation. Whether a nominal repetition or actual repetition is to be cancelled is dependent on the detailed design of PUSCH repetitions in the PUSCH session. Hence, it should be concluded after there is agreement on PUSCH repetitions.

Proposal 5: If PUSCH with repetitions are overlapped with URLLC transmission, the repetition that collides with URLLC transmission is cancelled.

- **FFS whether a nominal repetition or actual repetition is to be cancelled after there is conclusion on design of PUSCH repetitions in PUSCH session.**

■ **PUCCH with repetition**

If PUCCH with repetitions are overlapped with URLLC transmission, the repetition that collides with URLLC transmission is cancelled, if the cancellation timeline is satisfied. The repetitions of PUCCH that are not colliding with URLLC transmission can be transmitted.

Proposal 6: If PUCCH can be cancelled by UL CI, in case of PUSCH with repetitions overlapping with URLLC transmission, the repetition that collides with URLLC transmission is cancelled.

■ **Whether another PUSCH can be scheduled in non-pre-empted resource**

If a UE is scheduled with a PUSCH on a resource that is overlapping with URLLC transmission. UE cancels the PUSCH on the overlapped resource according to the indication by UL CI. If gNB schedules the UE another PUSCH on the non-preempted resource, the PUSCH on the non-preempted resource needs to correspond to a different HARQ process from that of the cancelled PUSCH. It is actually an out-of-order PUSCH scheduling case.

An example is shown in the Figure 1. PUSCH 1 is scheduled by UL grant #1 with HARQ process number #1. After that, PUSCH 1 is to be cancelled since it is overlapped with URLLC transmission. UL grant #2 is transmitted to schedule PUSCH 2 on the resource that is not overlapped with URLLC transmission. In such case, PUSCH 1 and PUSCH 2 are in out-of-order scheduling. If out-of-order scheduling is supported and different HARQ process is used, another PUSCH can be scheduled in non-preempted resource.

Proposal 7: If out-of-order scheduling is supported and different HARQ process is used, when a PUSCH is overlapped with the preempted resource and is cancelled by UL CI, another PUSCH can be scheduled with a different HARQ process in the non-preempted resource.

