TSG-RAN Working Group 1 meeting #6 **TSGR1#7(99)b31**
Hannover, Germany
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Agenda item:

Source: Ericsson

Title: Comments on first multiplexing

Document for: Decision

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1 Introduction

First multiplexing was included from the ARIB specification when the ARIB and ETSI specifications were merged into 25.212 [1]. In the ARIB specification, 1st multiplexing was described by figures in Annex D. The figures in Annex D were not included in 25.212 and description of 1st multiplexing was missing for some time. Ericsson therefore provided a text proposal [2] that was accepted.

When the ARIB and ETSI specifications were merged, Ericsson supported the idea of obtaining larger code blocks in order to increase the gain from coding. However, as the gaps of [3] have been filled, it is evident that the 1st multiplexing has several implications. Consequently, further changes are needed in both [3] and [4] for a complete and consistent description of the 1st multiplexing. Ericsson has not been able to identify cases where the 1st multiplexing would be very useful. Hence, rather than proposing the changes that the 1st multiplexing require, it is proposed that the 1st multiplexing is removed.

2 Arguments for removing first multiplexing

- *The original case that was used as argument for 1st multiplexing has lost some of it relevance due to the maximum turbo code block size*. The case described in Annex D of the ARIB specification was N TrCHs of 64 kbps. The transport block size was 640 bits and 16 bits CRC was used. With a transmission time interval (TTI) of 80 ms this results in 5248 bits. This is above maximum turbo code block size and segmentation will be performed. If a TTI of 40 ms is used then 2624 bits will result. Hence, two such TrCHs can not be multiplexed before coding since it would result in more than 5120 bits. Consequently, 1st multiplexing can only be used if TTI of 20 ms or less is used. However, it is currently not clear what the delay constraint will be. The gain from longer coding blocks may be lost due to shorter interleaving if 40 ms is acceptable from a delay point of view but TTI of 20 ms is used for obtaining larger code blocks.
- *Multiplexing can be performed at MAC layer if it is desirable to code several TrCHs together.* This was the argument in ETSI when the 1st multiplexing was removed. The disadvantage with this method is that an extra header is needed and the overhead therefore increases. On the other hand, only one CRC is added to the MAC multiplexed TrCHs, instead of one per individual TrCH.
- *A new transport format attribute must be introduced in [4] and signalled every time more than one TrCH is set up.*
- *It needs to be clarified if the transport format attributes are signalled per transport channel or per "output of the 1st multiplexing"*. Current assumption is that transport format is per transport channel. Hence, it must be specified how the transport format attributes are combined at layer 1 since rate matching is performed per "output of the 1st multiplexing". It is not believed that this is complicated from a technical point of view but it will require some changes in [3].

3 References

[1] Ad Hoc 4 chair "TSGR1#3(99)216 Report from Ad Hoc #4: Transport Channel Multiplexing".

[2] Ericsson, “TSGR1#5(99)636 First multiplexing”.

[3] TSG RAN WG1, “TS 25.212 Multiplexing and channel coding (FDD)”.

[4] TSG RAN WG2, “TS 25.302 Services provided by the physical layer”.

4 Text proposal for 25.212 (and 25.222)

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)
- Channel coding (see Section 4.2.3)
- Rate matching (see Section 4.2.6)
- Insertion of discontinuous transmission (DTX) indication bits (see Section 4.2.7)
- Interleaving (two steps, see Section 4.2.4 and 4.2.10)
- Radio frame segmentation (see Section 4.2.5)
- Multiplexing of transport channels (~~two steps,~~ see Section ~~4.2.2 and~~ 4.2.8)
- Physical channel segmentation (see Section 4.2.9)
- Mapping to physical channels (see Section 4.2.11)

The coding/multiplexing steps for uplink and downlink are shown in Figure 4-1 and Figure 4-2 respectively.

