RAN WG1 meeting **R1#10-00-122**
Place : **Beijin**
Date **18-21 January 00**
Title : **Proposal to take more time to study and standardise compressed mode method A2.**
Source : **Mitsubishi Electric**
Paper for : **Decision**

Introduction

In the RAN WG1 meeting #9 in Radebel a proposal to use compressed mode method A2 from Nokia came up. Some operators and infrastructure manufacturers were supportive of the proposal. Some UE manufacturers including us expressed concern about this.
In this paper, we analyse what is the impact on the standardisation and product development implied by the proposal.

Reference

[1] R1-99 G03 Text proposal to TS 25.212 for Implementation of compressed mode in the IL & MUX chain, source Mitsubishi Electric (MCRD)
[2] R1-99 J03 Means for compressed mode by puncturing in downlink, source Nokia
[3] R1-99 J04 CR019 25.212, Rate matching and multiplexing for compressed mode with puncturing (Method A), source Nokia
[4] R1-99539 Shuffle multiplexing definition and complexity, source Mitsubishi Electric
[5] R1-99672 Optimal Shuffling Multiplexing of coded QOS blocks, source Nortel Networks

Impact of method A2 in release 99

Benefits of compressed mode method A2

The main argumentation in favour of compressed mode method A2 relies on the two following points :

- compressed mode method B necessitates the use of secondary scrambling codes in case that the father of the current node in the OVSF tree is not free. The proponents of scrambling code method A2 argue that this would raise significantly the level of interference, all the more as they claim that it is not possible to measure how much the link would be degraded when the scrambling code is switched, and so, that bigger power margins need to be taken,
- compressed mode method B can allow only half frame time gap length, it cannot go down to the number of time slot actually need. So compressed mode method B might compress more than actually needed.
- compressed mode method A (A1 or A1) implies more puncturing. This more puncturing is possible only if we are not already at the puncturing limit, which is unlikely to happen in a code limited context.

On the first bullet point we would like to say that this is a very link level analysis. Up to now, we have not seen any system level analysis. So, for now, it is far from obvious that such a complex optimisation as compressed mode method A2 would bring a significant benefit to the system. On the other hand, what is quite sure, is that it will impact the UE complexity.

Furthermore, the arguments given in [2] need further study.

On the second bullet point, we don’t agree with the statement, as symbol repetitions can be dynamically made during the compressed frame by means of the blockwise repetition proposed in the compressed mode method A1 described in [1].

Impact on the standardisation of method A2

Up to very recently (RAN WG1 #7bis) the only thing that was said about compressed mode method A2 was summing up to one figure where a compression on 5 radio frames was shown. Clearly a compression on 5 radio frames does not make sense at all as this is not a divider or a multiple of any TTI duration. So, this figure and everything said about compressed mode method A2 was removed at that time from the specs.

In RAN WG1 #9 a contribution from Nokia provided a pseudo detailed description of compressed mode method A2. However, we are quite sure that this description is incomplete and arithmetically incorrect.

So, we are very concerned that this won't be completely described in time for release'99.

Impact on the implementation of compressed mode method A2

We must distinguish two aspects :

- computation of parameters for multiplexing and interleaving
- multiplexing and interleaving

computation of parameters for multiplexing and interleaving

We think that the algorithm to compute these parameters, like the block sizes and so on, will be significantly made more complex.
It might not be a problem when these parameters are computed once and for all for the connection, like now as long as new TrCH are not removed or inserted to the CCTrCH.

But, with compressed mode method A2 you will need to compute a new parameter set for each type of gap length. Even when the gap length (e.g. TGL = 7) is the same you need to compute different set of parameters when the gap is lying accross two consecutive frames in two different ways (e.g. on the one hand 3 slot in the first frame and 4 on the second one, and on the other hand 2 slots on the first frame and 5 on the second one).

This means that the number of parameters to compute, and how often you will have to compute them might increase significantly.