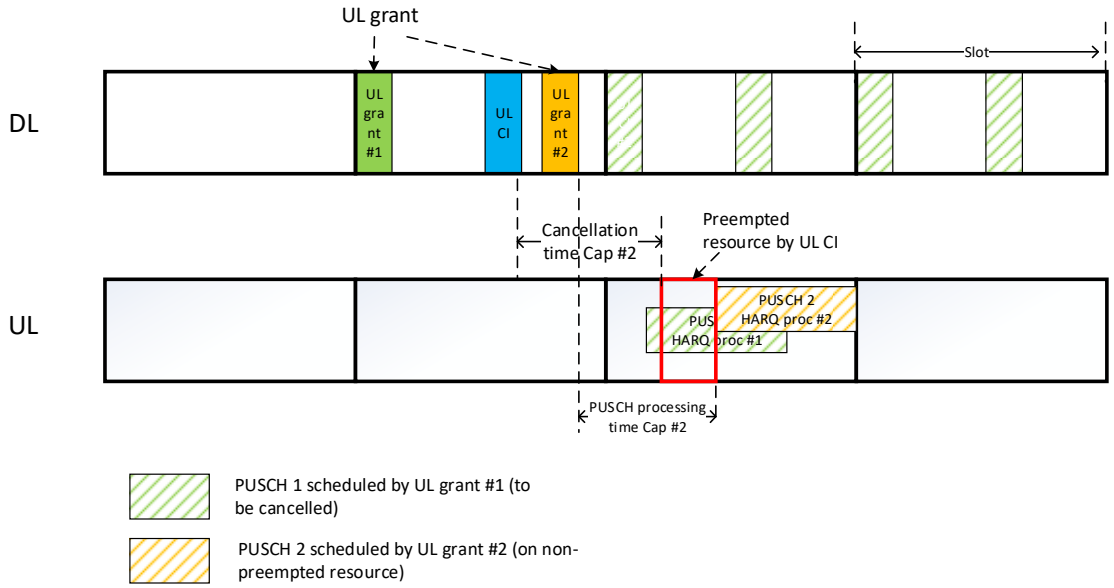

Figure 1: Example of another PUSCH scheduled after UL cancellation

2.2. UE Processing timeline for the UL cancelation indication

In RAN1 #98 meeting, it was agreed that the UE processing time requirement for UL cancelation indication based on N2 defined in Rel-15 UE cap#2 is supported. The remaining questions are whether to define the processing time requirement for UL cancelation indication larger than and/or shorter than Rel-15 UE cap#2.

A larger than Rel.15 defined cap#2 N2 processing time requirement for UL CI can relax the complexity for UE supporting UL CI, since the UE may not need to support processing time of capability #2. However, the drawback is that it may put limitation on the application of UL CI due that the sufficient cancellation time needs to be ensured when gNB transmits a UL CI.

In addition, when gNB schedules a URLLC transmission, gNB may not be able to send a UL cancellation indication due to no monitoring occasion at that moment for UL cancellation indication. In such case, gNB can

only transmit the UL cancellation indication in the first available monitoring occasion after scheduling URLLC and the cancellation time shorter than N2 could be needed.

Proposal 8: The processing time requirement for UL cancelation indication larger than N2 as defined in Rel-15 UE cap#2 can also be supported as an UE capability.

- **FFS shorter than *N*2 of Rel-15 UE processing time Capability #2.**

2.3. UL transmission to be potentially cancelled

In RAN1 #98 meeting, there was discussion on the UL transmissions that can be potentially cancelled by the UL cancellation indication. PUSCH with dynamic grant, configured grant or semi-persistent PUSCH can be cancelled by UL CI.

Following UL transmissions were proposed to be further discussed.

- FFS for SRS
- FFS for PUCCH
  - Option 1: PUCCH (all types) can be cancelled
  - Option 2: Some PUCCH can be cancelled, e.g. PUCCH carrying CSI
  - Option 3: PUCCH cannot be cancelled
- FFS for PRACH (preamble and/or MSG 3 PUSCH)

■ **<u>SRS</u>**

Regarding SRS in Rel.15, a SRS can be transmitted in a set of contiguous symbols with duration of 1, 2, or 4, which are located in the last 6 symbols of a slot. A ZC sequence is used for SRS transmission. Allowing SRS to be cancelled has limited impact since a SRS can be still transmitted on the non-preempted resource. Meanwhile, it is beneficial to ensure performance of URLLC transmission, otherwise a URLLC UE may need to boost its transmission power to alleviate the interference from SRS transmission. Besides, if a SRS is overlapped with URLLC transmission, the accuracy of channel measurement is also affected.

■ **<u>PUCCH</u>**

Regarding PUCCH for eMBB UE, there may be a case that PUCCH of eMBB needs to be cancelled when wide bandwidth is allocated to URLLC transmission while eMBB PUCCH transmission is scheduled within a narrow bandwidth and frequency hopping is enabled. An example is shown in the Figure 2. eMBB UE1 is scheduled with PUCCH transmission carrying HARQ-ACK with frequency hopping in UE1 UL BWP. The scheduled URLLC transmission of UE2 is not overlapping with 1st hop of PUCCH of UE1 while there is overlapping between URLLC PUSCH and eMBB PUCCH 2nd hop. In such case, UE behavior for cancelling or transmitting eMBB PUCCH needs to be specified.

