TSG-RAN Working Group 1 meeting #6
Hannover, Germany
August 30 – September 3, 1999

TSGR1#7(99)b29

Agenda item:

Source: Ericsson

Title: Proposal for new notation in 25.212

Document for: Decision

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1 Introduction

This paper proposes modifications so that the notation in [1] becomes consistent throughout the document. The changes are of editorial nature but at a few places a short motivation for the change is given. These explanations are marked as *<Ericsson's note>* and they are of course not part of the text proposal.

In the text proposal, the bits after each block in the multiplexing chain are assigned a lower case letter with index. The same letter is used when the functionality of the next block is described. Using this approach, the position of each bit, as it propagates through the chain, is clearly defined. As far as possible the same notation is used for uplink and downlink. When this has not been possible due to different order of the blocks in uplink and downlink, the letters *x*, *y*, and *z* have been used and the meaning of them defined in subsections.

Ericsson has several contributions on multiplexing for TSG RAN WG1 meeting number 7. No objections to these proposals has so far been sent on the reflector and the text proposal in this contribution therefore assume the following:

- There is no 1st multiplexing [2]
- DTX insertion with flexible positions of the TrCHs is done before physical channel segmentation. [3]
- All transport blocks on one TrCH are always coded together.[4]

If concerns are raised against these proposals on the meeting, the text proposal in this contribution will of course have to be updated accordingly.

2 References

[1] TSG RAN WG1, "TS 25.212 Multiplexing and channel coding (FDD)".

[2] Ericsson, "TSGR1#7(99)B31 Comments on first multiplexing".

[3] Ericsson, "TSGR1#7(99)B30 DTX insertion in case of multicode".

[4] Ericsson, "TSGR1#7(99)B32 Transport block concatenation and code block segmentation".

3 Text proposal for 25.212

3.2 Symbols

For the purposes of the present document, the following symbols apply:
<symbol> <Explanation>

éxù round towards ¥, i.e. integer such that *x* £ *éxù* < *x*+1
ëxû round towards -¥, i.e. integer such that *x*-1 < *ëxû* £ *x*
çxç absolute value of *x*

Unless otherwise is explicitly stated when the symbol is used, the meaning of the following symbols is:
i TrCH number
j TFC number
k Bit number
l TF number
m Transport block number
n Radio frame number
p PhCH number
r Code block number
I Number of TrCHs in a CCTrCH.
C_i Number of code blocks in one TTI of TrCH *i.*
F_i Number of radio frames in one TTI of TrCH *i.*
M_i Number of transport blocks in one TTI of TrCH *i.*
P Number of PhCHs used for one CCTrCH.
PL Puncturing Limit for the uplink. Signalled from higher layers
RM_i Rate Matching attribute for TrCH *i*. Signalled from higher layers.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:
<ACRONYM> <Explanation>

ACS Add, Compare, Select
ARQ Automatic Repeat Request
BCH Broadcast Channel
BER Bit Error Rate
BLER Block Error Rate
BS Base Station
CCPCH Common Control Physical Channel
CCTrCH Coded Composite Transport Channel
DCH Dedicated Channel
DL Downlink (Forward link)
DPCH Dedicated Physical Channel
DPCCH Dedicated Physical Control Channel
DPDCH Dedicated Physical Data Channel
DS-CDMA Direct-Sequence Code Division Multiple Access
DSCH Downlink Shared Channel
FACH Forward Access Channel
FDD Frequency Division Duplex
FER Frame Error Rate
Mcps Mega Chip Per Second

MS	Mobile Station
OVSF	Orthogonal Variable Spreading Factor (codes)
PCH	Paging Channel
PRACH	Physical Random Access Channel
PhCH	Physical Channel
RACH	Random Access Channel
RX	Receive
SCH	Synchronisation Channel
SF	Spreading Factor
SIR	Signal-to-Interference Ratio
TF	Transport Format
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TPC	Transmit Power Control
TrCH	Transport Channel
TTI	Transmission Time Interval
TX	Transmit
UL	Uplink (Reverse link)

