TSG-RAN Working Group1 meeting #11 TSGR1#11(00)445

San Diego, CA, U.S.A., February 29 – March 3, 2000 (this is a rev. of 343)

Agenda Item : **AH04 + AH08**

Source : **Mitsubishi Electric (MCRD)**

Title : **Downlink Compressed Mode by Puncturing, revision 1**

Document for : **Discussion and Decision**

Introduction

Compressed mode by puncturing has been intensively discussed in RAN WG1 #10. In this paper we :

- highlight some problems existing in the current proposal [1]
- propose another solution based on segmentation coefficients.

References

[1] TSGR1#11(00)272 Downlink Compressed Mode by Puncturing, update, source Nortel Networks

[2] TSGR1#11(00)343 Downlink Compressed Mode by Puncturing, source Mitsubishi Electric

Problems on the current proposition [1]

Problems in the determination of the amounts $\Delta N_{cm,i,l}^{TTI}$ in flexible positions

In the proposition [1] this amount is computed by means of the 'Z formula'. The object of this formula is to share in a weighed way an integer amount between several TrCH. In the case of compressed mode the amount shared it the amount of gap bits in the frame affected by compressed mode.

The problem with the current proposal [1] is that this sharing assumes some Transport Format Combination *j*. However [1] does not tell how to determine *j*. So our conclusion is that [1] is at best incomplete.

In fixed positions, there is no such problem, as one only needs to take a 'TFC' (be it virtual) where all the TrCH are simultaneously at highest bitrate.

Problems in the concept of sharing the gap.

In the current proposal [1], the gap is share by only the TrCH whose TTI are overlapping with the gap. We think that this is a bit restrictive as shown by the Figure 1 below.

Figure 1 show something that cannot be done by the current proposal in [1], but that can be done with our proposal.

On this figure we consider 2 TrCHes, the white one and the grey one, the white TrCH has a TTI of 10ms while the grey TrCH has a TTI of 20ms. We assume that the 2 TrCh are constant rate TrCH. The surface of the squares represent the amount of data after rate matching.

As shown on this figure, not only (1.) and (3.) are compressed, but also (2.). The compression in the (frame 1) shorter TTI that does not overlap the gap is done by the intermediate of a TrCH whose (frames 0 & 1) longer TTI overlaps both the (frame 0) gap and the (frame 1) shorter TTI.

What is happening is like a kind 'communicating vase' thing :The gap is pressing on 1 and 3, 3 is in contact with 2, so 2 is also compressed. That is to say the grey TrCH giving bits to the gap, can also take bits from the 2nd TTI of the shorter TTI of the white TrCH.

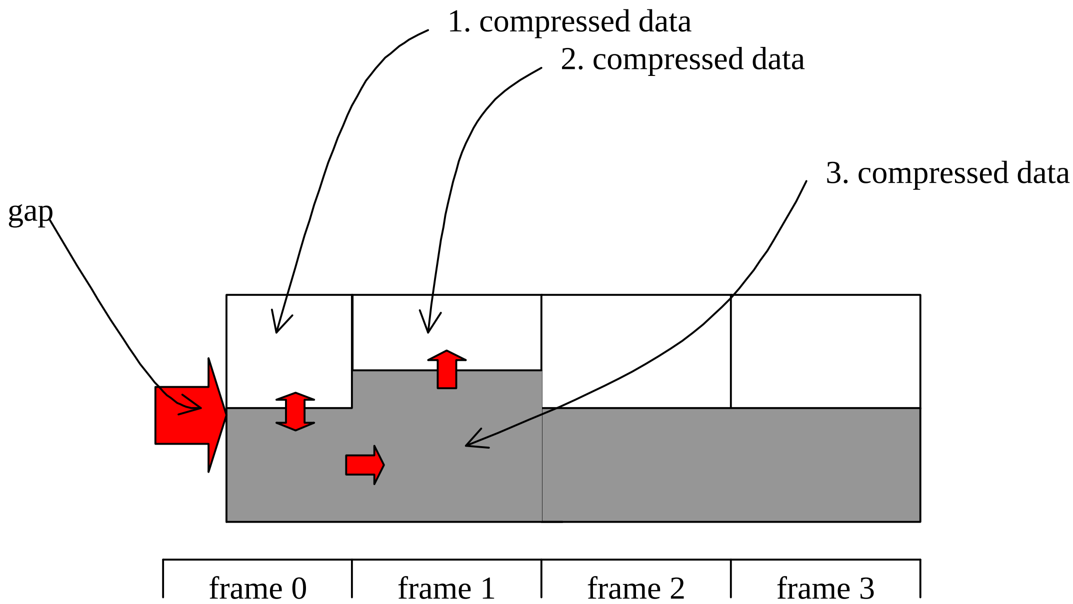


Figure 1 Example of compressed mode with several TTI durations

Of course, such kind of thing is relying on this that there is enough bit rate on the longer TTI TrCH compared to the shorter TTI TrCH. We believe that quite often this condition is fulfilled: for instance for the speech service we can have 40ms DCCH, and 20 ms DTCHes. The TrCH bit rate on the DCCH is roughly one third (≈4kbps) of that of the DTCHes (≈12kbps), but when seen after the channel coding this proportion is most likely higher because the BER requirement of the DCCH is lower than that of the DTCHes. Moreover, we will have also the rate command that can be of 40ms TTI.

Note that our approach allows to keep the TrCH balanced, compared to [1] where for Figure 1 example the power will need power increase in frame 1as required by the longer TTI TrCH, and so the shorter TTI TrCH will have too good quality.

Difference between this paper and [2]

The joint use of higher layer scheduling and compressed mode by puncturing is no longer considered.

The 1st IL section has been rewrote to make it in the same spirit as 25.212

The 1st IL is not such as p-bit are in the beginning of each column, as this appeared to be agreeable by all companies.

A note have been added in this section that is stating that the removal of the p-bits can be done every where from after the 1st IL up to before the 2nd IL.

The frame segmentation section has been rewritten in a mode concise way.

The formula for computation of $N_{data,*}^{cm,n}$ has been review, so that only frames overlapping with a transmission gap use slot format A, and the other use normal mode slot format.

In section 3.2 (Symbols), it was clarified that the TF *l* index can be dropped in the $H_{i,l}$ and $H_{i,l}^{cm,n}$ notation for the sake of alleviation of notations.

Moreover H_i, $H_{i,l}$ and $H_{i,l}^{cm,n}$ are renamed to FS_i, $FS_{i,l}$ and $FS_{i,l}^{cm,n}$ (standing for radio Frame Segment size), whereas H_i now designates the block size after 1st RM.

A new proposal based on segmentation coefficients.

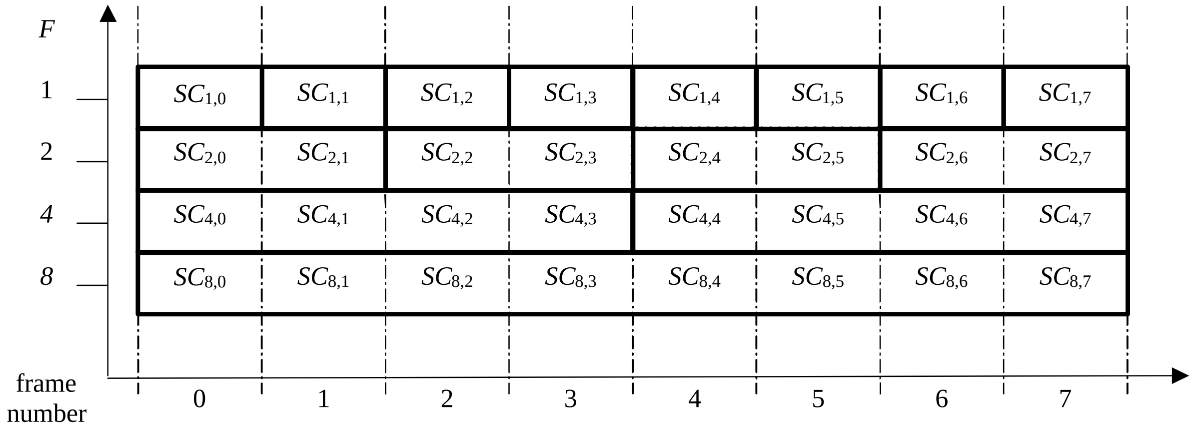
Our proposal is based on a set of segmentation coefficients SC_{Fn}. There are $F_{\max}$ segmentation coefficients for each possible TTI duration in the CCTrCH.

