TSG-RAN Working Group1 meeting #7 **TSGR1#7(99)D58**
30 August – 3 September 1999
Hanover, Germany

Agenda item: **AH4 Text proposals**

Source: **QUALCOMM Europe**

Title: **Revised text proposal for radio frame equalization, 1st interleaving and radio frame segmentation**

Document for: **Decision**

Introduction

This is an updated version of the text proposal presented in Tdoc R1-99B05 and approved in principle by AH04. The revision is mostly editorial so that the notation is aligned with the one suggested in Tdoc R1-99B29 and approved by AH04. In contrast to the original proposal this revised scheme is only applicable in the UL (the present proposal assumes that the rate matching scheme described in Tdoc R1-99B80 is approved).

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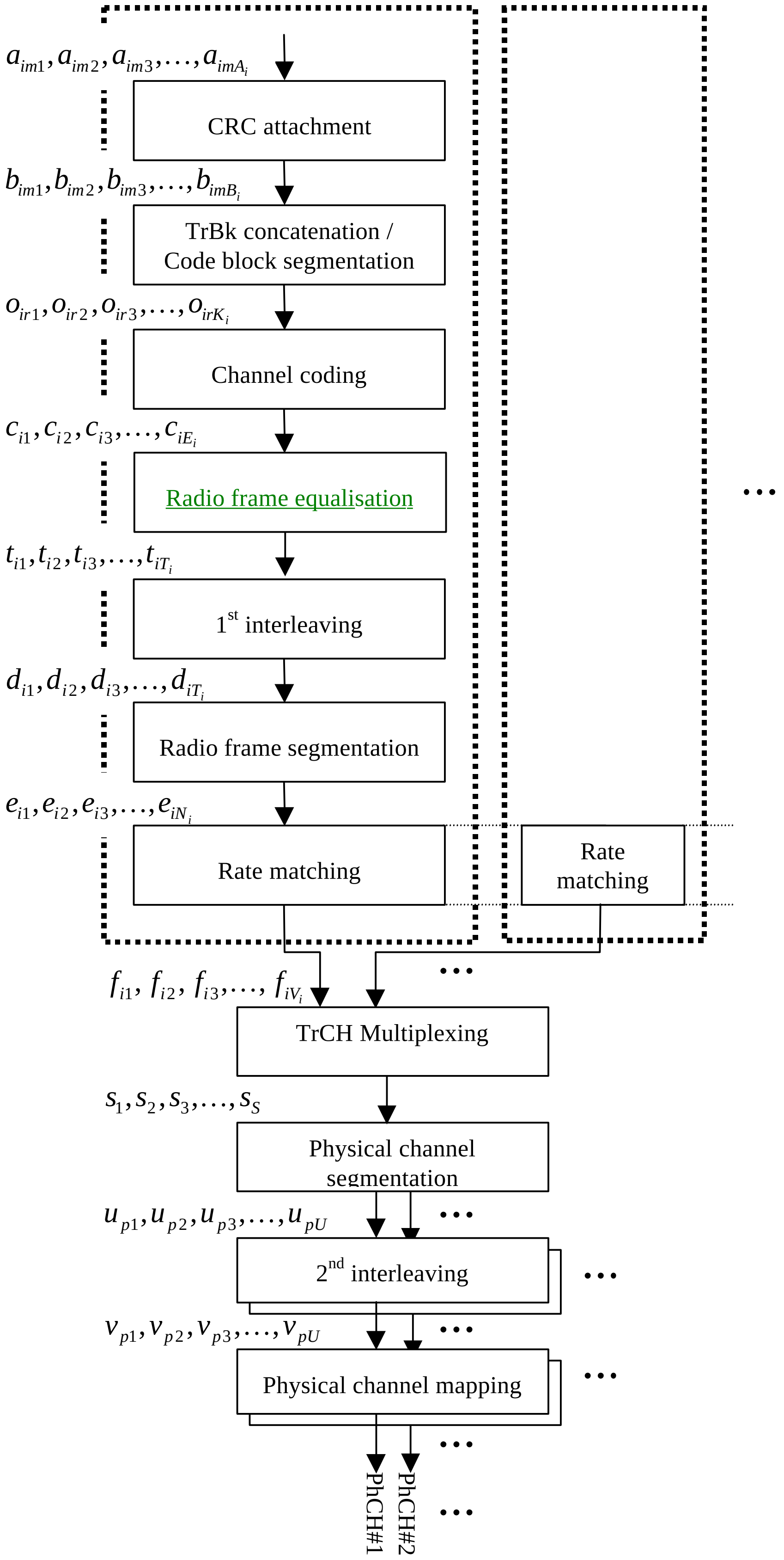
4.2 Transport-channel coding/multiplexing