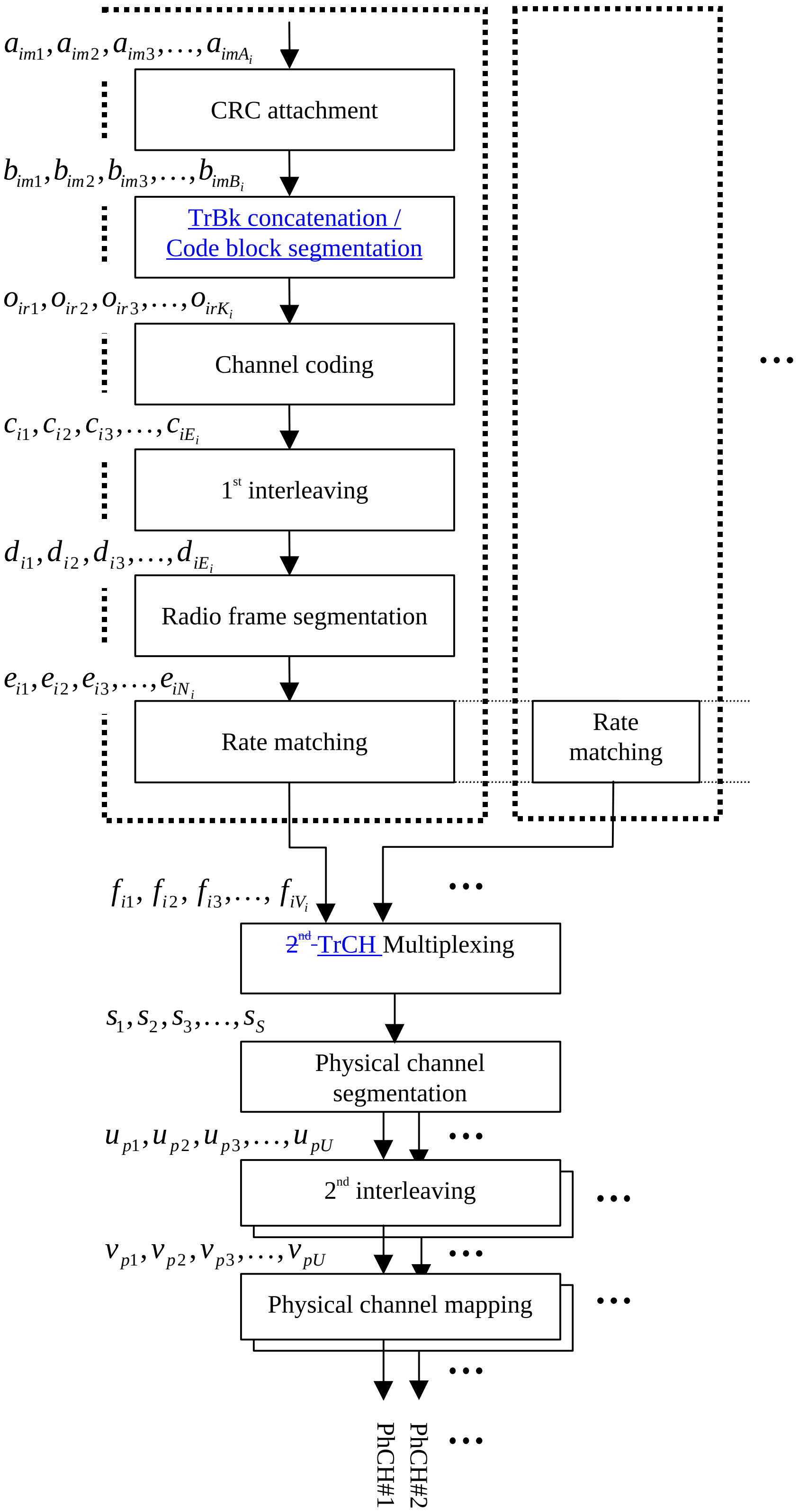
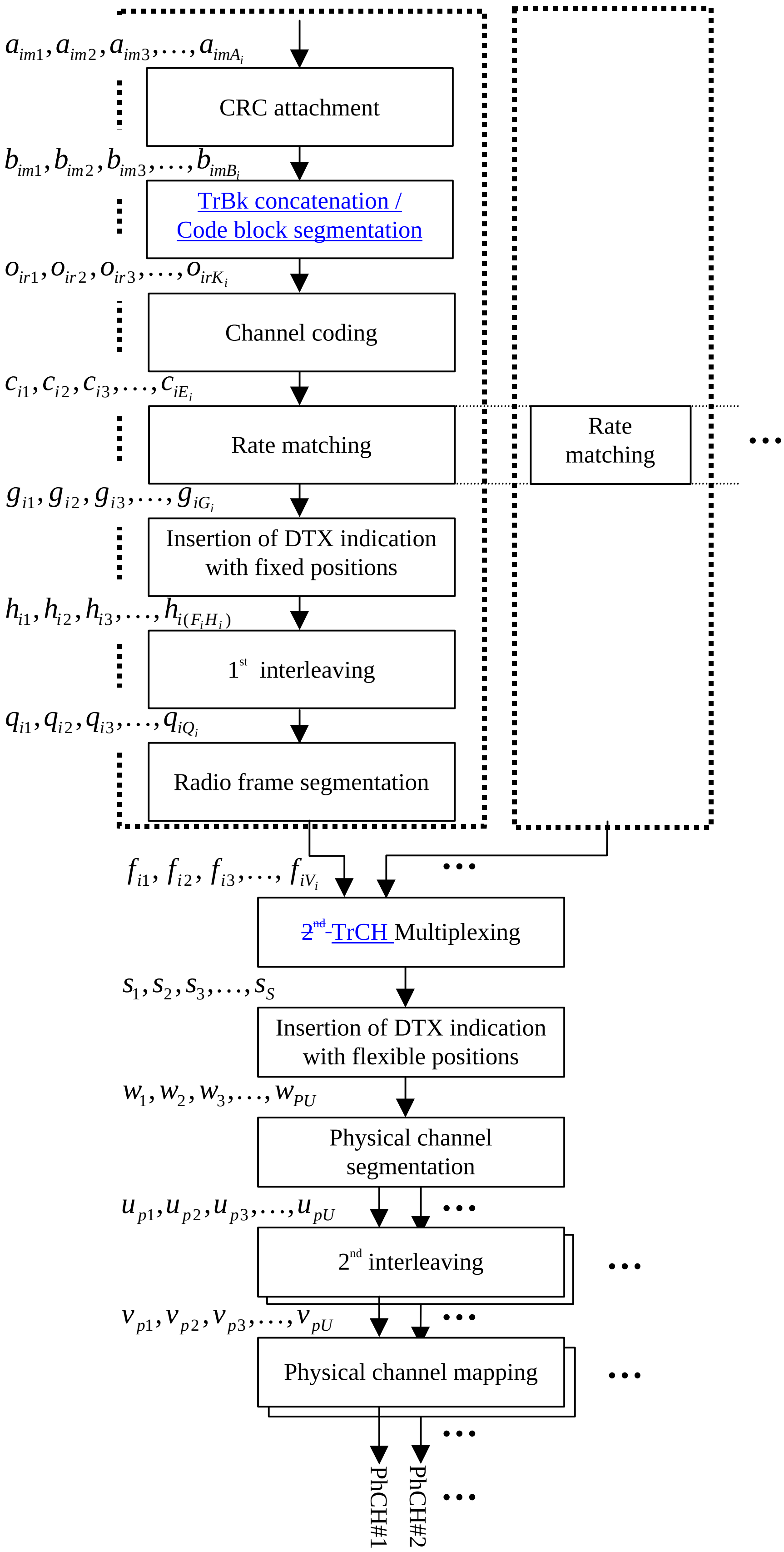


Figure 4-1. Transport channel multiplexing structure for uplink.



$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$
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
$c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$
Rate matching
Rate matching
$g_{i1}, g_{i2}, g_{i3}, \ldots, g_{iG_i}$
Insertion of DTX indication with fixed positions
$h_{i1}, h_{i2}, h_{i3}, \ldots, h_{i(F_i H_i)}$
1st interleaving
$q_{i1}, q_{i2}, q_{i3}, \ldots, q_{iQ_i}$
Radio frame segmentation
$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$
2nd TrCH Multiplexing
$s_1, s_2, s_3, \ldots, s_S$
Insertion of DTX indication with flexible positions
$w_1, w_2, w_3, \ldots, w_{PU}$
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 4-2. Transport channel multiplexing structure for downlink.

4.2.1 Error detection

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

4.2.1.1 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:

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

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

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$ ~~$b_1, b_2, b_3, \ldots b_N$~~, and the parity bits by $p_{im1}, p_{im2}, p_{im3}, \ldots, p_{imL_i}$ ~~$p_1, p_2, \ldots p_L$~~. ~~N~~A_i is the length of ~~the~~a transport block of TrCH *i*, *m* is the transport block number, and L_i is 16, 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

$$a_{im1}D^{A_i+15} + a_{im2}D^{A_i+14} + \ldots + a_{imA_i}D^{16} + p_{im1}D^{15} + p_{im2}D^{14} + \ldots + p_{im15}D^1 + p_{im16}$$

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

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

$$a_{im1}D^{A_i+7} + a_{im2}D^{A_i+6} + \ldots + a_{imA_i}D^{8} + p_{im1}D^{7} + p_{im2}D^{6} + \ldots + p_{im7}D^1 + p_{im8}$$

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

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

4.2.1.2 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 $b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$ ~~$w_1, w_2, w_3, \ldots w_{N+L}$, where L is 16, 8, or 0~~, where $B_i = A_i + L_i$. The relation between ~~b~~a_{imk} and ~~w~~b_{imk} is:

$b_{imk} = a_{imk}$ $\quad k = 1, 2, 3, \ldots, A_i$

$b_{imk} = p_{im(L_i+1-(k-A_i))}$ $\quad k = A_i + 1, A_i + 2, A_i + 3, \ldots, A_i + L_i$

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

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

4.2.2 Transport block concatenation and code block segmentation

All transport blocks in a TTI are serially concatenated. If the number of bits in a TTI is larger than *Z*, then code block segmentation is performed after the concatenation of the transport blocks. The maximum size of the code blocks depend on if convolutional or turbo coding is used for the TrCH.