- The index F tells the TTI durations: $F \in \{1,2,4,8\}$.
- The index n identifies one radio frame within the longest TTI: $n \in \{0,1,\ldots,F_{\max}-1\}$,

The segmentation coefficient $SC_{F,m\cdot F+n}$ gives for any TrCH of TTI with a duration of *F* radio frames, for the TTI number *m* within the largest TTI, and for the radio frame number *n* within this TTI number *m*, the proportion of data falling into the corresponding segment. Hence, the segmentation coefficients are positive numbers summing up to 1 within one TTI, and therefore we have the following equation that by definition is always held:

$$\left(\begin{array}{c}\forall F \in \{1,2,4,8\} \\ \forall m \in \left\{0,1,\ldots,\dfrac{F_{\max}}{F}-1\right\}\end{array}\right) \quad \sum_{n=0}^{n=F-1} SC_{F,m\cdot F+n} = 1$$

This is summarised by the figure below where we assume that all TTI duration $F \in \{1,2,4,8\}$ are used (and so $F_{\max} = 8$). The segmentation coefficients summing up to 1 are placed in the same bold outline box.



Note that equal segmentation of TTI number *m* for TTI duration *F* equates to the following relation:

$$\forall n \in \{0,1,\ldots,F-1\}\, SC_{F,m \cdot F+n} = \frac{1}{F}$$

The rate matching can be determined is a very similar way as in the normal mode scheme, except for this that the $\frac{1}{F}$ factor is replaced by $SC_{F,m,n}$.

Determination of segmentation coefficients.

In this proposal we assume that the segmentation coefficient are signalled from the higher layers, that is from the network to the UE.

However, if required by other delegates we can present the methods that can be used in order to compute them.

Open items

- Dynamic and granularity of segmentation coefficient : we propose from 0 to $1\text{-}2^{-10}$ by steps of 2^{-10} as a working assumption

- Whether segmentation coefficients are to be signalled or calculated in both end. For the time being we propose signalled as a working assumption.

Conclusion

We propose the draft CR given in the sequel, to be taken as a basis for the CM by puncturing working assumption.

3GPP/SMG Meeting RAN WG1#11
San Diego, USA, Feb 2000

Document R1-00xxx
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.212 CR xxx Current Version: 3.1.1

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	RAN#7	for approval	X	strategic	(for SMG use only)
list expected approval meeting # here ↑		for information		non-strategic	

Form: CR cover sheet, version 2 for 3GPP and SMG *The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Form-v2.doc*

Proposed change affects: (U)SIM [ ] ME [X] UTRAN / Radio [X] Core Network [ ]
(at least one should be marked with an X)

Source: Mitsubishi Electric **Date:**

Subject: Downlink Compressed Mode by puncturing

Work item: TS 25.212

Category: *(only one category shall be marked with an X)*

F	Correction		
A	Corresponds to a correction in an earlier release		
B	Addition of feature	X	
C	Functional modification of feature	X	
D	Editorial modification		

Release:

Phase 2	
Release 96	
Release 97	
Release 98	
Release 99	X
Release 00	

Reason for change: Introduction of a method for compressed mode by puncturing, by use of segmentation coefficients.

Clauses affected: To be completed

Other specs affected:

Other 3G core specifications		→ List of CRs:
Other GSM core specifications		→ List of CRs:
MS test specifications		→ List of CRs:
BSS test specifications		→ List of CRs:
O&M specifications		→ List of CRs:

Other comments: ΔN_{max} has been renamed $\Delta N_{i,\max}^{TTI}$ because it was commented by some delegates that the ΔN_{max} notation was confusing.
R_I and C_I have been renamed RI and CI because C_I interferes with C_i when $i = I$

help.doc

<-------- double-click here for help and instructions on how to create a CR.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

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*

N_{first} The first slot in the *TG*.
N_{last} The last slot in the *TG*. N_{last} is either a slot in the same radio frame as N_{first} or a slot in the radio frame immediately following the slot that contains N_{first}.

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_i Radio frame number of TrCH i.
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.
$SC_{F,n}$ DL compressed mode by puncturing Segmentation coefficient for TTI duration F in radio frame count, and radio frame number n within largest TTI ($0 \le n \le F_{max}$).
$FS_{i,l}^{cm,n}$ DL radio frame segment size for TrCH i, for TF l, and for radio frame number n within longest TTI, when compressed mode by puncturing is in use. This notation can be alleviated to $FS_i^{cm,n}$ by dropping the TF index when this does not lead to an ambiguity.
$FS_{i,l}$ DL radio frame segment size for TrCH i, and for TF l when compressed mode by puncturing is not in use. This notation can be alleviated to FS_i by dropping the TF index when this does not lead to an ambiguity.

Temporary variables, i.e. variables used in several (sub)sections with different meaning.

x, X
y, Y
z, Z
x', X'
y', Y'

4.2 Transport-channel coding/multiplexing

Data arrives to the coding/multiplexing unit in form of transport block sets once every transmission time interval. The transmission time interval is transport-channel specific from the set {10 ms, 20 ms, 40 ms, 80 ms}.

The following coding/multiplexing steps can be identified:

- Add CRC to each transport block (see section 4.2.1)
- Transport block concatenation and code block segmentation (see section 4.2.2)
- Channel coding (see section 4.2.3)
- Rate matching (see section 4.2.7)
- Insertion of discontinuous transmission (DTX) indication bits (see section 4.2.9)
- Interleaving (two steps, see sections 4.2.4 and 4.2.11)
- Radio frame segmentation (see section 4.2.6)
- Multiplexing of transport channels (see section 4.2.8)
- Physical channel segmentation (see section 4.2.10)
- Mapping to physical channels (see section 4.2.12)

The coding/multiplexing steps for uplink and downlink are shown in figure 1 and figure 2 respectively.

