RAN WG1 meeting #5 **TSGR1#5(99) 538**
Place : Corea
Date : (1-4 June)
Title : A rule to determine the rate matching ratio
Source : Mitsubishi Electric
Paper for : Discussion

1 Introduction

Currently only the rate matching algorithm is specified, no clear rule to compute the rate matching size conversion has been proposed. The purpose of this paper is to start discussion on this.

We would like to stress, as done in the section "3 Motivation", that this kind of issue also impacts WG2, and that we should discuss jointly with them.

2 References

[1] S1.12 v2.0.0 FDD Multiplexing and channel coding

3 Motivation

3.1 Problem of UL connection signalling

A rule to determine the size Y of a rate matched block based on the size X of a block before rate matching is needed, because for the UL, due to dynamic rate matching there might be quite many values for Y, and it would not be acceptable for upper layers to signal all of the $\{(X_i,Y_i)\}$ sets of mappings for all the TFCI.

3.2 Problem of Eb/I further adjustments

Also the exact Eb/I balancing is depending on the channel decoder technology for each QoS. Imagine two QoS A and B, and two manufacturers M and N. M and N have the same channel decoder for QoS A, but M has a channel decoder that is quite better than N's one for QoS B. Then clearly manufacturer M could benefit of a tighter Eb/I for QoS B, for instance M could sell more equipments to operators by arguing that they allow higher capacity. Then in the future it might be desirable to be able to adjust dynamically the Eb/I balancing by upper layer signalling. Once again signalling would be simplified if only a few parameters need to be signalled.

Adjusting dynamically Eb/I balancing would mean that instead of specifying a fixed Eb/I coefficient for each QoS there would be specified an initial value, a minimum value and a maximum value.

3.3 Problem of transport format combination set determination

There will certainly be specified combinations of services, and along with them specified transport format combination sets. This is likely to be the case for the plain voice only terminal, where the combination of service will be well specified and fixed, and there is not much to negotiate or to trade off.

However the number of potential combinations might be increasing in the future, then there is a need for clear rules to automatically compute which combinations are possible, and possibly make negotiations, and re-negotiations, in the upper layers.

This kind of discussion must be carried out jointly with RAN WG2, but WG1 has also some role to play in the extent that the physical limit of the equipment is the maximum radio frame raw payload. Then, in order to determine all of the possible potential transport format combinations the upper layers need to know :

- 1st the rule to convert transport block size to code block size,
- 2nd the rule to convert code block segment unit size to rate matched block size

The 2nd bullet is the subject of this paper.

4 Proposal

4.1 Proposed solution

Then we propose that each QoS be characterised by two parameters E and P being respectively a Eb/I coefficient, and a maximum puncturing ratio. This way only E and P need to be signalled between UE and network. Then both in the UE and in the network there would be the same algorithm implemented in order to compute the X→Y mapping based on the set {(E,P)} given for all the QoS.

The final algorithm is handling only integers, that is to say fixed point computation. The reason why so are the following:

- fixed point computation is faster and simpler to implement
- by specifying computation on integers we are sure that exactly the same result are obtained in both sides (UE and network), and that there is no discrepancies due to different implementation of floating points.

In this paper we give an algorithm without specifying dynamics. We give only formal dynamics (EMAX, PMAX, …). Further work will be needed to discuss the algorithm and to decide about the dynamic of parameters, and about the granularity needed (PBASE, LBASE).

4.2 General algorithm (undefined dynamics)

4.2.1 Parameter dynamics notation

We propose the following dynamic for parameters E and P:

- E is an integer from 1 to EMAX,
- P is an integer from 0 to PMAX, such that $\frac{\text{P}}{\text{PBASE}}$ is the maximum puncturing ratio.

Then to summarise we have to integer parameters E and P, and three integer constants, EMAX, PMAX and PBASE.

In the following we also a constant LBASE that is related with precision of computation.

Note that although we use the same notation EMAX, PMAX, PBASE and LBASE both for UL and DL this paper does not assume that the value is the same for both directions.

4.2.2 X and Y Notations

In the following we will use the same notations with a slightly different meaning in UL and in DL.
Also we define a mapping Q that gives the QoS for some block index.

4.2.2.1 Notations for DL

In DL we denote by X_1, X_2, …, X_k all the possible block sizes for all the QoS. That is to say if we have QoS from 1 to p, then :

$X_{k_0+1}, \ldots, X_{k_1}$	are all the possible block sizes for QoS	1
$X_{k_1+1}, \ldots, X_{k_2}$	are all the possible block sizes for QoS	2
… …	… … … … …	…
$X_{k_{p-1}+1}, \ldots, X_{k_p}$	are all the possible block sizes for QoS	p

with the convention that $k_0 = 0$ and $k_p = k$.

Also we consider some mapping Q from {1,…,k} to {1,…,p} that gives the QoS for one given block size index:

$$Q: \{1 \ \ldots \ k\} \rightarrow \{1 \ldots \ k\}$$

$$i \rightarrow Q(i) = j \{ \text{ for } k_{j-1} < i \le k_j; \text{with } k_0 = 0 \text{ and } k_p = k$$

Note that it is possible to have the same twice block size ($X_i = X_j$ with $i \neq j$) provided that this is not for the same Qos ($Q(i) \neq Q(j)$).

4.2.2.2 Notations for UL

In UL we number by 1, 2, …, k the blocks that are to be rate matched for some radio frame, and X_1, X_2, …, X_k are their respective sizes.