4.2.2.1 Concatenation of transport blocks

The bits input to the transport block concatenation are denoted by $b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$ where *i* is the TrCH number, *m* is the transport block number, and B_i is the number of bits in each block (including CRC). The number of transport blocks on TrCH *i* is denoted by M_i. The bits after concatenation are denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$, where *i* is the TrCH number and $X_i = M_iB_i$. They are defined by the following relations:

$x_{ik} = b_{i1k}$ $k = 1, 2, \ldots, B_i$

$x_{ik} = b_{i,2,(k-B_i)}$ $k = B_i + 1, B_i + 2, \ldots, 2B_i$

$x_{ik} = b_{i,3,(k-2B_i)}$ $k = 2B_i + 1, 2B_i + 2, \ldots, 3B_i$

$\ldots$

$x_{ik} = b_{i,M_i,(k-(M_i-1)B_i)}$ $k = (M_i - 1)B_i + 1, (M_i - 1)B_i + 2, \ldots, M_iB_i$

4.2.2.2 Code block segmentation

<Ericsson's note: It is proposed that filler bits are set to 0.>

Segmentation of the bit sequence from transport block concatenation is performed if $X_i > Z$. The code blocks after segmentation are of the same size. The number of code blocks on TrCH i is denoted by C_i. If the number of bits input to the segmentation, X_i, is not a multiple of C_i, filler bits are added to the last block. The filler bits are transmitted and they are always set to 0. The maximum code block sizes are:

convolutional coding: $Z = 512 - K_{tail}$

turbo coding: $Z = 5120 - K_{tail}$

The bits output from code block segmentation are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$, where i is the TrCH number, r is the code block number, and K_i is the number of bits.

Number of code blocks: $C_i = \lceil X_i / Z \rceil$

Number of bits in each code block: $K_i = \lceil X_i / C_i \rceil$

Number of filler bits: $Y_i = C_iK_i - X_i$

If $X_i \le Z$, then $o_{i1k} = x_{ik}$, and $K_i = X_i$.

If $X_i \ge Z$, then

$o_{i1k} = x_{ik}$ $k = 1, 2, \ldots, K_i$

$o_{i2k} = x_{i,(k+K_i)}$ $k = 1, 2, \ldots, K_i$

$o_{i3k} = x_{i,(k+2K_i)}$ $k = 1, 2, \ldots, K_i$

$\ldots$

$o_{iC_ik} = x_{i(k+(C_i-1)K_i)}$ $k = 1, 2, \ldots, K_i - Y_i$

$o_{iC_ik} = 0$ $k = (K_i - Y_i) + 1, (K_i - Y_i) + 2, \ldots, K_i$

4.2.3 Channel coding

Code blocks are delivered to the channel coding block. They are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$, where i is the TrCH number, r is the code block number, and K_i is the number of bits in each code block. The number of code blocks on TrCH i is denoted by C_i. After encoding the bits are denoted by $x_{ir1}, x_{ir2}, x_{ir3}, \ldots, x_{irX_i}$. The encoded blocks are serially multiplexed so that the block with lowest index r is output first from the channel coding block. The bits output are denoted by $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where i is the TrCH number and $E_i = C_iX_i$. The output bits are defined by the following relations:

$c_{ik} = x_{i1k}$ $k = 1, 2, \ldots, X_i$

$c_{ik} = x_{i,2,(k-X_i)}$ $k = X_i + 1, X_i + 2, \ldots, 2X_i$

$c_{ik} = x_{i,3,(k-2X_i)}$ $k = 2X_i + 1, 2X_i + 2, \ldots, 3X_i$

$\ldots$

$c_{ik} = x_{i,C_i,(k-(C_i-1)X_i)}$ $k = (C_i - 1)X_i + 1, (C_i - 1)X_i + 2, \ldots, C_iX_i$

The relation between o_{irk} and x_{irk} and between K_i and X_i is dependent on the channel coding scheme.

The following channel coding schemes can be applied to transport channelTrCHs.

- Convolutional coding
- Turbo coding
- No channel coding

Table 4-1. Error Correction Coding Parameters

Transport channel type	Coding scheme	Coding rate
BCH	Convolutional code	1/2
PCH		
FACH		
RACH		
DCH		1/3, 1/2, or no coding
DCH	Turbo code	

Note1: The exact physical layer encoding/decoding capabilities for different code types are FFS.
Note2: In the UE the channel coding capability should be linked to the terminal class.

<Ericsson's note: Combined mode is assumed as indicated in the introduction.>

<Editor's note: Combined or segmented mode with Turbo coding is F.F.S.>

4.2.3.1 Convolutional coding

4.2.3.1.1 Convolutional coder

- Constraint length K=9. Coding rate 1/3 and ½.
- The configuration of the convolutional coder is presented in Figure 4-3.
- The output from the convolutional coder shall be done in the order starting from output0, output1, and output2, output0, output1, …,output2 . (When coding rate is 1/2, output is done up to output 1).
- K-1 tail bits (value 0) shall be added to the end of the codeing block before encoding.
- The initial value of the shift register of the coder shall be "all 0".

-- snip --

4.2.4 1st interleaving

The 1st interleaving is a block interleaver with inter-column permutations.of channel interleaving consists of two stage operations. The bits input to the 1st interleaver are denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$, where i is TrCH number and X_i the number of bits. 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.~~

~~**First Stage:**~~

(1) ~~(1)~~ Select ~~a column~~the number of columns C_1 from Table 4-3.
(2) ~~(2)~~ Determine ~~a row~~the number of rows R_1 by finding minimum integer R_1 such that,

$$\sout{K_1} X_i \sout{<=} \leq R_1 \times C_1.$$

(3) ~~(3)~~ The bits input ~~sequence of~~to the 1st interleaving ~~is~~are written into the $R_1 \times C_1$ rectangular matrix row by row.

$$\begin{bmatrix} x_{i1} & x_{i2} & x_{i3} & \cdots & x_{iC_1} \\ x_{i,(C_1+1)} & x_{i,(C_1+2)} & x_{i,(C_1+3)} & \cdots & x_{i,(2C_1)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x_{i,((R_1-1)C_1+1)} & x_{i,((R_1-1)C_1+2)} & x_{i,((R_1-1)C_1+3)} & \cdots & x_{i,(R_1C_1)} \end{bmatrix}$$

~~**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 4-1~~ 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}.

$$\begin{bmatrix} y_{i1} & y_{i,(R_1+1)} & y_{i,(2R_1+1)} & \cdots & y_{i,((C_1-1)R_1+1)} \\ y_{i2} & y_{i,(R_1+2)} & y_{i,(2R_1+2)} & \cdots & y_{i,((C_1-1)R_1+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{iR_1} & y_{i,(2R_1)} & y_{i,(3R_1)} & \cdots & y_{i,(C_1R_1)} \end{bmatrix}$$

(5) ~~(2)~~ The output of the 1st interleaving is the bit sequence read out column by column from the inter-column permuted $R_1 \times C_1$ matrix. ~~and t~~The output is pruned by deleting bits that were not present in the input bit sequence, i.e. bits y_{ik} that corresponds to bits x_{ik} with $k>X_i$ are removed from the output. The bits after 1st interleaving are denoted $z_{i1}, z_{i2}, z_{i3}, \ldots, z_{iX_i}$, where z_{i1} corresponds to the bit y_{ik} with smallest index k after pruning, z_{i2} corresponds to the bit y_{ik} with second smallest index k after pruning, and so on.~~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

TTI~~Interleaving span~~	~~Column n~~Number of columns 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}

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

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

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

4.2.4.2 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, $z_{ik} = q_{ik}$, $Q_i = F_i H_i$ if fixed positions are used, and $Q_i = G_i$ if flexible positions are used.

4.2.5 Radio frame segmentation

If the transmission time interval is longer than 10 ms, the bits in the TTI are segmented into several radio frames. The radio frame segmentation is done so that the number of bits in each radio frame is the same. If the number of bits in the TTI is not a multiple of the number of radio frames in the TTI, then filler bits are added to the radio frames which contain one bit less than the first radio frame.

