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RAB Design using ECSD channel coding

1 Introduction

GERAN R'00 will provide a dedicated unacknowledged radio bearer towards the Iu-ps interface. This bearer could be used by services having a fairly constant bit rate, e.g. streaming.

In this document, we will present an RLC-layer proposal and parameters for the dedicated unacknowledged bearer. The physical layer is proposed to be based on the circuit switched coding schemes since they give good performance in terms of bit error rate due to the robust coding and long interleaving.

The content of this paper was first presented in [1], the paper is updated with simulation results on TCH/F9.6 and TCH/F14.4.

2 Proposal

2.1 Physical layer

The circuit switched data rates, including the EDGE circuit switched data rates, offer a wide range of data rates. The long interleaving and the robust coding make them an excellent choice for streaming services. TCH/F9.6 and TCH/F14.4 are two examples of coding schemes giving low data rates at low C/I.

	TCH/F9.6	**TCH/F14.4**
Nr of payload bits	240	290
Nr of coded bits	488	588
Nr of punctured bits	32	132

Table 1. Code parameters for the circuit switched data rates.

The ECSD coding scheme includes three data rates; 28.8 kbps, 32.0 kbps, and 43.2 kbps. They are denoted E-TCH/F28.8, E-TCH/F32.0, and E-TCH/F43.2 respectively. All three coding schemes use a rate r=1/2 convolutional code with memory 6 and diagonal interleaving over 22 bursts. In addition to the convolutional code, E-TCH/F28.8 and E-TCH/F32.0 use a Reed-Solomon code over GF(2^8) to attain a more robust coding, see Table 2 for details on code parameters. In ECSD, some bits of the payload are used as control bits for E-TCH/F28.8 and E-TCH/F43.2. The number of coded bits after puncturing is 1368 in ECSD.

We propose that TCH/F9.6, TCH/F14.4, E-TCH/F28.8, E-TCH/F32.0, and E-TCH/F43.2 are used on dedicated unacknowledged channels for streaming services. The RLC header defined in Section 2.3 is concatenated with the data part of the payload and fitted into the radio block, the payload bit stream can if necessary be truncated to fit both data and header into the block to be encoded.

	E-TCH/F28.8	E-TCH/F32.0	E-TCH/F43.2
Nr of user data bits	576	640	864
Nr of payload bits	584	640	870
RS code	RS(85,73)	RS(92,80)	-
Nr of coded bits	1372	1484	1752
Nr of punctured bits	4	116	384

Table 2. Code parameters for the ECSD data rates.

2.2 RLC design

The RLC-layer for ECSD based bearers operates in unacknowledged mode and it is designed similarly to the unacknowledged RLC-design in UMTS [1]. The purpose of not reusing the RLC/MAC-header in EGPRS is to avoid protocol-overhead. Thus, we propose a reduced RLC-header that only consists of the following fields

- Block Sequence Number (BSN),
- Length Indicator (LI), and
- Extension bit (E).

The RLC-PDU is assembled in the following fashion depicted in Figure 1.

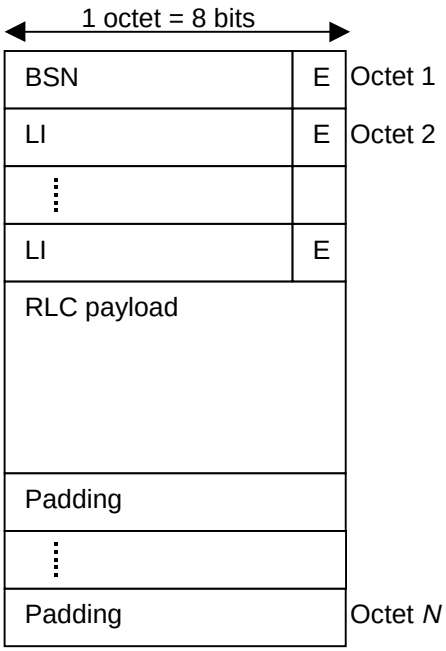

Figure 1. RLC PDU for unacknowledged operation. The header consists of a block sequence number (BSN), a number of length indicators (LI), and extension bits (E).