$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$
CRC attachment
$b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$
TrBk concatenation / Code block segmentation
$o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$
Channel coding
$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$
Radio frame equalisation
$t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$
1st interleaving
$d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$
Radio frame segmentation
$e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$
Rate matching
Rate matching
$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$
TrCH Multiplexing
$s_1, s_2, s_3, \ldots, s_S$
Physical channel segmentation
$u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU}$
2nd interleaving
$v_{p1}, v_{p2}, v_{p3}, \ldots, v_{pU}$
Physical channel mapping
PhCH#1
PhCH#2

Figure 1. Transport channel multiplexing structure for uplink.

4.2.4 Radio frame size equalisation

Radio frame size equalisation is padding the input bit sequence in order to ensure that the output can be segmented in F_i data segments of same size as described in section 4.2.6. Radio frame size equalisation is only performed in the UL (DL rate matching output block length is always an integer multiple of F_i)

The input bit sequence to the radio frame size equalisation is denoted by $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where i is TrCH number and E_i the number of bits. The output bit sequence is denoted by $t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$, where T_i is the number of bits. The output bit sequence is derived as follows:

$t_{ik} = c_{ik}$, for k = 1… E_i and

$t_{ik} = \{0 \mid 1\}$ for k= E_i +1… T_i, if $E_i < T_i$

where

$T_i = F_i * N_i$ and

$N_i = \lfloor (E_i - 1)/F_i \rfloor + 1$ is the number of bits per segment after size equalisation.

~~4.2.4~~4.2.5 1st interleaving

The 1st interleaving is a block interleaver with inter-column permutations.~~of channel interleaving consists of two stage operations.~~ The input bit sequence to the 1st interleaver is denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$, where i is TrCH number and X_i the number of bits (at this stage X_i is assumed and guaranteed to be an integer multiple of TTI). ~~In first stage, the input sequence is written into rectangular matrix row by row. The second stage is inter-column permutation. The two-stage operations are described as follows, the input block length is assumed to be K_1.~~ The output bit sequence is derived as follows:

~~**First Stage:**~~

(1) Select ~~a~~ the ~~column~~ number of columns ~~C_1~~ C_I from ~~Table 1~~Table 4-3.

(2) Determine ~~a~~ the ~~row~~ number of rows ~~R_1~~ R_I defined as ~~by finding minimum integer R_1 such that,~~

$R_I = X_i/C_I$ ~~$K1 <= R_1 \times C_1$.~~

(3) ~~(3)~~ Write ~~T~~the input bit sequence ~~of the 1st interleaving is written~~ into the ~~R_1~~ R_I × ~~C_1~~ C_I rectangular matrix row by row starting with bit $x_{i,1}$ in the first column of the first row and ending with bit $x_{i,(R_I C_I)}$ in column C_I of row R_I:~~.~~

$$\begin{bmatrix} x_{i1} & x_{i2} & x_{i3} & \ldots & x_{iC_I} \\ x_{i,(C_I+1)} & x_{i,(C_I+2)} & x_{i,(C_I+3)} & \ldots & x_{i,(2C_I)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ x_{i,((R_I-1)C_I+1)} & x_{i,((R_I-1)C_I+2)} & x_{i,((R_I-1)C_I+3)} & \ldots & x_{i,(R_I C_I)} \end{bmatrix}$$

~~**Second Stage:**~~

(4~~1~~) Perform the inter-column permutation based on the pattern $\{P_1(j)\}$ (j=0,1, ..., C-1) ~~that is~~ shown in Table 4-3, where $P_1(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by y_{ik}:

$$\begin{bmatrix} y_{i1} & y_{i,(R_I+1)} & y_{i,(2R_I+1)} & \cdots y_{i,((C_I-1)R_I+1)} \\ y_{i2} & y_{i,(R_I+2)} & y_{i,(2R_I+2)} & \cdots y_{i,((C_I-1)R_I+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{iR_I} & y_{i,(2R_I)} & y_{i,(3R_I)} & \cdots & y_{i,(C_I R_I)} \end{bmatrix}$$