<Ericsson's note: It is proposed that filler bits are set to 0.>

The number of radio frames in the transmission time interval of TrCH *i* is denoted by F_i and the number of bits in the TTI by X_i. The number of filler bits Z_i for TrCH *i* is calculated as:

<Ericsson's note: The current formula is not correct since it results in F_i filler bits if (X_i mod F_i)=0. A second mod operator has therefore been added.>

$Z_i = (F_i - (X_i \bmod F_i)) \bmod F_i$ $\qquad (Z_i \in \{0, 1, 2, \ldots, F_i-1\})$

The radio frames are numbered 1 £ n_i £ F_i. The bits input to physical channel segmentation are denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$, and the output by $y_{i1}, y_{i2}, y_{i3}, \ldots, y_{iY_i}$. The radio frame segmentation is defined by the following relations, where $Y_i = (X_i + Z_i) / F_i$:

$n_i = 1$ $\qquad y_{ik} = x_{ik}$ $\qquad k = 1, 2, \ldots, Y_i$

$n_i = 2$ $\qquad y_{ik} = x_{i(k+Y_i)}$ $\qquad k = 1, 2, \ldots, Y_i$

…

$n_i = F_i - Z_i$ $\qquad y_{ik} = x_{i(k+(F_i-Z_i-1)Y_i)}$ $\qquad k = 1, 2, \ldots, Y_i$

$$n_i = F_i - Z_i + 1 \quad \begin{cases} y_{ik} = x_{i(k+(F_i-Z_i)Y_i)} & k = 1, 2, \ldots, Y_i - 1 \\ y_{iY_i} = 0 \end{cases}$$

…

$$n_i = F_i \quad \begin{cases} y_{ik} = x_{i(k+(F_i-1)Y_i)} & k = 1, 2, \ldots, Y_i - 1 \\ y_{iY_i} = 0 \end{cases}$$

The bits from radio frame segmentation are output radio frame by radio frame in ascending order with respect to n_i.

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

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

The bits output from the radio frame segmentation are 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, $y_{ik} = e_{ik}$ and $Y_i = N_i$.

4.2.5.2 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 bits output from the radio frame segmentation are 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 in a radio frame. Hence, $y_{ik} = f_{ik}$ and $Y_i = V_i$.

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 A-3 and A-4 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 A-3 and A-4, 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 $i = 0, 1, 2, \ldots, N$

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 $(1, 2, 3, \ldots, T_i)$ for a given i^{th} channel coding and multiplexing chain

$r_i = T_i - (L_i \bmod T_i)$ Î $\{0, 1, 2, \ldots, T_i-1\}$ // 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 r_i 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)*

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

$((L_i+r_i)/T_i$ 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)*

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

...

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

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

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

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

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

...

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

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

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

4.2.6 Rate matching

Rate matching means that bits on a transport channelTrCH are repeated or punctured. Higher layers assign a rate-matching attribute for each transport channelTrCH. This attribute is semi-static and can only be changed through higher layer signalling. The rate-matching attribute is used when the number of bits to be repeated or punctured is calculated.

The number of bits on a transport channelTrCH can vary between different transmission time intervals. In the downlink the transmission is interrupted if the number of bits is lower than maximum. When the number of bits between different transmission time intervals in uplink is changed, bits are repeated or punctured to ensure that the total bit rate after second multiplexing is identical to the total channel bit rate of the allocated dedicated physical channels.

Notation used in Section 4.2.6 and subsections:

N_{ij}: Number of bits in a radio frame before rate matching on transport channelTrCH *i* with transport format combination *j* .

N_{ij}^{TTI} : Number of bits in a transmission time interval before rate matching on transport channelTrCH *i* with transport format *j*.

ΔN_{ij} : If positive - number of bits that should be repeated in each radio frame on transport channelTrCH *i* with transport format combination *j*.
If negative - number of bits that should be punctured in each radio frame on transport channelTrCH *i* with transport format combination *j*.

ΔN_{ij}^{TTI} : If positive - number of bits to be repeated in each transmission time interval on transport channelTrCH *i* with transport format *j*.
If negative - number of bits to be punctured in each transmission time interval on transport channelTrCH *i* with transport format *j*.

RM_i: Semi-static rate matching attribute for ~~transport channel~~TrCH *i*. Signalled from higher layers.

PL: Puncturing limit for uplink. This value limits the amount of puncturing that can be applied in order to avoid multicode or to enable the use of a higher spreading factor. Signalled from higher layers.

$N_{data,j}$: Total number of bits that are available for the CCTrCH in a radio frame with transport format combination j.

~~T~~I: Number of ~~transport channel~~TrCHs in the CCTrCH.

Z_{mj}: Intermediate calculation variable.

F_i: Number of radio frames in the transmission time interval of ~~transport channel~~TrCH *i*.

~~k~~n_i: Radio frame number in the transmission time interval of ~~transport channel~~TrCH *i* (*0 £* ~~k~~n_i < F_i).

q: Average puncturing distance.

I_F(~~k~~n_i): The inverse interleaving function of the 1st interleaver (note that the inverse interleaving function is identical to the interleaving function itself for the 1st interleaver).

S(~~k~~n_i): The shift of the puncturing pattern for radio frame ~~k~~n_i.

$TF_i(j)$: Transport format of ~~transport channel~~TrCH *i* for the transport format combination *j*.

The following relations are used when calculating the rate matching pattern:

$$Z_{0,j} = 0$$

$$Z_{mj} = \left\lfloor \frac{\sum_{i=1}^{m} RM_i \cdot N_{ij}}{\sum_{i=1}^{I} RM_i \cdot N_{ij}} \cdot N_{data,j} \right\rfloor$$

for all *m* = 1 .. *I~~T, where ë û means round downwards~~*

$$\Delta N_{ij} = Z_{ij} - Z_{i-1,j} - N_{ij}$$

for all *i* = 1 .. *I~~T~~*

4.2.6.1 Determination of rate matching parameters in uplink

In uplink puncturing can be used to avoid multicode or to enable the use of a higher spreading factor. The maximum amount of puncturing that can be applied is signalled ~~at connection setup~~ from higher layers and denoted by *PL*. The number of available bits in the radio frames for all possible spreading factors is given in [2]. Denote these values by N_{256}, N_{128}, N_{64}, N_{32}, N_{16}, N_8, and N_4, where the index refers to the spreading factor. The possible values of N_{data} then are { N_{256}, N_{128}, N_{64}, N_{32}, N_{16}, N_8, N_4, $2N_4$, $3N_4$, $4N_4$, $5N_4$, $6N_4$}.Depending on the UE capabilities, the supported set of N_{data} , denoted SET0, can be a subset of { N_{256}, N_{128}, N_{64}, N_{32}, N_{16}, N_8, N_4, $2N_4$, $3N_4$, $4N_4$, $5N_4$, $6N_4$}. $N_{data,j}$ for the transport format combination j is determined by executing the following algorithm:

SET1 = { N_{data} in SET0 such that $N_{data} - \sum_{i=1}^{I} \frac{RM_i}{\min_l \{RM_l\}} \cdot N_{ij}$ is non negative }

If the smallest element of SET1 requires just one ~~DPDCH~~PhCH then
$N_{data,j}$ = min SET1
else

SET2 = { N_{data} in SET0 such that $N_{data} - PL \cdot \sum_{i=1}^{I} \frac{RM_i}{\min_l \{RM_l\}} \cdot N_{ij}$ is non negative }

Sort SET2 in ascending order
N_{data} = min SET2

While N_{data} is not the max of SET2 and the follower of N_{data} requires no additional ~~DPDCH~~PhCH do

N_{data} = follower of N_{data} in SET2

End while

$N_{data,j} = N_{data}$

End if

The number of bits to be repeated or punctured, DN_{ij}, within one radio frame for each ~~transport channel~~TrCH i is calculated with the relations given in Section 4.2.6 for all possible transport format combinations j and selected every radio frame. For each radio frame, the rate-matching pattern is calculated with the algorithm in Section 4.2.6.3, where $DN = DN_{ij}$ and $N = N_{ij}$.