Up to now there was no serious study of this impact. So we are not ready to accept something before we are sure that the complexity is remaining acceptable for the UE.

multiplexing and interleaving

The impact of compressed mode method A2 on the multiplexing and interleaving is the following :

- The 1st interleaver shall handle interleaving depth that are not a multiple of F the number of columns in the interleaver matrix. This means that the interleaver needs an additional pruning function, in order to puncture the interleaving addresses that are beyond the interleaving depth. When this interleaver is made by an ASIC this means a significant increase of complexity as an additional address counter needs to be added (you need both the not-punctured address, and the punctured-address so you need two counters where before only one was needed), also you need to have an additional comparer to compare the not-punctured address to the interleaver depth in order to trigger address puncturing. Finally you need some control logic to make all of this work together.
- The radio frame segmentation is unequal, this means that the way you multiplex data is no longer defined by the sole knowledge of the TFCI, you must also take into account the value of the n_i where

  $$n_i = \text{CFN modulo } F_i,$$

  and where F_i is TTI duration as a number of radio frames. With the current specification you need only to know one segment size, but with the compressed mode method A2 you need the size of each segment, and the value of n_i to know which one to select.

We think that the two above point significantly impact the UE design. Even if the increase in complexity is not dramatic, such a late change will potentially bring significant delays as some designed might need to be thoroughly reviewed.

degradation of the interleaving gain

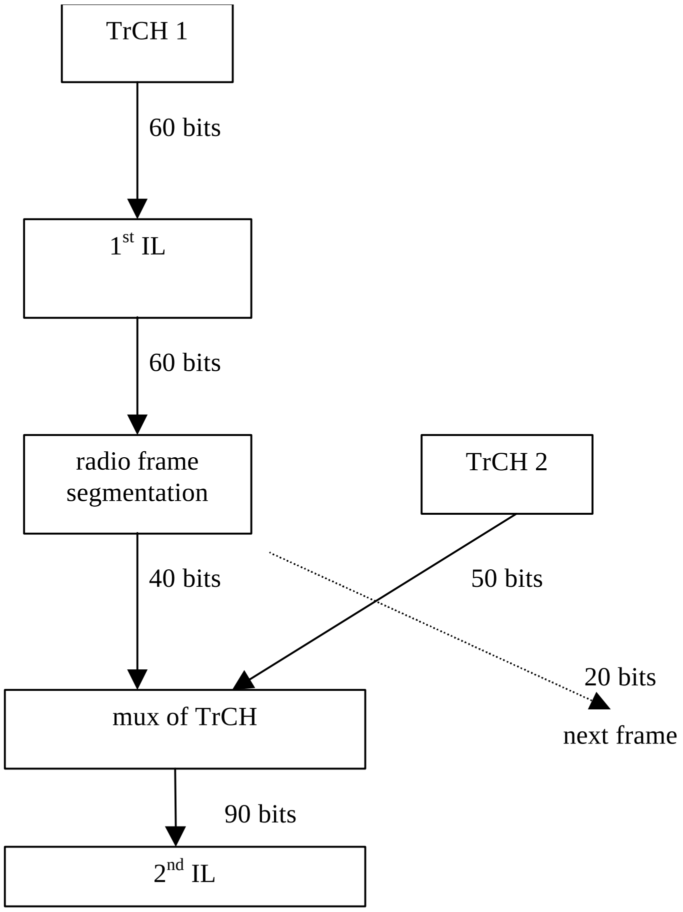
The first interleaver followed by an equal segmentation can be view as a shuffle demultiplexer. That is to say the bit received in each radio frame are equally shuffled in the TTI at reception. When the segmentation is no longer equal, this might be no longer true.

Let F_i be the TTI duration as a number of radio frames ($F_i \in \{1,2,4,8\}$). Currently the bits interleaved by the second interleaver are spaced by F_i in the data block before the 1st intereleaver, that is to say they are very close. So consecutive bits before the 2nd interleaver are close bits before the 1st interleaver, more generally speaking the distance between 2 bits before the 2nd interleaver is directly a $1/F_i$ ratio of the distance between the same bits before the 1st interleaver. This special property is in our opinion why the scheme does work, that is to say why the 1st and the second interleaver work well together.
The current scheme can be considered as a shuffle de-multiplexer followed by a complex interleaver, it is the other way round of an alternative scheme that Nortel proposed and which was a complex interleaver followed by a shuffle multiplexer. So, as we can see, this very special property of putting in serial in the same flow a shuffling module and an interleaving module is more general and fundamental a principle as the sole application to the current scheme.

Let us now assume that the segmentation is unequal. Let us assume that one segment lies over two columns of the 1st interleaver. What will happen is that bits distant before the 2nd interleaver are in fact consecutive bits before the 1st interleaver. Since both the construction of the 2nd the 1st interleaver are rather simple and regular, there might well be some rare cases where this would lead to catastrophic behaviours.