The proposed header will provide both framing and segmentation and reassembly under the assumption that the RLC-layer is given a higher-layer SDU as a packet and not as a bit-stream.

The RLC payload's size depends on the header-size. The header-size will depend on the number of higher-layer SDUs that are carried in one RLC PDU since each SDU

requires an LI and an E bit. Thus, the payload has to be truncated to fit into the RLC PDU size for the chosen coding scheme.

2.2.1 Block sequence number

The block sequence number consists of 7 bits and this gives 128 different BSNs. The BSN is used to secure detection of missing RLC PDUs. A missing RLC PDU will otherwise result in an erroneous RLC SDU which is delivered to the higher protocol layer without further actions.

2.2.2 Length indicator

The length indicator field is 7 or 15 bits long depending on which coding scheme that is used. All coding schemes (E-TCH/F28.8, E-TCH/F32.0, and E-TCH/F43.2) except GERAN58.8 require only a 7 bit LI since they offer ≤ 125 octets payload. (See below for definition of GERAN58.8.) However, as explained below, a GERAN58.8 RLC PDU is 1176 bits long and thus it cannot be fully addressed by 7 bits. Instead, 15 bits are used for LI for GERAN58.8.

The LI contains the number of octets counting from the last LI to the last bit in the corresponding higher-layer SDU segment. The order of the LIs in the header must be identical to the order of the higher-layer SDU segments mapped on the RLC PDU.

2.2.3 Extension bit

The extension bit is 1 if more length-indicator fields follow, otherwise it is 0. The E-bit's purpose is to delimit the header.

2.3 New data rates

The data rates supported by the circuit switched coding schemes are in the range 9.6 kbps to 43.2 kbps. To support higher data rates a few additional coding schemes based on the ECSD coding schemes could be designed. We have designed one additional coding schemes denoted GERAN58.8, see Table 3 for details on code parameters. The data rate is chosen to support a user data rate of approximately 56 kbps. The physical layer data rate is somewhat higher to make room for the RLC header.

	GERAN58.8
Nr of payload bits	1176
RS code	-
Nr of coded bits	2364
Nr of punctured bits	996

Table 3. Code parameters for the new proposed data rate.

This new data rate is easily added to the other three if there is a need for support of additional data rates. Since it is based on the ECSD coding scheme and use the same interleaving, the impact on the standard is considered to be small.

2.4 User data rates

The number of payload bits available for each coding scheme is denoted in Tables 1, 2, and 3. The user data rates will be somewhat smaller since the RLC header has to be fitted into the payload as well. The header will be at least one octet long, see Section 2.3. The total header length depends on the length of the PDCP blocks arriving to the RLC protocol layer.

3 Simulations results

To measure the performance of the proposed coding schemes, they have been simulated on a TU3 channel with ideal frequency hopping. Detailed results are presented in Annex A.

The performance in terms of C/I at 0.1% bit error rate and 10% block error rate are given in Table 4. The radio interface data rates given in the table are the data rates on the air interface. The user data rate depends on the header size which was explained in more detail above. If an RLC SDU is larger than the RLC PDU, the header will be 16 bits at most times. The user data rates in Table 4 assume that the header is 16 bits.

	Appr. user data rate	**Radio interface data rate**	**BER=0.001 (dB)**	**BLER=0.1 (dB)**
TCH/F9.6	11.2 kbps	12.0 kbps	7.4	6.2
TCH/F14.4	13.7 kbps	14.5 kbps	9.4	8.3
E-TCH/F28.8	28.4 kbps	29.2 kbps	14.6	11.3
E-TCH/F32.0	31.2 kbps	32.0 kbps	14.8	12.4
E-TCH/F43.2	42.7 kbps	43.5 kbps	16.5	15.9
GERAN58.8	58.0 kbps	58.8 kbps	24.0	23.4

Table 4. Performance in terms of C/I at 0.1% bit error rate and 10% block error rate.