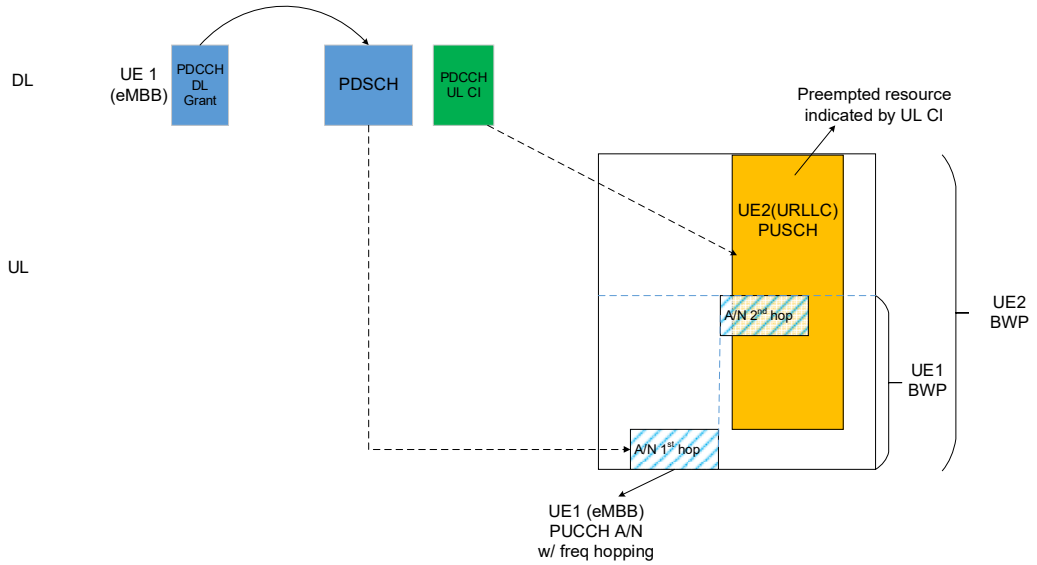

Figure 2: Example of inter-UE multiplexing between eMBB PUCCH and URLLC PUSCH

On the other hand, it was proposed that whether a PUCCH can be cancelled or not is dependent on the priority of PUCCH, e.g. UCI type transmitted in the PUCCH. If such priority would be defined, the UL cancellation behavior is complicated and it requires more specification work. Therefore, compared to cancelling PUCCH regardless priority, there is no significant benefit for cancelling PUCCH depending priority.

Proposal 9: An UE can be configured to monitor UL cancellation indication that potentially cancels UL transmission including

- **Dynamic scheduled UL transmissions, including PUCCH, SRS**
- **Semi-persistent UL transmissions, including PUCCH, SRS**
- **Periodic UL transmissions, including PUCCH, SRS**

One thing we should note is that the UL transmissions to be potentially cancelled are only for the case of UEs supporting eMBB only. If in case of UL transmissions of UEs supporting eMBB and URLLC, further study is definitely needed.

2.4. Signaling methods of UL cancellation indication

Regarding PDCCH transmission carrying UL cancellation indication, it is agreed to adopt group common DCI for cancelation indication. When group common DCI is used, the mechanism of DCI format 2_1 for DL pre-emption indication or DCI format 2_2 for TPC command can be considered for UL cancellation indication.

Similar to DL pre-emption indication, a group of UEs can be indicated by a group common DCI carrying time/frequency resource indication for cancellation. The structure of DL pre-emption indication can be reused. The advantage is that it can save the signalling overhead especially when a large number of UEs are grouped. A potential issue is that there may be false indication for some of the UEs in the group whose scheduled resources are not overlapped with URLLC transmission. If the granularity of time and frequency domain indication are sufficiently fine, it will avoid the false indication as much as possible. For UE configured with UL CI, it is important to control the BD number for UL CI monitoring. In principle, DCI size of UL CI is aligned with DL PI such that BD complexity can be reduced.

An alternative is that TPC command structure is adopted. Multiple cancellation indication fields are multiplexed in a DCI, each of which is indicated for a UE. However, if small payload is adopted for each UE, it may result in coarse indication of resource for each UE. Therefore, there could be false indication. If fine indication is adopted, it will result in large payload of UL CI.

