TSG-RAN Working Group 1 meeting #9 **TSGR1#9(99)j25**

Dresden, Germany

November 30 – December 3, 1999

Agenda item:

Source: Ericsson

Title: CR 25.212-010r1: Clarification of bit separation and collection

Document for: Decision

This document contains a revised version of CR 25.212-010 (Tdoc TSGR1#9(99)i54). The following changes have been made:

1) ***Page 27:*** $N_{max} = \max_{l\in TFS(i)} (N_{il}^{TTI}/3)$ ~~$N_{max} = \max_{l\in TFS(i)} \lfloor N_{il}^{TTI}/3 \rfloor$~~ ***Not needed since always a multiple of 3.***

2) ***Page 31:*** $z_{i,3\lfloor N_i/3\rfloor+k} = y_{1,i,\lfloor N_i/3\rfloor+k}$ ~~$z_{i,3\lfloor N_i/3\rfloor+k} = y_{i,\lfloor N_i/3\rfloor+k}$~~ ***Typo***

Bit separation and bit collection is currently not sufficiently described in 25.212. Modifications were proposed in TSGR1#8(99)f28. It is proposed that instead of making the limited changes proposed in f28, the section should be rewritten with a notation more similar to the rest of 25.212. The changes proposed in this document are listed below.

Entire section 4.2.7	The following notation is currently used for the number of bits before rate matching: UL: $N = N_i = N_{ij}$ DL: $N = E_i = N_{il}^{TTI}$ It is proposed that N is replaced by X_i so that it is possible to distinguish between different TrCHs. Similarly, it is proposed that DN is replaced by DN_i.
Entire section 4.2.7	Index b is introduced to indicate systematic or parity bits.
Section 4.2.7.1.2 / 4.2.7.2.1 / 4.2.7.2.2	Divided into subsections to ease understanding. (Note that current text does not define rate matching for uncoded TrCHs.)
Section 4.2.7.1.2 / 4.2.7.2.1 / 4.2.7.2.2	Minor correction: N (X_i) is known not determined.
Section 4.2.7.1.2.2 / 4.2.7.2.1.2 / 4.2.7.2.2.2	Last row removed. Only puncturing is used in this section.
Section 4.2.7.2.1.2 / 4.7.2.2.2	Removed round down since N_{il}^{TTI} always is a multiple of three.
Section 4.2.7.3	Completely rewritten. A new notation is introduced for the bits. The section is divided into subsections. Clearly states what happens in UL when N_{ij} is not a multiple of three (the last 1 or 2 bits can not be punctured).

Section 4.2.7.5 / 4.2.7.6	Removed since they are now covered in 4.2.7.3

3GPP TSG RAN WG1 Meeting #9
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Document ??99???
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**	**010r1**	Current Version:	3.0.0

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

For submission to:	TSG-RAN #6	for approval	X	Strategic		*(for SMG*
list expected approval meeting # here ↑		for information		non-strategic		*use only)*

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: *(at least one should be marked with an X)*

(U)SIM	ME	UTRAN / Radio	Core Network
	X	X	

Source:	Ericsson
Date:	1999-11-24
Subject:	Clarification of bit separation and collection
Work item:	

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

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

Release:

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

Reason for change: Current description of bit separation and collection can easily be misinterpreted.

Clauses affected: 4.2.7

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:

help.doc

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

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

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

where

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

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

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

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

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

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

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

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

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

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

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 ~~second~~TrCH multiplexing is identical to the total channel bit rate of the allocated dedicated physical channels.

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.

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*.

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

q: Average puncturing distance. 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 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 ~~4.2.7.4~~4.2.7.5.

e_{plus} Increment of variable *e* in the rate matching pattern determination algorithm of section ~~4.2.7.4~~4.2.7.5.

e_{minus} Decrement of variable *e* in the rate matching pattern determination algorithm of section ~~4.2.7.4~~4.2.7.5.

~~X~~b: Indicates systematic and parity bits
b=1: Systematic bit. *X(t)* in section 4.1.3.2.1.
~~Y:~~ b=2: 1st parity bit (from the upper Turbo constituent encoder). *Y(t)* in section 4.1.3.2.1.
~~Y':~~ b=3: 2nd parity bit (from the lower Turbo constituent encoder). *Y'(t)* in section 4.1.3.2.1.

