3GPP TSG RAN WG1 Meeting #AH1 **R1-1900352**
Taipei, Taiwan, January 21-25, 2019

Agenda Item: **7.2.6.2**
Source: **TCL Communication**
Title: **Multiplexing eMBB over URLLC Resources**
Document for: **Discussion and decision**

1 Introduction of Dynamic Multiplexing

In NR, a gNB will be able to schedule pre-configured resources for URLLC users. But the gNB does not have any prior information which of these configured grant (CG) resources will actually be used by URLLC users, neither it has the information which of the users among the group configured for the resources will use a specific resource. Now if the gNB schedules some eMBB user on the resource overlapping with configured-grant occasion, as shown in Figure 1, there is going to be transmission collision of dynamically scheduled eMBB and URLLC CG-based transmission.

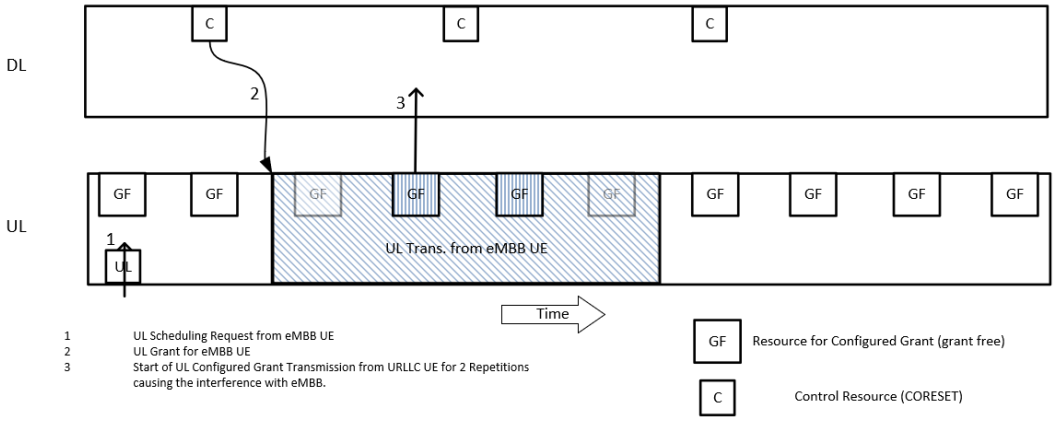

Figure 1: A collision of UL URLLC (CG-transmission) with eMBB Transmission in case of FDD

In the case when the gNB is able to identify the URLLC user from its DMRS sequence, it may try to quickly reschedule the user over non-overlapping resources. It may thus move the user from CG to grant-based UL transmission.

The increased interference due to overlapping transmissions from eMBB and URLLC users may lead to situations when the base station may not even identify the URLLC UE. This situation is particularly catastrophic for URLLC users. The HARQ structure in UL transmission for NR (Release 15 of 3GPP) is timer based, which means that upon transmission of packet the UE will start the HARQ timer. If it receives an UL grant for the re-transmission of the same transport block (TB) from the base station, it does the re-transmission over the resources scheduled in the UL grant. If it receives no UL grant (for re-transmission) from the base station and the HARQ timer expires, it considers that the TB was successfully decoded at the base station and it discards the data in the buffer.

1.1 Previous 3GPP Agreements

Agreements RAN1#94 (20-24 August, 2018 – Gothenburg, Sweden)::

- RAN1 to study the potential enhancements for UL inter UE Tx prioritization/multiplexing
  - Study the UE UL cancelation mechanisms, including at least the following aspects
    - The potential mechanisms may include UE UL cancelation/pausing indication, UL continuation indication, UL re-scheduling indication
    - Physical channel/signal used for the UL cancelation indication
    - UE Processing timeline for the UL cancelation indication
    - UE monitoring behaviors for the UL cancelation indication
    - UE PDCCH monitoring capability, if the UL cancelation indication is by PDCCH
    - Methods to ensure the reliability of the indication for UE UL cancelation
  - Study the UL power control enhancements
  - Study other enhancements for the multiplexing between a grant-based UL transmission from a UE and a grant-free UL transmission from another UE

Agreements RAN1#94B (8-12 October, 2018 – Chengdu, China):

- Potential UL power control enhancements are to be studied further:
  - Enhanced dynamic power boost for URLLC UE
    - Dynamic change of power control parameters, e.g. P0, alpha without SRI configured
    - Enhanced TPC, e.g. increased TPC range, finer granularity
    - Currently, the need of URLLC UE power change during one transmission instance is not envisioned

In 3GPP many proposals have been submitted. Some of the proposals discuss the eMBB side strategies whereas others propose URLLC side strategies. We believe that due to vast array of scenarios, there is no single optimal solution which covers all the settings. Thus, we need to standardize URLLC and eMBB side strategies and the appropriate combination can be activated to respond to a specific situation.