Proposal 10: For UL cancellation indication,

- **Framework of DCI format 2_1 is reused for UL cancellation indication, i.e. a time/frequency domain indication is provided in the cancelation indication DCI for a group of UEs to derive the UL cancelation behavior.**
- **Bit-size of a UL cancellation indication is 14 bits, as the size of a DL preemption indication.**

2.5. Indication of time resource for UL CI

2.5.1. Time region definition

- **<u>Starting time of time region</u>**

Similar to DL preemption indication, a time region for UL cancellation indication can be defined. It is useful for the signaling design and overhead control. To starting time and duration of a time region need to be determined.

Upon detecting a PDCCH for UL CI, a time region starts from X symbols after the ending symbol of the CORESET in which the PDCCH for UL CI is detected. The length of X can be determined by following options.

- Option 1: X is implicitly derived by the minimum processing time for UL cancellation.
- Option 2: X is explicitly indicated by UL CI or RRC

For either options, the start of time region may not necessarily be aligned with the slot boundary. Option 1 has smaller DCI/RRC overhead than option 2. Thus, option 1 is more preferable.

Proposal 11: A time region starts from X symbols after the ending symbol of the CORESET in which the PDCCH for UL CI is detected, where X is implicitly derived by the minimum processing time for UL cancellation

■ **<u>Duration of time region</u>**

For a time region, the duration of time region can be determined by following options.

- Option 1: Time region duration equals to the monitoring periodicity of PDCCH carrying UL cancellation indication.
- Option 2: Time region duration is configured explicitly by RRC.

Option 1 is simple but has limited flexibility. There is no overlapping between different time regions since each time region has the same duration.

Option 2 provides the flexibility for gNB to configure the duration of time region.

For option 2, some restrictions of duration configuration for time region are needed. If the duration of time region is larger than the monitoring periodicity of PDCCH for UL CI, the duration needs to be aligned with an integer times of the monitoring periodicity. Note that in such case different time region may be overlapped. If the starting time of time region is determined implicitly or by RRC, the overlapped part of time regions can be associated with multiple monitoring occasion for PDCCH of UL CI. Regarding whether smaller than monitoring periodicity is allowed for the duration of time region, further discussion is needed, especially whether it is useful for TDD case.

Proposal 12: Time region duration is configured explicitly by RRC

- **Duration of time region can be configured to be equal to one or multiple monitoring periodicities for UL CI.**

For the definition of time region, an example is given in the Figure 3. The duration of time region is configured RRC, where the duration of time region equals to 2 * monitoring periodicity of PDCCH for UL CI. The starting time of time region is implicitly derived by the minimum processing time for cancellation respective to the ending symbol of PDCCH monitoring occasion for UL CI. In the figure, there is overlapping between two consecutive time region. For example, for PUSCH 1 located in the time region #1, it can be cancelled by the UL CI #1, while PUSCH 2 located in both the time region #2 and #3 can be indicated by UL CI #2 or #3. Hence, more flexibility for indication by UL CI can be achieved compared to non-overlapped time region case. Besides, it can also be useful for TDD case when there is conflict between monitoring occasions for UL CI and UL symbols given by TDD configuration.