~~NOTE: Time index t in section 4.1.3.2.1 is omitted for simplify the rate matching description.~~

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** *x* **do** $X_x = Y$ ". In the right wing of an assignment, the meaning is that "$Y = X_*$ " is equivalent to "**take any** *x* **and do** $Y = X_x$ "

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

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

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

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

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 used to avoid multicode or to enable the use of a higher spreading factor when this is needed because the UE does not support SF down to 4. 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 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 $N_{data} - \sum_{x=1}^{I} \frac{RM_{x,}}{\min_{1 \le y \le I}\{RM_y\}} \cdot N_{x,j}$ 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 $N_{data} - PL \cdot \sum_{x=1}^{I} \frac{RM_x}{\min_{1 \le y \le I}\{RM_y\}} \cdot N_{x,j}$ 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, ΔN_{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 $N^{cm}_{data,j}$ in Equation 1. $N^{cm}_{data,j}$ is given from the following relation:

$N^{cm}_{data,j} = 2N_{data,j} - N_{TGL}$, where

$$N_{TGL} = \begin{cases} \frac{TGL}{15} 2N_{data,j}, & \text{if } N_{first} + TGL \le 15 \\ \frac{15 - N_{first}}{15} 2N_{data,j}, & \text{in first frame if } N_{first} + TGL > 15 \\ \frac{TGL - (15 - N_{first})}{15} 2N_{data,j}, & \text{in second frame if } N_{first} + TGL > 15 \end{cases}$$

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 ~~4.2.7.4~~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~~Otherwise, for~~ determining e_{ini}, e_{plus}, and e_{minus}~~, and N the following parameters are needed~~ (regardless if the radio frame is compressed or not).~~:~~

~~For convolutional codes,~~

4.2.7.1.2.1 Uncoded and convolutionally encoded TrCHs

q= $\lfloor N_{ij} /(| \Delta N_{ij} |) \rfloor$

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

$S(I_F (\lceil x*q' \rceil \bmod F_i)) = (\lceil x*q' \rceil \text{ div } F_i)$

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 ~~4.2.7.4~~4.2.7.5, where :

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

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

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

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

puncturing for DN_i<0, repe~~ating~~tition otherwise.

4.2.7.1.2.2 Turbo encoded TrCHs

~~For turbo codes, if repetition is to be performed, such as $DN_{i,j}$ >0, parameters for turbo codes are the same as parameter for convolutional codes~~. 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 ~~are as follows~~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~~for *Y* sequence, and~~

a=1 when *b*=3~~for *Y'* sequence.~~

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{i,j} / 2 \rfloor, & b=2 \\ \lceil \Delta N_{i,j} / 2 \rceil, & b=3 \end{cases}$$ ~~$DN = \begin{cases} \lfloor \Delta N_{i,j} / 2 \rfloor \text{for Y sequence} \\ \lceil \Delta N_{i,j} / 2 \rceil \text{for Y' sequence} \end{cases}$~~

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

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

if(q ≤ 2)

for *x*=0 to F_i-1

S[I$_F$[(3x+b-1) mod F$_i$]] = x mod 2;~~ if(Y sequence)~~

~~S[I$_F$[(3x+1) mod F$_i$]] = x mod 2;~~

~~if(Y' sequence)~~

~~S[I$_F$ [(3x+2) 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 = ⌈ x*q' ⌉ mod F$_i$;

S[I$_F$[(3r+b-1) mod F$_i$]] = ⌈ x*q' ⌉ div F$_i$;~~if(Y sequence)~~

~~S[I$_F$[(3r+1) mod F$_i$]] = ⌈ x*q' ⌉ div F$_i$;~~

~~if(Y' sequence)~~

~~S[I$_F$[(3r+2) mod F$_i$]] = ⌈ x*q' ⌉ div F$_i$;~~

endfor

endif

For each radio frame, the rate-matching pattern is calculated with the algorithm in section ~~4.2.7.4~~4.2.7.5, where:

~~N~~X_i is as above,

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

$e_{plus} = a \cdot X_i$ ~~N~~

$e_{minus} = a \cdot |DN_i|$

~~puncturing for $\Delta N<0$, repeating otherwise.~~

4.2.7.2 Determination of rate matching parameters in downlink

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

4.2.7.2.1 Determination of rate matching parameters for fixed positions of TrCHs

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:

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

If $\Delta N_{i,*}^{TTI} = 0$ 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 ~~4.2.7.4~~4.2.7.5 does not need to be executed.

If $\Delta N_{i,*}^{TTI} \neq 0$ the parameters listed in sections 4.2.7.2.1.1 and 4.2.7.2.1.2 shall be used~~Otherwise,~~ for determining e_{ini}, e_{plus}, and e_{minus}.~~, and N the following parameters are needed:~~

~~For convolutional codes,~~

4.2.7.2.1.1 Uncoded and convolutionally encoded TrCHs

$$\Delta N_i = \Delta N_{i,*}^{TTI}$$

a=2

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

For each transmission time interval of TrCH i with TF l, the rate-matching pattern is calculated with the algorithm in section ~~4.2.7.4~~4.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI} \quad \sout{N = N_{il}^{TTI}}$$

$$e_{ini} = N_{max}$$

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

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

Puncturing if $\Delta N_i < 0$ ~~$\Delta N < 0$~~, repetition otherwise.

