

Agenda Item: 9.3.1.5

Source: Samsung

Title: On the status of Rel-17 NR coverage enhancement work in RAN WG1

Document for: Discussion

Status: Overall RAN1 Discussions

- ◇ RAN1 work on Rel-17 Coverage Enhancement has been done with the following AIs
 - ◆ PUSCH enhancements
 - Enhancements on PUSCH repetition type A
 - TB processing over multi-slot PUSCH (TBoMS)
 - Joint channel estimation for PUSCH
 - ◆ PUCCH enhancements
 - ◆ Type A PUSCH repetitions for Msg3 PUSCH repetition

- ◇ There are few remaining issues for the following but they will be able to be handled in maintenance phase
 - ◆ DMRS bundling for PUSCH and PUCCH
 - ◆ Signaling to support MCS indication for Msg3 retransmission

- ◇ However, one essential issue was incomplete in RAN1#107-e to complete Rel-17 NR coverage enhancement work
 - ◆ Determination of the index of the starting coded bit in a slot for TBoMS (TB processing over multi-slot PUSCH)

Status: RAN1 Discussions on TBoMS

- ◇ RAN1 discussed how to determine the index of the starting coded bit in a slot for TBoMS, and two options for down-selection were identified:
 - ◆ Option B: the index of the starting coded bit in a slot considers the impact of UCI multiplexing
 - ◆ Option C: the index of the starting coded bit in a slot does NOT consider the impact of UCI multiplexing impacts

- ◇ How to handle/specify the UCI impact were discussed for **Option B**:
 - ◆ #1: based on actually multiplexed UCI bits and specify equation determined by $offset_1 = (N_{RE}^1 - Q'_{ACK,1} - Q'_{CSI-1,1} - Q'_{CSI-2,1}) * q$
 - ◆ #2: based on pre-configured multiplexed UCI bits and specify equation determined by $offset_1 = (N_{RE}^1) * q * \alpha$
 - ◆ #3: based on actually multiplexed UCI bits but no agreement on the equation (leave to the editor how to capture the agreement)

Option	Pros	Cons
Option B #1	Actual UCI bits are considered, no resource waste	Relatively higher requirement to UE implementation
Option B #2	Preconfigured UCI bit size are considered	Always max allowed UCI bit size, waste of resource Parameter α to be defined
Option B #3	Actual UCI bits are considered, no resource waste	Depending on how the offset is captured in the specifications, different requirement to UE implementation
Option C	Easy UE implementation	Not consider UCI multiplexing, may impact the PUSCH performance when the UCI takes REs, originally for PUSCH systematic bits, in a slot.

- ◇ In RAN1#107-e, RAN1 also discussed a merged solutions (refer to Appendix) but could not reach consensus and no way forward or conclusion was agreed

Observation and Proposal

- ◇ Observation: Without the determination of the starting coded bit in a slot for TBoMS, Rel-17 RAN1 work on Coverage Enhancement cannot be completed.
- ◇ Proposal: For the determination of the starting coded bit in a slot for TBoMS in Rel-17 NR coverage enhancement, Option C is supported.

- ◇ FL's proposal 12-v4 (supported by 11 companies)
- ◇ For the determination of the index of the starting coded bit in a transmitted slot for TBoMS:
 - For the first TBoMS repetition:
 - For the first allocated slot for the first TBoMS repetition, the index of the starting coded bit s_1 is determined based on the applied redundancy version.
 - For the second allocated slot for the first TBoMS repetition, Option B is used, where the index of the starting coded bit for the second slot of the first TBoMS repetition is given by $s_2 = s_1 + \text{offset}_1$, where (Note from FL: only one or none of the following two sub-option is downselected)
 - $\text{offset}_1 = (N_{RE}^1 - Q_{ACK,1}^1 - Q_{CSI-1,1}^1 - Q_{CSI-2,1}^1) * q$
 - ◇ or
 - $\text{offset}_1 = (N_{RE}^1) * q * \alpha$, where α is a higher layer parameter (can reuse existing RRC parameter *scaling* in PUSCH-Config)
 - For the i -th slot allocated for the first TBoMS repetition, with $2 < i \leq N$, Option C is used.
 - For all other TBoMS repetitions, if any:
 - For the first allocated slot for all other TBoMS repetitions, the index of the starting coded bit is determined based on the applied redundancy version.
 - For the i -th slot allocated for all other TBoMS repetitions, with $1 < i \leq N$, Option C is used.
 - ◇ [Where Option B and Option C are as follows:
 - Option B: for each transmitted slot for TBoMS, the index of the starting coded bit in the circular buffer is the index continuous from the position of the last bit selected in the previous allocated slot
 - Option C: for each transmitted slot for TBoMS, the index of the starting coded bit in the circular buffer is the index continuous from the position of the last bit selected in the previous allocated slot, regardless of whether UCI multiplexing occurred in the previous allocated slot or not.
 - ◇ Note: the following definition based on existing logics in TS 38.212 are used in the text above:
 - q is the modulation order
 - N_{RE}^{k-1} is the number of REs available in the (k-1)-th slot for transmission and is given by $M_{SC}^{PUSCH} * N_{\text{sym,per slot}}^{PUSCH}$, where
 - M_{SC}^{PUSCH} is the scheduled bandwidth of the TBOMS transmission, expressed as a number of subcarriers.
 - $N_{\text{sym,per slot}}^{PUSCH}$ is the number of symbols allocated per slot of TBOMS as per the indicated/configured row of TDRA table.
 - Q_{ACK}^1 , Q_{CSI-1}^1 , and Q_{CSI-2}^1 are the number of coded modulation symbols for ACK and CSI payloads in the first slot and follow the definitions in Section 6.3.2.4 of TS 38.212, with $Q_{ACK}^1 = 0$ if $O_{ACK} \leq 2$.

THANK YOU