Additionally, the following parameters are needed:

$q=$ ëN_{ij} /(ôDN_{ij}ô)û ~~, where ë û means round downwards and ô ô means absolute value.~~

if q is even

then $q' = q - gcd(q, F_i)/F_i$ -- where $gcd(q, F_i)$ means greatest common divisor of q and F_i

-- note that q' is not an integer, but a multiple of 1/8

else

$q' = q$

endif

for $l = 0$ to F_i-1

$S(I_F$ (é$l*q'$ù mod F_i)) = (é$l*q'$ù div F_i) ~~-- where é ù means round upwards.~~

end for

4.2.6.2 Determination of rate matching parameters in downlink

For downlink $N_{data,j}$ does not depend on the transport format combination j. $N_{data,j}$ is given by the channelization code(s) assigned by higher layers.

Note: The rule to convert the rate matching attributes in downlink to the parameters input to rate matching pattern algorithm are working assumption. So, it remains to be verified that they hold for all possible transport format combinations. It has been identified that the case when the transport format combination with highest rate include a transport format with zero bits need special treatment.

Radio frame segmentation is performed after 1st interleaving and N_{ij} is therefore calculated as:

$$l = TF_i(j) \quad \text{and} \quad N_{ij} = \left\lceil \frac{N_{i,l}^{TTI}}{F_i} \right\rceil$$

The number of bits repeated or punctured, DN_{iL}, within one radio frame for each ~~transport channel~~TrCH is calculated for the transport format combination L with highest bitrate with the relations given in Section 4.2.6.

If ~~fix~~fixed positions of the ~~transport channel~~TrCHs in the radio frame are used then the same DN_{ij} is used for all transport format combinations and the last part of the rate-matching pattern omitted. That is to say for all transport format combinations j we have:

$$\Delta N_{ij} = \Delta N_{iL}$$

When flexible positions of the ~~transport channel~~TrCHs are used, the number of bits DN_{ij} repeated or punctured for all transport format combinations j other than L is calculated as:

$$\Delta N_{ij} = \left\lfloor \frac{\Delta N_{iL}}{N_{iL}} \cdot N_{ij} \right\rfloor$$

For each transmission time interval, the rate-matching pattern is calculated with the algorithm in Section 4.2.6.3. The following parameters are used as input:

l = $TF_i(j)$ and $\Delta N = \Delta N_{il}^{TTI} = F_i \Delta N_{ij}$

$N = N_{il}^{TTI}$

S=0.

4.2.6.3 Rate matching algorithm

Denote the bits before rate matching by:

~~$e_1, e_2, e_3, \ldots e_N$~~ $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iN}$, where *i* is the TrCH number and *N* is the number of bits before rate matching.

The rate matching rule is as follows:

```
if puncturing is to be performed

    y = -DN
    e = (2*S(~~k~~n_i) * y +  N) mod 2N     -- initial error between current and desired puncturing ratio
    m = 1                                  -- index of current bit
    do while m <= N
        e = e – 2 * y                      -- update error
        if e <= 0 then                     -- check if bit number m should be punctured
            puncture bit ~~e~~x_m
            e = e + 2*N                    -- update error
        end if
        m = m + 1                          -- next bit
    end do
else
    y = DN

    e = (2*S(~~k~~n_i) * y +  N) mod 2N     -- initial error between current and desired puncturing ratio
    m = 1                                  -- index of current bit
    do while m <= N
        e = e – 2 * y                      -- update error
        do while e <= 0                    -- check if bit number m should be repeated
            repeat bit ~~e~~x_m
            e = e +  2*N  -- update error
        enddo
        m = m + 1                          -- next bit
    end do
end if
```

A repeated bit is placed directly after the original one.

4.2.6.4 Relation between input and output of the rate matching block in uplink

The bits input to the rate matching are denoted by $e_{i1}, e_{i2}, e_{13}, \ldots, e_{iN_i}$, where *i* is the TrCH.

Hence, $x_{ik} = e_{ik}$ and $N = N_{ij} = N_i$.

The bits output from the rate matching are denoted by $f_{i1}, f_{i2}, f_{13}, \ldots, f_{iV_i}$, where *i* is the TrCH number and $V_i = N + DN = N_{ij} + DN_{ij}$.

Note that the transport format combination number *j* for simplicity has been left out in the bit numbering.

4.2.6.5 Relation between input and output of the rate matching block in downlink

The bits input to the rate matching are denoted by $c_{i1}, c_{i2}, c_{13}, \ldots, c_{iE_i}$, where i is the TrCH number and l the transport format number. Hence, $x_{ik} = e_{ik}$ and $N = N_{il}^{TTI} = E_i$.

The bits output from the rate matching are denoted by $g_{i1}, g_{i2}, g_{13}, \ldots, g_{iG_i}$, where i is the TrCH number and $G_i = N + \Delta N = N_{il}^{TTI} + \Delta N_{il}^{TTI}$.

Note that the transport format number l for simplicity has been left out in the bit numbering.

4.2.7 4.2.8 2nd TrCH Mmultiplexing

For both uplink and downlink, radio frames in each channel coding and multiplexing chains are serially multiplexed into a 10 msec coded composite transport channel.Every 10 ms, one radio frame from each TrCH is delivered to the TrCH multiplexing. These radio frames are serially multiplexed into a coded composite transport channel (CCTrCH).

Figure A-3 and A-4 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. Following subsection describes the input-output relationship of 2nd multiplexing in bit-wise manner, referring to the notations in Figure A-3 and A-4, where the notation in each data block, for examples L_1, R_1, K_1, P/M, etc., indicate number of bits of the data block.

The bits input to the TrCH multiplexing are 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 in the radio frame of TrCH i. The number of TrCHs is denoted by I.