4.2.7.2.1.2 Turbo encoded TrCHs

For turbo codes, if repetition is to be performed, such as $\Delta N_{i,*}^{TTI} > 0$, parameters for turbo codes are the same as parameter for convolutional codes. If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{i,*}^{TTI} > 0$, the parameters in section 4.2.7.2.1.1 are used.

If puncturing is to be performed, the parameters are as followsbelow 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*=2for *Y* sequence,

a=1 when *b*=3for *Y'* sequence.

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

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{i,*}^{TTI} / 2 \rfloor, & b = 2 \\ \lceil \Delta N_{i,*}^{TTI} / 2 \rceil, & b = 3 \end{cases} \quad \Delta N = \begin{cases} \lfloor DN_{i,*}^{TTI} / 2 \rfloor & \text{for Y sequence} \\ \lceil DN_{i,*}^{TTI} / 2 \rceil & \text{for Y' sequence} \end{cases}$$

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

For each transmission time interval of TrCH *i* with TF *l*, the rate-matching pattern is calculated with the algorithm in section 4.2.7.44.2.7.5. The following parameters are used as input:

$$X_i = N_{il}^{TTI} / 3 \quad N = \lfloor N_{il}^{TTI} / 3 \rfloor$$

$$e_{ini} = N_{max}$$

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

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

Puncturing if $\Delta N < 0$, repetition otherwise.

4.2.7.2.2 Determination of rate matching parameters for flexible positions of TrCHs

First an intermediate calculation variable N_{ij} is calculated for all transport channels *i* and all transport format combinations *j* by the following formula:

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

Then rate matching ratios RF_i 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 ratios are defined by the following formula:

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

The computation of $\Delta N_{i,l}^{TTI}$ parameters is then performed in two phases. In a first phase, tentative temporary values of $\Delta N_{i,l}^{TTI}$ are computed, and in the second phase they are checked and corrected. The first phase, by use of the RF_i 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 $N_{data,*}$. 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 $\Delta N_{i,l}^{TTI}$ for all transport channel *i* and any of its transport format *l* by use of the following formula:

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

The second phase is defined by the following algorithm:

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

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

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

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

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

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

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

end-if

end-for

end-if

end-for

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

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 ~~4.2.7.4~~4.2.7.5 does not need to be executed.

If $\Delta N_{i,l}^{TTI} \neq 0$ the parameters listed in sections 4.2.7.2.2.1 and 4.2.7.2.2.2 shall be used~~Otherwise,~~ for determining e_{ini}, e_{plus}, and e_{minus}~~., and *N* the following parameters are needed:~~

~~For convolutional codes,~~

4.2.7.2.2.1 Uncoded and convolutionally encoded TrCHs

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

a=2

For each transmission time interval of TrCH *i* with TF *l*, the rate-matching pattern is calculated with the algorithm in section ~~4.2.7.4~~4.2.7.5. The following parameters are used as input:

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

$e_{ini} = N_{il}^{TTI}$ ~~$e_{ini} = N$~~

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

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

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

4.2.7.2.2.2 Turbo encoded TrCHs

~~For turbo codes, if repetition is to be performed, such as $\Delta N_{il}^{TTI} > 0$, parameters for turbo codes are the same as parameter for convolutional codes.~~ If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{il}^{TTI} > 0$, the parameters in section 4.2.7.2.2.1 are used.

If puncturing is to be performed, the parameters ~~are as follows~~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~~for *Y* sequence,~~

a=1 when *b*=3~~for *Y'* sequence.~~

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

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{il}^{TTI} / 2 \rfloor, & b=2 \\ \lceil \Delta N_{il}^{TTI} / 2 \rceil, & b=3 \end{cases}$$ ~~$\Delta N = \begin{cases} \lfloor DN_{il}^{TTI} / 2 \rfloor \text{for Y sequence} \\ \lceil DN_{il}^{TTI} / 2 \rceil \text{for Y' sequence} \end{cases}$~~

For each transmission time interval of TrCH *i* with TF *l*, the rate-matching pattern is calculated with the algorithm in section ~~4.2.7.4~~4.2.7.5. The following parameters are used as input:

$X_i = N_{il}^{TTI} / 3$ ~~$N = \lfloor N_{il}^{TTI} / 3 \rfloor$~~,

$e_{ini} = X_i$ ~~$e_{ini} = N$~~,

$e_{plus} = a \cdot X_i$ ~~$e_{plus} = a \cdot N$~~

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

~~puncturing for $\Delta N < 0$, repeating otherwise.~~

4.2.7.3 Bit separation and collection in uplink

The systematic bits (excluding bits for trellis termination) of turbo encoded TrCHs shall not be punctured. The systematic bit, first parity bit, and second parity bit in the bit sequence input to the rate matching block are therefore separated from each other. Puncturing is only applied to the parity bits and systematic bits used for trellis termination.

