Agenda Item: Plenary

Source: Panasonic

Title: Clarification of the limitation on the downlink rate matching repetition

Document for: Discussion and decision

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1. Introduction

In RAN1#17 Stockholm, Panasonic and Mitsubishi Electric (Trium-RD) contributed R1-00-1456, the limitation on the downlink rate matching repetition. In the meeting and email reflector, discussion has been held.

This document has three parts:
1. To compare four method to limit the rate of repetition
2. To propose the constant factor for limitation
3. CR for 25.212

The attached CR is based on above discussion and clarifies the UE memory requirement for the input memory size of de-rate match. The number of bits is calculated from UE transport channel capability parameter.

2. Discussion

1) The method of limitation

R1-00-1456 and after the discussion from RAN1#18, four methods were proposed. We summarize pros and cons.

Method	Pros	Cons
Method 1) The limitation by each TrCH	- Each TrCH does not share same memory. This makes parallel decoding of each TrCH easy.	- All the each TrCH is limited by the rate of repetition.
Method 2) The limitation by the sum of turbo capability, the convolutional coding capability, the sum of all TrCH capability	- TC, CC and NC don't share same memory. This makes parallel decoding for each coding scheme easy. - Some of TrCHs can be over the limitation, if the sum of each coding scheme is under the memory requirement.	
Method 3) The limitation by the sum of all TrCHs	- Some of TrCHs can be over the limitation if the sum is under the memory requirement.	
Method 4) The declaration the memory size before de-rate match	- The choice of UE manufacture is wide.	- UE capability parameter should be newly added. This means RRC spec should be modified.

We propose the **method 2** from above pros and cons.

After RAN#9, TR25.926 are moved to TS25.306. So both TS 25.306 and TS 25.212 are "core" specification. This discussion is mainly layer 1 issue. Hence we propose to TS25.212.

2) The factor of the repetition rate

In above-mentioned method 2, we have three factors of the repetition rate. These factors are:
- all sum of TrCHs
- convolutional coding
- turbo coding

<u>All sums of TrCHs</u>

Over two times repetition, you can use bigger value of spreading factor (lower symbol rate) in considering the total number of CCTrCHs. And usually near the two, puncturing is recommended to avoid short shortage problem in downlink. In case of multiple TrCHs case, to get QoS difference, some TrCHs should have the rate of repetition over two. But this all sum of TrCHs relate to average repetition rate to CCTrCH. We can say the repetition rate "two" is good value.

The transport channel capability, "Maximum sum of number of bits of all transport blocks being received at an arbitrary time instant" is before rate match and before coding in downlink transmit chain. The maximum coding rate in channel coding is three from turbo coding and convolutional coding.

The number of bit after rate-match increases from addition of CRC addition, code block segmentation and termination bits. But considering the safely puncturing rate, we can say again the repetition rate "two" is good value.

Hence we propose the rate from all sum of TrCHs is 6 (2×3) from UE transport channel capability.

<u>Convolutional coding</u>

In convolutional coding, to get QoS difference over turbo coding, allowing repetition rate over two is recommended. We propose 2.5 as the rate of the repetition of convolutional coding.

Hence we propose the rate for convolutional coding is 7.5 (2.5×3) from UE convolutional transport channel capability.

Please note that the rate of convolutional coding repetition is also limited by the all sum of TrCHs. This can show following examples.

	Before de-rate match	The L1-L2 interface (UE transport channel capability point)
CC	420	50
TC	100	55

Limitation by all sum is (420+100)/(50+55) = 4.95. The limitation by all sum of TrCHs are OK. Limitation by CC is 420/50 = 8.4. The limitation by CC is not OK. This example does not pass the limitation.

<u>Turbo coding</u>

Turbo coding has a good performance over the convolutional coding, we simply propose the same value to all sum of TrCHs.

Hence we propose the rate for turbo coding is 6 (2×3) from UE turbo transport channel capability. Please note that the rate of turbo coding repetition also limited by the all sum of TrCHs.

3. Conclusion

We propose attached CR according above discussion.

Reference

[1] 3GPP R1-00-1456, "Limitation on the downlink rate matching repetition", Panasonic and Mitsubishi Electric (Trium-RD), November 2000

CR-Form-v3

CHANGE REQUEST

✍	**25.212**	**CR**	**102**	✍ rev **0** ✍	Current version:	**3.5.0** ✍

*For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ✍ symbols.*

Proposed change affects: ✍ (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title: ✍	Limitation on the downlink rate matching repetition
Source: ✍	Panasonic (Matsushita Communication Co. Ltd)
Work item code: ✍	
Date: ✍	9, January, 2001
Category: ✍	**F**
Release: ✍	R99

Use one of the following categories:
F *(essential correction)*
A *(corresponds to a correction in an earlier release)*
B *(Addition of feature),*
C *(Functional modification of feature)*
D *(Editorial modification)*
Detailed explanations of the above categories can be found in 3GPP TR 21.900.