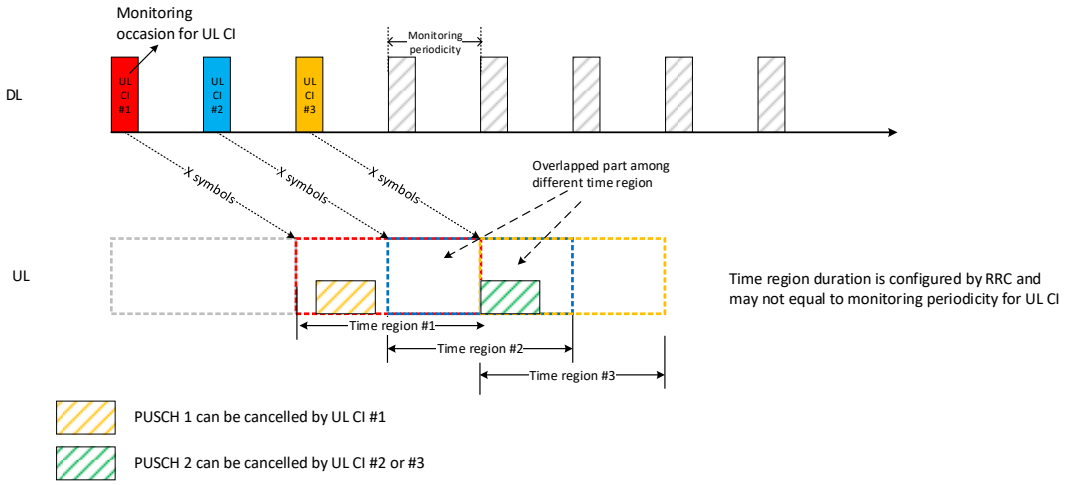

Figure 3: Example of time region and association with monitoring occasion for UL cancellation indication

2.5.2. Time domain resource indication

- **Granularity of time domain resource indication**

The bit-size for time domain indication for UL CI is related to the granularity of time domain indication. A configurable granularity for time domain indication can be adopted to achieve the flexibility.

Proposal 13: Granularity of time domain resource indication is configured by RRC.

- **Time domain resource indication**

An eMBB UE is indicated by the DCI a set of symbol(s) within the determined time region on which the UL transmission has to be canceled. Regarding indicating the time resources of time region, there are following alternatives.

- Alt.1: Time domain bitmap to indicate the preempted time resource
- Alt.2: Time domain SLIV to indicate the staring position and length of the preempted time resource
- Alt.3: Time and frequency dimension bitmap to indicated the preempted time/frequency resource grid

Alt. 1 is a 1-D bitmap to indicate time domain resource. The benefit for bitmap indication is that non-contiguous time resource can be indicated. This is potentially useful since multiple URLLC transmissions may be scheduled on different non-contiguous time resources. The drawback for bitmap indication is that the size of bitmap is dependent on the duration of time region.

Alt. 2 is similar to the time domain resource indication in the scheduling grant, i.e. a start and length indication vector is adopted. It is efficient to determine the starting and ending position of the cancellation resource considering the signaling overhead. The shortage of Alt.2 is that only consecutive time resource can be indicated by SLIV.

Alt. 3 is similar to DL preemption indication where each bit represents one or multiple symbols of the time region. Same as Alt. 1, it is beneficial to indicate non-contiguous time resources for cancellation. The difference from Alt.1 is time domain bitmap and frequency domain bitmap are jointly encoded, which provides the flexibility to indicate any time/frequency resource grid of the time/frequency region. If size of time/frequency resources to be indicated for UL CI is small, e.g. similar to DL PI, 2-D bitmap indication is beneficial.

2.6. Indication of frequency resource for UL CI

- **Frequency region definition**

Similar to DL PI, the frequency region can be implicitly determined by the BWP, i.e. the frequency region for UL CI equals to the UL active BWP. It is also beneficial for signaling reduction compared to frequency region configured by RRC explicitly.

Proposal 14: Frequency region for UL CI is derived based on UL active BWP.

- **Granularity of frequency domain resource indication**

The granularity of frequency domain resource indication is determined by RRC configuration. The granularity of bitmap indication is configurable such that the UL BWP is divided into a number of subsets where UL cancellation indication can indicate the subsets of UL BWP as cancelled frequency resources. E.g. similar mechanism as DCI format 2_1 can be used. The granularity of frequency domain indication is derived by the granularity of time domain indication and the payload size of UL CI.

Proposal 15: Granularity of frequency domain resource indication is determined based on RRC configuration, e.g. by time domain granularity and size of a UL CI.

- **Frequency domain resource indication**

Similar to time domain indication, following options are considered.