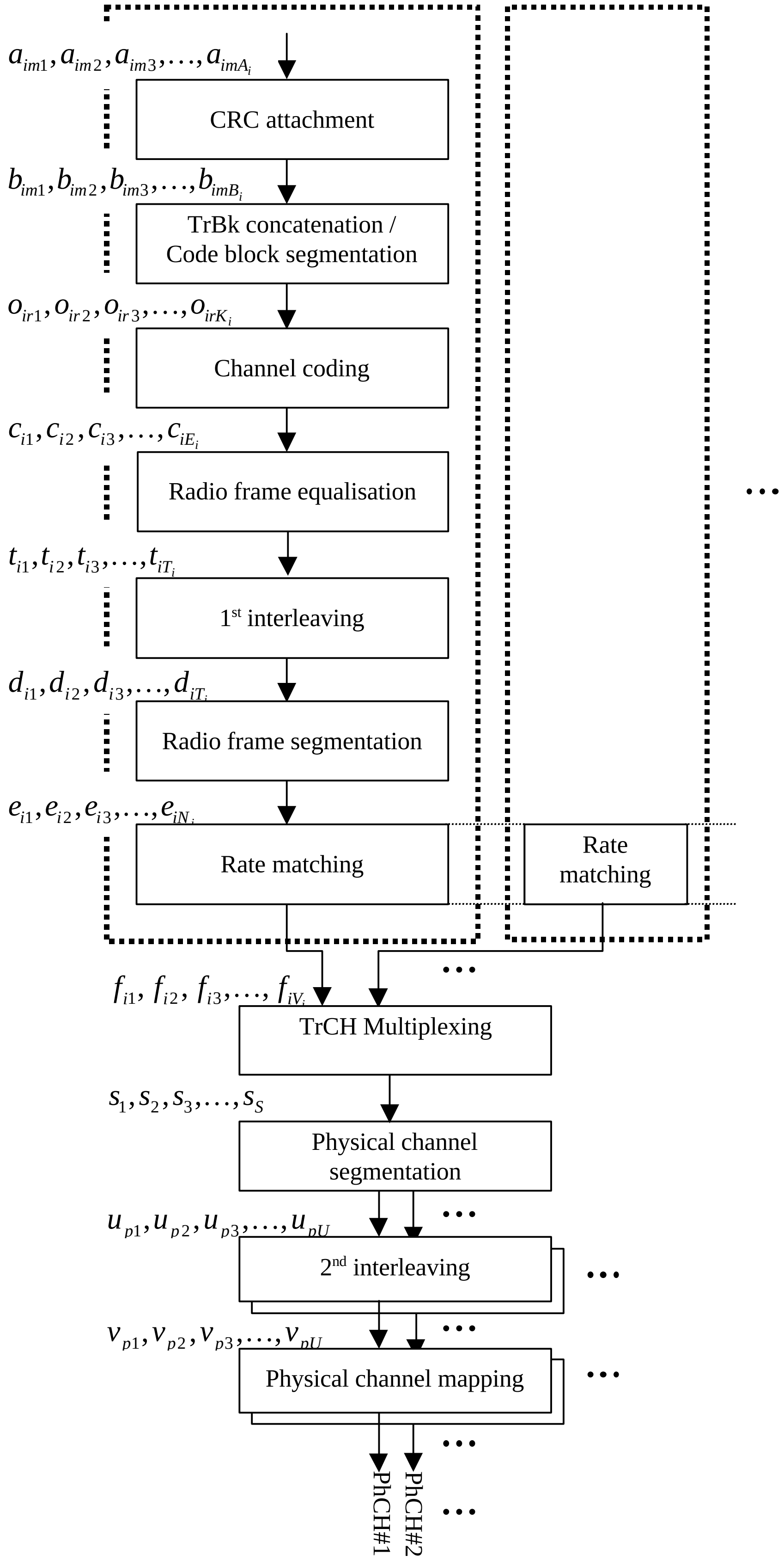
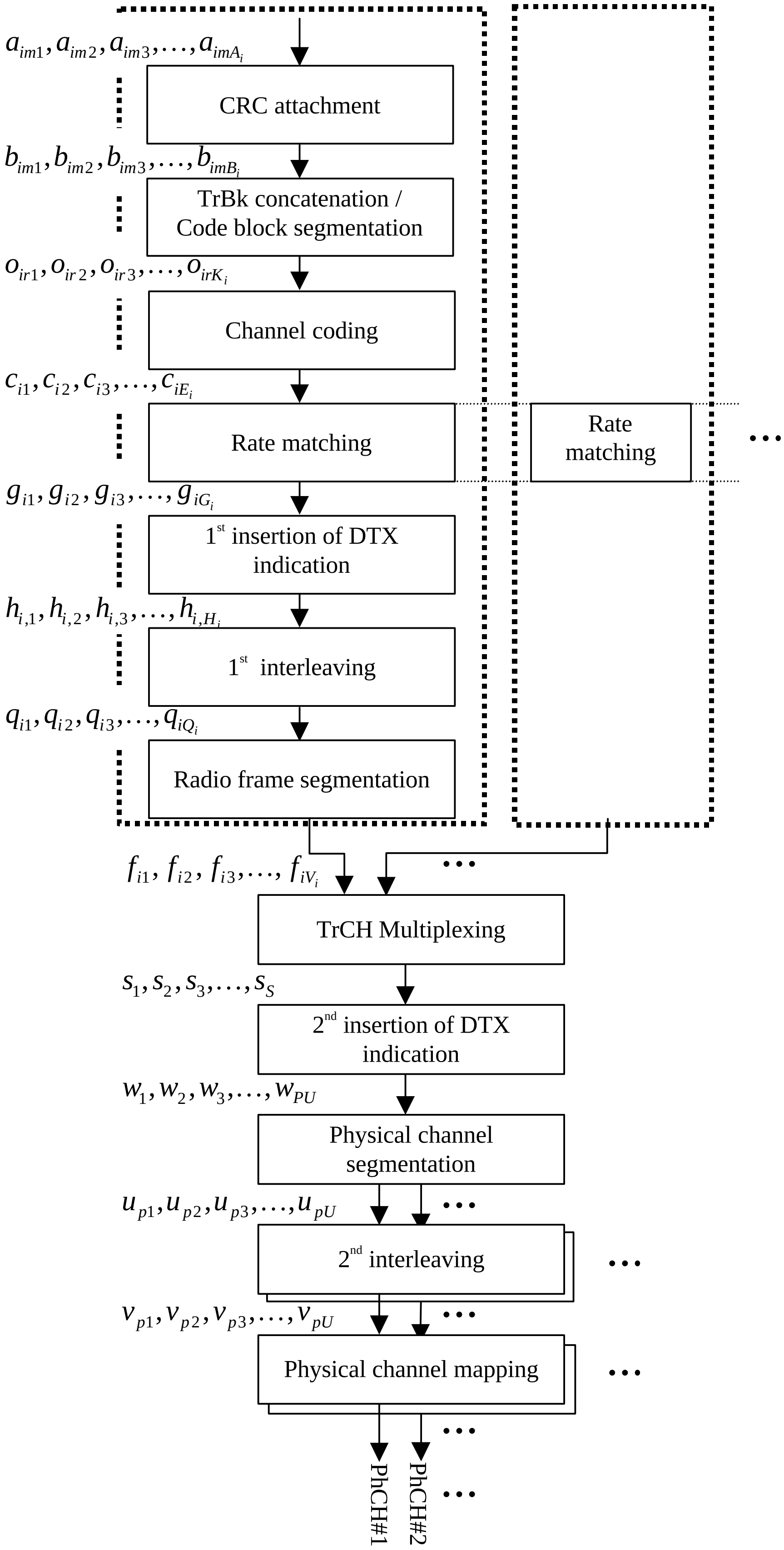


Figure 1: Transport channel multiplexing structure for uplink


$a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$
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
$g_{i1}, g_{i2}, g_{i3}, \ldots, g_{iG_i}$
1st insertion of DTX indication
$h_{i,1}, h_{i,2}, h_{i,3}, \ldots, h_{i,H_i}$
1st interleaving
$q_{i1}, q_{i2}, q_{i3}, \ldots, q_{iQ_i}$
Radio frame segmentation
$f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$
TrCH Multiplexing
$s_1, s_2, s_3, \ldots, s_S$
2nd insertion of DTX indication
$w_1, w_2, w_3, \ldots, w_{PU}$
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