Use one of the following releases:
2 (GSM Phase 2)
R96 (Release 1996)
R97 (Release 1997)
R98 (Release 1998)
R99 (Release 1999)
REL-4 (Release 4)
REL-5 (Release 5)

Reason for change: ✍	Current specification has no limitation on the rate of the repetition in rate matching. This requires huge size of memory that will probably not used.
Summary of change: ✍	The total number of bit after rate matching repetition was clarified according to the UE capability.
Consequences if not approved: ✍	UE should have the huge memory that will not be used. This makes UE cost high and to delay the wide use of UMTS.

Clauses affected: ✍	2, 4.2.7, 4.2.7.2
Other specs affected: ✍	[ ] Other core specifications ✍ [ ] Test specifications [ ] O&M Specifications
Other comments: ✍	

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Comprehensive information and tips about how to create CRs can be found at: http://www.3gpp.org/3G_Specs/CRs.htm. Below is a brief summary:

1) Fill out the above form. The symbols above marked ✍ contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under ftp://www.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2000-09 contains the specifications resulting from the September 2000 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- ?? References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- ?? For a specific reference, subsequent revisions do not apply.
- ?? For a non-specific reference, the latest version applies.

[1] 3GPP TS 25.201: "Physical layer – General Description".

[2] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".

[3] 3GPP TS 25.213: "Spreading and modulation (FDD)".

[4] 3GPP TS 25.214: "Physical layer procedures (FDD)".

[5] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".

[6] 3GPP TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)".

[7] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)".

[8] 3GPP TS 25.223: "Spreading and modulation (TDD)".

[9] 3GPP TS 25.224: "Physical layer procedures (TDD)".

[10] 3GPP TS 25.225: "Physical layer – Measurements (TDD)".

[11] 3GPP TS 25.302: "Services Provided by the Physical Layer".

[12] 3GPP TS 25.402: "Synchronisation in UTRAN, Stage 2".

[13] 3GPP TS 25.306: "UE Radio Access Capabilities"

***** Next modified sub-clause *****

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 subclause~~subcaluse~~ 4.2.7 and subclauses:

$N_{i,j}$: 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).

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

$? N_{i,j}$: 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).

$? N_{i,l}^{TTI}$: If positive - number of bits to be repeated in each transmission time interval on TrCH *i* with transport format *l*.

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

Used in downlink only.

$Np_{i,l}^{TTI,m}$, $m=0$ to $(F_{max} / F_i) - 1$:Positive or null: number of bits to be removed in TTI number *m* within the largest TTI, to create the required gaps in the compressed radio frames of this TTI, in case of compressed mode by puncturing, for TrCH *i* with transport format *l*. In case of fixed positions and compressed mode by puncturing, this value is noted $Np_{i,\max}^{TTI,m}$ since it is calculated for all TrCH with their maximum number of bits; thus it is the same for all TFCs

Used in downlink only.

$Np_{i,l}^{n}$ $n=0$ to $F_{max}-1$:Positive or null: number of bits, in radio frame number *n* within the largest TTI, corresponding to the gap for compressed mode in this radio frame, for TrCH *i* with transport format *l*. The value will be null for the radio frames not overlapping with a transmission gap. In case of fixed positions and compressed mode by puncturing, this value is noted $Np_{i,\max}^{n}$ since it is calculated for all TrCHs with their maximum number of bits; thus it is the same for all TFCs

Used in downlink only.

$N_{TGL}[k]$, $k=0$ to $F_{\max}-1$: Positive or null: number of bits in each radio frame corresponding to the gap for compressed mode for the CCTrCH.

RM_i: Semi-static rate matching attribute for transport channel *i*. RM_i is provided by higher layers or takes a value as indicated in section 4.2.13.

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. The allowed puncturing in % is actually equal to (1-PL)*100.

$N_{data,j}$: 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.

$Z_{i,j}$: Intermediate calculation variable.

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

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

$$F_{\max} ? \max_{1?i?I} F_i$$

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.

$P1_F(n_i)$: The column permutation function of the 1st interleaver, $P1_F(x)$ is the original position of column with number x after permutation. P1 is defined on table 4 of section 4.2.5.2 (note that the $P1_F$ is self-inverse). Used for rate matching in uplink only.

$S[n]$: The shift of the puncturing or repetition pattern for radio frame n_i when $n = P1_{F_i}(n_i)$. 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 subclause 4.2.7.5.

e_{plus} Increment of variable e in the rate matching pattern determination algorithm of subclause4.2.7.5.