The bits output from TrCH multiplexing are denoted by $s_1, s_2, s_3, \ldots, s_S$, where S is the number of bits, i.e. $S = \sum_i V_i$. The TrCH multiplexing is defined by the following relations:

$s_k = f_{1k}$ $\quad k = 1, 2, \ldots, V_1$

$s_k = f_{2,(k-V_1)}$ $\quad k = V_1+1, V_1+2, \ldots, V_1+V_2$

$s_k = f_{3,(k-(V_1+V_2))}$ $\quad k = (V_1+V_2)+1, (V_1+V_2)+2, \ldots, (V_1+V_2)+V_3$

…

$s_k = f_{I,(k-(V_1+V_2+\ldots+V_{I-1}))}$ $\quad k = (V_1+V_2+\ldots+V_{I-1})+1, (V_1+V_2+\ldots+V_{I-1})+2, \ldots, (V_1+V_2+\ldots+V_{I-1})+V_I$

4.2.7.1 4.2.8.1 Second multiplexing in uplink

The bits before second multiplexing in uplink are described as follows:

Bits from rate matching 1: $e_{11}, e_{12}, \ldots e_{1K_1}$

Bits from rate matching 2: $e_{21}, e_{22}, \ldots e_{2K_2}$

Bits from rate matching 3: $e_{31}, e_{32}, \ldots e_{3K_3}$

…

Bits from rate matching N: $e_{N1}, e_{N2}, \ldots e_{NK_N}$

The bits after second multiplexing are denoted by $d_1, d_2, \ldots, d_P$ and defined by the following relationships:

For $j=1,2,3\ldots,P$ where $P=K_1+K_2+\ldots+K_N$

$d_j = c_{1j}$ $j=1,2,\ldots K_1$
$d_j = c_{2,(j-K_1)}$ $j= K_1+1, K_1+2, \ldots, K_1+K_2$
$d_j = c_{3,(j-(K_1+K_2))}$ $j=(K_1+K_2)+1, (K_1+K_2)+2, \ldots, (K_1+K_2)+ K_3$
$\ldots$
$d_j = c_{N,(j-(K_1+K_2+\ldots+K_{N-1}))}$ $j=(K_1+K_2+\ldots+ K_{N-1})+1, (K_1+K_2+\ldots+ K_{N-1})+2, \ldots, (K_1+K_2+\ldots+ K_{N-1})+K_N$

4.2.7.24.2.8.2 Second multiplexing in downlink

The bits before second multiplexing in downlink are described as follows:

Bits from radio frame segmentation 1: $c_{11}, c_{12}, \ldots c_{1K_1}$

Bits from radio frame segmentation 2: $c_{21}, c_{22}, \ldots c_{2K_2}$

Bits from radio frame segmentation 3: $c_{31}, c_{32}, \ldots c_{3K_3}$

$\ldots$

Bits from radio frame segmentation *N*: $c_{N1}, c_{N2}, \ldots c_{NK_N}$

The bits after second multiplexing are denoted by $d_1, d_2, \ldots, d_P$
and defined by the following relationship:

For $j=1,2,3 \ldots,P$ where $P=K_1+K_2+ \ldots +K_N$

$d_j = c_{1j}$ $j=1,2,\ldots K_1$
$d_j = c_{2,(j-K_1)}$ $j= K_1+1, K_1+2, \ldots, K_1+K_2$
$d_j = c_{3,(j-(K_1+K_2))}$ $j=(K_1+K_2)+1, (K_1+K_2)+2, \ldots, (K_1+K_2)+ K_3$
$\ldots$
$d_j = c_{N,(j-(K_1+K_2+\ldots+K_{N-1}))}$ $j=(K_1+K_2+\ldots+ K_{N-1})+1, (K_1+K_2+\ldots+ K_{N-1})+2, \ldots, (K_1+K_2+\ldots+ K_{N-1})+K_N$

4.2.8 4.2.7 Insertion of discontinuous transmission (DTX) indication bits

<Ericsson's note: It is Ericsson's understanding that fixed or flexible positions is chosen on CCTrCH basis (not TrCH).>

In the downlink, DTX is used to fill up the radio frame with bits. The insertion point of DTX indication bits depends on whether fixed or flexible positions of the transport channelTrCHs in the radio frame are used in the radio frame. It is up to the UTRAN to decide for each CCTrCH whether fixed or flexible positions are used during the connection for each transport channel. . DTX indication bits only indicate when the transmission should be turned off, they are not transmitted.

4.2.8.1 4.2.7.1 Insertion of DTX indication bits with fixed positions

This step of inserting DTX indication bits is used only if the positions of thefor those transport channelTrCHs in the radio frame are fixedwhich use fixed position scheme. With fixed position scheme a fixed number of bits is reserved for each transport channelTrCH in the radio frame.

Denote tThe bits from rate matching blockare denoted by $g_{i1}, g_{i2}, g_{i3}, \ldots, g_{iG_i}$ $r_1, r_2, r_3, \ldots, r_N$, where G_iN is the number of these bits per L*10 ms, which is in one TTI of TrCH *i*the transmission time interval. r_1 is the first input bit to this block and r_N is the last input bit into this block. Denote the number of bits reserved forom one radio frame ofor TrCH *i*this transport channel (or fix rate TrCHs with the same transport format attributes) by H_iM, i.e. the maximum number of bits in a radio frame for any transport format of TrCH *i*. The number of radio frames in a TTI of TrCH *i* is denoted by F_i. The bits output from the DTX insertion are denoted by $h_{i1}, h_{i2}, h_{i3}, \ldots, h_{i(F_i H_i)}$. Note that these bits are three valued. They are defined by the following relations:~~After inserting the DTX indication bits, there are three valued symbols s_k. They can be described as follows:~~

$h_{ik} = g_{ik}$ $k = 1, 2, 3, \ldots, G_i$

$h_{ik} = d$ $k = G_i+1, G_i+2, G_i+3, \ldots, F_iH_i$

where DTX indication bits are denoted by *d*. Here $g_{ik} \in \{0, 1\}$ and $d \notin \{0, 1\}$.

~~$s_k = r_k$ k=1,2,3,…,N~~
~~$s_k = x$ k=N+1, N+2, N+3, …, LM~~

~~where DTX indication bits are denoted by x. Here $r_k \in \{0,1\}$and $x \notin \{0,1\}$. s_1 is the first output symbol from this block and s_{LM} is the last~~ output symbol from this block.

4.2.8.2 ~~4.2.7.2~~ Insertion of DTX indication bits with flexible positions

<Note: Below, it is assumed that all physical channels belonging to the same CCTrCH use the same SF. Hence, U_p=U=constant.>

This step of inserting DTX indication bits is used only if the positions of the ~~transport channel~~TrCHs in the radio frame are ~~use~~ flexible~~ position scheme~~. ~~In flexible position scheme transport channels have been concatenated one after another in the 2nd multiplexing step.~~ The DTX indication bits shall be placed at the end of the radio frame. Note that the DTX will be distributed over all slots after 2nd interleaving.~~, after all the encoded data bits.~~

The bits input to the DTX insertion block are denoted by $s_1, s_2, s_3, \ldots, s_S$, where *S* is the number of bits from TrCH multiplexing. The number of PhCHs is denoted by *P* and the number of bits in one radio frame, including DTX indication bits, for each PhCH by *U*.

The bits output from the DTX insertion block are denoted by $w_1, w_2, w_3, \ldots, w_{(PU)}$. Note that these bits are threevalued. They are defined by the following relations:

~~Denote the bits from physical channel segmentation into one physical channel by p_1, p_2, p_3, …, p_N, where N is the number of these bits per one radio frame. p_1 is the first input bit to this block and p_N is the last input bit to this block. Denote the number of bits that can be fitted to DPDCH field of one radio frame by M. After insertion of the DTX indication bits, there are three valued symbols s_k. They can be described as follows:~~

$w_k = s_k$ ~~$s_k = p_k$~~ $k = 1, 2, 3, \ldots,$ ~~N~~ S

$w_k = d$ ~~$s_k = x$~~ $k = S$~~N~~$+1$, S~~N~~$+2$, S~~N~~$+3$, …, PU~~M~~

where DTX indication bits are denoted by ~~x~~*d*. Here ~~p~~$s_k \in \{0, 1\}$ and ~~x~~$d \notin \{0, 1\}$. ~~s_1 is the first output symbol from this block and s_M is the last output symbol from this block.~~