The bit separation function is transparent for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition. The bit separation and bit collection are illustrated in figures 6 and 7.

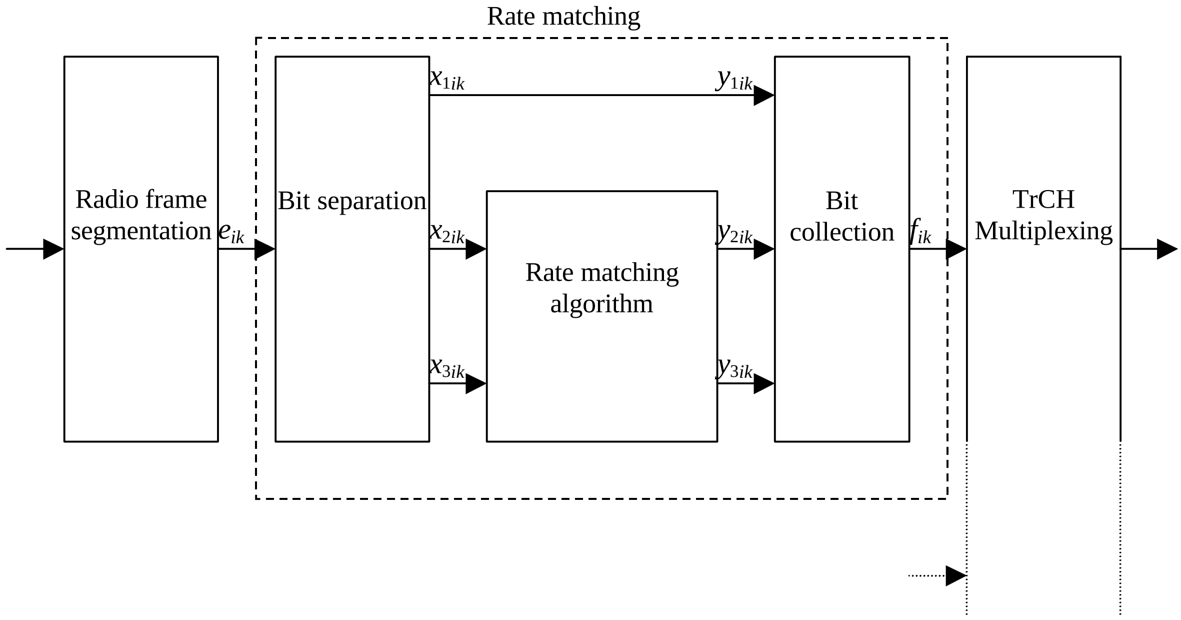

Figure 6: Puncturing of turbo encoded TrCHs

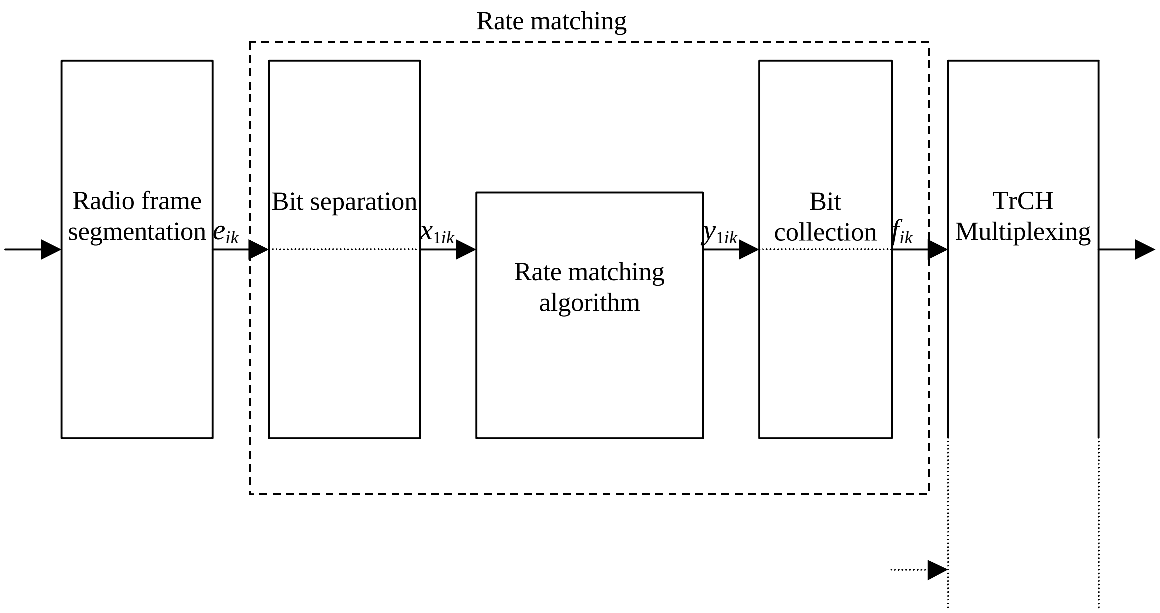

Figure 7: Rate matching for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition.

The bit separation is dependent on the 1st interleaving and offsets are used to define the separation for different TTIs. The offsets a_b for the systematic (b=1) and parity bits ($b \in \{2, 3\}$) are listed in table 4.

Table 4: TTI dependent offset needed for bit separation

TTI (ms)	a_1	a_2	a_3
10, 40	0	1	2
20, 80	0	2	1

The bit separation is different for different radio frames in the TTI. A second offset is therefore needed. The radio frame number for TrCH i is denoted by n_i. and the offset by b_{n_i}.

Table 5: Radio frame dependent offset needed for bit separation

TTI (ms)	b_0	b_1	b_2	b_3	b_4	b_5	b_6	b_7
10	0	NA	NA	NA	NA	NA	NA	NA
20	0	1	NA	NA	NA	NA	NA	NA
40	0	1	2	0	NA	NA	NA	NA
80	0	1	2	0	1	2	0	1

4.2.7.3.1 Bit separation

The bits input to the rate matching 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 input to the rate matching block. Note that the transport format combination number j for simplicity has been left out in the bit numbering, i.e. $N_i=N_{ij}$. The bits after separation are denoted by $x_{bi1}, x_{bi2}, x_{bi3}, \ldots, x_{biX_i}$. For turbo encoded TrCHs with puncturing, b indicates systematic, first parity, or second parity bit. For all other cases b is defined to be 1. X_i is the number of bits in each separated bit sequence. The relation between e_{ik} and x_{bik} is given below.