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

b: Indicates systematic and parity bits

b=1: Systematic bit. x_k in subclause 4.2.3.2.1.

b=2: 1st parity bit (from the upper Turbo constituent encoder). z_k in subcalause 4.2.3.2.1.

b=3: 2nd parity bit (from the lower Turbo constituent encoder). z'_k in subclause 4.2.3.2.1.

UEC_{all} Maximum sum of number of bits of all transport blocks being received at an arbitrary time instant. Defined in section 4.5.1 of [13].

UEC_{CC} Maximum sum of number of bits of all convolutionally coded transport blocks being received at an arbitrary time instant. Defined in section 4.5.1 of [13]

UEC_{TC} Maximum sum of number of bits of all turbo coded transport blocks being received at an arbitrary time instant. Defined in section 4.5.1 of [13]

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:

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

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

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

***** Next modified sub-clause *****

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. Denote the number of physical channels used for the CCTrCH by *P*. $N_{data,*}$ is the number of bits available to the CCTrCH in one radio frame and defined as $N_{data,*}=P?15?(N_{data1}+N_{data2})$, where N_{data1} and N_{data2} are defined in [2]. Note that contrary to the uplink, the same rate matching patterns are used in TTIs containing no compressed radio frames and in TTIs containing radio frames compressed by spreading factor reduction or higher layer scheduling.

In the following, the total amount of puncturing or repetition for the TTI is calculated.

The total amount of repetition is limited by UE capability [13]. The number of bits from rate matching are denoted by G_i is the number of bits in one TTI of TrCH *i*.

$$\begin{cases} \sum_{i?all} G_i ? 6 ? UEC_{all} \\ \sum_{i?CCS} G_i ? 7.5 ? UEC_{CC} \\ \sum_{i?TCS} G_i ? 6 ? UEC_{TC} \end{cases}$$

Where CCS is the partition of the set of transport channels {1, 2, …, I} according to whether the coding scheme is convolutional coding. Where TCS is the partition of the set of transport channels {1, 2, …, I} according to whether the coding scheme is turbo coding.

Additional calculations for TTIs containing radio frames compressed by puncturing in case fixed positions are used, are performed to determine this total amount of rate matching needed.

For compressed mode by puncturing, in TTIs where some compressed radio frames occur, the puncturing is increased or the repetition is decreased compared to what is calculated according to the rate matching parameters provided by higher layers. This allows to cope with reduction of available data bits on the physical channel(s) if the slot format for the compressed frame(s) contains fewer data bits than for the normal frames(s), and to create room for later insertion of marked bits, noted p-bits, which will identify the positions of the gaps in the compressed radio frames.

The amount of additional puncturing corresponds to the number of bits to create the gap in the TTI for TrCH *i*, plus the difference between the number of data bits available in normal frames and in compressed frames, due to slot format change. In case of fixed positions, it is calculated in addition to the amount of rate matching indicated by higher layers. It is noted $Np_{i,\max}^{TTI,m}$.

In fixed positions case, to obtain the total rate matching $?N_{i,\max}^{TTI,cm,m}$ to be performed on the TTI *m*, $Np_{i,\max}^{TTI,m}$ is subtracted from $?N_{i,\max}^{TTI,m}$ (calculated based on higher layers RM parameters as for normal rate matching). This allows to create room for the $Np_{i,\max}^{TTI,m}$ bits p to be inserted later. If the result is null, i.e. the amount of repetition matches exactly the amount of additional puncturing needed, then no rate matching is necessary.

In case of compressed mode by puncturing and fixed positions, for some calculations, $N'_{data,*}$ is used for radio frames with gap instead of $N_{data,*}$, where $N'_{data,*} ? P ? 15 ? (N'_{data1} ? N'_{data2})$. N'_{data1} and N'_{data2} are the number of bits in the data fields of the slot format used for the current compressed mode, i.e. slot format A or B as defined in [2] corresponding to the Spreading Factor and the number of transmitted slots in use.

The number of bits corresponding to the gap for TrCH *i*, in each radio frame of its TTI is calculated using the number of bits to remove on all Physical Channels N_{TGL}[k], where k is the radio frame number in the largest TTI.

For each radio frame k of the largest TTI that is overlapping with a transmission gap, N_{TGL}[k] is given by the relation:

$$N_{TGL} ? \begin{cases} \frac{TGL}{15} ? N'_{data,*}, \text{ if } N_{first} + TGL ? 15 \\ \end{cases}$$

$$\frac{15 ? N_{first}}{15} ? N'_{data,*} \text{, in first radio frame of the gap if } N_{first} + TGL > 15$$

$$\frac{TGL ? (15 ? N_{first})}{15} ? N'_{data,*} \text{, in second radio frame of the gap if } N_{first} + TGL > 15$$

N_{first} and TGL are defined in subclause 4.4.

Note that $N_{TGL}[k] = 0$ if radio frame k is not overlapping with a transmission gap.