4 Conclusions

We propose circuit switched coding schemes to realize radio bearers for dedicated unacknowledged mode. Coding, puncturing, and interleaving are easily reused from the coding schemes TCH/F9.6, TCH/14.4, E-TCH/F28.8, E-TCH/F32.0, and E-TCH/F43.2 to attain data rates ranging from 11 kbps to 43 kbps. To achieve a wider range of data rates, one additional coding scheme is proposed. It is based on the ECSD coding scheme and uses the same interleaving. Since there is no need for a full EGPRS RLC/MAC header, an optimized RLC header is fitted into the payload and encoded together with user data.

We propose that the coding schemes TCH/F9.6, TCH/F14.4, E-TCH/F28.8, E-TCH/F32.0, E-TCH/F43.2, and GERAN58.8 together with the RLC design presented in Section 2.3 are used for unacknowledged bearer on dedicated channels.

5 Reference

[1] “RAB Design Using ECSD Channel Coding”, Tdoc GERAN 063/00, Helsinki, Finland, August 7 – 11, 2000, source Ericsson.

[2] 3G TS 25.322 V3.3.0, Technical Specification, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; RLC Protocol Specification, (Release 1999).

Annex A Simulation Results

Simulation results are presented for each data rate in Figures 2 – 7.

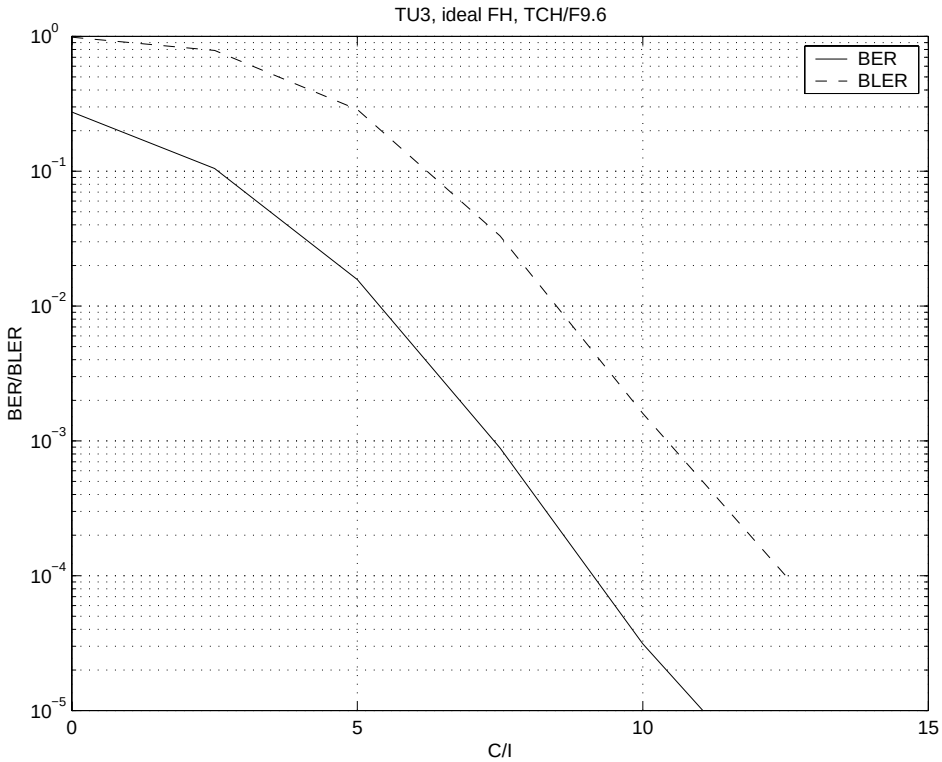

Figure 2. Bit error rate and block error rate for TCH/F9.6.