4.2.9 Physical channel segmentation

~~*<Editor's note: for physical channel segmentation, it is assumed that the segmented physical channels use the same SF>*~~*<Note: Below, it is assumed that all physical channels belonging to the same CCTrCH use the same SF. Hence, U_p=U=constant.>*

~~Data after multiplexing of transport channels with different QoS can get segmented into multiple physical channels, which are transmitted in parallel during 10ms interval.~~

~~Figure A-3 and A-4 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, and *M* physical channels. The following subsection describes input-output relationship of physical channel segmentation in bit-wise manner, referring to the notations in Figure A-3 and A-4, where the notation in each data block, for examples L_1, R_1, K_1, P/M, etc., indicate number of bits of the data block.~~

~~The bits before physical channel segmentation are described as follows:~~

Bits from second multiplexing: $d_1, d_2, \ldots, d_P$
When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $x_1, x_2, x_3, \ldots, x_Y$, where *Y* is the number of bits input to the physical channel segmentation block. The number of PhCHs is denoted by *P*.
M is the number of physical channel

The bits after physical channel segmentation are denoted $u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU}$, where *p* is PhCH number and *U* is the number of bits in one radio frame for each PhCH, i.e. $U = \frac{Y}{P}$. The relation between x_k and u_{pk} is given below.defined by the following relationship:

The first physical channel bBits on first PhCH after physical channel segmentation:

$u_{1k} = x_k$ $\quad k = 1, 2, \ldots, U$

$e_{1j} = d_j$ $\quad j=1,2,\ldots,P/M$

The second physical channel bBits on second PhCH after physical channel segmentation:

$u_{2k} = x_{(k+U)}$ $\quad k = 1, 2, \ldots, U$

$e_{2j} = d_{(j+P/M)}$ $\quad j=1,2,\ldots,P/M$

…

The M^{th} physical channel bBits on the P^{th} PhCH after physical channel segmentation:

$u_{Pk} = x_{(k+(P-1)U)}$ $\quad k = 1, 2, \ldots, U$

$e_{Mj} = d_{(j+(M-1)P/M)}$ $\quad j=1,2,\ldots,P/M$

4.2.9.1 Relation between input and output of the physical segmentation block in uplink

The bits input to the physical segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$. Hence, $x_k = s_k$ and $Y = S$.

4.2.9.2 Relation between input and output of the physical segmentation block in downlink

If fixed positions of the TrCHs in a radio frame are used then the bits input to the physical segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$. Hence, $x_k = s_k$ and $Y = S$.
If flexible positions of the TrCHs in a radio frame are used then the bits input to the physical segmentation are denoted by $w_1, w_2, w_3, \ldots, w_{(PU)}$. Hence, $x_k = w_k$ and $Y = PU$.

4.2.10 2nd interleaving

The 2nd interleaving of channel interleaving consists of two stage operations is a block interleaver with inter-column permutations. The bits input to the 2nd interleaver are denoted $u_{p1}, u_{p2}, u_{p3}, \ldots, u_{pU}$, where *p* is PhCH number and *U* is the number of bits in one radio frame for one PhCH. 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_2.

First Stage:

(1) ~~(1)~~ Set ~~a column~~ the number of columns C_2 = 30. The columns are numbered 0, 1, 2, …, C_2-1 from left to right.

(2) ~~(2)~~ Determine ~~a row~~the number of rows R_2 by finding minimum integer R_2 such that~~,~~ U~~K_2~~ ~~<=~~$\leq$ R_2 ~~×~~ C_2.

(3) ~~(3)~~ The bits input ~~sequence of~~to the 2nd interleaving ~~is~~are written into the $R_2 \times C_2$ rectangular matrix row by row.

$$\begin{bmatrix} u_{p1} & u_{p2} & u_{p3} & \cdots & u_{p30} \\ u_{p31} & u_{p32} & u_{p33} & \cdots & u_{p60} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ u_{p,((R_2-1)30+1)} & u_{p,((R_2-1)30+2)} & u_{p,((R_2-1)30+3)} & \cdots & u_{p,(R_2 30)} \end{bmatrix}$$

~~**Second Stage:**~~

(6) ~~(1)~~ Perform the inter-column permutation based on the pattern $\{P_2(j)\}$ $(j = 0, 1, ..., C_2-1)$ that is shown in Table 4-4, where $P_2(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by y_{pk}.

$$\begin{bmatrix} y_{p1} & y_{p,(R_2+1)} & y_{p,(2R_2+1)} & \cdots & y_{p,(29R_2+1)} \\ y_{p2} & y_{p,(R_2+2)} & y_{p,(2R_2+2)} & \cdots & y_{p,(29R_2+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{pR_2} & y_{p,(2R_2)} & y_{p,(3R_2)} & \cdots & y_{p,(30R_2)} \end{bmatrix}$$

(7) ~~(2)~~ The output of the 2nd interleaving is the bit sequence read out column by column from the inter-column permuted $R_2 \times C_2$ matrix. ~~and t~~The output is pruned by deleting bits that were not present in the input bit sequence, i.e. bits y_{pk} that corresponds to bits x_{pk} with $k>U$ are removed from the output. ~~non-existence bits in the input sequence, where the deleting bits number l_2 is defined as: $l_2 = R_2 \times C_2 - K_2$.~~ The bits after 2nd interleaving are denoted by $v_{p1}, v_{p2}, \ldots, v_{pU}$, where v_{p1} corresponds to the bit y_{pk} with smallest index k after pruning, v_{p2} to the bit y_{pk} with second smallest index k after pruning, and so on.

Table 4-4

~~Column n~~Number of columns C_2	Inter-column permutation pattern
30	{0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17}

4.2.11 Physical channel mapping

The PhCH for both uplink and downlink is defined in [2]. The bits input to the physical channel mapping are denoted by $v_{p1}, v_{p2}, \ldots, v_{pU}$, where p is the PhCH number and U is the number of bits in one radio frame for one PhCH. The bits v_{pk} are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k.

4.2.11.1 Uplink

~~On the uplink, transport data after 2nd interleaving is mapped onto one DPDCH. Continuous transmission is applied for uplink DPDCH at all times.~~ In uplink, the DPCCH and all PhCHs used during a radio frame are completely filled with bits that are transmitted over the air.

4.2.11.2 Downlink

In downlink, the PhCHs do not need to be completely filled with bits that are transmitted over the air. Bits