Mitsubishi Electric has already raised this important point during the RAN WG1 #9 meeting, but as it was rather difficult to explain orally such a concern, it went unnoticed : up to now there was no serious study of the consequence of unequal segmentation on the interleaving gain. We believe that it is worth taking time in studying this (maybe there is no problem, and we hope so, but now it is wiser to check this thoroughly).

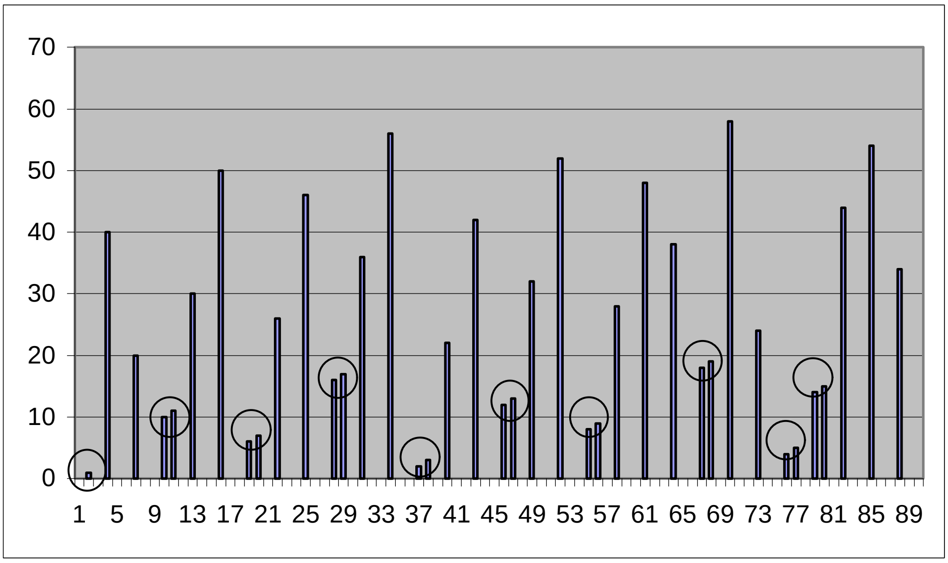
Here we give an example of what sort of problem can happen : we consider 2 TrCH's, the TrCH 1 has a TTI of 20ms and outputs 60bits every TTI to the 1st IL. The unequal segmentation is such that the first segment contains 40bits and the second segment contains 20bits. In other words the 1st segment overlaps over the 2 30bit columns of the 1st IL. During the radio frame of the 1st segment we assume that we get furthermore 50 bits from the TrCH 2 after the radio frame segmentation. So the 40 + 50 = 90 bits are fed to the second interleaver
This is summarised on the figure below :



Now we have replaced the bits from by numbers from 0 to 59 according to their position before the 1st IL, and on the figure below we have represented them by histograms bars at the output of the 2nd IL. So the x-axis is the position from 0 to 89 in the block outputted by the 2nd IL, while the y-axis is the position of bits before the 1st IL of TrCH 1. No bars are represented for positions on the x-axis corresponding to bits from TrCH 2. We can see that there are 10 occurrences when 2 consecutive bits at the input of the 1st IL are still consecutive at the output of the 2nd IL, this occurrences are marked by a circle.

What has happened ? : The 1st IL has just 30 lines that is to say the number of column of the 2nd IL. With the unequal segmentation we have 10 bits of the 1st IL second column that are belonging to the 1st segment.

Because the 1st IL has 30 line, these 10 bits are 30 bits apart after the 1st IL from 10 respective bits that are consecutive to them before the 1st IL. This pairs of bits are put together again by the 2nd IL because the 2nd IL has 30 columns and we get it.



Of course we admit that this is a very well chosen example. However it is enough to show that before incorporating the unequal segmentation into the standard we need more thorough thinking about the consequences.

And identified solution of above mentioned problem is to replace the blocks "1st IL + radio frame segmentation" by a shuffle-demultiplexer. Shuffle-multiplexer algorithm were given by Nortel Networks and by Mitsubishi Electric in papers [4] and [5] at the time of the channel interleaving scheme selection during WG1 #5 in Cheju island.
We believe that if such a solution proves out to be necessary, this would be a very profound and late change, and accepting this for release'99 is probably not a very good idea from the UE development point of view.

Conclusion

In view of :

- the delay that would be incurred both by the standardisation and by the development of products,
- the lack of real proof about the benefit of compressed mode method A2 at this stage, and
- the potential risk of getting catastrophic interleaving by using unequal segmentation

we propose that compressed mode method A2 be introduced calmly and safely for release 2000.