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Agenda Item : Ad Hoc 4

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Title: TFCI repetition for compressed mode in uplink

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1. Introduction

TFCI bits are coded and transmitted over one frame. In current specification, TFCI is coded with (32, 10) and (16,5) Reed Muller code and one bit or two bits from the code word are punctured to fit the number of the slot. Consequently, (30, 6) or (15, 5) coding are used.

For the normal transmission, the current coding and puncturing scheme has no problem but for some other cases in which the additional allocation of TFCI code bits is needed, the current scheme misses some optimisation rule. Generally speaking, puncturing after repetition is more performance promising than repetition after puncturing. Additional bits for TFCI code is not the repetition of (32, 10) or (16, 5) but the repetition of (30, 10) or (15, 5) code.

One example of that is the case of uplink compressed mode B where the frame format is changed that the number of TFCI bit per slot is 3-4 in order to transmit TFCI bits without reducing TFCI bits. In that case, the TFCI bits are punctured and then repeated. The puncturing and repetition should be considered simultaneously. This principle was issued in the rate matching algorithm. With repetition of non-punctured code word, we gain the performance gain compared to the current TFCI repetition scheme.

2. TFCI repetition for uplink compressed

For uplink compressed mode, the slot format is changed so that no TFCI bits are lost. And TFCI bits are repeated to be matched to the frame formats and the number of TFCI bits. Therefore the number of repetition is determined according to the frame format, that is, the number of the idle slot. The number of idle slots in one radio frame is 1-7 slots. In current TFCI code is repeated from punctured code word. To improve the performance, the repetition should be based on the non-punctured TFCI coded bits, that is, 32 bits code word. The current spec that describes TFCI coding in the uplink compressed mode B should be changed as below.

4.2.5.4.2.1 Uplink

For uplink compressed mode by method B the frame format is changed so that no TFCI bits are lost. The different frame formats in compressed mode can not match the exact number of TFCI bits for all possible TGLs. Repetition of the TFCI bits is therefore used.

Denote the number of bits available in the TFCI fields of one compressed radio frame by *D*, the repeated bits by d_k, and the number of bits in the TFCI field in a slot by N_{TFCI}. Let *E*=32~~30~~-1-($N_{first}N_{TFCI}$)mod 32~~30~~. If $N_{last}\neq 14$, then *E* corresponds to the number of the first TFCI bit in the slot directly after the TG. The following relations then define the repetition.

~~$d_{D-31} = c_{E \bmod 30}, d_{D-32} = c_{(E-1) \bmod 30}, d_{D-33} = c_{(E-2) \bmod 30}, \ldots, d_0 = c_{(E-(D-31)) \bmod 30}$~~

$$d_{D-33} = c_{E \bmod 32}, d_{D-34} = c_{(E-1) \bmod 32}, d_{D-35} = c_{(E-2) \bmod 32}, \ldots, d_0 = c_{(E-(D-33)) \bmod 32}$$

When the number of available TFCI bit is smaller than 32, i.e. 30, 31, no repetition is performed. The bits are mapped to the slots in descending order starting with the original bits($c_{31}, \ldots c_0$) and followed by the repeated ones, i.e. c_{2931} is sent as first bit in the TFCI field of the first transmitted slot and d_0 as last bit in the TFCI field of the last transmitted slot.

And the other texts that describe the compressed mode with 30 code word should be changed.

The repeated bits of TFCI are 2-12 bits when code word of 30 bits is considered. On the other hand, the repeated bits are 0-10 bits when repetition is done with 32 bits code word. The hamming distance and weight of the current specification and that of the proposed are compared. Table 1 shows the minimum hamming distance and its weight of the current scheme and the proposed scheme. TFCI bits is 10 bits and N_{last} is 14. We can see that the coding gain is obtained by the proposed method. Though the increment of the minimum hamming distance is different case by case, the minimum hamming distance is increased compared to the current scheme.

Table 1. Comparison of the minimum hamming distance

N_{TFCI}	Transmitted slots per radio frame	Proposed scheme		Current scheme	
		Number of repeated bits	Minimum Hamming Distance	Number of repeated bits	Minimum Hamming Distance
3	14	10	12	12	11
3	13	7	12	9	10
3	12	4	12	6	10
4	9	4	12	6	10
3	11	1	12	3	10
4	8	0	12	2	10

Table 2 shows the minimum hamming distances of the current scheme and the proposed one. N_{first} is 6.