For turbo encoded TrCHs with puncturing:

$x_{1,i,k} = e_{i,3(k-1)+1+(a_1+b_{n_i}) \bmod 3}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = \lfloor N_i / 3 \rfloor$

$x_{1,i,\lfloor N_i/3 \rfloor + k} = e_{i,3\lfloor N_i/3 \rfloor + k}$ $k = 1, \ldots, N_i \bmod 3$ Note: When (N_i mod 3) = 0 this row is not needed.

$x_{2,i,k} = e_{i,3(k-1)+1+(a_2+b_{n_i}) \bmod 3}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = \lfloor N_i / 3 \rfloor$

$x_{3,i,k} = e_{i,3(k-1)+1+(a_3+b_{n_i}) \bmod 3}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = \lfloor N_i / 3 \rfloor$

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$x_{1,i,k} = e_{i,k}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = N_i$

4.2.7.3.2 Bit collection

The bits x_{bik} are input to the rate matching algorithm described in section 4.2.7.5. The bits output from the rate matching algorithm are denoted $y_{bi1}, y_{bi2}, y_{bi3}, \ldots, y_{biY_i}$.

Bit collection is the inverse function of the separation. The bits after collection are denoted by $z_{bi1}, z_{bi2}, z_{bi3}, \ldots, z_{biY_i}$. After bit collection, the bits indicated as punctured are removed and the bits are then denoted by $f_{i1}, f_{i2}, f_{i3}, \ldots, f_{iV_i}$, where i is the TrCH number and $V_i = N_{ij} + DN_{ij}$. The relations between y_{bik}, z_{bik}, and f_{ik} are given below.

For turbo encoded TrCHs with puncturing ($Y_i=X_i$):

$z_{i,3(k-1)+1+(a_1+b_{n_i}) \bmod 3} = y_{1,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

$z_{i,3\lfloor N_i/3 \rfloor + k} = y_{1,i,\lfloor N_i/3 \rfloor + k}$ $k = 1, \ldots, N_i \bmod 3$ Note: When (N_i mod 3) = 0 this row is not needed.

