TSG-RAN WG1 meeting #7 **TSG WG1#7 (99) b85**
Hannover, Germany 30.8-3.9.1999

Source: Nokia

Effect of EEP and UEP on channel coding for AMR

1. Introduction

This study report is produced due to the recent arguments regarding the necessity of unequal error protection (UEP) to effectively support AMR speech codec in the 3rd generation WCDMA system. This report includes some simulation results comparing the difference between unequal and equal error protection schemes applied on AMR codec's 12.2 kbps mode. The result shows quite clear gain of UEP over EEP in terms of power savings.

2. General description of simulation

The AMR speech codec at 12.2 kbps mode produces 244 speech bits per 20 ms frame. Table 1 and 2 show the bit arrangement made for UEP and EEP channel coding.

Table 1: Bit allocation for EEP

Operation	Number of resultant bits per 20 ms frame
Number of speech bits delivered per 20 ms frame	244
Addition of 8-bit application CRC computed over 81 most important bits	8 + 81 + 163 = 252
Addition of 8-bit system CRC computed over whole frame	8 + 252 = 260
8-bit tail addition and rate 1/3 convolutional coding	(260 + 8) x 3 = 804

Table 2: Bit allocation for UEP

Operation	Number of resultant bits per 20 ms frame		
Number of speech bits delivered per 20 ms frame	244		
Separation into classes	Class A 81 bits	Class B 103 bits	Class C 60 bits
Addition of 8-bit application and system CRC computed over class A	8+81 = 89	103	60
8-bit tail addition and convolutional coding (rate 1/3 for class A and B and 1/2 for class C)	(89 + 8) x 3 = 291	(103 + 8) x 3 = 333	(60 + 8) x 2 = 136
Rate matching (puncturing/repetition)	291 + 88 = 379 (+30%)	333 - 33 = 300 (-10%)	136 - 11 = 125 (-8%)
Resultant	804		

2.1 Simulation Environment and Parameters

The simulation is done using a COSSAP® down-link WCDMA chain. The simulation parameters are listed below:

- Down-link Physical channel
- Spreading factor (SF) = 128
- Channel bit rate = 64 kbps
- Channel symbol rate = 32 ksps
- Simulation length 15 sec
- Mobile speed 120 km/hr (Vehicular A)
- Power control step 1 dB, 4% TPC command error
- Number of other users 20
- Real channel estimation, two slot average
- DPCCH and DPDCH equal power
- 16 slots per 10 ms
- DPCCH has 8 pilot and 2 TPC bits per slot
- Chip rate 4.096 MHz

2.2 Simulation Results

Following figures show the results of the simulation. Before that different terms are explained here.

FER_EEP: the frame error rate detected by 8-bit application CRC computed over 81 class A bits (EEP); used for bad frame handling by speech decoder.

PFER_EEP: the frame error rate detected by 8-bit system CRC computed over whole frame and used for outer loop power control (EEP)

FER_A_UEP: the frame error rate of class A in UEP. Used both for bad frame handling and power control.

FER_B_UEP: FER of class B in UEP (single bit error means frame error; however this FER is not calculated or used in real life)

FER_C_UEP: FER of class C in UEP (single bit error means frame error, this FER is also not calculated or used in real life)

BER_EEP: bit error rate in case of EEP (whole frame including application and system CRCs)

RBER_EEP: residual bit error rate in case of EEP. BER is calculated for frames detected as GOOD FRAME by application CRC