(~~2~~5) Read ~~T~~the output bit sequence $y_{i1}, y_{i2}, y_{i3}, \ldots, y_{i,(C_I R_I)}$ of the 1st interleaving ~~is the sequence read out~~ column by column from the inter-column permuted $R_I \times C_I$ ~~$R_1 \times C_1$~~ matrix. Bit $y_{i,1}$ corresponds to the first row of the first column and bit $y_{i,(R_I C_I)}$ corresponds to row R_I of column C_I. ~~and the output is pruned by deleting the non-existence bits in the input sequence, where the deleting bits number l_1 is defined as:~~

~~$l_1 = R_1 \times C_1 - K_1$.~~

Table 4-3

~~Interleaving span~~TTI	~~Column n~~Number of columns C_I ~~C_1~~	Inter-column permutation patterns
10 ms	1	{0}
20 ms	2	{0,1}
40 ms	4	{0,2,1,3}
80 ms	8	{0,4,2,6,1,5,3,7}

4.2.5.1 Relation between input and output of 1st interleaving in uplink

The bits input to the 1st interleaving are denoted by $t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$, where i is the TrCH number and E_i the number of bits. Hence, $x_{ik} = t_{ik}$ and $X_i = T_i$.

The bits output from the 1st interleaving are denoted by $d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$, and $d_{ik} = y_{ik}$.

4.2.5.2 Relation between input and output of 1st interleaving in downlink

If fixed positions of the TrCHs in a radio frame is used then the bits input to the 1st interleaving are denoted by $h_{i1}, h_{i2}, h_{i3}, \ldots, h_{i(F_i H_i)}$, where i is the TrCH number. Hence, $x_{ik} = h_{ik}$ and $X_i = F_i H_i$.

If flexible positions of the TrCHs in a radio frame is used then the bits input to the 1st interleaving are denoted by $g_{i1}, g_{i2}, g_{i3}, \ldots, g_{iG_i}$, where i is the TrCH number. Hence, $x_{ik} = h_{ik}$ and $X_i = G_i$.

The bits output from the 1st interleaving are denoted by $q_{i1}, q_{i2}, q_{i3}, \ldots, q_{iQ_i}$, where i is the TrCH number and Q_i is the number of bits. Hence, $q_{ik} = y_{ik}$, $Q_i = F_i H_i$ if fixed positions are used, and $Q_i = G_i$ if flexible positions are used.

4.2.54.2.6 Radio frame segmentation

When the transmission time interval is longer than 10 ms, the input bit sequence is segmented and mapped onto consecutive radio frames. Following rate matching in the DL and radio frame size equalisation in the UL the input bit sequence length is guaranteed to be an integer multiple of F_i.

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The Fi output bit sequences per TTI are denoted by $y_{i,n_i1}, y_{i,n_i2}, y_{i,n_i3}, \ldots, y_{i,n_iY_i}$ where n_i is the radio frame number in current TTI and Y_i is the number of bits per radio frame for TrCH i. The output sequences are defined as follows:

$y_{i,n_ik} = x_{i,((n_i-1)Y_i)+k}$, $n_i = 1\ldots F_i$, $j = 1\ldots Y_i$

where

$Y_i = (X_i / F_i)$ is the number of bits per segment,

x_{ik} is the k^th^ bit of the input bit sequence and

y_{i,n_ik} is the k^th^ bit of the output bit sequence corresponding to the n^th^ radio frame

The n_i -th segment is mapped to the n_i -th radio frame of the transmission time interval.

4.2.6.1 Relation between input and output of the radio frame segmentation block in uplink

The input bit sequence to the radio frame segmentation is denoted by $d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{ik} = d_{ik}$ and $X_i = T_i$.

The output bit sequence corresponding radio frame n_i is denoted by $e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$, where i is the TrCH number and N_i is the number of bits. Hence, $e_{i,k} = y_{i,n_ik}$ and $N_i = Y_i$.

4.2.6.2 Relation between input and output of the radio frame segmentation block in downlink

The bits input to the radio frame segmentation are denoted by $q_{i1}, q_{i2}, q_{i3}, \ldots, q_{iQ_i}$, where i is the TrCH number and Q_i the number of bits. Hence, $x_{ik} = q_{ik}$ and $X_i = Q_i$.

The output bit sequence corresponding to radio frame n_i is denoted by $f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$, where i is the TrCH number and V_i is the number of bits. Hence, $f_{i,k} = y_{i,n_ik}$ and $V_i = Y_i$.