$z_{i,3(k-1)+1+(a_2+b_{n_i}) \bmod 3} = y_{2,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

$z_{i,3(k-1)+1+(a_3+b_{n_i}) \bmod 3} = y_{3,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

After the bit collection, bits $z_{i,k}$ with value d, where $d \in \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$$z_{i,k} = y_{1,i,k} \qquad k = 1, 2, 3, \ldots, Y_i$$

When repetition is used, $f_{i,k}=z_{i,k}$ and $Y_i=V_i$.

When puncturing is used, $Y_i=X_i$ and bits $z_{i,k}$ with value d, where $d \in \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

4.2.7.4 Bit separation and collection in downlink

The systematic bits (excluding bits for trellis termination) of turbo encoded TrCHs shall not be punctured. The systematic bit, first parity bit, and second parity bit in the bit sequence input to the rate matching block are therefore separated from each other. Puncturing is only applied to the parity bits and systematic bits used for trellis termination.

The bit separation function is transparent for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition. The bit separation and bit collection are illustrated in figures 6 and 7.

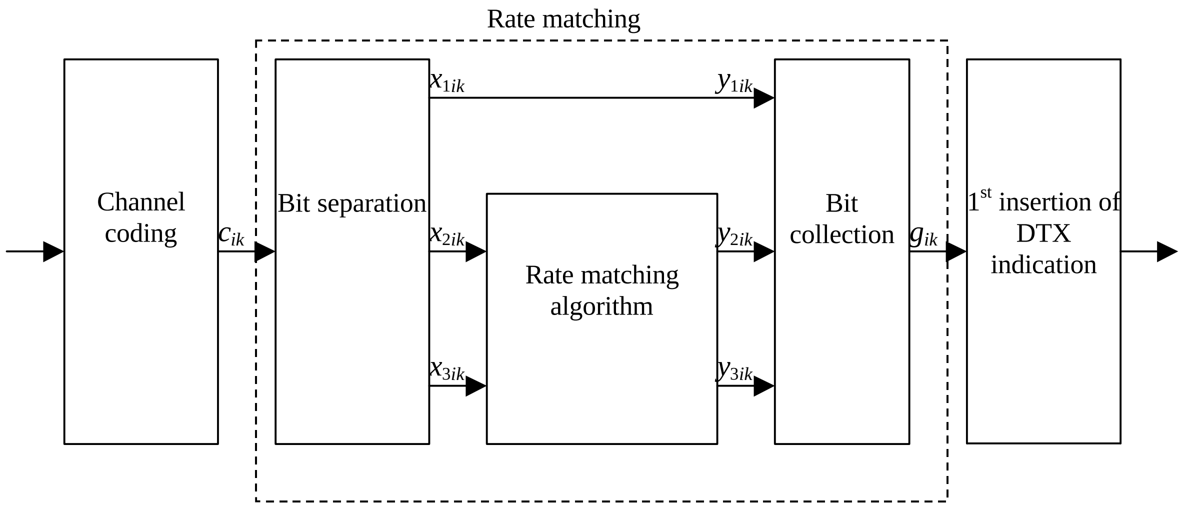

Figure 6: Puncturing of turbo encoded TrCHs

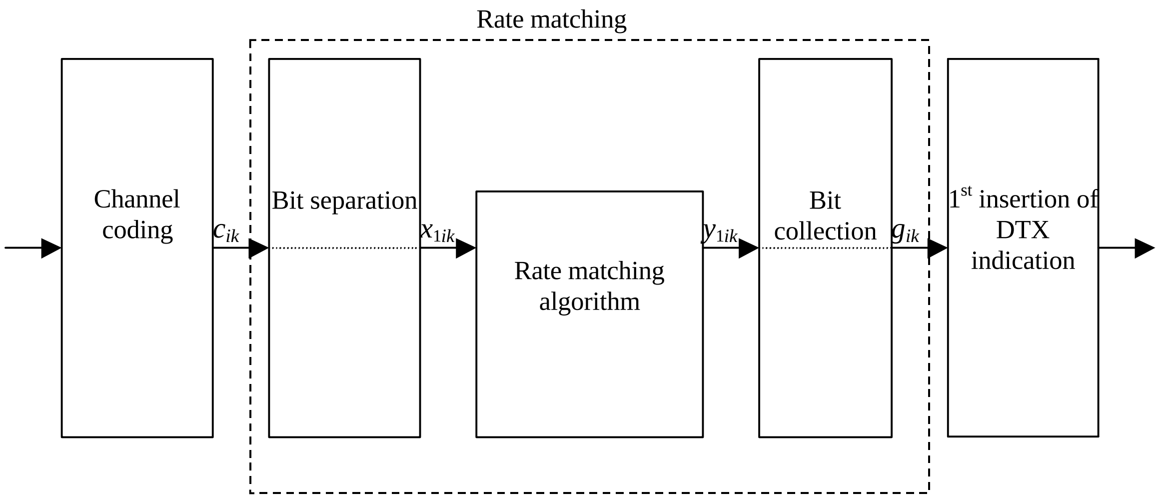

Figure 7: Rate matching for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition.