In Section 2, we propose a URLLC side strategy to handle the dynamic multiplexing from eMBB users. In Section 3, we propose a strategy for eMBB action in case of dynamic multiplexing.

2 Handling Dynamic Multiplexing through URLLC Side

This document proposes a strategy to handle the dynamic multiplexing of eMBB users over the configured grant resources by enforcing additional actions on the URLLC users' side. The proposed strategy comprises of two steps. First step is the resource overlap indication and the second step consists of making the overlapping transmissions based upon explicit HARQ feedback.

In the first step, upon scheduling a grant-based transmission from eMBB UE over the configured grant resources, the base station sends an indication of resource overlap to the URLLC users. As base station does not know which of the URLLC UEs configured for CG resources may become active in the current interval, this indication needs to be sent to UEs who have been configured with the CG resources in the current interval. Upon receiving this overlap indication, the URLLC UEs will become aware of the resource which has been dynamically scheduled for other users (eMBB users for example) and in case of transmission, they know that their transmissions will be received with increased interference.

Proposal 1:

Upon scheduling an UL transmission over the resources overlapping with UL configured grant resources, the base station sends an indication for the users configured with configured grant transmissions, informing them of the resource overlap. The overlap indication includes the time-frequency resource scheduled dynamically having an overlap with the CG resource.

With the knowledge of the resource dynamically scheduled, the URLLC UEs will know about the overlap and the increased resulting interference their transmissions face over the air.

The second step of the proposed strategy comprises of making the overlapping transmissions use the explicit HARQ feedback structure. The resource overlap indication can serve this purpose of making the transmissions explicit HARQ feedback based, rather than legacy timer based HARQ. Upon receiving this indication, the URLLC users, who transmit on the overlapping resources, expect to receive explicit HARQ feedback for their transmissions.

Proposal 2:

Upon scheduling a transmission over the resources overlapping with configured grant occasions, the overlap indication from the base station indicates that the CG transmissions having overlap will have explicit HARQ feedback structure.

In a variation of the proposed scheme, the second step, of making the transmissions explicit HARQ feedback-based, can be altered to use scheduling request. The base station can indicate the CG users to send a scheduling request (SR) for the transport block transmitted over the overlapping CG resources. The scheduling request sent to the base station will provide a further means, an additional diversity mechanism to the base station, to react fast to the interfered CG transmission. When the base station is able to decode the data successfully, it can send some indication to the user about the successful detection. For the case, when the base station is unable to identify the user making the CG transmission, the base station can react fast to the received scheduling request by sending an UL grant to this user and trying to have the successful data reception within its latency target.

Proposal 3:

Upon scheduling a transmission over the resources overlapping with configured grant occasions, the overlap indication from the base station can indicate that the users transmitting over overlapping CG resources should transmit a scheduling request for the transmitted transport block.

3 Handling Dynamic Multiplexing through eMBB Side

In uplink transmission, when the eMBB UEs have data to transmit, they send SR and receive UL grant from the gNB with resource allocation. After that, if the gNB detects another transmission of a URLLC UE in the resource scheduled to the eMBB UEs, it may send PI to the eMBB UEs to cancel or stop temporarily the eMBB transmissions so that the interference among the eMBB UEs and URLLC UEs can be avoided. It can be further investigated whether to prioritize stop-and-resume or complete cancellation strategies.

URLLC transmission is mini-slot transmission. Thereby, in case PI is transmitted to the eMBB UEs, it must be done in mini-slot level to be likely to stop the transmission in time and satisfy the traffic critical delay. This design requires that the eMBB UEs monitor PI in mini-slot level. However, the eMBB UEs transmit data in slot level and also only monitors DCI in slot level. This means that if DCI is used as PI, the eMMB

UEs are required to increase monitoring periodicity. Monitoring capability of the eMBB UEs also must be enhanced with a growth of monitoring occasions. Therefore, if the eMBB UEs are configured to monitor PI in mini-slot level all the time after being scheduled, power consumption would rise significantly. A mechanism to select the eMBB UEs and trigger an increase of monitoring periodicity and capability is necessary.