- Alt.1: Frequency domain bitmap to indicate the preempted frequency resource

- Alt.2: Frequency domain SLIV to indicate the staring position and length of the preempted frequency resource
- Alt.3: Time and frequency dimension bitmap to indicated the preempted time/frequency resource grid

As discussed above, time domain bitmap and frequency domain bitmap are jointly encoded, which provides the flexibility to indicate any time/frequency resource grid of the time/frequency region. If size of DCI for UL CI is small, e.g. similar to DL PI, 2-D bitmap indication is beneficial.

Proposal 16: If size for time/frequency resource indication is small, 2-D bitmap for time and frequency resource is supported for time domain indication in UL CI.

2.7. Configuration of UL CI

- **RNTI for UL CI**

For UE configured with monitoring of UL CI, a group-specific RNTI is configured by RRC. The configured RNTI is different from the INT-RNTI for DL PI. This is because the DCI payload of DL PI and UL CI are not necessarily to be different. If the a common RNTI is used for DL PI and UL CI, there is no way to distinguish UL CI from DL PI if DCI size budget is not satisfied where the same DCI payload for UL CI and DL PI is needed.

Proposal 17: A RNTI is separately configured by RRC for UE configured with UL CI.

- **DCI payload size for UL CI**

Regarding the DCI payload size of UL CI, although the exact size of payload for UL CI is dependent on the design of signaling in time and frequency domain, the DCI payload size should be configurable to provide flexibility to meet the DCI size budget or reduce BD complexity by aligning DCI size with other group common DCI. Therefore, DCI payload size of UL CI configured by RRC should be supported.

Proposal 18: DCI payload size of UL CI is configured by RRC.

- **Cross-carrier indication for UL CI**

In case of CA scenario, e.g. a UE scheduled with an eMBB UL transmission in a SCell and is configured with UL CI monitoring in PCell. When gNB schedules a URLLC UL transmission in the SCcell that is overlapping with the eMBB UL transmission, a UL CI can be transmitted in the PCell to indicate the preempted resource in the SCell.

This is a typical case for CA scenario. Similar as DL preemption indication, cross-carrier indication by UL CI can be supported. In case of CA, multiple UL CI fields for different serving cells can be included in the DCI for UL CI. The number of serving cell that is indicated by the DCI for UL CI and a position index to associate with a given serving cell are configured by RRC.

Proposal 19: Support cross-carrier indication by UL CI. The association between the fields in DCI and corresponding serving cells is configured by RRC.

3. Enhanced UL power control

3.1. Power control enhancement for dynamic grant

In RAN1 #98 meeting, it was agreed that an open-loop parameter set indicated to the UE by scheduling DCI using a different field other than SRI is supported for dynamic grant PUSCH. Details of indication open-loop parameter set in the scheduling DCI needs further discussion.

For a UE, at least one open-loop parameter set is configured by RRC. In Rel.15, multiple open-loop parameter sets are configured to be associated with SRI. For an open-loop parameter set, P0 and alpha are included. For URLLC UE, transmission power needs to be boosted if scheduled. For such case, separate P0 value for URLLC transmission is needed. An offset of P0 is configured by RRC. Regarding alpha, it may not be necessary to use a different value for URLLC transmission.

Therefore, the open-loop parameter set for URLLC transmission includes P0 value for determining open-loop power control parameter. One alternative is to configure a separate P0 value in the open-loop parameter set for URLLC. However, when a URLLC UE operating in FR2 which is configured with SRI is scheduled to boost its transmission power, there may be issue to determine the open-loop parameter since another P0 is indicated by SRI in DCI.

To solve the problem, an P0 offset is configured by RRC for the open-loop parameter set for URLLC. When URLLC transmission is scheduled, the P0 offset can be enabled by DCI to determine the open-loop power control parameter. When the P0 offset configured by RRC is applicable to each open-loop parameter set configured by *P0-PUSCH-AlphaSet*. If SRI is configured, UE determines open-loop parameter set based on *P0-PUSCH-AlphaSet*, SRI and the P0 offset.