BER_A_UEP: BER of class A and 8-bit CRC in UEP

BER_B_UEP: BER of class B in UEP

BER_C_UEP: BER of class C in UEP

Es/No: energy required to transmit each coded bit

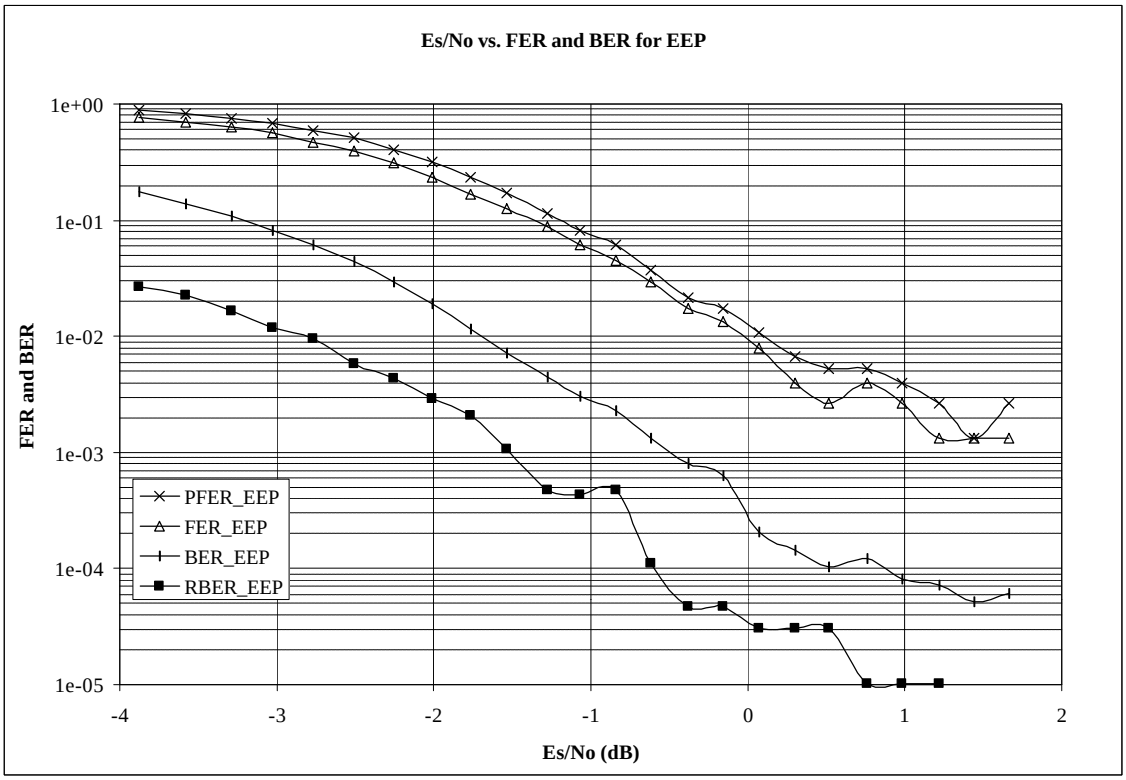

Figure 1: Es/No for EEP

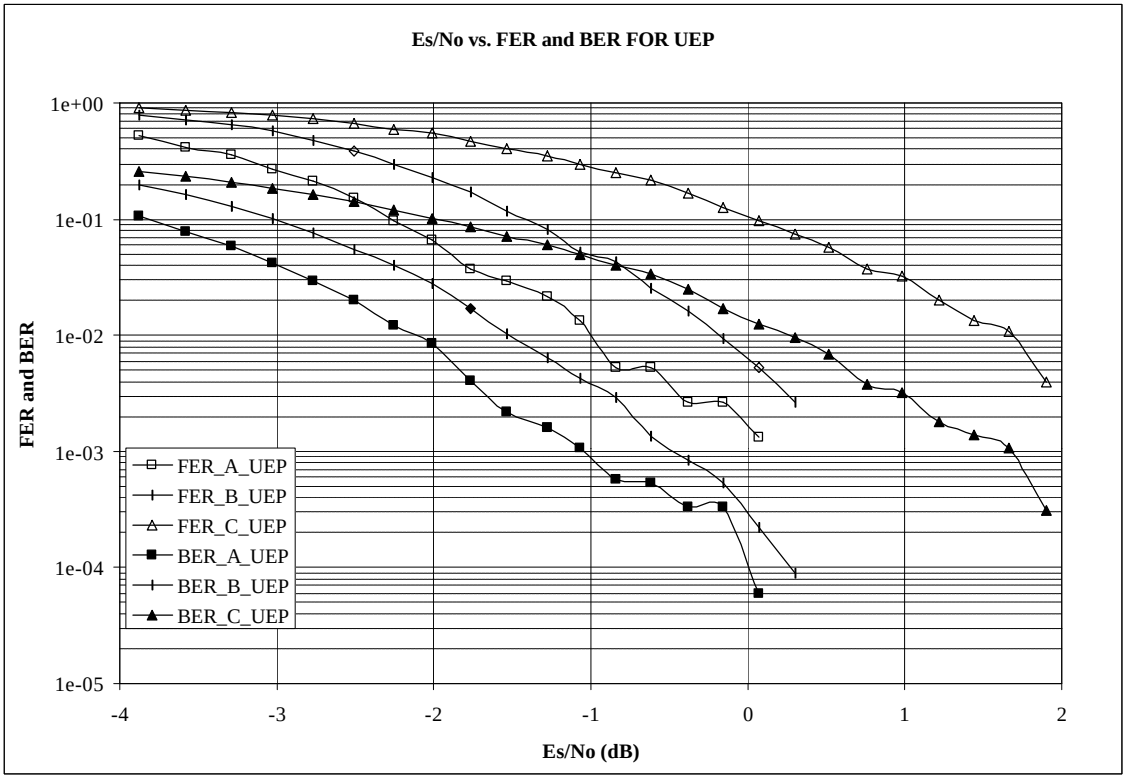

Figure 2: Es/No for UEP

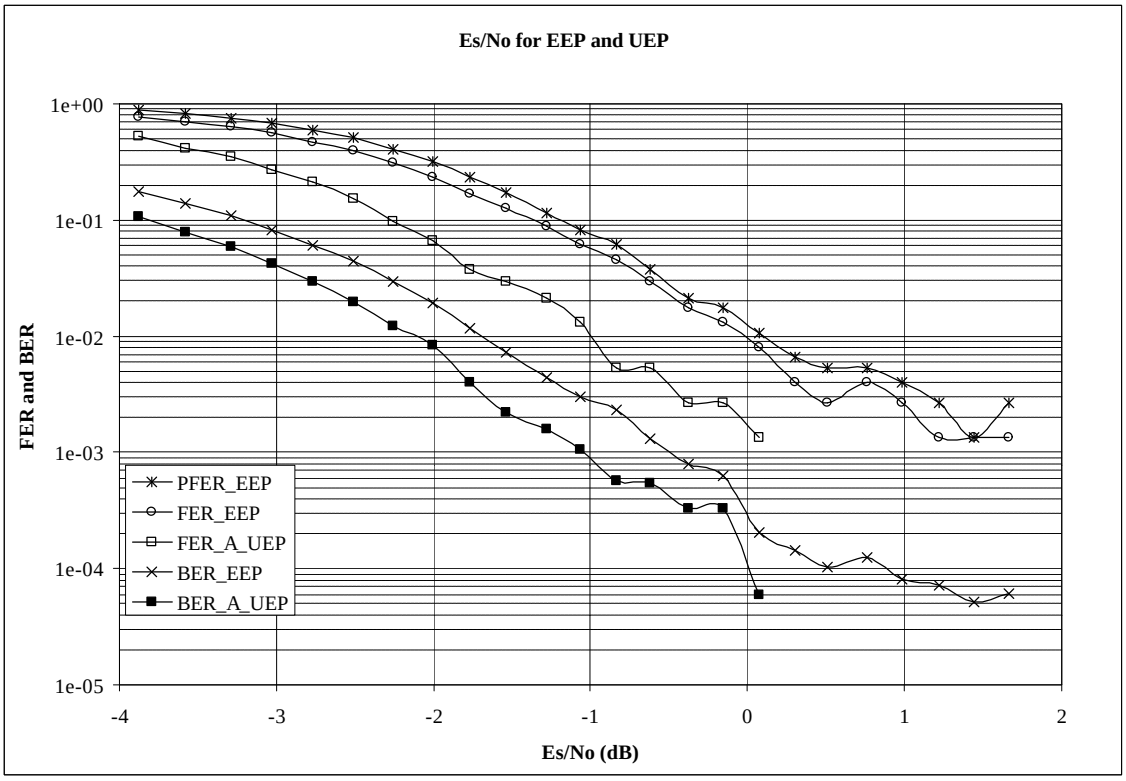

Figure 3: Es/No for EEP and UEP

3. Discussion

In this UEP design the BER of class A is around1e-4, BER of Class B is around 3e-4 and BER of Class C is around 1e-2 (Ref figure 2 at Es/No 0 dB). This almost meets the requirement understood previously by codec experts. By comparing the Es/N0 required for with this design to EEP with BER=1e-4, the gain in Es/N0 is around 0.5 dB.

The difference in Es/N0s if FER_EEP is compared to FER_A_UEP is around 0.9 dB at a level of 1% frame error rate, which is considered maximum allowable FER by codec experts.

Actual speech samples were used in the simulation and it was found that at the same Es/No value, samples coded by UEP have better quality than samples coded by EEP.

These simulations contained only 15000 frames. It is necessary to increase the simulation length extensively to get more accurate curves at low BER levels. Here we can however already see the tendency.

4. Conclusion of the simulation results

These simulation result shows a clear advantage of UEP over EEP coding schemes applied on AMR 12.2 kbps mode and down-link channel.