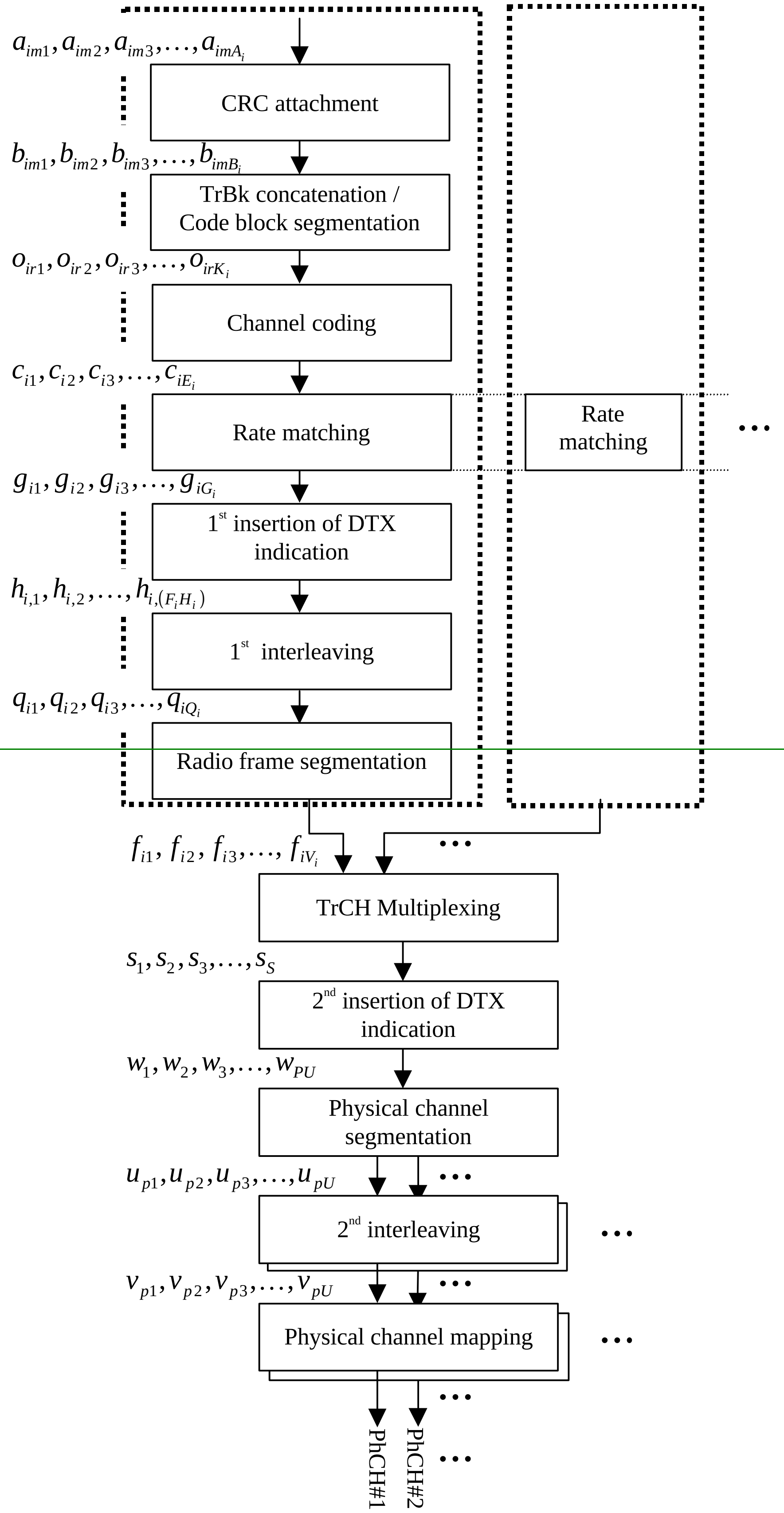


Figure 2: Transport channel multiplexing structure for downlink<u><Mitsubishi note : the only change to figure 2 is in $h_{i,1}, h_{i,2}, h_{i,3}, \ldots, h_{i,H_i}$ where $F_i \cdot H_i$ is replaced by H_i ></u>

The single output data stream from the TrCH multiplexing is denoted *Coded Composite Transport Channel (CCTrCH)*. A CCTrCH can be mapped to one or several physical channels.

4.2.5 1st interleaving

The 1st interleaving is a block interleaver with inter-column permutations. 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)~~. The output bit sequence is denoted by $y_{i1}, y_{i2}, y_{i3}, \ldots, y_{iY_i}$, where i is TrCH number and Y_i the number of bits.

Two intermediate bit sequences are respectively denoted by $x'_{i1}, x'_{i2}, x'_{i3}, \ldots, x'_{iX'_i}$ or $y'_{i1}, y'_{i2}, y'_{i3}, \ldots, y'_{iY'_i}$, where i is TrCH number and X'_i or Y'_i the respective number of bits. The $x'_{i1}, x'_{i2}, x'_{i3}, \ldots, x'_{iX'_i}$ is hereinafter called the intermediate input bit sequence, while the $y'_{i1}, y'_{i2}, y'_{i3}, \ldots, y'_{iY'_i}$ is called the intermediate ouptu bit sequence.

The output bit sequence is derived as follows:

4.2.5.1 Operation of the 1st interleaver on the intermediate bit sequences

At this stage X'_i is assumed and guaranteed to be an integer multiple of F_i

(1) ~~Select the number of columns C_I from table 3.~~ Set the number of columns CI to F_i, as in table 3

(2) Determine the number of rows RI ~~R_I~~ defined as

$$\cancel{R_I = X_i/C_I}\; RI = X'_i/CI$$

(3) Write the intermediate input bit sequence from $x'_{i,1}$ to x'_{i,X'_i} ~~x_{i,X_i}~~ into the ~~$R_I \times C_I$~~ $RI \times CI$ rectangular matrix row by row starting with bit $x_{i,1}$ in the first column of the first row and ending with bit $x'_{i,RI\cdot CI}$ ~~$x_{i,(R_I C_I)}$~~ in column CI of row RI:

$$\begin{bmatrix} x'_{i,1} & x'_{i,2} & x'_{i,3} & \dots & x'_{i,CI} \\ x'_{i,(CI+1)} & x'_{i,(CI+2)} & x'_{i,(CI+3)} & \dots & x'_{i,(2CI)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ x'_{i,((RI-1)CI+1)} & x'_{i,((RI-1)CI+2)} & x'_{i,((RI-1)CI+3)} & \dots & x'_{i,(RI\cdot CI)} \end{bmatrix}$$

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

(4) Perform the inter-column permutation based on the pattern $\{P_{1,CI}(j)\}$ (j=0,1, ..., CI-1) shown in table 3, where $P_{1,CI}(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by $\cancel{y_{ik}}$ $y'_{i,k}$, $Y'_i = X'_i$, and constitute the intermediate output sequence:

$$\begin{bmatrix} y'_{i,1} & y'_{i,(RI+1)} & y'_{i,(2RI+1)} & \dots & y'_{i,((CI-1)RI+1)} \\ y'_{i,2} & y'_{i,(RI+2)} & y'_{i,(2RI+2)} & \dots & y'_{i,((CI-1)RI+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y'_{i,RI} & y'_{i,(2RI)} & y'_{i,(3RI)} & \dots & y'_{i,(CI\cdot RI)} \end{bmatrix} \begin{bmatrix} y_{i1} & y_{i,(R_I+1)} & y_{i,(2R_I+1)} & \dots & y_{i,((C_I-1)R_I+1)} \\ y_{i2} & y_{i,(R_I+2)} & y_{i,(2R_I+2)} & \dots & y_{i,((C_I-1)R_I+2)} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ y_{iR_I} & y_{i,(2R_I)} & y_{i,(3R_I)} & \dots & y_{i,(C_IR_I)} \end{bmatrix}$$

(5) Read the intermediate output bit sequence $y'_{i1}, y'_{i2}, y'_{i3}, \dots, y'_{i,(CI\cdot RI)}$ $\cancel{y_{i1}, y_{i2}, y_{i3}, \dots, y_{i,(C_IR_I)}}$ of the 1st interleaving column by column from the inter-column permuted $RI \times CI$ $\cancel{R_I \times C_I}$ matrix. Bit $y'_{i,1}$ $\cancel{y_{i,1}}$ corresponds to the first row of the first column and bit $y'_{i,(R_IC_I)}$ $\cancel{y_{i,(R_IC_I)}}$ corresponds to row R_I of column C_I.

Table 3

TTI	Number of columns CI $\cancel{C_I}$	Inter-column permutation patterns $\{P_{1,CI}(0), P_{1,CI}(1), \dots, P_{1,CI}(CI-1)\}$
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}

4.2.5.2 Relation between input or output and intermediate bit sequence in other case than DL compressed mode by puncturing

In other cases than DL compressed mode by puncturing, the input bit sequence and the intermediate input bit sequence are identical, that is to say :

$$X'_i = X_i$$

$$x'_{i,k} = x_{i,k} \text{ for } k = 1,2,\dots,X_i.$$

Moreover, the intermediate output bit sequence and the output bit sequence are identical, that is to say :

$$Y_i = Y'_i$$

$$y_{i,k} = y'_{i,k} \text{ for } k = 1,2,\dots,Y'_i.$$

4.2.5.3 Relation between input or output and intermediate bit sequence in the case of DL compressed mode by puncturing

In this section we use dummy bits called p-bits, that take a fourth value on top of the 3 bit values {0,δ,1}.

The number of bits in the intermediate bit sequence is defined as follows :

$$Y_i' = X_i' = F_i \cdot \left(\max_{\substack{m \cdot F_i \le n \\ n < (m+1) \cdot F_i}} FS_i^{cm,n} \right)$$

Moreover we have also the following relations :

$$Y_i = X_i = \sum_{n=m \cdot F_i}^{n=(m+1) \cdot F_i - 1} FS_i^{cm,n}$$

The intermediate input bit sequence $x'_{i1}, x'_{i2}, x'_{i3}, \ldots, x'_{iX'_i}$ is obtained from the input bit sequence $x_{i,1}, x_{i,2}, x_{i,3}, \ldots, x_{i,X_i}$ by inserting p-bits into it. The p-bits are inserted so that they are grouped in the beginning of each interleaver matrix column.

To that purpose we use a F_i p-bit count-downs $pbcd_0$, $pbcd_1$, …, $pbcd_{F_i - 1}$, counting the number of p-bits still to be inserted in the beginning of the respective column.