For example, if SRI is 1-bit and 2 open-loop parameter sets are configured. Meanwhile, P0 offset is also configured by RRC. When SRI is indicated as 0 in DCI, open-loop parameter set 1, i.e. $P0_1$ is used. For such UE, if URLLC transmission is scheduled, P0 offset is used. Therefore, the open-loop power control parameter $P0 = P0_1 + P0_{offset}$. If SRS is indicated as 1 and open-loop parameter set 2, $P0_2$ is used. The open-loop power control parameter $P0 = P0_2 + P0_{offset}$.

In the scheduling DCI, 1-bit is used to indicated whether P0 offset is used for determine the open-loop parameter for the UL transmission.

Proposal 20: For dynamic grant PUSCH,

- **Open-loop parameter set including P0 offset is configured by RRC. P0 offset is applicable to each open-loop parameter set configured by *P0-PUSCH-AlphaSet*.**
- **1-bit in the scheduling DCI is used to indicate whether P0 offset is used for determine the open-loop parameter is used for the UL transmission.**

If UE is configured with multiple open-loop parameter sets, closed-loop power control loop should be common for different open-loop parameter sets. This is because UE needs to boost its transmission power even when switching open-loop parameter sets.

Proposal 21: For different open-loop parameter sets, UE shares the same closed-loop power control loop.

3.2. Power control enhancement for configured grant

For configured grant PUSCH, the potential enhanced UL power control may include following options:

- Option 1: Indication of open-loop parameter sets by group-common DCI
- Option 2: Indication of TPC with increased range by group-common DCI
- Option 3: UE boost the transmission power if the CG-PUSCH transmission overlaps with the time and frequency resource indicated by the group common DCI

Option 1 is similar to dynamic grant PUSCH case. A group-common DCI is used for indication of open-loop parameter sets for configured grant UEs. E.g. mechanism of DCI format 2_2 can be reused for URLLC UEs for power boosting.

For option 3, it was proposed that UL CI is also monitored by URLLC UE with configured grant. If UE with configured grant detects UL CI, transmission power for configured grant PUSCH is boosted accordingly. For such URLLC UE, it needs to monitor UL CI. Besides, different UE behaviors upon detecting UL CI depending on different services type need to be specified, which requires much specification work.

Proposal 22: For UL configured grant PUSCH, an open-loop parameter set is indicated to the UE by group common DCI.

4. RRC parameters for UL inter-UE prioritization

To facilitate the UL CI and enhanced power control features, new RRC parameters/configurations are expected. Follow table provides a list of potential RRC parameters for UL inter-UE prioritiztion functionalities.

Table 1: Potential RRC parameters for UL cancellation indication and enhanced power control

Parameter name	New or existing in R15	Description
ULCI-RNTI	New	RNTI used for UL cancellation indication.
dci-PayloadSize	New	Total length of the DCI payload scrambled with INT-RNTI
servingCellId	New	Indicates the index of the serving cell corresponding to the position of the UL CI
positionInDCI	New	Starting position (in number of bit) of the UL CI field applicable for this serving cell (*servingCellId*) within the DCI payload. FFS restriction
TimeIndicationGranularity	New	Granularity for time domain resource indication for UL CI
timeRegionDuration	New	Duration of time region for UL CI
monitoringSlotPeriodicityAndOffset	Existing	Monitoring periodicity in slot level for UL cancellation indication.
monitoringSymbolsWithinSlot	Existing	Monitoring occasion in symbol level for UL cancellation indication.
P0-offset	New	Offset of P0 for open-loop parameter set

5. Conclusion

In this contribution, we provide our views on UL inter-UE Tx prioritization for URLLC. The proposals are summarized below.

Proposal 1: For eMBB UE supporting UL cancellation,

- **Monitoring periodicity can be 2, 4, 7 or 14, 28 symbols as starting point**

Proposal 2: For UL transmission with associated PDCCH, following conditions for eMBB UE UL CI monitoring are considered.