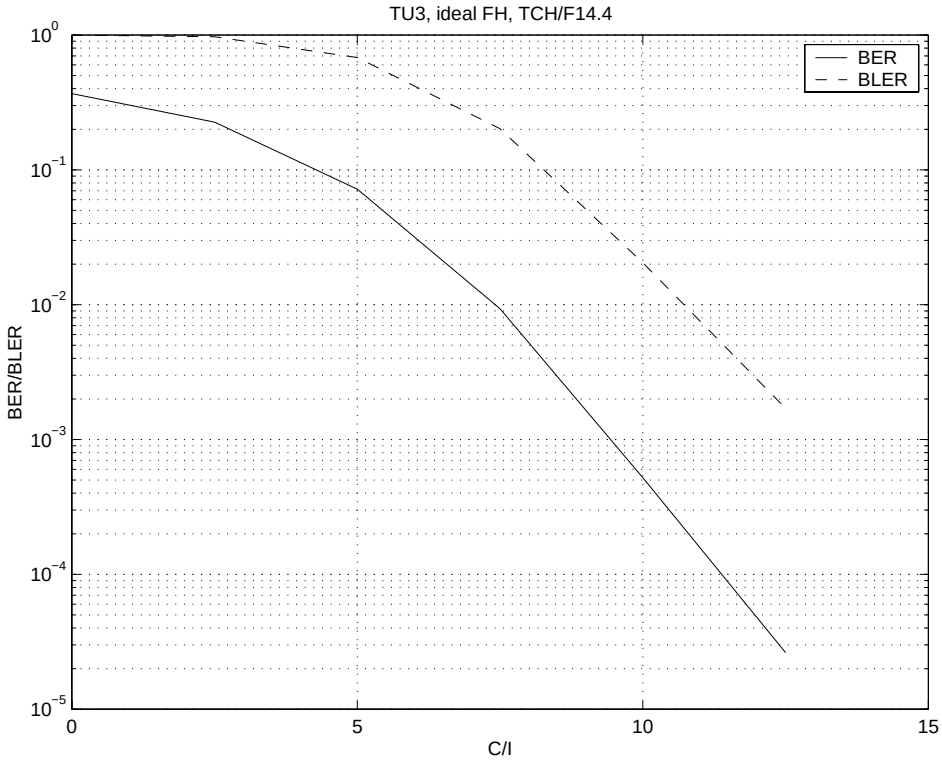

Figure 3. Bit error rate and block error rate for TCH/F14.4.