Each transport channel with transmission time interval 10, 20, 40, or 80 msec is segmented into 10 msec equi-sized data blocks. Those segmented 1, 2, 4, or 8 blocks, depending on transmission time interval, are output to rate matching for uplink and 2nd multiplexing for downlink in block-wise order at every 10 msec. Figure B-1 and B-2 illustrate data flow from 1st interleaver down to 2nd interleaver in both uplink and downlink channel coding and multiplexing chains. In the figures, it is assumed that there are N different channel coding and multiplexing chains. The following subsections describe input-output relationship of radio frame segmentation in bit-wise manner, referring to the notations in Figure B-1 and B-2, where the notations in each data block, for examples L_1, R_1, K_1, P/M, etc., indicate number of bits of the data block. Define some notations:

L_i = Size of i^{th} transport channel data in bits to radio frame segmentation

T_i = Transmission Time Interval of i^{th} channel coding and multiplexing chain (msec) / 10 (msec)

So, T_i Î {1, 2, 4, 8} for i = 0, 1, 2, .., N

4.2.5.1 Radio frame size equalization

i^{th} transport channel data of size L_i is segmented into radio frames of size L_i/T_i. Since the size of radio frame, L_i/T_i is not necessarily an integer, some of T_i the radio frames will contain one bit less than others. For systematic process of the proceeding functional blocks, the radio frame sizes are equalized to be one finite size by considering the number of proper filler bits. Note that maximum possible filler bits are 7 for transmission time interval of 80 msec. These filler bits are evenly distributed over the one-bit short radio frames. Following is the algorithm of radio frame size equalization.

t = radio frame index (1, 2, 3, ., T_i) for a given i^{th} channel coding and multiplexing chain

$r_i = T_i - (L_i \bmod T_i)$ Î {0, 1, 2, ., T_i-1} // number of filler bits

$(L_i + r_i)/T_i = R_i$ // Target radio frame size for uplink

$(L_i + r_i)/T_i = K_i$ // Target radio frame size for downlink

If ri ¹ 0 then

For each t (³ T_i-r_i+1)

Add one filler bit to the end of t^{th} radio frame

End

End If

4.2.5.2 Radio frame segmentation rule

Parameter r_i for segmentation are determined in radio frame size equalization.

The bits before radio frame segmentation for i^{th} channel coding and multiplexing chain are denoted by:

$b_{i1}, b_{i2}, \ldots b_{iL_i}$

Bits after radio frame segmentation block are 10 msec-based and denoted by:

$c_{i1}, \ldots c_{i,(L_i+r_i)/T_i}$

and related to the input bits to radio frame segmentation as follows.

Bits after radio frame segmentation in the first 10 msec time interval: *(t=1)*

$c_{ij} = b_{ij}$ $\quad j=1,2, ., (L_i+r_i)/T_i$

($(L_i + r_i)/T_i$ equals to R_i and K_i for uplink and downlink, respectively.)

Bits after radio frame segmentation in the second 10 msec time interval: *(t=2)*

$c_{ij} = b_{i,(j+(L_i+r_i)/T_i)}$ $\quad j=1,2, ., (L_i+r_i)/T_i$

…

Bits after radio frame segmentation in the $(T_i - r_i)^{th}$ 10 msec time interval: *$(t=T_i-r_i)$*

$c_{ij} = b_{i,(j+(T_i-r_i-1)\cdot(L_i+r_i)/T_i)}$ $\quad j=1,2, ., (L_i+r_i)/T_i$

Bits after radio frame segmentation in the $(T_i - r_i+1)^{th}$ 10 msec time interval: *$(t=T_i-r_i+1)$*

$c_{ij} = b_{i,(j+(T_i-r_i)\cdot(L_i+r_i)/T_i)}$ $\quad j=1,2, ., (L_i+r_i)/T_i-1$

c_{ij} = filler_bit(0/1) $\quad j= (L_i+r_i)/T_i$ $\quad$ (filler bit)

…

Bits after radio frame segmentation in the T_i^{th} 10 msec time interval: *$(t=T_i)$*

~~$c_{ij} = b_{i,(j+(T_i-1)\cdot(L_i+r_i)/T_i)}$ $j=1,2,\ldots,(L_i+r_i)/T_i-1$~~

~~c_{ij} = filler_bit(0/1) $j=(L_i+r_i)/T_i$ (filler bit)~~

Annex B (informative): Data flow from radio frame segmentation to physical channel segmentation

Remove Annex B