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Title: **Link performance of low-rate AMR-encoded speech services (TDD)**

Document for: Discussion

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1. Abstract

This document presents link level simulation results for unequal-error-protected (UEP) AMR-speech services with net data rates of 7,95 kbps and 4,75 kbps. These results show that it is beneficial to use convolutional encoding with a mothercode of 1/3 for these lower rates. Compared to the performance of convolutional encoder with ½ mothercode the gain is up to 0,4 dB.

2. Introduction

The Adaptive-Multirate (AMR) speech codec provides 8 different codec modes with different data rates.

For each mode there are two or three classes of bits defined , which have to be protected individually by the channel encoding process. The codec modes, number of classes and the number of bits for each class are defined in [2].

In document [3] the gain of an UEP-encoded 12,2 kbps AMR speech service in comparison to an EEP-encoded service for TDD is shown.

This document presents link-level simulation results for 7,95 kbps and 4,75 kbps using a mothercode of ½ and 1/3 for the convolutional coding and decoding.

Furthermore, matched coding schemes are proposed for the bit classes. With these coding schemes the BER of the two bit classes are reaching their specific target bit error rate at the same C/I or Eb/No (raw).

3. General Simulation assumptions

- Uplink
- dual antenna diversity
- JD-receiver
- four active users in the same TS
- chiprate 3,84 Mcps , 15 TS,
- SF = 16
- TFCI (16 bits) and TPC (2 bits) included, but not evaluated
- Power control applied
- Channel mode C1 (indoor, 3 km/h)
- Real channel estimation
- Coding, interleaving and rate matching as described in [1].

4. Simulation results

4.1 AMR 7,95 kbps speech service

Target BER

AMR 7,95 kbps	Class A	Class B
Net bit per 20 ms	75+8	84
Target BER	$1*10^{-4}$	$3*10^{-4}$

Proposed matching AMR 7,95 UEP bit classes

	Class A	Class B
Net bits per 20 ms	75+8	84
MC ½		
Convolutional encoding (MC 1/2)	(83)*2 = 166 bits	(84) * 2 = 168 bits
Rate matching (MC ½)	(166+88) = 254 (+53%)	168+30= 198 (+ 18 %)
Coderate (MC ½)	0,327	0,424
MC 1/3		
Convolutional encoding (MC 1/3)	(83)*3 = 249 bits	(84) * 2 = 252 bits
Rate matching (MC 1/3)	(249+5) = 254 (+2%)	252-54= 198 (- 21 %)
Coderate (MC1/3)	0,327	0,424

The following figure shows the simulation results for the two bit classes.

