TSG-RAN Working Group1 meeting #7 **_TSGR1#7(99)c54_**
Hannover, Germany, 30th August – 3rd September 1999

Agenda Item: **Ad Hoc 4**

Source: **NTT DoCoMo**

Title: **Blind rate detection for AMR speech transmission**

Document for: **Discussion and Decision**

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1. Introduction

The AMR speech codec, which is specified in TSG SA WG4, has eight different rates for speech data and one rate for SID frame [1], [2]. In the contribution [3], it was shown that blind rate detection (BRD) method enable efficient transmission of such AMR variable rate data. This document discuses about the actual BRD performance and then proposes to add another CRC with suitable parity length in order to achieve both the reasonable BRD performance and the transmission efficiency simultaneously. This document also mentions the requirement when BRD is applied to UEP scheme.

2. Performance of blind rate detection for rates set of AMR

In this section, the actual performance of BRD applied to AMR is evaluated for some cases of using CRC by means of the computer simulation. We simulated the probability of false detection (this happens if the detected rate is wrong but the CRC misses the error detection) for BRD using CRCs with some kind of parity lengths and also using soft values of Viterbi decoding (this is corresponding to section A.2 in [4]).

The following simulation conditions were assumed in the simulations:

- Transmitted data rate: 10 rates (i.e. 244, 204, 159, 148, 134, 118, 103, 95, 35 and 0-bit) are randomly transmitted.
- Physical channel: downlink format and channel bit rate = 64 kbps (SF = 128)
- Channel coding: R=1/3 convolutional code with constraint length of 9
- Channel decoding: soft decision Viterbi decoding
- BRD with using CRC: CRC party lengths = 8, 10, 12, 14 and 16-bit
- BRD with using soft values of Viterbi decoding: trellis path selection threshold (sec. A.2 in [4]) = 2.0 dB
- Interleaving span: 20 ms
- Channel estimation: 2-slot averaging
- Diversity: 2-branch antenna space diversity and 2-finger Rake/branch
- TPC: off
- Channel model: 2-path Rayleigh fading channel with having equal average power per each path
- fDTslot = 0.05

The simulation results are shown in Figure 1. This figure shows the average false detection rate (FDR) performance for both BRD cases with only using CRC and with using CRC + soft values in Viterbi decoding. The average frame error rate (FER) is also shown in the figure. From this figure, it can been seen that longer CRC parity gives lower FDR and the BRD with using both CRC and soft values of Viterbi decoding achieves one tenth lower FDR compared to the BRD with only using CRC.