-- initialisation of $pbcd_n$ p-bit count downs

for n = 0 to F_i-1 do

$n' = P_{1,F_i}(n)$

cbi[n] = $X_i'/F_i - FS_i^{cm, m \cdot F_i + n'}$

end for

-- p-bit insertion

n = 0

k = 1

l = 1

while l = 1 to X_i' do

if cbi[n] ≠ 0 then

$x'_{i,l}$ = p-bit

else

$x'_{i,l} = x_{i,k}$

k = k+1

cbi[n] = cbi[n]-1

end if

$n = n$+1 mod F_i

end for

The output bit sequence $y_{i,1}, y_{i,2}, y_{i,3}, \ldots, y_{i,Y_i}$ is obtained from the intermediate output bit sequence $y'_{i,1}, y'_{i,2}, y'_{i,3}, \ldots, y'_{i,Y'_i}$ by removing the p-bits from it. In other words, the following algorithm is applied :

k = 1

l = 1

for l = 1 to Y'_i

if $y'_{i,l} \neq$ p-bit then

$y_{i,k} = y'_{i,l}$

$k = k$+1

end-if

end-for

Note : In this description the p-bits are removed in the 1st interleaver. However, alternative descriptions, equivalent from the point of view of the CCTrCH output, would remove them in any other step after the 1st interleaver and before the 2nd interleaver : if for instance they are removed after the radio frame segmentation, the segments, including p-bits, are all of equal size over a TTI, like in normal mode.

4.2.5.~~1~~3 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 T_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~~4 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 $h_{i1}, h_{i2}, h_{i3}, \ldots, h_{i,H_i}$ $\cancel{h_{i1}, h_{i2}, h_{i3}, \ldots, h_{i,F_iH_i}}$, where i is the TrCH number. Hence, $x_{ik} = h_{ik}$ and $X_i = \cancel{F_i}H_i$.

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, $q_{ik} = y_{ik}$, $Q_i = \cancel{F_i}H_i$ if fixed positions are used, and $Q_i = G_i$ if flexible positions are used.

4.2.6 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 not in compressed mode by puncturing and radio frame size equalisation in the UL in compressed or normal loop, the input bit sequence length is guaranteed to be an integer multiple of F_i.

In the DL in compressed mode by puncturing the input bit sequence is not necessarily an integer multiple of F_i. Note that a TrCH TTI is concerned by this when the largest TTI containing it is overlapping with at least one transmission gap.

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 :

$$y_{i,n_i,1}, y_{i,n_i,2}, y_{i,n_i,3}, \ldots, y_{i,n_i,Y_{i,n_i}} \quad \cancel{y_{i,n_i1}, y_{i,n_i2}, y_{i,n_i3}, \ldots, y_{i,n_iY_i}}$$

where n_i is the radio frame number in current TTI and ~~Y_i~~ Y_{i,n_i} is the number of bits ~~per~~ in radio frame number n_i for TrCH *i*. The output sequences are defined as follows:

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

$y_{i,n_i,k} = x_{i,l}$ where n_i = 1, …, F_i-1, k = 1, 2, …., Y_{i,n_i} , and $l = \left(\sum_{x=0}^{x=n_i-1} Y_{i,x}\right) + k$

where

~~$Y_i = (X_i / F_i)$~~ Y_{i,n_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+1^th~~ radio frame number n_i

The (n_i+1) -th segment is mapped to the (n_i+1) -th radio frame of the transmission time interval.

In DL compressed mode by puncturing :

$$Y_{i,n} = FS_i^{cm, m \cdot F_i + n}$$ for frame number n = 0, 1, …, F_i-1 within the TTI, and TTI number *m* within the longest TTI.

Otherwise

$$Y_{i,n} = X_i / F_i$$ for all frame number n = 0, 1, …, F_i-1 within the TTI.

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, $e_{i,k} = y_{i,n_i k}$ and N_i = ~~Y_i~~ Y_{i,n_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, $f_{i,k} = y_{i,n_i k}$ and $V_i = Y_i$.

4.2.7 Rate matching

Rate matching means that bits on a transport channel are repeated or punctured. Higher layers assign a rate-matching attribute for each transport channel. 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 channel 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 TrCH multiplexing is identical to the total channel bit rate of the allocated dedicated physical channels.

If no bits are input to the rate matching for all TrCHs within a CCTrCH, the rate matching shall output no bits for all TrCHs within the CCTrCH and no uplink DPDCH will be selected in the case of uplink rate matching.

Notation used in section 4.2.7 and subsections:

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

For downlink : An intermediate calculation variable (not an integer but a multiple of 1/8).

N_{il}^{TTI} : Number of bits in a transmission time interval before rate matching on TrCH i with transport format l. Used in downlink only.

ΔN_{ij} : For uplink: If positive - number of bits that should be repeated in each radio frame on TrCH i with transport format combination j.

If negative - number of bits that should be punctured in each radio frame on TrCH i with transport format combination j.

For downlink : An intermediate calculation variable (not an integer but a multiple of 1/8).

ΔN_{il}^{TTI} : If positive - number of bits to be repeated in each transmission time interval on TrCH i with transport format j.

If negative - number of bits to be punctured in each transmission time interval on TrCH i with transport format j.

Used in downlink only.

$N_{data,*}^{cm,n}$, $n=0$ to F_{max} -1 : in the DL, total number of bits available to the CCTrCH in a radio frame such that the longest TTI in use is overlapping with a compressed mode gap. n is the frame number within this longest TTI.

RM_i: Semi-static rate matching attribute for transport channel 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.

I: Number of TrCHs in the CCTrCH.

Z_{ij}: Intermediate calculation variable.

F_i: Number of radio frames in the transmission time interval of TrCH i.

F_{maxc} Maximum number of radio frames in a transmission time interval used in the CCTrCH :

$$F_{\max} = \max_{1 \le i \le I} F_i$$

n_i: Radio frame number in the transmission time interval of TrCH i ($0 \le n_i < F_i$).

q: Average puncturing or repetition distance (normalised to only show the remaining rate matching on top of an integer number of repetitions). Used in uplink only.

$I_F(n_i)$: 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). Used in uplink only.

$S(n_i)$: The shift of the puncturing or repetition pattern for radio frame n_i. Used in uplink only.

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

$TFS(i)$ The set of transport format indexes l for TrCH i.

$TFCS$ The set of transport format combination indexes j.

e_{ini} Initial value of variable e in the rate matching pattern determination algorithm of section 4.2.7.5.

e_{plus} Increment of variable e in the rate matching pattern determination algorithm of section 4.2.7.5.

e_{minus} Decrement of variable e in the rate matching pattern determination algorithm of section 4.2.7.5.

b: Indicates systematic and parity bits

b=1: Systematic bit. $X(t)$ in section 4.2.3.2.1.

b=2: 1st parity bit (from the upper Turbo constituent encoder). $Y(t)$ in section 4.2.3.2.1.

b=3: 2nd parity bit (from the lower Turbo constituent encoder). $Y'(t)$ in section 4.2.3.2.1.

The * (star) notation is used to replace an index x when the indexed variable X_x does not depend on the index x. In the left wing of an assignment the meaning is that "$X_* = Y$" is equivalent to "**for all** $\underline{x}$ **do** $X_x = Y$ ". In the right wing of an assignment, the meaning is that "$Y = X_*$ " is equivalent to "**take any** $\underline{x}$ **and do** $Y = X_x$ "

The following relations, defined for all TFC j, are used when calculating the rate matching parameters:

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

$$Z_{ij} = \left\lfloor \frac{\sum_{m=1}^{i} RM_m \cdot N_{mj}}{\sum_{m=1}^{I} RM_m \cdot N_{mj}} \cdot N_{data,j} \right\rfloor \quad \text{for all } i = 1 \,..\, \mathrm{I} \qquad (1)$$

$$\Delta N_{ij} = Z_{ij} - Z_{i-1,j} - N_{ij} \qquad \text{for all } i = 1 \,..\, \mathrm{I}$$

4.2.7.1 Determination of rate matching parameters in uplink

4.2.7.1.1 Determination of SF and number of PhCHs needed

In uplink, puncturing can be applied to match the CCTrCH bit rate to the PhCH bit rate. The bit rate of the PhCH(s) is limited by the UE capability and restrictions imposed by UTRAN, through limitations on the PhCH spreading factor. The maximum amount of puncturing that can be applied is signalled 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 capability and the restrictions from UTRAN, the allowed 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 $N_{data} - \sum_{x=1}^{I} \frac{RM_{x,}}{\min\limits_{1\le y\le I}\{RM_y\}} \cdot N_{x,j}$ is non negative }

