

Agenda item: 5
Source: Qualcomm Incorporated
Title: Discussion of LS from RAN2 on skipping uplink transmission
Document for: Discussion and Decision

1 Introduction

In [1], RAN2 sends RAN1 an LS on their agreements/working assumptions on skipping Uplink transmission for SPS for the latency reduction WI:

- a. RAN2 agreed to introduce shorter SPS periodicity (e.g. 1ms) for latency reduction and that the UE can skip UL transmission on PUSCH when there is no UL data in the transmit buffer. The UL transmission skipping is RRC configured separately for SPS and dynamic grant.
- b. RAN2 agreed to allow and prioritize non-adaptive retransmission over new transmission on SPS resource. RAN2 understands the eNB may not be able to distinguish between UL transmission and skipped UL transmission (i.e. DTX), thus if some PUSCH transmission detection is missed, the eNB may not always be able to combine retransmissions with implicitly increased RV as currently defined for non-adaptive retransmissions. Therefore, RAN2 took a working assumption that non-adaptive retransmissions on SPS resource are done based on RV 0.
- c. RAN2 assumes that if MAC does not generate a TB as a result of enabling UL skipping, the UCI should be sent on PUCCH even if there is a valid PUSCH allocation on that subframe. RAN2 would like RAN1 to confirm whether there is any concern from RAN1 point of view.

In this paper, we propose some RAN1 responses.

2 Discussion

The items (a) and (c) seem to be reasonable, and we can confirm them.

For item (b), the current agreement mentioned about the case that the retransmission for an SPS transmission happens in another SPS subframe, but does not cover the case that the retransmission happens in a non-SPS subframe. If we do not define new behaviour, the legacy behaviour is as follows:

- If subframe N is a SPS subframe, and N+8 is also a SPS subframe, the UE will read PHICH in subframe N+4, and retransmit in N+8 if the PHICH reads as NAK, and transmit new data in N+8 if PHICH reads as ACK.
- If subframe N is a SPS subframe, and N+8 is not a SPS subframe, the UE reads the PHICH in subframe N+4 and will automatically retransmit when if PHICH is decoded as NAK.

However, when there is SPS skipping, potentially there are issues.

When SPS PUSCH skipping is supported, there are two possible eNB behaviors

- Option 1: Always transmit NAK when SPS PUSCH is not detected, i.e., assuming SPS PUSCH skipped.
 - As a result, the PHICH transmission is wasted when SPS PUSCH is skipped
- Option 2: Do not transmit ACK or NAK when SPS PUSCH is not detected.

First we will need RAN2 to confirm which is their intention.

If SPS PUSCH is transmitted, but for some reason, it is not detected at the eNB, then for option 1, UE will detect NAK at N+4, and for option 2, UE will detect NAK roughly with 50% probability. Note here we ignore all detection errors. Assume N+8 is not a SPS subframe. Then following the legacy behaviour, the UE will interpret the NAK at N+4 as a trigger for retransmission. However on the eNB side, the retransmission is not expected at N+8, and eNB will not attempt to decode, so the retransmission will fail again. Additionally, the eNB potentially will grant the resource at N+8 to some other UE, and that transmission will be interfered by the SPS retransmission and likely cannot get through as well. The transmission by the UE at N+8 will also cause unintended inter-cell interference. To summarize, the loss due to the NAK from SPS PUSCH misdetection is quite large and needs to be addressed.

One potential solution is: When the retransmission in N+8 is in a non-SPS subframe, the UE does not detect the PHICH at N+4 and does not retransmission at N+8.

Under this proposal, we give up the retransmission in a non-SPS subframe when the SRS PUSCH is detected but decoding failure to avoid the problematic error scenarios described above. To reduce the loss from this, we would need to have as reliable SPS PUSCH decoding as possible. Note also that the eNB can send an explicit grant to address this issue as well.

For SPS retransmission, the RAN2 working assumption is the RV 0 will always be used for non-adaptive retransmission on SPS resources. This is intended to resolve the ambiguity at eNB side when it is possible that the eNB cannot properly detect the SPS transmission when skipping is allowed. However, we believe for a proper eNB implementation, for each SPS decoding attempt, the eNB needs to try different hypotheses on which transmission this is (1st transmission, 2nd transmission, etc), and proper soft combining of the LLRs from the previous transmission needs to be performed. Otherwise, we lose the soft combining gain of the HARQ transmissions. More precisely, the eNB needs to perform the following attempted decodings, at an SPS receiving opportunity

- Assume this is the first transmission, with no soft combining.
- Assume this is the second transmission, with soft combining with potential SPS transmission 8 subframes before
- Assume this is the third transmission, with soft combining with potential SPS transmission 8 and 16 subframes before
- Assume this is the fourth transmission, with soft combining with potential SPS transmission 8, 16, and 24 subframes before
- Repeat this up to the maximum number of SPS retransmissions.

If we assume the eNB performs proper hypotheses decoding and soft combining as above, always assuming RV 0 does not bring any savings anymore. Instead, we can still follow the legacy 0/2/3/1 sequence of RVs, and perform the proper soft combining for each hypothesis decoding attempts. This provides the best possible decoding reliability for SPS PUSCH decoding.

3 Conclusions

Based on the discussion presented in the paper, we propose to send the following to RAN2:

1. We confirm (a) and (c)
2. For (b), we need to clarify if eNB will transmit ACK/NAK if the SPS PUSCH is not detected (either skipped or simply not detected)
 - a. In case the answer to 2 is 'No', i.e. ACK/NAK is not always transmitted then the non-adaptive retransmission behavior should be configurable, i.e. it should be possible to semi-statically disable it while the SPS PUSCH skipping feature is enabled. This is needed due to the high likelihood of RLC holes created by the UE decoding PHICH DTX as ACK.
3. For (b), we propose if the retransmission of SPS PUSCH falls in a non-SPS subframe, instead of the legacy behavior, a new behavior is introduced that the UE does not retransmit even if NAK was received.
4. For (b), we question the necessity of the working assumption that RV 0 is always used. The legacy behavior of using fixed RV sequence of 0/2/3/1 should be kept.

4 References

[1] R2-164554 “LS to RAN1 on RAN2 agreements on skipping Uplink transmission”, RAN2 #94