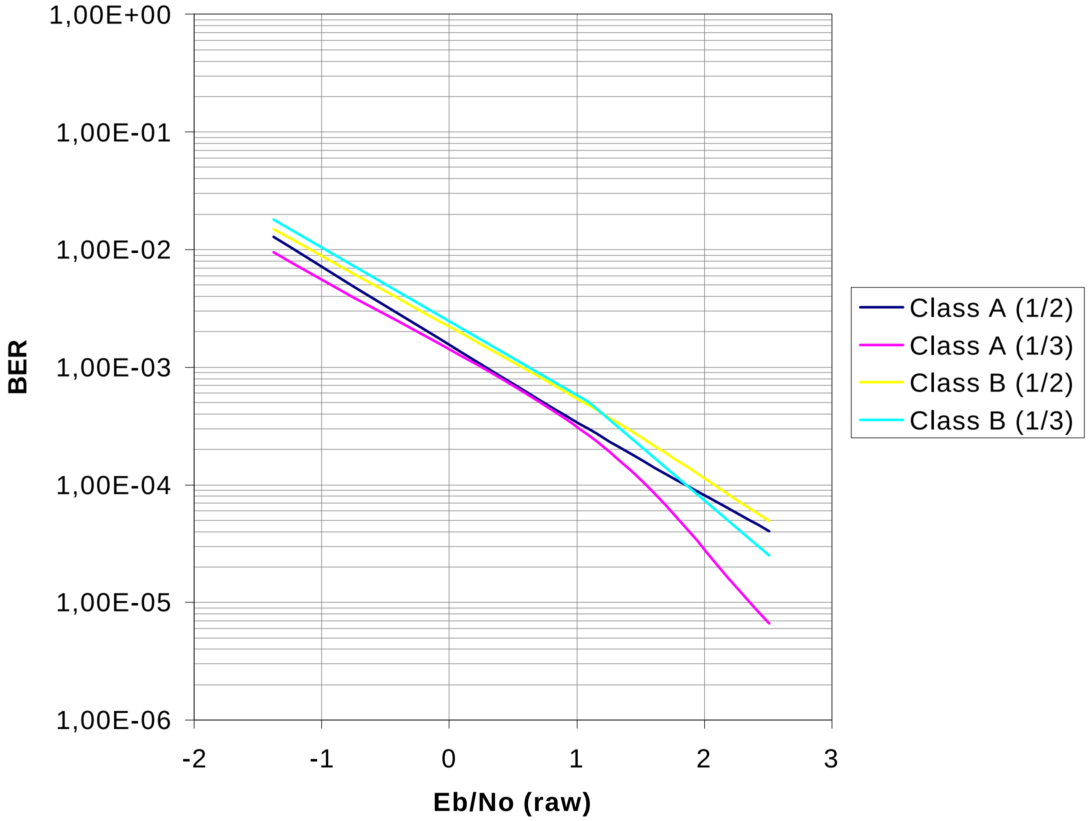

Figure 1: AMR 7,95 coding performance for class A and B

It can be seen, that using the 1/3 convolutional encoder will result in a performance gain of 0,4 dB compared to ½ convolutional encoding with the same overall coderate for class A.

Furthermore these results show, that the performance of the 1/3-encoded class B with 21 % puncturing is comparable with the performance of ½ encoded and repeated class B bits. This means, that the mothercode of 1/3 can be used for both classes.

For 1/3 encoding, the target BERs of the two classes will be reached at an Eb/No (raw) of 1,45 dB.

4.2 AMR 4,75 kbps speech service

Target BER

AMR 4,75 kbps	Class A	Class B
Net bit per 20 ms	39+8	56
Target BER	$1*10^{-4}$	$3*10^{-4}$

Proposed matching AMR 4,75 UEP bit classes

	Class A	Class B
Net bits per 20 ms	39+8	56
MC 1/2		
Convolutional encoding MC(1/2)	(47+8)*2 = 110 bits	(56+8) * 2 = 128 bits
Rate matching (MC ½)	(110+144) = 254 (+131%)	128+70 = 198 (+ 55 %)
Coderate (MC ½)	0,185	0,283
MC 1/3		
Convolutional encoding (MC 1/3)	(47+8)*3 = 165 bits	(56+8) * 3 = 192 bits
Rate matching (MC 1/3)	(165+83) = 248 (+50%)	192+12 = 204 (+ 6 %)
Coderate MC (1/3)	0,190	0,275