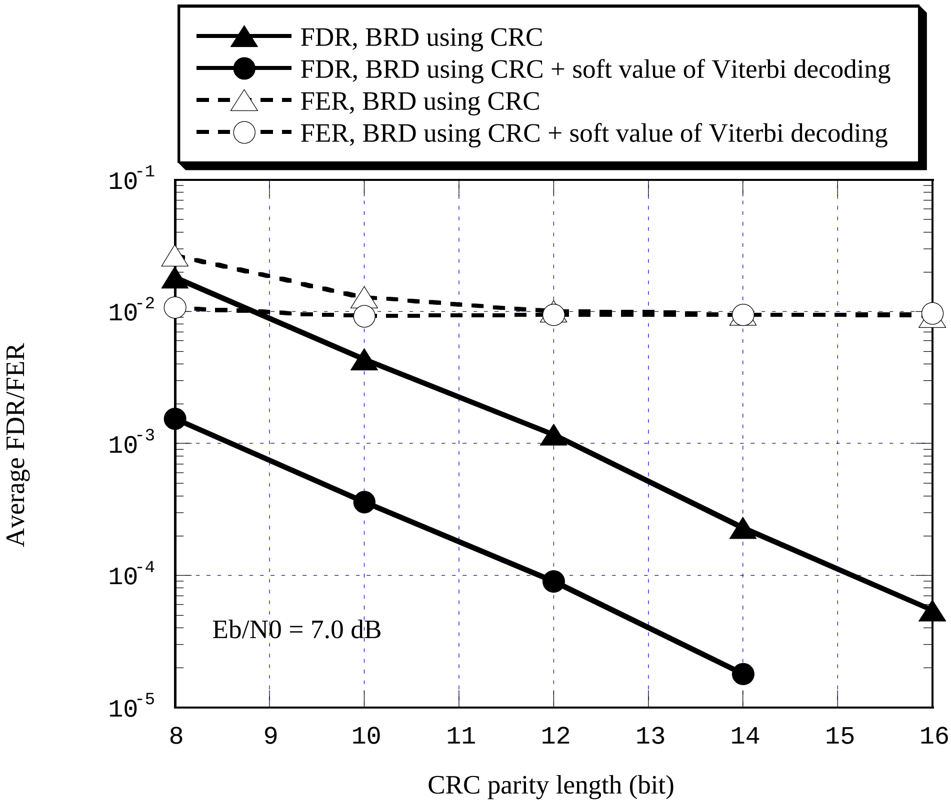

Figure 1 False detection rate performance (FDR) vs. CRC parity length

3. Proposal for addition of another CRC parity length

In the current L1 specification [4], CRC with 16, 8 and 0-bit parity lengths are specified already. If it is assumed that BRD is performed using these CRC, the following erroneous AMR frame, which will affect the speech quality, would be occurred:

- In case of 8-bit CRC, since simulated FDR is around 2*1e-3, such an erroneous AMR frame would then be happened per 10 seconds. In this case, the parity length gives minimum overhead and the effect of erroneous AMR frames on speech quality could not on the other hand be ignored.

- In case of 16-bit CRC, since estimated FDR is around 5*1e-6, such an erroneous AMR frame would then be happened per about 1 hour. In this case, the effect of erroneous AMR frames on speech quality could be ignored and the parity length on the other hand gives too large overhead.

In order to achieve both the reasonable FDR performance and the transmission efficiency in BRD simultaneously, we propose to add another CRC with suitable parity length i.e. 12-bit CRC.

In case of 12-bit CRC, since simulated FDR is around 1*1e-4, an erroneous AMR frame would then be happened per 3 minutes. We think this parity length has an appropriate overhead and gives a low frequency of erroneous AMR frame. Of course, the having this additional parity length will also give a benefit to the optimisation of transmission efficiency in case of using TFCI. The proposed text of additional 12-bit CRC for TS 25.212 and TS 25.222 is shown below. The code generation polynomial of 12-bit CRC in this text is led from a primitive polynomial of degree 11 and the generated code has a minimum distance of 4.

- Text proposal for TS 25.212 (TS 25.222):

== Start of Text ==

4.2.1 (6.2.1) Error detection

Error detection is provided on transport blocks through a Cyclic Redundancy Check. The CRC is 16, 12, 8 or 0 bits and it is signalled from higher layers what CRC length that should be used for each transport channel.

4.2.1.1 (6.2.1.1) CRC Calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

$g_{CRC16}(D) = D^{16} + D^{12} + D^5 + 1$

$g_{CRC12}(D) = D^{12} + D^{11} + D^3 + D^2 + D + 1$

$g_{CRC8}(D) = D^8 + D^7 + D^4 + D^3 + D + 1$

Denote the bits in a transport block delivered to layer 1 by $b_1, b_2, b_3, \ldots b_N$, and the parity bits by $p_1, p_2, \ldots p_L$. N is the length of the transport block and L is 16, 12, 8, or 0 depending on what is signalled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial

$b_1D^{N+15} + b_2D^{N+14} + \ldots + b_ND^{16} + p_1D^{15} + p_2D^{14} + \ldots + p_{15}D^1 + p_{16}$

yields a remainder equal to 0 when divided by $g_{CRC16}(D)$, the polynomial~~. Similarly,~~

$b_1D^{N+11} + b_2D^{N+10} + \ldots + b_ND^{12} + p_1D^{11} + p_2D^{10} + \ldots + p_{11}D^1 + p_{12}$

yields a remainder equal to 0 when divided by $g_{CRC12}(D)$ and the polynomial

$b_1D^{N+7} + b_2D^{N+6} + \ldots + b_ND^8 + p_1D^7 + p_2D^6 + \ldots + p_7D^1 + p_8$

yields a remainder equal to 0 when divided by $g_{CRC8}(D)$.