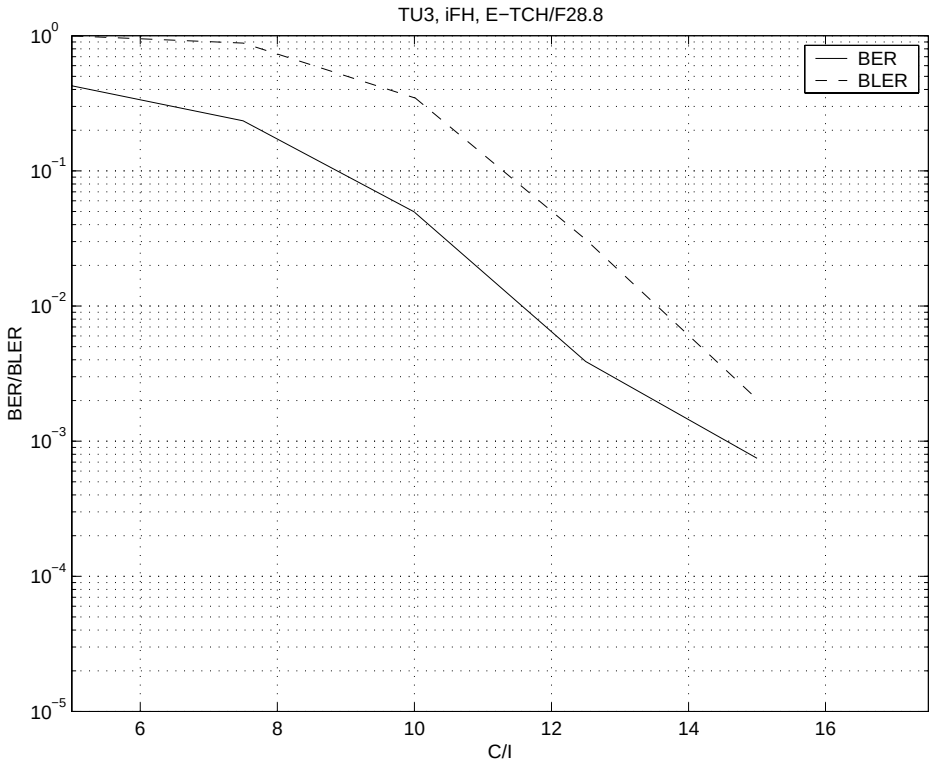

Figure 4. Bit error rate and block error rate for E-TCH/F28.8.

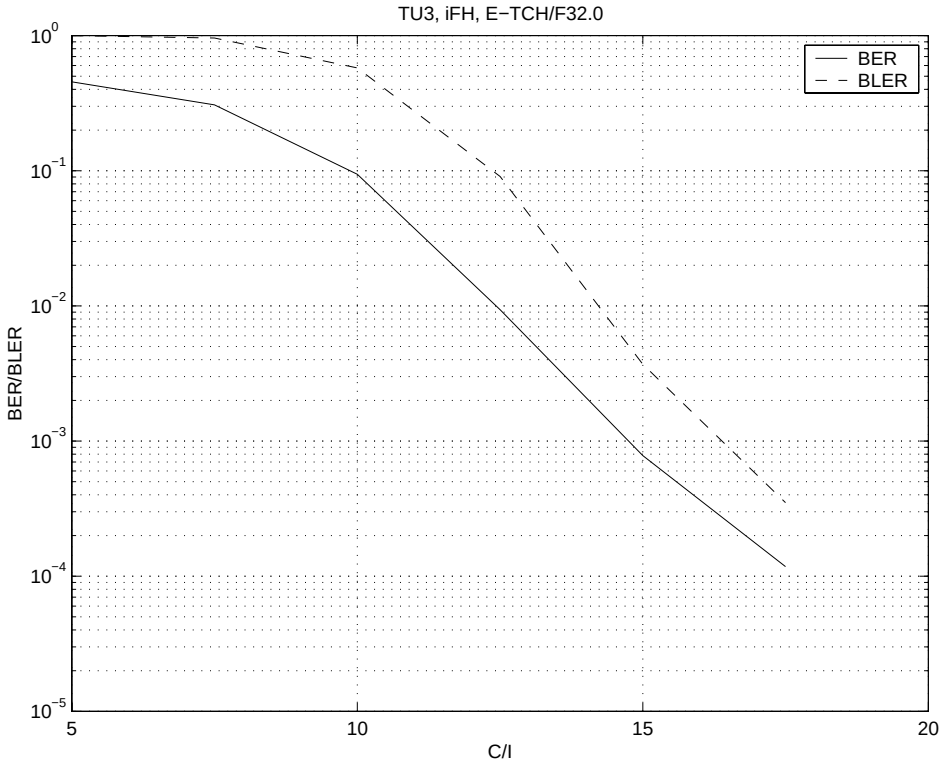

Figure 5. Bit error rate and block error rate for E-TCH/F32.0.