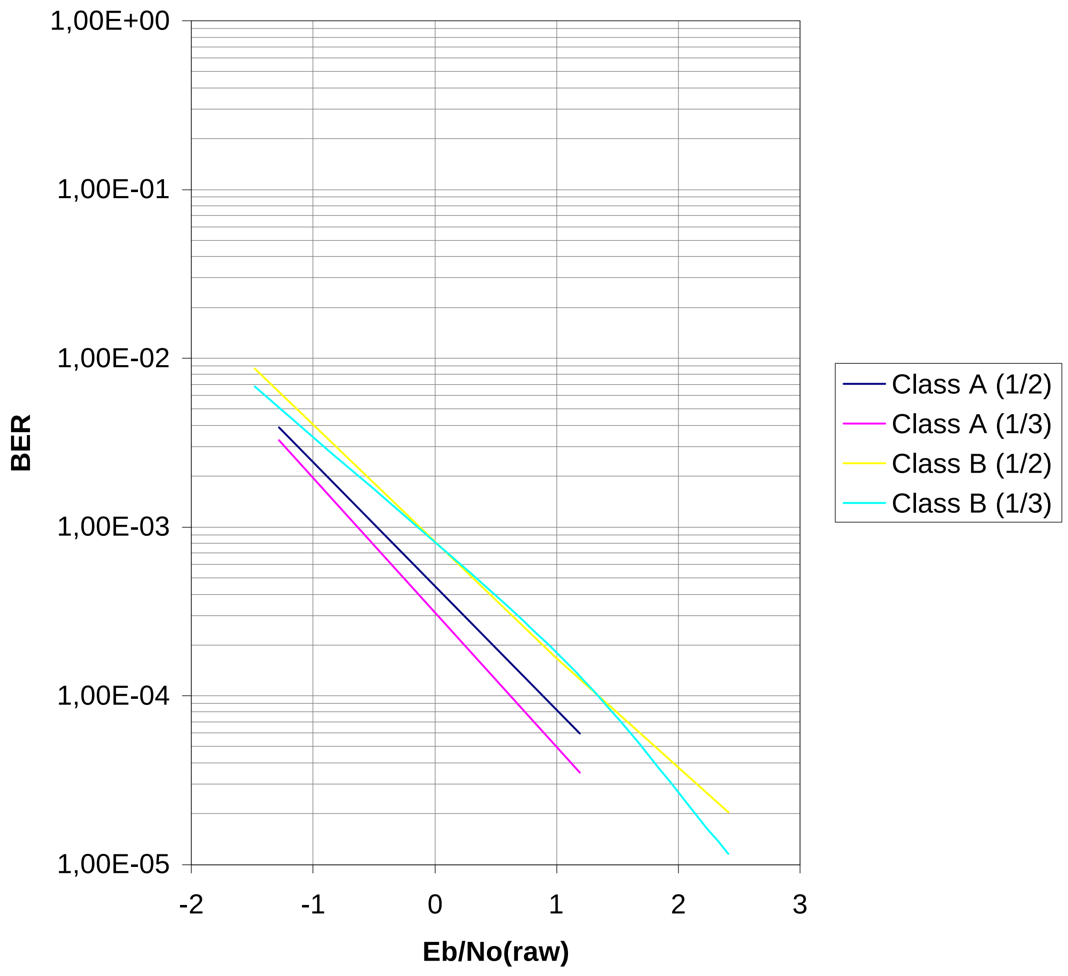

Figure 2: AMR 4,75 coding performance for class A and B

Also for the 4,75 kbps AMR speech service the use of the 1/3 mother code will result in a performance gain of 0,3 dB for class A, although less raw bits are used for 1/3 coding for a better matching to class B. The required Eb/No (raw) for reaching the target BER is 0,6 dB for both classes.

5. AMR performance range

The following table shows the required Eb/No (raw) for the different AMR data rates, derived from the simulations shown in this document and in [3]. The simulations were done for the Case #1 environment (indoor, mobile speed 3 km/h) with target bit error rates for the classes A, B and C (for 12,2 kbps) as stated. All AMR classes are mapped into one physical channel (one code, one timeslot) including 16 TFCI bits and 2 TPC bits.

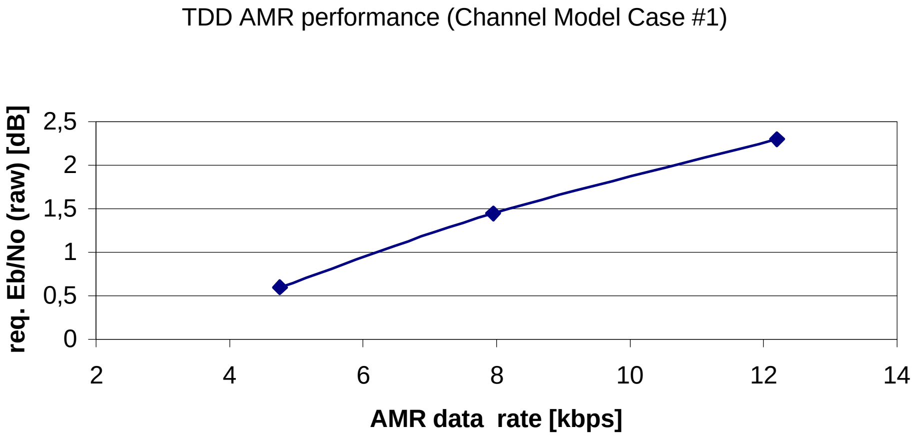

Figure 3: Required Eb/No (raw) versus AMR data rate

The AMR performance covers a range of 1,7 dB from the lowest to highest data rate for the required Eb/No (raw), that means for the needed energy for a bit "on air".

6. Conclusion

The presented simulation results show, that the a mothercode of 1/3 should be used for the convolutional coding of AMR speech modes with data rates of 7,95 kbps and below for both bit classes. Especially the better protected class A will have a performance gain of up to 0,4 dB by maintaining the same overall coderate when using 1/3 instead of 1/2 with a high repetition rate.

7. References

[1] 3GPP TSG RAN WG1 Multiplexing and channel coding (TDD) TS25.222 V2.2.0 1999-09

[2] 3GPP TS 26.101 AMR speech codec frame structure; General description TS26.101 V1.4.0 1999-10

[3] "Link peformance of UEP for AMR encoded speech services (TDD)", Source: Siemens , TSGR1#8(99)g40