If SET1 is not empty and the smallest element of SET1 requires just one PhCH then

$N_{data,j}$ = min SET1

else

SET2 = { N_{data} in SET0 such that $N_{data} - PL \cdot \sum_{x=1}^{I} \frac{RM_x}{\min\limits_{1\le y\le I}\{RM_y\}} \cdot N_{x,j}$ 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 PhCH do

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

End while

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

End if

4.2.7.1.2 Determination of parameters needed for calculating the rate matching pattern

The number of bits to be repeated or punctured, DN_{ij}, within one radio frame for each TrCH *i* is calculated with equation 1 for all possible transport format combinations *j* and selected every radio frame. $N_{data,j}$ is given from section 4.2.7.1.1. In compressed mode $N_{data,j}$ is replaced by $N_{data,j}^{cm}$ in Equation 1. $N_{data,j}^{cm}$ is given from the following relation:

$N_{data,j}^{cm} = 2N_{data,j} - 2N_{TGL}$, for compressed mode by spreading factor reduction

$N_{data,j}^{cm} = N_{data,j} - N_{TGL}$, for compressed mode by higher layer scheduling

$$N_{TGL} = \begin{cases} \frac{TGL}{15} N_{data,j}, & \text{if } N_{first} + TGL \le 15 \\ \frac{15 - N_{first}}{15} N_{data,j}, & \text{in first frame if } N_{first} + TGL > 15 \\ \frac{TGL - (15 - N_{first})}{15} N_{data,j}, & \text{in second frame if } N_{first} + TGL > 15 \end{cases}$$

N_{first} and *TGL* are defined in section 4.4.

If $DN_{ij} = 0$ then the output data of the rate matching is the same as the input data and the rate matching algorithm of section 4.2.7.5 does not need to be executed.

If $DN_{ij} \neq 0$ the parameters listed in sections 4.2.7.1.2.1 and 4.2.7.1.2.2 shall be used for determining e_{ini}, e_{plus}, and e_{minus} (regardless if the radio frame is compressed or not).

4.2.7.1.2.1 Uncoded and convolutionally encoded TrCHs

$R = DN_{ij} \bmod N_{ij}$ -- note: in this context $DN_{ij} \bmod N_{ij}$ is in the range of 0 to N_{ij}-1 i.e. -1 mod 10 = 9.

if $R \neq 0$ and $2R \leq N_{ij}$

then $q = \lceil N_{ij} / R \rceil$

else

$q = \lceil N_{ij} / (R - N_{ij}) \rceil$

endif

-- note: q is a signed quantity.

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 x = 0 to F_i-1

$S(I_F(|\lfloor x*q' \rfloor| \bmod F_i)) = (|\lfloor x*q' \rfloor| \operatorname{div} F_i)$

end for

$\Delta N_i = \Delta N_{i,j}$

a = 2

For each radio frame, the rate-matching pattern is calculated with the algorithm in section 4.2.7.5, where :

$X_i = N_{i,j}$., and

$e_{ini} = (a \cdot S(n_i) \cdot |\Delta N_i| + 1) \bmod (a \cdot N_{ij})$.

$e_{plus} = a \cdot N_{ij}$

$e_{minus} = a \cdot |\Delta N_i|$

puncturing for DN<0, repetition otherwise.

4.2.7.1.2.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $DN_{i,j} > 0$, the parameters in section 4.2.7.1.2.1 are used.

If puncturing is to be performed, the parameters below shall be used. Index *b* is used to indicate systematic (*b*=1), 1st parity (*b*=2), and 2nd parity bit (*b*=3).

$a=2$ when b=2

$a=1$ when b=3

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{i,j}/2 \rfloor, & b=2 \\ \lceil \Delta N_{i,j}/2 \rceil, & b=3 \end{cases}$$

$X_i = \lfloor N_{i,j}/3 \rfloor$,

$q = \lfloor X_i / |\Delta N_i| \rfloor$

if($q \leq 2$)

for x=0 to F_i-1

S[I_F[(3x+b-1) mod F_i]] = x mod 2;

end for

else

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 x=0 to F_i -1

r = $\lceil x*q' \rceil$ mod F_i;

S[I_F[(3r+b-1) mod F_i]] = $\lceil x*q' \rceil$ div F_i;

endfor

endif

For each radio frame, the rate-matching pattern is calculated with the algorithm in section 4.2.7.5, where:

X_i is as above,

$e_{ini} = (a \cdot S(n_i) \cdot |\Delta N_i| + X_i) \bmod (a \cdot X_i)$, if e_{ini} =0 then $e_{ini} = a \cdot X_i$.

$e_{plus} = a \cdot X_i$

$e_{minus} = a \cdot |\Delta N_i|$

4.2.7.2 Determination of rate matching parameters in downlink

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

For downlink in compressed mode, for the frame with number $n \in \{0,1,\ldots,F_{\max}-1\}$ relative to the longest CCTrCH's TTI overlapping with at least one compressed mode transmission gap we have

$$N_{data,*}^{cm,n} = P \cdot N_{tr} \cdot (N_{data1} + N_{data2})$$

where

when frame number n overlaps with a transmission gap N_{data1} and N_{data2} are the number of bits in the data fields of a slot for slot format A as defined in [2], and N_{tr} is the number of transmitted slot in the radio frame.

when frame number *n* does not overlap with a transmission gap, N_{data1} and N_{data2} are the number of bits in the data fields of a slot for normal slot format as defined in [2], and $N_{tr} = 15$.

Note that $N_{data,*}^{cm,n} = N_{data,*}$ when frame *n* is not compressed.

In the following, the amount of puncturing or repetition for the TTI, as determined by the rate matching parameters provided by higher layers is calculated. In normal mode it is noted $\Delta N_{i,\max}^{TTI}$ for fixed positions, and noted $\Delta N_{i,l}^{TTI}$ for flexible positions. Similarly, in compressed mode it is noted $\Delta N_{i,\max}^{TTI,cm,m}$ for fixed positions, and noted $\Delta N_{i,l}^{TTI,cm,m}$ for flexible positions, where *m* stands for the TTI number within the largest TTI affected by at least a compressed mode transmission gap. $m \in \left\{0,1,\ldots,\frac{F_{\max}}{F}\right\}$.

< Mitsubishi Note : be careful with this that $\Delta N_{i,\max}^{TTI,cm,m}$ and $\Delta N_{i,l}^{TTI,cm,m}$ differ from the Nortel's $\Delta N_{cm,i,\max}^{TTI}$ and $\Delta N_{cm,i,l}^{TTI}$ of tdoc R1-00-272. $\Delta N_{i,\max}^{TTI,cm}$ and $\Delta N_{i,l}^{TTI,cm}$ are the amount of rate matching to b done, they don't need to be added up to the value computed in normal mode.>

Furthermore, the radio frame segment size, that is to say the amount of data falling into each radio frame is also determined. For TrCH *i*, and TF *l*, it is denoted $FS_{i,l}$ for normal mode, and $FS_{i,l}^{cm,n}$ for compressed by puncturing. Index *l* meaning TF may be dropped when there is no ambiguity.

4.2.7.2.1 Determination of segmentation coefficients for DL compressed mode by puncturing

<Mitsubishi Note: to be completed in next revision>.

4.2.7.2.~~1~~2 Determination of rate matching parameters for fixed positions of TrCHs

4.2.7.2.2.1. Determination of segment size $FS_{i,*}$ and puncture/repeat count $\Delta N_{i,\max}^{TTI}$ in normal mode

First an intermediate calculation variable $N_{i,*}$ is calculated for all transport channels *i* by the following formula:

$$N_{i,*} = \frac{1}{F_i} \cdot \max_{l \in TFS(i)} N_{i,l}^{TTI}$$

The computation of the $\Delta N_{i,l}^{TTI}$ parameters is then performed in for all TrCH *i* and all TF *l* by the following formula, where $\Delta N_{i,*}$ is derived from $N_{i,*}$ by the formula given at section 4.2.7:

$$FS_{i,*} = N_{i,*} + \Delta N_{i,*}$$

$$\Delta N_{i,\max}^{TTI} = F_i \cdot \Delta N_{i,*} \cancel{\Delta N_{max} = F_i \cdot \Delta N_{i,*}}$$

4.2.7.2.2.2 Use of puncture/repeat count $\Delta N_{i,\max}^{TTI}$ or $\Delta N_{i,\max}^{TTI,cm,m}$ in fixed positions, both in normal and compressed mode, for the RM pattern setting

The parameter $\Delta N_{i,\max}^{TTI,cm,n}$ used in this section is determined in section 4.2.7.2.3.1.