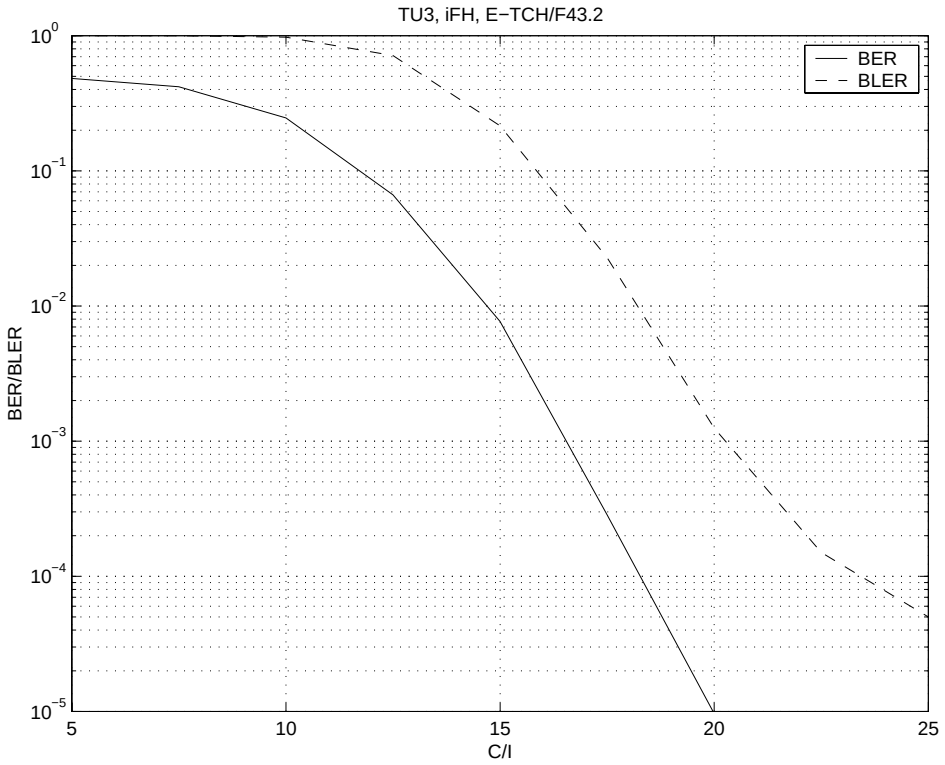

Figure 6. Bit error rate and block error rate for E-TCH/F43.2.

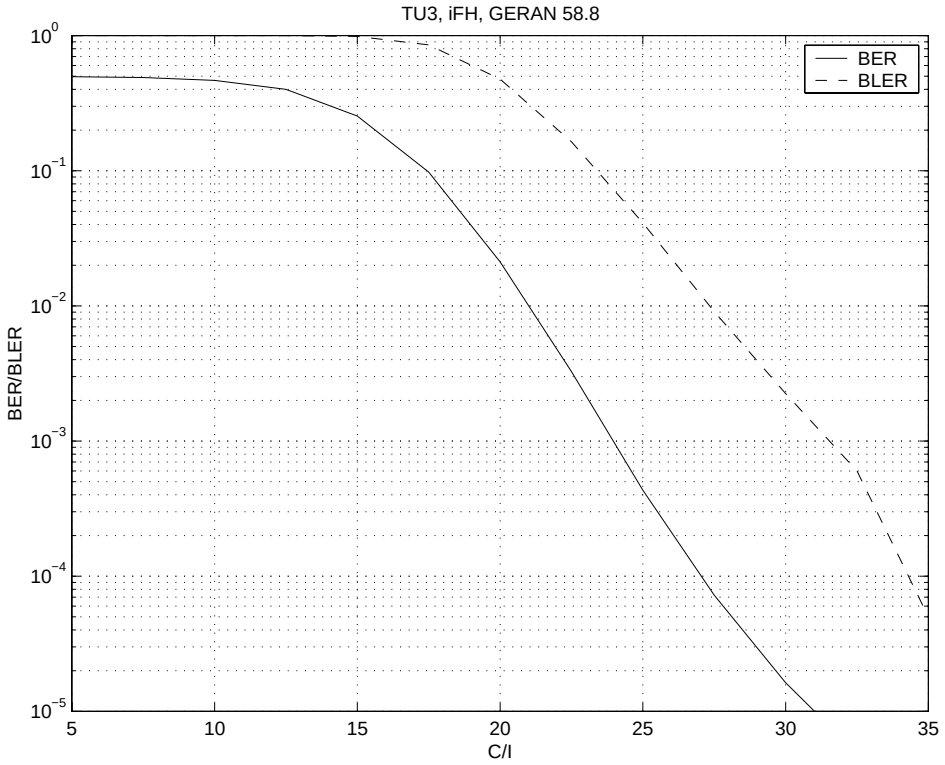

Figure 7. Bit error rate and block error rate for GERAN58.8.