4.2.7.4.1 Bit separation

The bits input to the rate matching are denoted by $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where *i* is the TrCH number and E_i is the number of bits input to the rate matching block. Note that E_i is a multiple of 3 for turbo encoded TrCHs and that the transport format combination number *j* for simplicity has been left out in the bit numbering, i.e. $E_i=N_{ij}$. The bits after separation are denoted by $x_{bi1}, x_{bi2}, x_{bi3}, \ldots, x_{biX_i}$. For turbo encoded TrCHs with puncturing, *b* indicates systematic, first parity, or second parity bit. For all other cases *b* is defined to be 1. X_i is the number of bits in each separated bit sequence. The relation between c_{ik} and x_{bik} is given below.

For turbo encoded TrCHs with puncturing:

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

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

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

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$x_{1,i,k} = c_{i,k}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = E_i$

4.2.7.4.2 Bit collection

The bits x_{bik} are input to the rate matching algorithm described in section 4.2.7.5. The bits output from the rate matching algorithm are denoted $y_{bi1}, y_{bi2}, y_{bi3}, \ldots, y_{biY_i}$.

Bit collection is the inverse function of the separation. The bits after collection are denoted by $z_{bi1}, z_{bi2}, z_{bi3}, \ldots, z_{biY_i}$. After bit collection, the bits indicated as punctured are removed and the bits are then denoted by $g_{i1}, g_{i2}, g_{i3}, \ldots, g_{iG_i}$, where *i* is the TrCH number and $G_i= N_{ij}+\Delta N_{ij}$. The relations between y_{bik}, z_{bik}, and g_{ik} are given below.

For turbo encoded TrCHs with puncturing ($Y_i=X_i$):

$z_{i,3(k-1)+1} = y_{1,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

$z_{i,3(k-1)+2} = y_{2,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

$z_{i,3(k-1)+3} = y_{3,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

After the bit collection, bits $z_{i,k}$ with value δ, where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $g_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index *k* after puncturing, bit $g_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index *k* after puncturing, and so on.

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$z_{i,k} = y_{1,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

When repetition is used, $g_{i,k}=z_{i,k}$ and $Y_i=G_i$.

When puncturing is used, $Y_i=X_i$ and bits $z_{i,k}$ with value δ, where $\delta \notin \{0, 1\}$, are removed from the bit sequence. Bit $g_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index *k* after puncturing, bit $g_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index *k* after puncturing, and so on.

4.2.7.3 Bit separation for rate matching

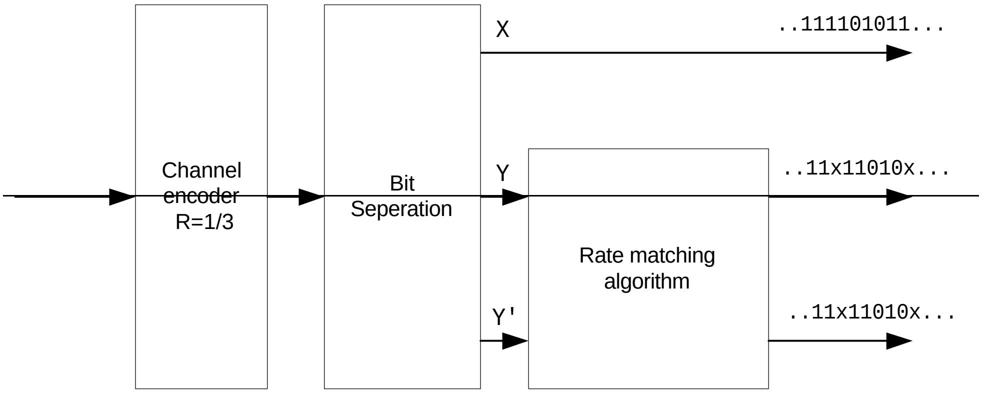

Figure 6: Overall rate matching block diagram before first interleaving where x denotes punctured bit