Table 2. Minimum hamming distance

N_{TFCI}	Transmitted slots per radio frame	Proposed scheme		Current scheme	
		Number of repeated bits	Minimum Hamming Distance	Number of repeated bits	Minimum Hamming Distance
3	14	10	13	12	12
3	13	7	12	9	10
3	12	4	12	6	10
3	11	1	12	3	10

Two simulations are performed to compare the performance of current scheme and that of the proposed. Firstly, the SER performance of the modified scheme in AWGN channel is shown in figure 1 when 2 extra bits are available. Here TGL=7, N_{first} =6, the number of repeated bits for the current scheme is 2, and 0 bit is repeated for the proposed one. For this case, minimum hamming distance is improved by 2. It shows a gain of 0.25dB at a SER of 10E-5.

The repeated bits are beneficial for power control and the performance evaluation of the modified scheme needs some sophisticated simulation of uplink compressed mode. But the simulation in the AWGN channel could provide some insight of performance gain of the modified scheme. When the additional 12 TFCI bits are available, the SER of performance of the modified scheme is as below. In this case, 10 bits are repeated for the modified scheme and 12 bits for the original scheme. Here TGL=1, N_{first} =6. For this case, minimum hamming distance is improved by 1. The modified scheme gets a gain of 0.15dB at a SER of 2*10^-5.

Unfortunately we could not perform simulation on fading environment. However we could guess that the performance gain could be obtained on the same reason as AWGN environment.

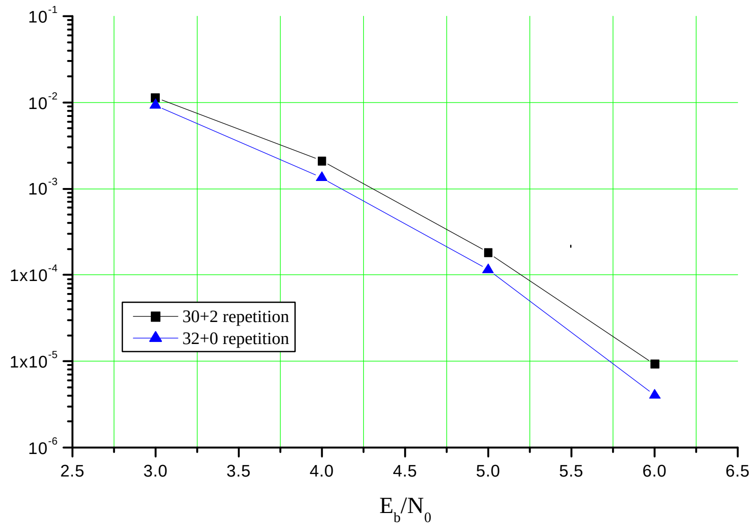

fig 1. Simulation result when 2 bits are repeated.

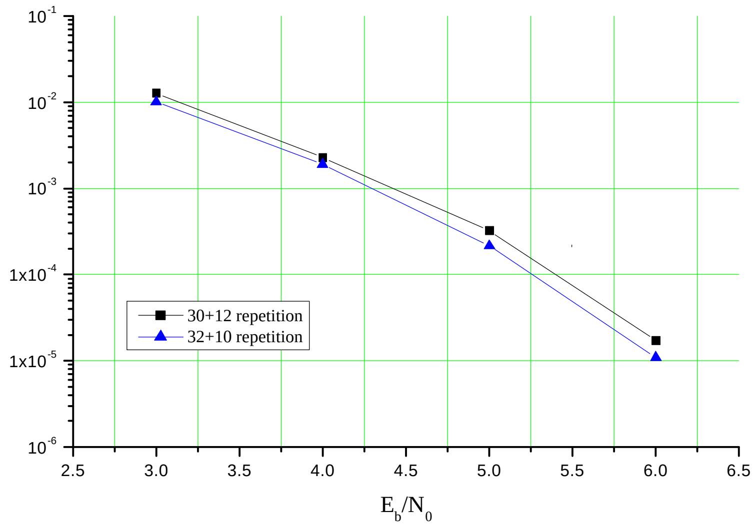

Fig 2. Simulation result when12 bits are repeated.

3. Conclusion

In uplink compressed mode TFCI bits are repeated to prevent the loss of TFCI bits. And mapping of TFCI bits are performed based on the punctured code word in current specification. The performance gain can be obtained by considering repetition from the code word that is not punctured. This is because the minimum hamming distance is increased by the proposed method. We recommend that the repetition of TFCI should be done with non-punctured TFCI code word.

Reference

[1] 3GPP TSG RAN WG1 Multiplexing and Channel Coding(FDD) TS 25.212 V3.0.0 (1996. 10)

[2] 3GPP TSG RAN WG1 R1-99e96 Compressed Mode, Ericsson.