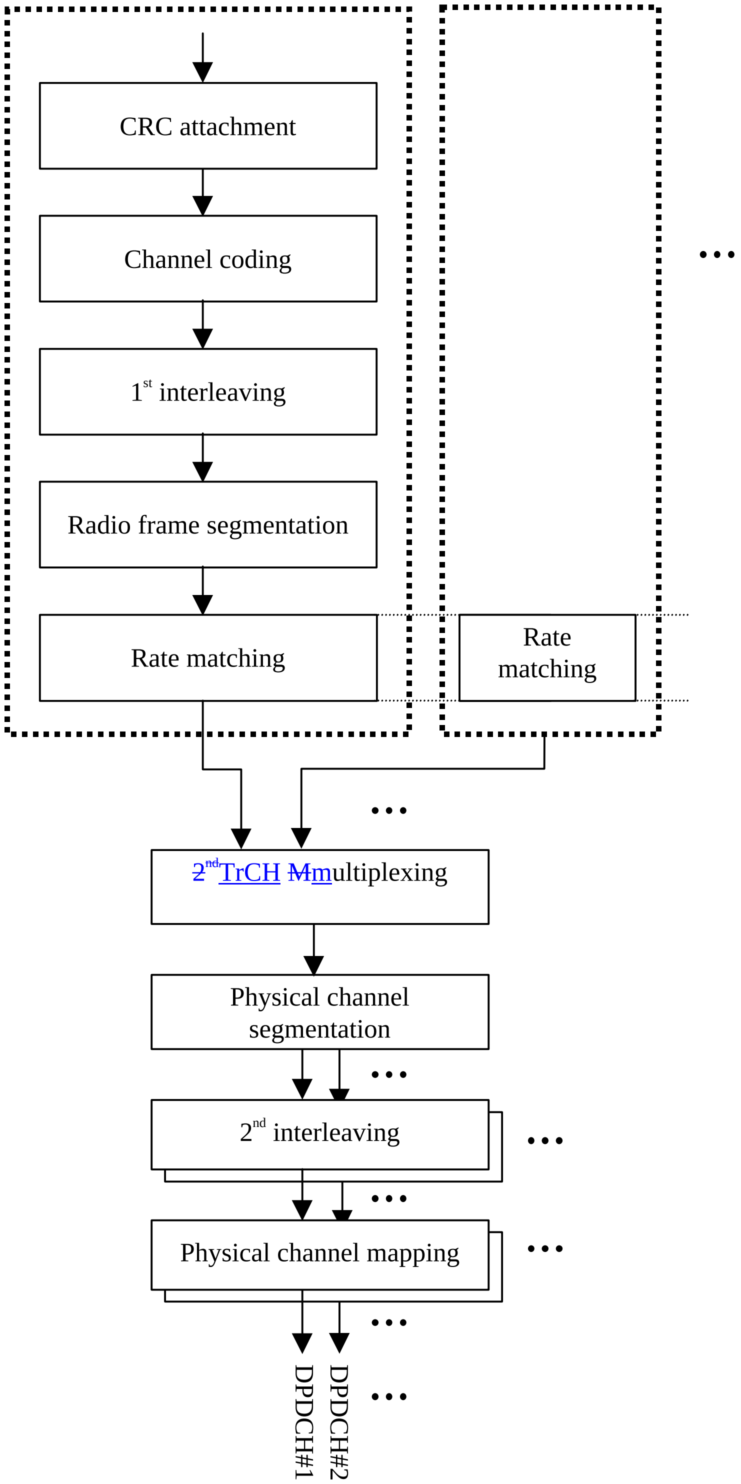

Figure 4-1. Transport channel multiplexing structure for uplink.