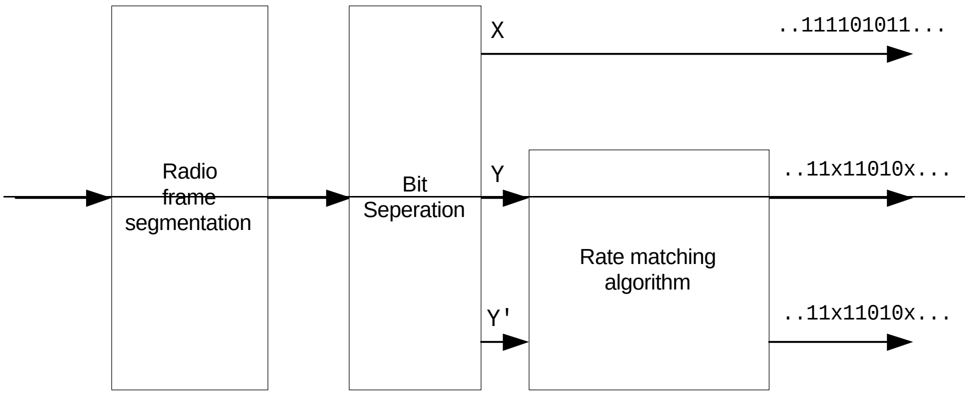

Figure 7: Overall rate matching block diagram after first interleaving where x denotes punctured bit

Rate matching puncturing for Turbo codes in uplink is applied separately to *Y* and *Y'* sequences. No puncturing is applied to *X* sequence. Therefore, it is necessary to separate *X*, *Y*, and *Y'* sequences before rate matching is applied.

For uplink, there are two different alternation patterns in bit stream from radio frame segmentation according to the TTI of a TrCH as shown in table 4.

Table 4: Alternation patterns of bits from radio frame segmentation in uplink

TTI (msec)	Alternation patterns
10, 40	… *X,Y,Y'*,…
20, 80	… *X,Y',Y*,…

In addition, each radio frame of a TrCH starts with different initial parity type. Table 5 shows the initial parity type of each radio frame of a TrCH with TTI = {10, 20, 40, 80} msec.

Table 5: Initial parity type of radio frames of TrCH in uplink

TTI (msec)	Radio frame indexes (n_i)							
	0	1	2	3	4	5	6	7
10	*X*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
20	*X*	*Y*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
40	*X*	*Y'*	*Y*	*X*	*NA*	*NA*	*NA*	*NA*
80	*X*	*Y*	*Y'*	*X*	*Y*	*Y'*	*X*	*Y*

~~Table 4 and table 5 defines a complete output bit pattern from radio frame segmentation.~~

~~Ex. 1. TTI = 40 msec, n_i = 2~~
~~Radio frame pattern: Y, Y', X, Y, Y', X, Y, Y', X, …~~

~~Ex. 2 TTI = 40 msec, n_i = 3~~
~~Radio frame pattern: X, Y, Y', X, Y, Y', X, Y, Y', X, …~~

~~Therefore, bit separation is achieved with the alternative selection of bits with the initial parity type and alternation pattern specified in table 4 and table 5 according to the TTI and n_i of a TrCH.~~

~~Rate matching puncturing for Turbo codes in downlink is applied separately to Y and Y's sequences. No puncturing is applied to X sequence. Therefore, it is necessary to separate X, Y, and Y' sequences before rate matching is applied.~~

~~For downlink, output bit sequence pattern from Turbo encoder is always X, Y, Y', X, Y, Y', …. Therefore, bit separation is achieved with the alternative selection of bits from Turbo encoder.~~

4.2.7.54 Rate matching pattern determination

Denote the bits before rate matching by:

$x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ ~~$x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iN}$~~, where i is the TrCH number and ~~N~~X_i is the -parameter given in sections 4.2.7.1 and 4.2.7.2.

The rate matching rule is as follows:

if puncturing is to be performed

e = e_{ini} -- initial error between current and desired puncturing ratio

m = 1 -- index of current bit

do while m <= X_i~~N~~

e = e – e_{minus} -- update error

if e <= 0 then -- check if bit number m should be punctured

~~puncture~~set bit $x_{i,m}$ to d where $d \in \{0, 1\}$

e = e + e_{plus} -- update error

end if

m = m + 1 -- next bit

end do

else

e = e_{ini} -- initial error between current and desired puncturing ratio

m = 1 -- index of current bit

do while m <= X_i~~N~~

e = e – e_{minus} -- update error

do while e <= 0 -- check if bit number m should be repeated

repeat bit $x_{i,m}$

e = e + e_{plus} -- update error

end do

m = m + 1 -- *next bit*

end do

end if

A repeated bit is placed directly after the original one.

4.2.7.5 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 $V_i = N + \Delta N = N_{ij} + \Delta N_{ij}$.

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

4.2.7.6 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.

4.2.8 TrCH multiplexing

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).

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:

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

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

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

…

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

4.2.9 Insertion of discontinuous transmission (DTX) indication bits

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 TrCHs in the radio frame are used. It is up to the UTRAN to decide for each