4.2.1.2 (6.2.1.2) Relation between input and output of the Cyclic Redundancy Check

Bits delivered to layer 1 are denoted $b_1, b_2, b_3, \ldots b_N$, where N is the length of the transport block. The bits after CRC attachment are denoted by $w_1, w_2, w_3, \ldots w_{N+L}$, where L is 16, 12, 8, or 0. The relation between b and w is:

$w_k = b_k$ $\quad k = 1, 2, 3, \ldots N$

$w_k = p_{(L+1-(k-N))}$ $\quad k = N+1, N+2, N+3, \ldots N+L$

== End of Text ==

4. Requirement for BRD applied to UEP scheme

In this section, a requirement for BRD application to UEP scheme is mentioned. From the AMR format in [1], there are three speech data classes as shown in Table 1. If each speech data of different class is separately transmitted on different TrCH i.e. using UEP scheme, BRD should be performed with relying on the CRC attached to class A data because the highest transmission quality is given for the class A data. Otherwise the BRD performance will be degraded due to given lower transmission quality of class B or C data. In Table 1, the duplicated number of bits in class A data is specified at both ARM6.7 and 5.9 mode and BRD with only relying on class A CRC could not distinguish these two modes basically.

Table 1 Number of bits in different classes of AMR speech data

Codec Mode	Number of speech bits delivered per block (K_d)	Number of class A bits per block	Number of class B bits per block	Number of class C bits per block
AMR12.2	244	81	103	60
AMR10.2	204	65	99	40
AMR7.95	159	75	84	0
AMR7.4	148	61	87	0
AMR6.7	134	**55**	79	0
AMR5.9	118	**55**	63	0
AMR5.15	103	49	54	0
AMR4.75	95	39	56	0

However, if the bit assignment among two classes: class A and B could be slightly modified e.g. higher important bits of just 3 (= (61 – 55) / 2) bits of class B are re-assigned to class-A bits, the BRD enables to easily distinguish the two AMR modes. Class A and B then have 58 bits and 76 bits respectively and since only 2 % speech data bits of AMR6.7 are moved between different classes in this case, it is supposed that such slightly modification causes almost no influence on the transmission efficiency and speech quality.

In order to achieve the efficient transmission scheme and the rate detection with high accuracy, we suggest to ask the possibility of the slightly modification on the AMR data format like the above to TSG SA WG4 codec working group by means of LS.

5. Conclusion

- We evaluated the actual BRD performances in terms of false detection rate FDR and then found the another CRC parity length i.e. 12-bit CRC gives the reasonable FDR. This additional CRC parity length also has a benefit on the case of using TFCI. We therefore propose to add 12-bit CRC to TS 25.212 and 25.222.

- The current AMR format include a duplicated number of bits in class A of specific modes and the blind rate detection will not be performed well for those modes. In order to achieve the efficient transmission scheme and the rate detection with high accuracy, we then suggest to ask the possibility of the slightly modification on the AMR data format to S4 codec working group.

References

[1] "Mandatory Speech Codec speech processing functions AMR Speech Codec; Frame Structure", TS 26.101
[2] TSG-S4 Codec Working Group, "Response to the TSG-R1 LS on Speech Services", TSGR1#3(99)314
[3] NTT DoCoMo, "Investigations of AMR speech transmission", TSGR1#6(99)a01
[4] TSG RAN WG1, "Multiplexing and channel coding (FDD)", TS 25.212