RAN WG1 meeting #7 **TSGR1#7(99) D67**
Place : Hanover
Date : August 30th to September 3rd, 1999
Title : Revised Text proposal for DL rate matching signalling in FDD
Source : Mitsubishi Electric (MCRD)
Paper for : Decision

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1 Introduction

In [3] a rule has been proposed to compute the rate matching ratios in downlink. [3] solves the problem existing the current rule in [1]. [3] also fixes a problem with the initialisation of the e parameters in the rate matching pattern determination algorithm. [3] also allows to get rid of the "radio frame size equalisation" step in DL.

[3] was endorsed by AH04, however it was asked of the proponent to make the fixed positions and flexible positions mutually exclusive, this is the reason why this revised text proposal is contributed.

Compared to [3] the title "Rate matching algorithm" was also replaced by "Rate matching pattern determination" that is more appropriate for section 4.2.6.3.

Furthermore in this revised text care was taken to incorporate the change in the proposal [4] R1-(99)B29 by Ericsson to harmonise notation throughout [1]

2 References

[1] 3GPP TSG RAN WG1 R1-99A86 TS 25.212 V2.0.1: 'Multiplexing and channel coding (FDD)', Source: Editor

[2] 3GPP TSG RAN WG1 R1(99)612: 'Text proposal for rate matching signalling' , Source: Ericsson, Mitsubishi ELectric, Siemens,

[3] 3GPP TSG RAN WG1 R1(99)A80: 'Text proposal for rate matching signalling', Source Mitsubishi Electric

[4] 3GPP TSG RAN WG1 R1(99)b29 "Proposal for new notation in 25.212", Source Ericsson

3 Abbreviations :

refer to [4].

4 Text proposal

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4.2.6 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 multiplexing is identical to the total channel bit rate of the allocated dedicated physical channels.

Notation used in Section 4.2.6 and subsections:

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

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

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

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

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

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

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

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

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*.

~~*T*~~*I*: Number of TrCH~~transport channel~~s in the CCTrCH.

$Z_{\text{~~m~~}ij}$: Intermediate calculation variable.

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

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

q: Average puncturing distance. Used in uplink only.

I_F(n_i~~k~~): 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~~k~~): The shift of the puncturing pattern for radio frame n_i~~k~~. Used in uplink only.

$TF_i(j)$: Transport format of TrCH~~transport channel~~ *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 4.2.6.3.

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~~pattern~~:

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

$$\sout{Z_{mj} = \left\lfloor \frac{\sum_{i=1}^{m} RM_i \cdot N_{ij}}{\sum_{i=1}^{T} RM_i \cdot N_{ij}} \cdot N_{data,j} \right\rfloor} \quad Z_{ij} = \left\lfloor \frac{\sum_{m=1}^{i} RM_m \cdot N_{mj}}{\sum_{m=1}^{I} RM_m \cdot N_{mj}} \cdot N_{data,j} \right\rfloor$$ for all ~~m~~ i = 1 .. ~~T~~I, where ë û

means round downwards

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

4.2.6.1 Determination of rate matching parameters in uplink

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

SET1 = { N_{data} in SET0 such that $\sout{N_{data} - \sum_{i=1}^{T} \frac{RM_i}{\min_l\{RM_l\}} \cdot N_{ij}}$ $N_{data} - \sum_{x=1}^{I} \frac{RM_x}{\min_{1\le y\le I}\{RM_y\}} \cdot N_{x,j}$ is non negative }

If the smallest element of SET1 requires just one ~~DPDCH~~ PhCH then

$N_{data,j}$ = min SET1

else

SET2 = { N_{data} in SET0 such that

$\sout{N_{data} - PL \cdot \sum_{i=1}^{T} \frac{RM_i}{\min_l\{RM_l\}} \cdot N_{ij}}$ $N_{data} - PL \cdot \sum_{x=1}^{I} \frac{RM_x}{\min_{1\le y\le I}\{RM_y\}} \cdot N_{x,j}$ 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 ~~DPDCH~~ PhCH do

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

End while

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

End if

The number of bits to be repeated or punctured, $DN_{i,j}$, within one radio frame for each ~~transport channel~~TrCH *i* is calculated with the relations given in Section 0 for all possible transport format combinations *j* and selected every radio frame. ~~For each radio frame, the rate-matching pattern is calculated with the algorithm in Section 4.2.6.3, where $DN = DN_{ij}$ and $N = N_{ij}$.~~

Additionally, for determining e_{ini}, the following parameters are needed:

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

if *q* is even

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

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

else

q' = *q*

endif

for ~~l~~x = 0 to F_i-1

$S(I_F\ (\lceil lx*q' \rceil \bmod F_i)) = (\lceil lx*q' \rceil \operatorname{div} F_i)$ ~~-- where é ù means round upwards.~~

end for

For each radio frame, the rate-matching pattern is calculated with the algorithm in Section 4.2.6.3, where :

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

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

$$e_{ini} = \left(2 \cdot S(n_i) \cdot |\Delta N| + N\right) \mod 2N$$

4.2.6.2 Determination of rate matching parameters in downlink

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

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

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

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

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

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

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

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

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

4.1.1.1.1 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 4.2.6:

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

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

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

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

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

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

4.1.1.1.2 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 :

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

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 4.2.6

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.

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

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

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

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

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

S=0.

4.2.6.3 Rate matching pattern determinationalgorithm

Denote the bits before rate matching by:

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

$e_1, e_2, e_3, \ldots e_N$

The rate matching rule is as follows:

```
if puncturing is to be performed

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

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

A repeated bit is placed directly after the original one.

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