In this section, in normal mode, we set

$$\Delta N_{i,\max} = \Delta N_{i,\max}^{TTI}$$

In compressed mode, for TTI number *m* within the largest TTI overlapping at least one transmission gap, we set that :

$$\Delta N_{i,\max} = \Delta N_{i,\max}^{TTI,cm,m}$$

Note that TTI number *m* does not necessarily overlap with one gap.

<Mitsubishi Note : in the rest of the fixed positions section the only changes are editorial, that is to say, replacement of ΔN_{max} by $\Delta N_{i,max}$, replacement of N_{max} by $N_{i,max}$, and also $e_{\min us}$ is replace by e_{minus} because all the "minus" was not in italic, since min is automatically put to function font by the MS-equation editor>

If $\Delta N_{i,\max} = 0$ ~~$\Delta N_{\max} = 0$~~ then, for TrCH *i*, the output data of the rate matching is the same as the input data and the rate matching algorithm of section 4.2.7.5 does not need to be executed. In this case we have :

$$\forall l \in TFS(i)\ \Delta N_{i,l}^{TTI} = 0$$

If $\Delta N_{i,\max} \neq 0$ ~~$\Delta N_{\max} \neq 0$~~ the parameters listed in sections 4.2.7.2.~~1~~2.2.1 and 4.2.7.2.~~1~~2.2.2 shall be used for determining e_{ini}, e_{plus}, and e_{minus}.

4.2.7.2.~~1~~2.2.1 Uncoded and convolutionally encoded TrCHs

$$\Delta N_i = \Delta N_{i,max} \cancel{\Delta N_i = \Delta N_{max}}$$

a=2

$$N_{i,max} = \max_{l \in TFS(i)} N_{il}^{TTI} \cancel{N_{max} = \max_{l \in TFS(i)} N_{il}^{TTI}}$$

For each transmission time interval of TrCH *i* with TF *l*, the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

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

$$e_{ini} = 1$$

$$e_{plus} = a \cdot N_{i,max} \cancel{e_{plus} = a \cdot N_{max}}$$

$$e_{\min us} = a \cdot |\Delta N_i|$$

Puncturing if $\Delta N_i < 0$, repetition otherwise. The values of $\Delta N_{i,l}^{TTI}$ may be computed by counting repetitions or puncturing when the algorithm of section 4.2.7.5 is run.

4.2.7.2.2.2.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{i,\max} > 0$ $\cancel{\Delta N_{\max} > 0}$, the parameters in section 4.2.7.2.~~1~~2.2.1 are used.

If puncturing is to be performed, the parameters below shall be used. Index *b* is used to indicate systematic (*b*=1), 1st parity (*b*=2), and 2nd parity bit (*b*=3).

a=2 when *b*=2

a=1 when *b*=3

The bits indicated by *b*=1 shall not be punctured.

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{i,max}/2 \rfloor, & b=2 \\ \lceil \Delta N_{i,max}/2 \rceil, & b=3 \end{cases} \quad \cancel{\Delta N_i = \begin{cases} \lfloor \Delta N_{max}/2 \rfloor, & b=2 \\ \lceil \Delta N_{max}/2 \rceil, & b=3 \end{cases}}$$

$$N_{i,max} = \max_{l \in TFS(i)} (N_{il}^{TTI}/3) \quad \cancel{N_{max} = \max_{l \in TFS(i)} (N_{il}^{TTI}/3)}$$

For each transmission time interval of TrCH *i* with TF *l*, the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI}/3$$

$$e_{ini} = N_{i,max} \quad \cancel{e_{ini} = N_{max}}$$

$$e_{plus} = a \cdot N_{i,max} \quad \cancel{e_{plus} = a \cdot N_{max}}$$

$$e_{minus} = a \cdot |\Delta N_i| \quad \cancel{e_{\min us} = a \cdot |\Delta N_i|}$$

The values of $\Delta N_{i,l}^{TTI}$ may be computed by counting repetitions or puncturing when the algorithm of section 4.2.7.5 is run.

4.2.7.2.~~2~~3 Determination of rate matching parameters for flexible positions of TrCHs, and for fixed positions of TrCHs in compressed mode.

4.2.7.2.3.1 Determination of segment size ($FS_{i,l}$, $FS_{i,l}^{cm,n}$, $FS_{i,*}^{cm,n}$) and puncture/repeat count ($\Delta N_{i,l}^{TTI}$, $\Delta N_{i,l}^{TTI,cm,m}$, $\Delta N_{i,\max}^{TTI,cm,m}$)

First ~~an~~ intermediate calculation variables N_{ij} for normal mode, and $N_{i,j}^{cm,n}$ or $N_{i,*}^{cm,n}$ for compressed mode, ~~is~~are calculated for all transport channels *i* ~~and~~, all transport format combinations *j*, and for compressed mode for all largest TTI-wise radio frame number *n*, by the following formulas:

$$N_{i,j} = \frac{1}{F_i} \cdot N_{i,TF_i(j)}^{TTI} \text{ in normal mode}$$

$$N_{i,j}^{cm,n} = SC_{F_i,n} \cdot N_{i,TF_i(j)}^{TTI} \text{ in compressed mode in flexible positions.}$$

$$N_{i,*}^{cm,n} = SC_{F_i,n} \cdot \max_{l \in TFS(i)} N_{i,l}^{TTI}$$ in compressed mode in fixed positions.

Then rate matching ratios RF_i for normal mode, and $RF_i^{cm,n}$ for compressed mode, are calculated for each the transport channel i in order to minimise the number of DTX bits when the bit rate of the CCTrCH is maximum. The RF_i and RF_i^{cm} ratios are defined by the following formula:

$$RF_i = \frac{N_{data,*}}{\max\limits_{j \in TFCS} \sum\limits_{i=1}^{i=I} \left(RM_i \cdot N_{i,j}\right)} \cdot RM_i$$

$$RF_i^{cm,n} = \frac{N_{data,*}^{cm,n}}{\max\limits_{j \in TFCS} \sum\limits_{i=1}^{i=I} \left(RM_i \cdot N_{i,j}^{cm,n}\right)} \cdot RM_i$$

Note that in the definition of $RF_i^{cm,n}$ in fixed positions, the operator $\max\limits_{j \in TFCS}$ needs not to be used as $N_{i,j}^{cm,n}$ is independent of j.

The computation of $\Delta N_{i,l}^{TTI}$ or $\Delta N_{i,l}^{TTI,cm,m}$ parameters is then performed in two phases. In a first phase, tentative temporary values of $\cancel{\Delta N_{i,l}^{TTI}}$ segment sizes $FS_{i,l}$ or $FS_{i,l}^{cm,n}$ are computed, and in the second phase they are checked and corrected. The first phase, by use of the RF_i or $RF_i^{cm,n}$ ratios, ensures that the number of DTX indication bits inserted is minimum when the CCTrCH bit rate is maximum, but it does not ensure that the maximum CCTrCH bit rate is not greater than $N_{data,*}$ or $N_{data,*}^{cm,n}$. per 10ms. The latter condition is ensured through the checking and possible corrections carried out in the second phase.

At the end of the second phase, the latest value of $\Delta N_{i,l}^{TTI}$ is the definitive value.

