Title: Proposal for rate matching for Turbo Codes

Source: Nortel Networks[1]

0.0 Summary

In this document, puncturing for Turbo Codes is discussed for UTRA uplink and downlink. A solution allowing to perform optimal puncturing on Turbo Codes in uplin with minimal complexity is presented. The idea can also be reused in downlink.

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1.0 Introduction

In 3GPP, the current assumption is that 8PCCC Turbo Codes are the coding scheme selected for data services requiring BER 10^{-3} to 10^{-6} inclusive. Puncturing might be needed to ensure rate matching on these services. In order to achieve the optimum performance with this scheme while applying a certain dgree of puncturing, Some specific rules are recommended: not puncture systematic bits, and puncture in a balanced way the parity bits streams.

However, in uplink scheme of UTRA, rate matching is perfoirmed after channel interleaving, thus it is relatively complex to have knowledge of which bits are systematic bits and which are parity bits, therefore additonal multiplexing technique are required to ensure the maximum coding performance achieved by Turbo coding.

On one side, puncturing after channel interleaving can be viewed as random puncturing, and it should be further verifed whether such a puncturing really leads a noticeable perforamcne loss. If this is not the case, we current scheme multiplexing scheme can be kept.

On the other side, Nortel would like to propose a solution with minimal complexity which would solve this issue.

It should be noted that ownlink rate matching is performed right after channel coding and before channel interleaving. Either a modified puncturing scheme can be employed, or the idea that Nortel proposed for uplink can be re-used in order a chieve a unified algorithm.

2.0 Proposed scheme for Rate Matching Puncturing for 8-State PCCC Turbo Coding in UTRA uplink

Among all the studies available, for puncturing of Turbo codes, the following rules are applied:

- Systematic code symbols should not be punctured
- The number of the punctured parity symbols should be distributed evenly. In case of the exact even distribution is not possible due to the frame size constraint, the puncturing will be distributed as even as possible.

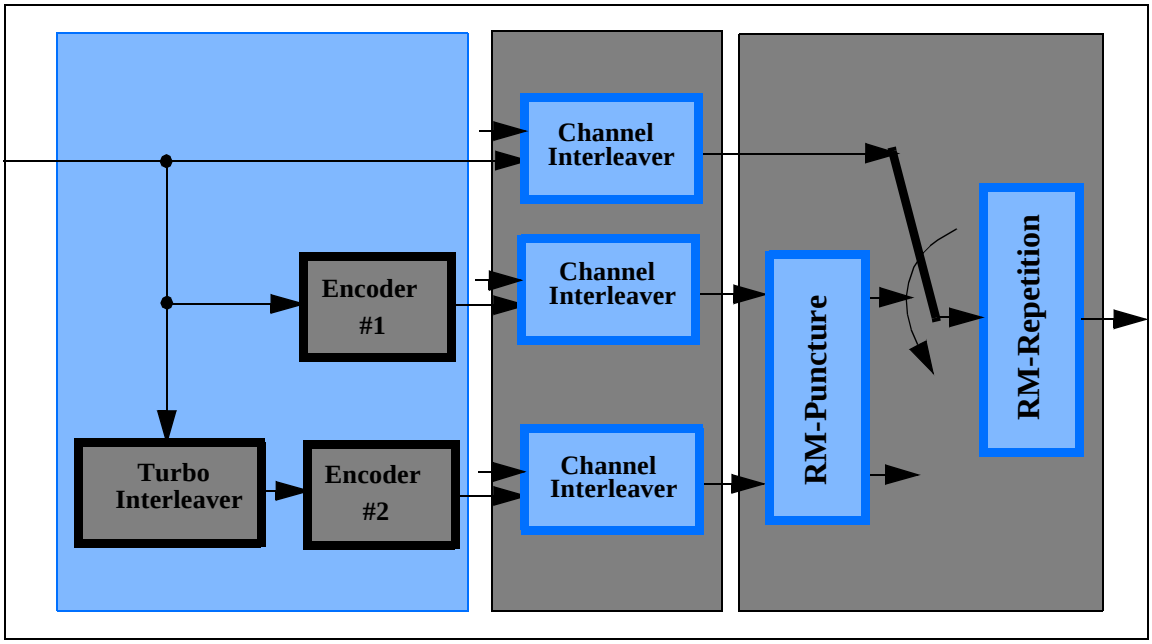
The impact of the uniform distributed puncturing position is proved by simulation to be minimum.

In order to implement these recommendations, we propose to separate the flow containing systematic bits and the two flows containing parity bits (in case of coding rate 1/3), and apply first channel interleaving separately on these three flows (inter-frame interleaving).

Then rate matching could be applied on the flows separately. Systematic flows would not be applied rate matching. The parity flows would be applied the same amount of puncturing, the algorithm could then be the same as the one which will have been selected as WA. These three flows would be re-combined using some simple shuffling algorithm which would dispatch the systematic and parity bits together without changing the order of the bits in each flow.

Figure 1 depicts the practical implementation of this scheme.

FIGURE 1. Channel Interelaving Rate Matching for Turbo Coding



3.0 Rate matching puncturing for 8-State PCCC Turbo Coding in 3GPP downlink

In the downlink, rate matching is performed just after coding and before channel interleaving. Thus the knowledge of the origine of the bits can be used to puncture in a controlled way.

One solution is then to use a modified algorithm coping with the specificity of 8PCCC Turbo Codes.

Another solution is to use the same idea as what is proposed for uplink in this document. The systematic and parity bits would be separated in different streams. Then, no puncturing would be applied on systematic flow, and uniform puncturing as defined currently in S documents can be applied on each of the parity flow with a balanced puncturing rate between these parity flows, but different starting offsets so that both parity bits corresponding to one systematic bit are not punctured. Then the flows are mixed again together alternating systematic and parity bits.

4.0 Conclusion

In this document, Nortel proposed a solution in order to cope with the recommendations in terms of puncturing for 8PCCC Turbo Codes, while applying rate matching after channel interleaving, which is the assumption in UTRA uplink. This solution has a minimal complexity and allows optimal puncturing on 8PCCC Turbo Codes. Therefore it is recommended to adopt this solution in 3GPP.

The same idea can be also used in downlink and would provide a unifed rate matching algorithm.