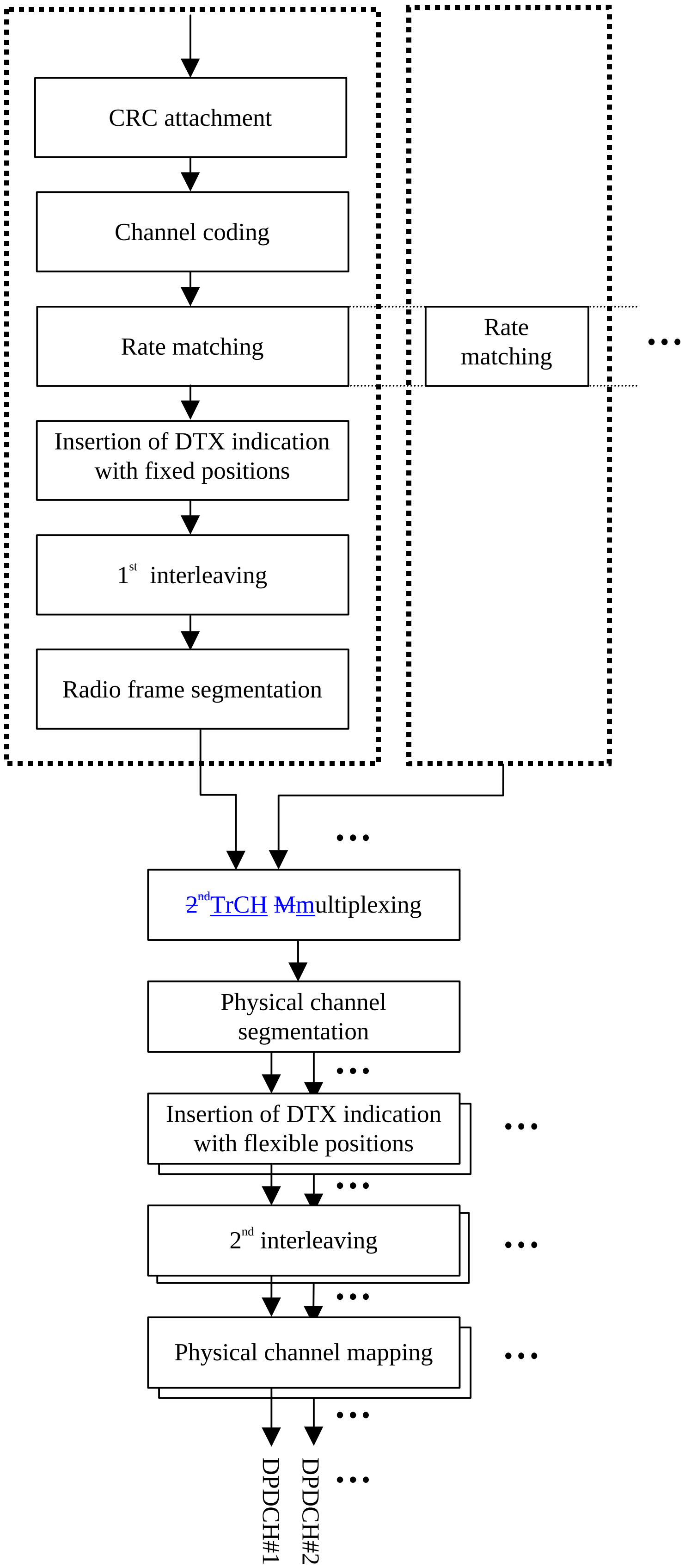

Figure 4-2. Transport channel multiplexing structure for downlink.

--snip --

~~4.2.21st Multiplexing~~

~~Fix rate transport channels that are characterised by the same transport format attributes (as defined in 25.302) can be multiplexed before coding. When this multiplexing step is present, the transport blocks from different transport channels are serially concatenated. Denote the number of transport channels (TrCHs) by R, the number of transport blocks on each TrCH by P, and the number of bits in each transport block, including CRC bits, by K. The bits before multiplexing can then be described as follows:~~

~~Bits from transport block 1 of transport channel 1: $w_{111}, w_{112}, w_{113}, \dots w_{11K}$~~

~~Bits from transport block 2 of transport channel 1: $w_{121}, w_{122}, w_{123}, \dots w_{12K}$~~

~~…~~

~~Bits from transport block P of transport channel 1: $w_{1P1}, w_{1P2}, w_{1P3}, \dots w_{1PK}$~~

~~Bits from transport block 1 of transport channel 2: $w_{211}, w_{212}, w_{213}, \dots w_{21K}$~~

~~…~~

~~Bits from transport block P of transport channel 2: $w_{2P1}, w_{2P2}, w_{2P3}, \dots w_{2PK}$~~

~~…~~

~~Bits from transport block 1 of transport channel R: $w_{R11}, w_{R12}, w_{R13}, \dots w_{R1K}$~~

~~…~~

~~Bits from transport block P of transport channel R: $w_{RP1}, w_{RP2}, w_{RP3}, \dots w_{RPK}$~~

~~The bits after first multiplexing are denoted by $d_1, d_2, d_3, \dots d_M$, and defined by the following relations:~~

~~$d_k = w_{11k}$ $k = 1, 2, \dots, K$~~

~~$d_k = w_{12(k-K)}$ $k = K + 1, K + 2, \dots, 2K$~~ } TrCH 1

~~…~~

~~$d_k = w_{1P(k-(P-1)K)}$ $k = (P - 1)K + 1, \dots, PK$~~

~~$d_k = w_{21(k-PK)}$ $k = PK + 1, \dots, (P + 1)K$~~

~~…~~ } TrCH 2

~~$d_k = w_{2P(k-(2P-1)K)}$ $k = (2P - 1)K + 1, \dots, 2PK$~~

~~…~~

~~$d_k = w_{R1(k-(R-1)PK)}$ $k = (R - 1)PK + 1, \dots, ((R - 1)P + 1)K$~~

~~…~~ } TrCH R

~~$d_k = w_{RP(k-(RP-1)K)}$ $k = (RP - 1)K + 1, \dots, RPK$~~

~~*<Note: Above it is assumed that all transport blocks have the same size. There are cases when the total number of bits that are sent during a transmission time interval is not a multiple of the number of transport blocks. A few padding bits are then needed but the exact insertion point (in the multiplexing chain) of these bits is for further study.>*~~

2nd TrCH Multiplexing

For both uplink and downlink, radio frames in each channel coding and multiplexing chains are serially multiplexed into a 10 msec coded composite transport channel.