Q is a mapping from {1,…,k} to {1,…,p}, that for the considered radio frame, maps the identifier i of a block on the QoS Q(i) for this block.

Note that with this convention it possible to have twice the same block size ($X_i = X_j$ with $i \neq j$) even for the same QoS ($Q(i) = Q(j)$) if the code block set outputted by the channel encoder for this QoS, and transmitted at least partly in the considered radio frame, contains more than one code blocks.

4.2.3 Common part to DL and UL

Let us assume that for all the QoS q we have the two characteristic integers E_q and P_q with the dynamic given in section 4.2.
The first step of the algorithm is to compute for all q a parameter L_q defined by :

$$L_q = \left\lfloor \frac{(\text{PBASE}-P_q)\cdot\text{LBASE}}{E_q} \right\rfloor$$

Then the next step is to define the LMAX parameter as :

$$\text{LMAX} = \max_q\{L_q\}$$

Then the static rate matching ratio is defined by for all QoS q:

$$S_q = \text{LMAX}\cdot E_q$$

The rate matching ratio $\frac{S_q}{\text{PBASE}\cdot\text{LBASE}}$ is the minimal rate matching ratio given the maximum puncturing ratios P_q.

4.2.4 Algorithm specific part for the DL

Now let be a block i of size X_i before rate matching , and Q(i) is the QoS for this block, the value Y_i that is the size of the block after rate matching is computed by the formula:

$$Y_i = \left\lceil \frac{S_{Q(i)} \cdot X_i}{\text{PBASE}\cdot\text{LBASE}} \right\rceil$$

4.2.5 Summary for DL

1. **for all** QoS q **do** $L_q = \left\lfloor \frac{(\text{PBASE}-P_q)\cdot\text{LBASE}}{E_q} \right\rfloor$

2. LMAX := $\max_q\{L_q\}$

3. **for all** QoS q **do** S_q := LMAX· E_q

4. **for** i := 1 **to** k **do** $Y_i := \left\lceil \frac{S_{Q(i)} \cdot X_i}{\text{PBASE}\cdot\text{LBASE}} \right\rceil$

4.2.6 Algorithm specific part for the UL

In the UL the rate matching has a dynamic part. That is to say it need to be computed for each transport format combination (TFC).s

Also there are several possible radio frame raw payload $\{N_1, \ldots, N_r\}$with $N_1 \leq \ldots \leq N_r$ because several SF can be used on the UL DPDCH, and also single-code or multicode transmission can be selected.

Then the algorithm for the UL shall select one of the possible payload N_{JSEL} and ensure that :

$$\sum_{i=1}^{k} Y_i = N_{JSEL} \quad (1)$$

Then the algorithm is two step, in the first step $X_i \rightarrow Y'_i$ we compute a Y'_i value by an algorithm similar to that for DL, in the second step $Y'_i \rightarrow Y_i$ we compute the final Y_i value that is such that equation (1) holds.

Then the first step defines Y'_i by:

$S_q = LMAX \cdot E_q$
$Y'_i = S_{Q(i)} \cdot X_i$

Then we find JSEL by the following :

$$JSEL = \min \left\{ j \;/\; \sum_{i=1}^{i=k} Y'_i \le PBASE \cdot LBASE.N_j \right\}$$

Note that we assume here that :

In other words JSEL is such that the least payload is selected.

Now we define $Z_0, Z_1, \ldots, Z_k$ by the following:
$Z_0 = 0$

for all i **from** 1 **to** k **do** $$Z_i = \left\lfloor \frac{\left(\sum_{j=1}^{j=i} Y'_j \right) \cdot N_{JSEL}}{\sum_{j=1}^{j=k} Y'_j} \right\rfloor$$

And then the Y_i are defined by :
for all i from 1 to k $Y_i = Z_i - Z_{i-1}$

4.2.7 Summary for UL

1. **for all** QoS q **do** $L_q = \left\lfloor \frac{(PBASE-P_q) \cdot LBASE}{E_q} \right\rfloor$

2. $LMAX := \max_q \{L_q\}$

3. **for all** QoS q **do** $S_q := LMAX \cdot E_q$

4. **for** i := 1 **to** k **do** $Y'_i := S_{Q(i)} \cdot X_i$

5. $JSEL := \min \left\{ j \;/\; \sum_{i=1}^{i=k} Y'_i \le PBASE \cdot LBASE.N_j \right\}$

6. **for all** i **from** 1 **to** k **do** $$Z_i = \left\lfloor \frac{\left(\sum_{j=1}^{j=i} Y'_j \right) \cdot N_{JSEL}}{\sum_{j=1}^{j=k} Y'_j} \right\rfloor$$

7. **for all** i **from** 1 **to** k **do** $Y_i = Z_i - Z_{i-1}$

5 Conclusion

In this paper we have started discussion on how the block sizes can be determined for rate matching. We propose that an LS be written to WG2 in order to inform them of the progress of our work on this subject, and in order to express our need in terms signalling by upper layers.
The rule proposed in this paper has not been evaluated in terms of performance. The driving force to establish it was :
- limit signalling by upper layers
- fulfil Eb/I balancing constraints
- fulfil maximum puncturing ratio constraint
- in UL, fulfil dynamic rate matching constraint (no DTX)

The rule also needs further refinements as far as dynamic and granularity of parameters are concerned.