- **Alt.1: If the PDCCH decoding time is specified, UE monitors UL CI from the timing of PDCCH decoded to the X symbols before the start of UL transmission.**
- **Alt. 2: If the PDCCH decoding time is not specified, UE monitors UL CI at least at the latest monitoring occasion ending no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.**
    - **UE buffers PDCCH in each monitoring occasion for UL CI. If a PDCCH for grant is decoded, UE starts to decode the PDCCH for UL CI at the latest monitoring occasion ending no later than X symbols before the start of the UL transmission.**

Proposal 3: For UL transmission without associated PDCCH, UE monitors UL CI at least at the latest monitoring occasion that ends no later than X symbols before the start of the UL transmission, and X is related to UL CI processing time.

Proposal 4: If SRS can be cancelled by UL CI, SRS can be transmitted on the non-pre-empted symbols.

Proposal 5: If PUSCH with repetitions are overlapped with URLLC transmission, the repetition that collides with URLLC transmission is cancelled.

- **FFS whether a nominal repetition or actual repetition is to be cancelled after there is conclusion on design of PUSCH repetitions in PUSCH session.**

Proposal 6: If PUCCH can be cancelled by UL CI, in case of PUSCH with repetitions overlapping with URLLC transmission, the repetition that collides with URLLC transmission is cancelled.

Proposal 7: If out-of-order scheduling is supported and different HARQ process is used, when a PUSCH is overlapped with the preempted resource and is cancelled by UL CI, another PUSCH can be scheduled with a different HARQ process in the non-preempted resource.

Proposal 8: The processing time requirement for UL cancelation indication larger than N2 as defined in Rel-15 UE cap#2 can also be supported as an UE capability

- **FFS shorter than *N*2 of Rel-15 UE processing time Capability #2.**

Proposal 9: An UE can be configured to monitor UL cancellation indication that potentially cancels UL transmission including

- **Dynamic scheduled UL transmissions, including PUCCH, SRS**
- **Semi-persistent UL transmissions, including PUCCH, SRS**
- **Periodic UL transmissions, including PUCCH, SRS**

Proposal 10: For UL cancellation indication,

- **Framework of DCI format 2_1 is reused for UL cancellation indication, i.e. a time/frequency domain indication is provided in the cancelation indication DCI for a group of UEs to derive the UL cancelation behavior.**
- **Bit-size of a UL cancellation indication is 14 bits, as the size of a DL preemption indication.**

Proposal 11: A time region starts from X symbols after the ending symbol of the CORESET in which the PDCCH for UL CI is detected, where X is implicitly derived by the minimum processing time for UL cancellation

Proposal 12: Time region duration is configured explicitly by RRC

- **Duration of time region can be configured to be equal to one or multiple monitoring periodicities for UL CI.**

Proposal 13: Granularity of time domain resource indication is configured by RRC.

Proposal 14: Frequency region for UL CI is derived based on UL active BWP.

Proposal 15: Granularity of frequency domain resource indication is determined based on RRC configuration, e.g. by time domain granularity and size of a UL CI.

Proposal 16: If size for time/frequency resource indication is small, 2-D bitmap for time and frequency resource is supported for time domain indication in UL CI.

Proposal 17: A RNTI is separately configured by RRC for UE configured with UL CI.

Proposal 18: DCI payload size of UL CI is configured by RRC.

Proposal 19: Support cross-carrier indication by UL CI. The association between the fields in DCI and corresponding serving cells is configured by RRC.

Proposal 20: For dynamic grant PUSCH,

- **For dynamic grant PUSCH, open-loop parameter set including P0 offset is configured by RRC. P0 offset is applicable to each open-loop parameter set configured by *P0-PUSCH-AlphaSet*.**
- **1-bit in the scheduling DCI is used to indicate whether P0 offset is used for determine the open-loop parameter is used for the UL transmission.**

Proposal 21: For different open-loop parameter sets, UE shares the same closed-loop power control loop.

Proposal 22: For UL configured grant PUSCH, an open-loop parameter set is indicated to the UE by group common DCI.

References

[1] Chairman's Notes RAN1 #97.

[2] Chairman's Notes RAN1 #98.