The first phase defines the tentative temporary $\cancel{\Delta N_{i,l}^{TTI}}$ $FS_{i,l}$, or $FS_{i,l}^{cm,n}$ for all transport channel i and any of its transport format l by use of the following formula:

$$FS_{i,l} = \left\lceil \frac{RF_i \cdot N_{i,l}^{TTI}}{F_i} \right\rceil \cancel{\Delta N_{i,l}^{TTI} = F_i \cdot \left\lceil \frac{RF_i \cdot N_{i,l}^{TTI}}{F_i} \right\rceil - N_{i,l}^{TTI}}$$

$$FS_{i,l}^{cm,n} = \left\lceil SC_{F_i,n} \cdot RF_i^{cm,n} \cdot N_{i,l}^{TTI} \right\rceil$$

<Mitsubshi Note : **There is no change in the current rule.** The change below is not functional, this does the same thing. The objective is to have similar description in compressed mode and in normal mode

There was a correction in the comment "CCTrCH bit rate (bits per 10ms) for TFC j" where 'l' was replaced by 'j' >

The second phase is defined by the following algorithm in flexible position + normal mode:

for all j in *TFCS* do -- for all TFC

$D = \sum_{i=1}^{i=I} FS_{i,TF_i(j)}$ $\cancel{D = \sum_{i=1}^{i=I} \frac{N_{i,TF_i(j)}^{TTI} + \Delta N_{i,TF_i(j)}^{TTI}}{F_i}}$ -- CCTrCH bit rate (bits per 10ms) for TFC ~~I~~j

if $D > N_{data,*}$ then

for *i* = 1 to *I* do -- for all TrCH

$FS = N_{i,j} + \Delta N_{i,j}$ $\cancel{\Delta N = F_i \cdot \Delta N_{i,j}}$ -- $\Delta N_{i,j}$ is derived from $N_{i,j}$ by the formula given at section 4.2.7.

if $FS > FS_{i,TF_i(j)}$ $\cancel{\Delta N_{i,TF_i(j)}^{TTI} > \Delta N}$ then

$FS_{i,TF_i(j)} = FS$ $\cancel{\Delta N_{i,TF_i(j)}^{TTI} = \Delta N}$

end-if

end-for

end-if

end-for

for *i*=1 to *I* do

for all *l* in *TFS*(*i*) do

$\Delta N_{i,l}^{TTI} = F_i \cdot FS_{i,l} - N_{i,l}^{TTI}$

end-for

end-for

NOTE: The order in which the transport format combinations are checked does not change the final result.

The second phase is defined by the following algorithm in compressed mode:

for all n = 0 to F_{max}-1 do

for all j in *TFCS* do -- for all TFC, in fixed positions, this loop can be omitted.

$D = \sum_{i=1}^{i=I} FS_{i,TF_i(j)}^{cm,n}$ -- CCTrCH bit rate (bits per 10ms) for TFC *j*

if $D > N_{data,*}^{cm,n}$ then

for *i* = 1 to *I* do -- for all TrCH

$FS = N_{i,j}^{cm,n} + \Delta N_{i,j}$ -- $\Delta N_{i,j}$ is derived from $N_{i,j}^{cm,n}$ by the formula given at section 4.2.7 where $N_{i,j}^{cm,n}$ is substituted to $N_{i,j}$ and $N_{data,*}^{cm,n}$ to $N_{data,j}$.

if $FS > FS_{i,TF_i(j)}^{cm,n}$ then

$$FS_{i,TF_i(j)}^{cm,n} = FS$$

end-if

end-for

end-if

end-for

Now, for compressed mode with flexible position we make the following computations

for i=1 to I do

for all m = 0 to $\frac{F_i}{F_{\max}} - 1$ do

for all l in $TFS(i)$ do

$$\Delta N_{i,l}^{TTI,cm,m} = \left(\sum_{n=m \cdot F_i}^{n=(m+1) \cdot F_i - 1} FS_{i,l}^{cm,n} \right) - N_{i,l}^{TTI}$$

end-for

end-for

end-for

NOTE: In flexible position, the order in which the transport format combinations are checked does not change the final result.

For compressed mode in fixed positions we make the following computations :

for i=1 to I do

for all m = 0 to $\frac{F_i}{F_{\max}} - 1$ do

$$N_{i,\max} = \max_{l \in TFS(i)} N_{i,l}^{TTI}$$

$$\Delta N_{i,\max}^{TTI,cm,m} = \left(\sum_{n=m \cdot F_i}^{n=(m+1) \cdot F_i - 1} FS_{i,*}^{cm,n} \right) - N_{i,\max}$$

end-for

end-for

4.2.7.2.3.2 Use of puncture/repeat count $\Delta N_{i,l}^{TTI}$ or $\Delta N_{i,l}^{TTI,cm,m}$ in flexible positions, both in normal and compressed mode, for the RM pattern setting

In the following the explanation given with $\Delta N_{i,l}^{TTI}$ for normal mode, hold in the same way for compressed mode, where to $\Delta N_{i,l}^{TTI}$ is to be substituted $\Delta N_{i,l}^{TTI,cm,m}$. In compressed mode *m* is the TTI number within the largest TTI affected by at least one transmission gap, id est $m \in \left\{0,1,\ldots,\frac{F_{\max}}{F}-1\right\}$ Note that TTI number *m* does not necessarily overlap with one gap.

If $\Delta N_{i,l}^{TTI} = 0$ then, for TrCH *i* at TF *l*, the output data of the rate matching is the same as the input data and the rate matching algorithm of section 4.2.7.5 does not need to be executed.

If $\Delta N_{i,l}^{TTI} \neq 0$ the parameters listed in sections 4.2.7.2.3.2.1 and 4.2.7.2.3.2.2 shall be used for determining e_{ini}, e_{plus}, and e_{minus}.

4.2.7.2.~~2~~3.2.1 Uncoded and convolutionally encoded TrCHs

$$\Delta N_i = \Delta N_{il}^{TTI}$$

$a=2$

For each transmission time interval of TrCH *i* with TF *l*, the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

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

$$e_{ini} = 1$$

$$e_{plus} = a \cdot N_{il}^{TTI}$$

$$e_{minus} = a \cdot |\Delta N_i|$$

puncturing for $\Delta N_i < 0$, repetition otherwise.

4.2.7.2.~~2~~3.2.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{il}^{TTI} > 0$, the parameters in section 4.2.7.2.3.2.1 are used.

If puncturing is to be performed, the parameters below shall be used. Index *b* is used to indicate systematic (*b*=1), 1st parity (*b*=2), and 2nd parity bit (*b*=3).

$a=2$ when $b=2$

$a=1$ when $b=3$

The bits indicated by *b*=1 shall not be punctured.

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{il}^{TTI} / 2 \rfloor, & b=2 \\ \lceil \Delta N_{il}^{TTI} / 2 \rceil, & b=3 \end{cases}$$

For each transmission time interval of TrCH *i* with TF *l*, the rate-matching pattern is calculated with the algorithm in section 4.2.7.5. The following parameters are used as input:

$X_i = N_{il}^{TTI} / 3$N,

$e_{ini} = X_i$,

$e_{plus} = a \cdot X_i$

$e_{minus} = a \cdot |\Delta N_i|$

4.2.9.1 1st insertion of DTX indication bits

This step of inserting DTX indication bits is used only if the positions of the TrCHs in the radio frame are fixed. With fixed position scheme a fixed number of bits is reserved for each TrCH in the radio frame.

The bits from rate matching are denoted by $g_{i1}, g_{i2}, g_{i3}, \ldots, g_{iG_i}$, where G_i is the number of bits in one TTI of TrCH i.

Denote the number of bits in ~~one radio frame of TrCH i by H_i.~~ after 1st DTX insertion by H_i.

In normal mode $H_i = F_i \cdot FS_i$ whereas in compressed mode by puncturing, for the TTI with number m within the longest TTI, $H_i = \sum_{n=m\cdot F_i}^{n=(m+1)\cdot F_i - 1} FS_i^{cm,n}$.

FS_i and $FS_i^{cm,n}$ are determined in the rate matching sections 4.2.7.2.2.1. and 4.2.7.2.3.1.

In normal or compressed mode by spreading factor reduction, H_i is constant and corresponds to the maximum number of bits from TrCH i in one ~~radio frame~~TTI for any transport format of TrCH i.

In compressed mode by higher layer scheduling, only a subset of the TFC Set is allowed. From this subset it is possible to derive which TFs on each TrCH that are allowed. The maximum number of bits belonging to one TTI of TrCH i for the allowed TFs is denoted by X_i. H_i is then calculated as $H_i = F_i \cdot \left\lceil \frac{X_i}{F_i} \right\rceil$ $\cancel{H_i = \left\lceil \frac{X_i}{F_i} \right\rceil}$, where F_i is the number of radio frames in a TTI of TrCH i. The bits output from the DTX insertion are denoted. by $h_{i1}, h_{i2}, h_{i3}, \ldots, h_{i,H_i}$ $\cancel{h_{i1}, h_{i2}, h_{i3}, \ldots, h_{i(F_i H_i)}}$. Note that these bits are three valued. They are defined by the following relations:

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

$h_{ik} = d$ $\quad k = G_i+1, G_i+2, G_i+3, \ldots, \cancel{F_i}H_i$

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