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Title: Outer-loop power control in compressed mode

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Introduction

In compressed mode by reducing the spreading factor by 2, the target SIR needs to be increased during compressed and recovery frames for two reasons:

- The instantaneous bit rate is increased during the compressed frame,
- Since the inner loop power control is no longer active during the transmission gaps, the performance is significantly degraded, mainly during compressed and recovery frames (frames following compressed frames)

Since the classical outer-loop power control algorithm is a slow process, an additional mechanism is required in compressed mode to change the target SIR during compressed and recovery frames. Such mechanism was proposed in [1], [2] and [3] and was accepted. Basically, two parameters are signalled with other compressed mode parameters (see RRC protocol specifications [4]):

- DeltaSIR: Delta in DL SIR target value to be set in the UE during the compressed frame (without including the effect of the change of bit rate).
- DeltaSIRafter: Delta in DL SIR target value to be set in the UE one frame after the compressed frames.

Then, during compressed mode, the UE increases the DL target SIR by ΔSIR where:

- ΔSIR = DeltaSIR + 3 during the compressed frames
- ΔSIR = DeltaSIRafter during the recovery frames
- ΔSIR = 0 for other frames

where TGL is the transmission gap length. The 3 dB offset aims to compensate for the bit rate increase. It does not need to be signaled from the UTRAN to the UE.

During the last WG1 meeting, it was agreed that the puncturing scheme be applied on a TTI by TTI basis (rather than on a frame by frame basis) as proposed in [5], since this enables to improve the performance. This requires that some modifications be done for the outer-loop power control algorithm in compressed mode. A first method was proposed in [5]. It proposes to signal a SIR target offset for each TTI length and thus up to four values.

However this algorithm has the following drawbacks:

- Many restrictions are required for the values of TGP, TGD and SFN. This limits the usage of the compressed mode by puncturing.
- The signalling is different from the one already agreed for compressed mode by reduction of the spreading factor. Thus two different signalling will have to be specified.

- When TGL1 = TGL2, up to four values need to be signalled whereas only two are required for compressed mode by reduction of the spreading factor.
- When TGL1 ≠ TGL2, the same SIR target offset is signalled for the two transmission gaps which causes some problems since the performance degradation due to the inner-loop power control interruption and the puncturing rate depend significantly on TGL (see clause 5 of [5]). To avoid this problem, it would be necessary to signal different SIR target offsets for the two transmission gap lengths, i.e. up to 8 values, which represents quite a large amount of signalling.
- The target SIR increase is applied during the whole TTI whereas it is mainly needed during the compressed and recovery frames, which is therefore not optimal.

Therefore, we rather propose a simpler and more efficient approach, similar to the one used for compressed by reducing the spreading factor. It has the advantage to not require any restriction on SFN, TGP and TGD values.

The basic idea is that the performance degradation due to the interruption of inner-loop power control is only significant during compressed and recovery frames. Moreover, the degradation due to excessive puncturing is only significant for TTI of 10 and 20 ms and is negligible otherwise (since TGL ≤ 7, the puncturing rate is lower than 7/(15*F) where F is the number of frames in the TTI). Therefore, we only need to signal the SIR target increase that is required in compressed and recovery frames, whatever the compressed method is (and not in all the TTI as proposed in [5]). This method was performed efficiently in [3] for compressed mode by reduction of the spreading factor by 2.

Proposed algorithm

Two values DeltaSIR and DeltaSIRafter are signalled by the UTRAN to the UE (as it is currently specified).

For each frame, the target SIR offset during compressed mode, compared to normal mode is:

ΔSIR = max (ΔSIR1_compression, …, ΔSIRn_compression) + ΔSIR_coding

where n is the number of TTI lengths for all TrChs of the CCTrCh, F_i is the length in number of frames of the i-th TTI and where ΔSIR_coding fulfills:

- ΔSIR_coding= DeltaSIR for compressed frames.

- ΔSIR_coding= DeltaSIRafter for recovery frames.

- ΔSIR_coding= 0 otherwise.

and ΔSIRi_compression is defined by :

- If the frames are compressed by reducing the spreading factor by 2:

  - ΔSIRi_compression= 3 dB for each compressed frame, where TGL is the gap length in number of slots (either from one gap or a sum of gaps) in the frame.

  - ΔSIRi_compression= 0 otherwise.

- If the frames are compressed by puncturing:

  - ΔSIRi_compression= 10 log ($15*F_i$ / ($15*F_i$ - TGL_i)) if there is a transmission gap within the current TTI of length F_i frames, where TGL_i is the gap length in number of slots (either from one gap or a sum of gaps) in the current TTI of length F_i frames.

  - ΔSIRi_compression= 0 otherwise.

ΔSIRi_compression aims to compensate for the increase bit rate during the compressed frames whereas ΔSIR_coding aims to compensate for the performance degradation due to excessive puncturing and interruption of the inner-loop power control during the transmission gap.

In the particular case where the transmission gap overlaps two frames (double-frame method), the second compressed frame (with the second part of the transmission gap) must be considered as the recovery frame (ΔSIR_coding = DeltaSIRafter). Thus, in this case, the first frame following the two consecutive compressed frames is not considered as a recovery frame (ΔSIR_coding=0). This enables to have different offset values for the first and second part of the transmission gap, knowing that no significant SIR target increase is needed in the first frame following the two consecutive compressed frames.

Since several compressed mode patterns may be used simultaneously, it may happen that several target SIR offsets from different compressed mode patterns apply to the same frame. In this case, all offsets must be added and the total target SIR offset is applied to the frame (as in proposal [5]).

Furthermore, during the last meeting it was proposed that two values of TGL are possible in each compressed mode pattern. If this is accepted, we propose that different values of DeltaSIR and DeltaSIRafter be signalled for each value of TGL:

- DeltaSIR1 and deltaSIRafter1 to be applied respectively for the compressed and recovery frames of the first transmission gap of length TGL1
- DeltaSIR2 and deltaSIRafter2 to be applied respectively for the compressed and recovery frames of the first transmission gap of length TGL2

Conclusion

Compared to the proposal in [5], The advantages of this proposal are:

- No restriction is required on TGP, TGD and SFN.
- The same signalling is done whatever the compressed mode (by reduction of the spreading factor or by puncturing)
- When TGL1 = TGL2, only two values (DeltaSIR and DeltaSIRafter) are needed compared to up to four values with the proposal in [5].
- When TGL1 ≠ TGL2, only four values are required to have different SIR target offsets for the two transmission gaps compared to up to eight with the proposal in [5].
- The target SIR is only increased in frames where it is needed and not always in the whole TTI

If this proposal is agreed, we suggest that a liaison statement be sent to RAN WG2 on this issue so that the algorithm is specified in WG2.

References

[1] 3GPP TSGR1#6(99)956, “Improvement of outer-loop power control in compressed mode”, July 1999, Alcatel

[2] 3GPP TSGR2#6(99)806, “Improvement of outer-loop power control in compressed mode”, August 1999, Alcatel

[3] 3GPP TSGR1#7(99)c05, “Simulation results for outer-loop power control in compressed mode”, August 1999, Alcatel

[4] 3GPP TS 25.331, “RRC protocol specifications”

[5] 3GPP TSGR1#10(00)86, “CR25.215-023rev1: Compressed mode by puncturing issues (revision)”, Nokia