Thus we would like to see that UEP with AMR is included into Release '99.

5. Proposal how to proceed with this AMR/UEP issue in WG1

Following things need to be decided in this AMR / UEP area in WG1. Here are some suggestions how to proceed, and reasons why we propose this particular way forward.

	Item	Proposal how to proceed	Argumentation why
1	Do we include UEP with AMR into release '99	- make a decision on this issue in WG1 # 7 meeting and then present the decision in next RAN meeting. - Our proposal: AMR/UEP should be included to release 99	- this decision affects many other WGs in RAN, so this should be decided soon. - Simulation results from different companies show that gain can be achieved with UEP over EEP.

And if the decision is that we decide to include UEP with AMR into release '99, then next questions are:

	Item	Proposal how to proceed	Argumentation why
2	How many transport channels (max) is reserved for AMR from the physical layer?	- Our proposal: 3 transport channels, one for each bitClass (A, B and C)	- This gives the maximum flexibility for UEP.
3	Can we use only one CRC (layer 1 CRC), or is the application CRC for Class A also needed ?	- Our WG3 delegates told that it should be possible that L1 CRC check result is passed up to the codec. Thus only one CRC is	- minimising the CRC overhead.

		needed: Layer 1 CRC attached to Class A bits. => however this needs a liaison statement to WG3.	
4	In what level we specify this UEP coding for AMR	Our proposal: - define the possible parameter values for coding rates and rate matching factors: e.g. coding 1/3, ½, rate matching with max. 20 % puncturing. All these allowed for all bit classes. - With the requirement that within the same class the rate matching factor stays the same even if the mode changes. Otherwise the BRD will be more complex. - Then network operator can choose which parameters it uses for each bit class.	Time schedule problem: It seems impossible to define the exact coding rates + rate matching factors by the end of this year. Especially since different companies have different opinions what QoS we should have for different Classes.
5	In what cases is it mandatory for UEs to support BRD for voice	- See our contribution b86: If the WG1 agrees with us that it is important to allow to fit AMR + signaling to SF=256 in downlink, then it is beneficial if UE support BRD for AMR + signaling with flexible positions - If the WG1 thinks that support of BRD for SF=256 case is not such important, then the support of BRD should be mandatory for AMR + signaling with fixed positions which is the case in SF=128.	This is important for mobile manufacturers to know what is required in BRD area.
6	Anything else?	-	