Figure B-1 and B-2 illustrate data flow from 1st interleaver down to 2nd interleaver in both uplink and downlink channel coding and multiplexing chains. In the figures, it is assumed that there are N different channel coding and multiplexing chains. Following subsection describes the input-output relationship of 2nd multiplexing in bit-wise manner, referring to the notations in Figure B-1 and B-2, where the notation in each data block, for examples L_1, R_1, K_1, P/M, etc., indicate number of bits of the data block.

SecondTrCH multiplexing in uplink

The bits before secondTrCH multiplexing in uplink are described as follows:

Bits from rate matching 1: $c_{11}, c_{12}, \ldots c_{1K_1}$
Bits from rate matching 2: $c_{21}, c_{22}, \ldots c_{2K_2}$
Bits from rate matching 3: $c_{31}, c_{32}, \ldots c_{3K_3}$
...
Bits from rate matching N: $c_{N1}, c_{N2}, \ldots c_{NK_N}$

The bits after second multiplexing are denoted by $d_1, d_2, \ldots, d_P$
and defined by the following relationships:

For $j=1,2,3 \ldots,P$ where $P=K_1+K_2+ \ldots +K_N$

$d_j = c_{1j}$ $\quad j=1,2, \ldots K_1$
$d_j = c_{2,(j-K_1)}$ $\quad j= K_1+1, K_1+2, \ldots, K_1+K_2$
$d_j = c_{3,(j-(K_1+K_2))}$ $\quad j=(K_1+K_2)+1, (K_1+K_2)+2, \ldots, (K_1+K_2)+ K_3$
…
$d_j = c_{N,(j-(K_1+K_2+\ldots+K_{N-1}))}$ $\quad j=(K_1+K_2+\ldots+ K_{N-1})+1, (K_1+K_2+\ldots+ K_{N-1})+2, \ldots, (K_1+K_2+\ldots+ K_{N-1})+K_N$

4.2.8.1 SecondTrCH multiplexing in downlink

The bits before second multiplexing in downlink are described as follows:

Bits from radio frame segmentation 1: $c_{11}, c_{12}, \ldots c_{1K_1}$
Bits from radio frame segmentation 2: $c_{21}, c_{22}, \ldots c_{2K_2}$
Bits from radio frame segmentation 3: $c_{31}, c_{32}, \ldots c_{3K_3}$
…
Bits from radio frame segmentation N: $c_{N1}, c_{N2}, \ldots c_{NK_N}$

The bits after second multiplexing are denoted by $d_1, d_2, \ldots, d_P$
and defined by the following relationship:

For $j=1,2,3 \ldots,P$ where $P=K_1+K_2+ \ldots +K_N$

$d_j = c_{1j}$ $\quad j=1,2, \ldots K_1$
$d_j = c_{2,(j-K_1)}$ $\quad j= K_1+1, K_1+2, \ldots, K_1+K_2$
$d_j = c_{3,(j-(K_1+K_2))}$ $\quad j=(K_1+K_2)+1, (K_1+K_2)+2, \ldots, (K_1+K_2)+ K_3$
…
$d_j = c_{N,(j-(K_1+K_2+\ldots+K_{N-1}))}$ $\quad j=(K_1+K_2+\ldots+ K_{N-1})+1, (K_1+K_2+\ldots+ K_{N-1})+2, \ldots, (K_1+K_2+\ldots+ K_{N-1})+ K_N$

Physical channel segmentation

<Editor's note: for physical channel segmentation, it is assumed that the segmented physical channels use the same SF>

Data after TrCH multiplexing ~~of transport channels with different QoS~~ can get segmented into multiple physical channels which are transmitted in parallel during 10ms interval.

Figure B-1 and B-2 illustrate data flow from 1st interleaver down to 2nd interleaver in both uplink and downlink channel coding and multiplexing chains. In the figures, it is assumed that there are *N* different channel coding and multiplexing chains, and *M* physical channels. The following subsection describes input-output relationship of physical channel segmentation in bit-wise manner, referring to the notations in Figure B-1 and B-2, where the notation in each data block, for examples L_1, R_1, K_1, P/M, etc., indicate number of bits of the data block.

The bits before physical channel segmentation are described as follows:
Bits from TrCH~~second~~ multiplexing: $d_1, d_2, \dots, d_P$

M is the number of physical channel

The bits after physical channel segmentation are defined by the following relationship:

The first physical channel bits after physical channel segmentation:
$e_{1j} = d_j \qquad j=1,2,\dots,P/M$

The second physical channel bits after physical channel segmentation:
$e_{2j} = d_{(j+P/M)} \qquad j=1,2,\dots,P/M$
…

The M^{th} physical channel bits after physical channel segmentation:
$e_{Mj} = d_{(j+(M-1)P/M)} \qquad j=1,2,\dots,P/M$

[In the figures of Annex B, 2nd should be replaced by TrCH. (The proponent can not edit Visio Drawing format)]