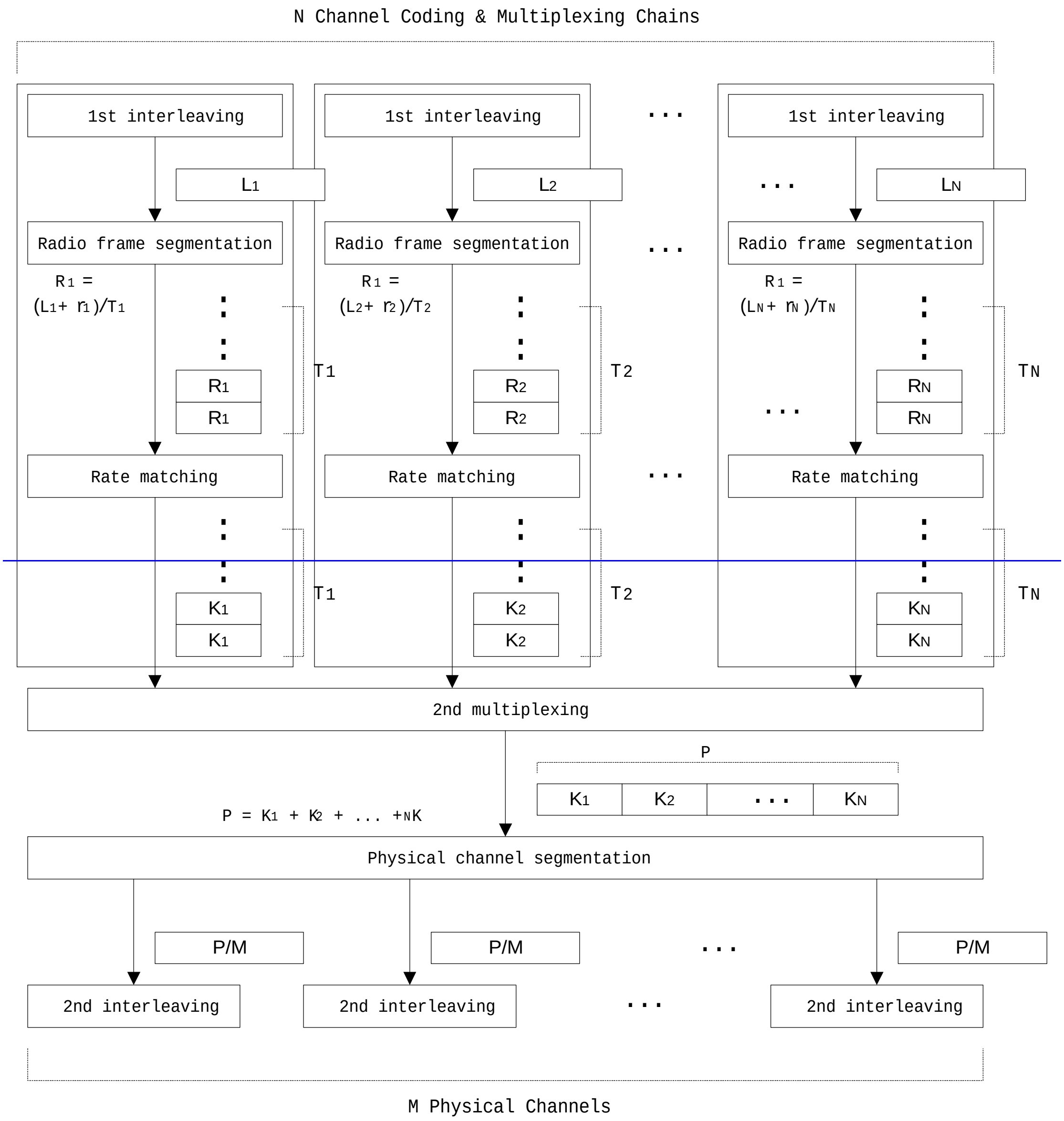
$v_{pk} \notin \{0, 1\}$ are not transmitted. The DPCCH is always completely filled with bits that are transmitted.
On the downlink, transport data after 2nd interleaving is mapped onto data fields in one DPDCH, which is defined in TS 25.211. If the total bit rate after transport channel multiplexing is not identical to the total channel bit rate of the allocated dedicated physical channels, discontinuous transmission is used.

- If transport data is less than the number of DPDCH bits in a radio frame, the DPDCH transmission can be turn off for data absent.

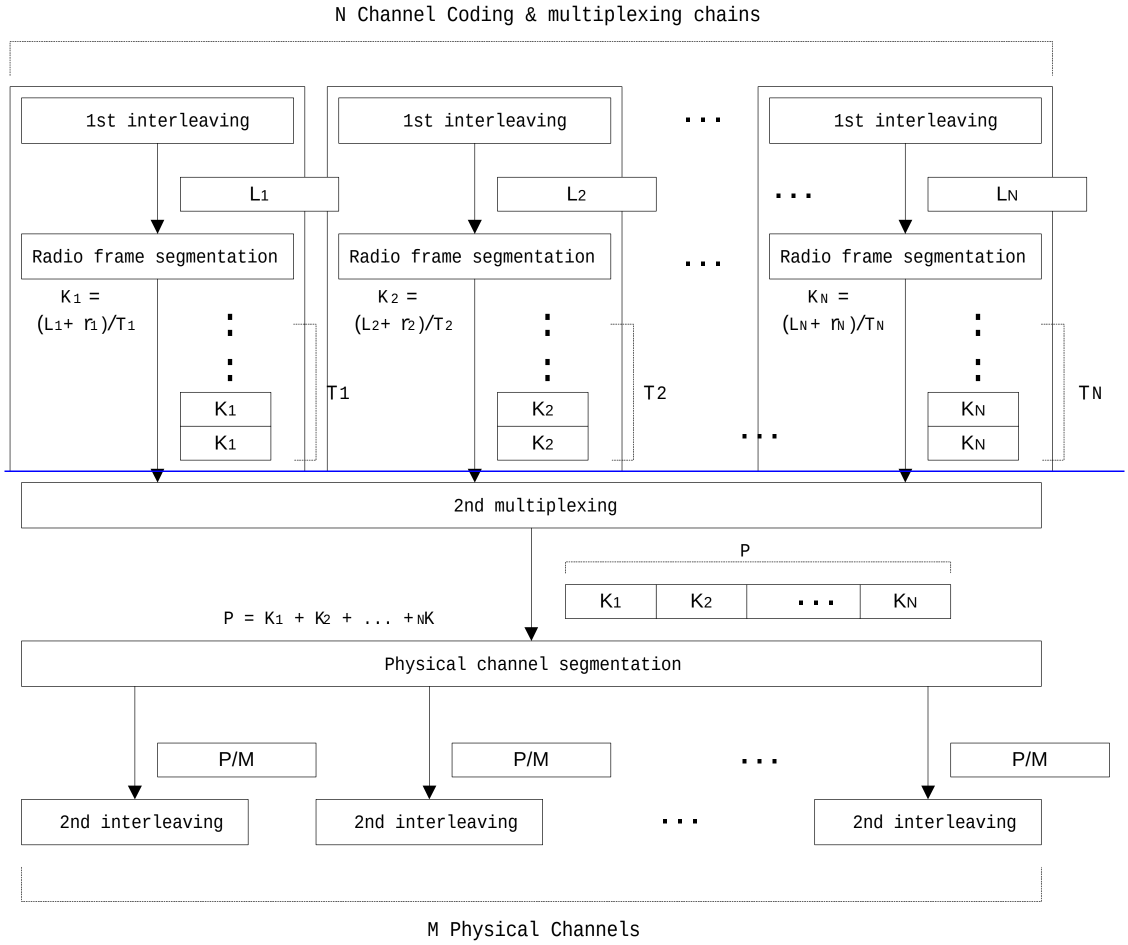
- The transmission of the DPDCH symbols shall be ON, only if there is data to transmit. If there is no data, the transmission shall be OFF.

- For transport channelTrCHs not relying on TFCI for transport format detection (blind transport format detection), the positions of the transport channels within the radio frame should be fixed.
- For transport channelTrCHs relying on TFCI for transport format detection, the UTRAN decides higher layers signal whether the positions of the transport channels should be fixed or flexible.
  - Pilot and TPC symbols are always transmitted regardless of the data existence.*<Ericsson's note: This is clear from 25.211 since the corresponding fields always are filled with bits.>*

A.3 Data Flow from Radio Frame Segmentation to Physical Channel Segmentation



~~Figure A-3 Part of uplink channel coding and multiplexing chains~~



~~Figure A-4. Part of downlink channel coding and multiplexing chains~~