All the eMBB UEs are not required to be configured in a static fashion to listen to pre-emption indication. Only the relevant eMBB UEs, who are scheduled for example in a zone where the gNB may schedule URLLC traffic or has already scheduled configured grant traffic, are triggered to increase the monitoring periodicity. This activation can be done by the gNB when it includes 1-bit flag in the UL grant to help the eMBB UEs perceive their situation and do monitoring in mini-slot level. The bit used as a flag can be a padding bit or the first bit in the field of frequency domain resource assignment.

Proposal 4:

The gNB can send a dynamic indication to eMBB UEs enabling them to listen to pre-emption indication. This dynamic indication can be sent in the UL grant DCI.

An increase of monitoring periodicity can be carried out without a big modification in the UE design. In 5G NR, the UE supports different sub-carrier spacing (SCS): 15 kHz, 30 kHz, 60 kHz, 120 kHz.

In 1 ms, the maximum number of slots are 8 slots with SCS 120 kHz. If the UEs monitor DCI in slot level, they have 8 monitoring occasions. This means that the UEs are already capable of supporting 8 monitoring occasions with their current design. Therefore, it is proposed that the number of monitoring occasions are still kept the same at 8 occasions in 1 ms even if the value of SCS decreases after the eMBB UEs receive 1-bit flag in UL grant. This value allows the eMBB UEs to monitor PI in mini-slot level when a low SCS is used. Normally, with SCS 60 kHz, there are only 4 monitoring occasions in 1 ms. However, with this proposal, the number of occasions are doubled to 8. At this moment, the UEs monitor DCI in non-slot level at each interval of 0.125 ms. The impact of this proposal is even bigger for low SCS 15 kHz and 30 kHz.

Monitoring capability also have to be enhanced if monitoring occasions increases, especially for SCS 15 kHz. In normal case, the UEs have 44 PDCCH candidates and 56 non-overlapped CCEs in a 1ms-slot with SCS 15 kHz. When the number of occasions grow to 8 in 1ms-slot, the UEs only have around 5 PDCCH candidates and 7 CCEs for each monitoring occasion. If an AL 8 is required for PI so as to guarantee the reliability, there are not enough CCEs for that PI. Due to the very high reliability of URLLC transmission, the reliability of PI to stop the eMBB transmission is also high and approximate to the requirement of URLLC (10-5). The maximum number of CCEs should be kept the same at 64 CCEs for all SCS to ensure that PI is bound to be transmitted with AL 8. Similar to the proposal of the value of monitoring occasions, this maximum number of CCEs are only applied after the eMBB UEs receive an indication of 1 bit-flag in UL grant. The maximum number of CCEs should be kept the same at a value to guarantee mini-slot monitoring for all SCS after the eMBB UE receives an indication by 1 bit-flag in UL grant to monitor PI in mini-slot level.

The number of monitoring occasions that an URLLC UE are able to increase can be defined by different criteria than SCS. Based on the processing time of DCI, the eMBB UE can define the maximum number of occasions that it can monitor and decode blindly DCI.

4 Conclusions

The followings proposals have been made in this document.

Proposal 1: Upon scheduling an UL transmission over the resources overlapping with UL configured grant resources, the base station sends an indication for the users configured with configured grant transmissions, informing them of the resource overlap. The overlap indication includes the time-frequency resource scheduled dynamically having an overlap with the CG resource.

Proposal 2: Upon scheduling a transmission over the resources overlapping with configured grant occasions, the overlap indication from the base station indicates that the CG transmissions having overlap will have explicit HARQ feedback structure.

Proposal 3: Upon scheduling a transmission over the resources overlapping with configured grant occasions, the overlap indication from the base station can indicate that the users transmitting over overlapping CG resources should transmit a scheduling request for the transmitted transport block.

Proposal 4: The gNB can send a dynamic indication to eMBB UEs enabling them to listen to pre-emption indication. This dynamic indication can be sent in the UL grant DCI.

References

[1] RAN1 Chairman's Notes, 3GPP TSG RAN WG1 Meeting #95.

[2] RAN1 Chairman's Notes, 3GPP TSG RAN WG1 Meeting #94Bis.

[3] RAN1 Chairman's Notes, 3GPP TSG RAN WG1 Meeting #94.