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Shin-Yokohama, Japan (18) 19-20, April 1999

TSGR1#4(99)375

Source: Siemens

Title: Text proposal for S1.22: ‘Multiplexing and channel coding (TDD)’

Document for: Decision

Introduction

In [1] some changes were proposed to S1.22 in order to accommodate TDD-specific requirements. Additionally, in those cases where FDD and TDD can be treated identically, reflecting the current status of ad hoc #4 discussions, the document S1.22 has to be aligned with the specification S1.12, ‘Multiplexing and channel coding (FDD)’.

Survey over the proposed changes

The following changes in content of the attached document have been made:

6.1: The last two sentences of this paragraph has been removed since they are not applicable any more.

6.2: Multiplexing of transport channels with the same QoS has been adapted to FDD. Additionally, dummy bit insertion has been removed, since this is not needed for TDD. Moreover, figure 6-1 has been replaced by the figure 4-1 from S1.12 since the TDD multiplexing scheme should be chosen according to FDD-uplink without DTX within a slot.

6.2.1: Aligned to FDD.

6.2.2.1: First sentence was removed since not applicable. Within the table Turbo code has been aligned with S1.12.

6.2.4: The first sentence as well as the last square brackets from the last point in the list were removed for harmonisation with S1.12. The respective editor note was adapted.

6.2.5: Figure 6-9 was replaced by figure 4-1 from S1.12.

6.2.6: This section describing part of figure 6-1 was missing in S1.22 and taken from S1.12. Therefore, all the following paragraphs were shifted, accordingly.

6.2.7: The description of the Physical channel mapping was adopted to the proposal that for TDD always dynamic rate matching is applied to avoid DTX within a slot, which exhibits drawbacks regarding base-band processing and the distribution of interference.

6.2.8: The section ‘Multicode Transmission’ was adapted to the working assumption for TDD mode.

6.2.9: The description of the option ‘Blind Rate Detection’ was changed in order to reflect that always dynamic rate matching is used.

6.5: The description of ‘Slotted mode’, which up to now is valid only for the ARIB TDD scheme, was adapted to the TDD working assumption

7: The Annex, which details blind rate detection and is only applicable for FDD downlink, was removed.

Conclusion

The proposed changes for S1.22 should be approved to enable both, a harmonisation with FDD whenever possible and an adoption of the TDD working assumption.

Reference

[1] R1-99162: ‘Multiplexing, channel coding and interleaving for TDD’, Source: Siemens

TS 1.22 V1.0.23 1999-034

Technical Report

3rd Generation Partnership Project (3GPP);
Technical Specification Group (TSG)
Radio Access Network (RAN);
Working Group 1 (WG1);
Multiplexing and channel coding (TDD);

Reference
<Workitem>

Keywords
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Contents

1 Intellectual Property Rights

<Editor's note: this section will be completed when an official format for the document is agreed>

2 Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project, Technical Specification Group Radio Access Network, Working Group 1 (3GPP TSG RAN WG1).

The contents of this TS may be subject to continuing work within the 3GPP and may change following formal TSG approval. Should the TSG modify the contents of this TS, it will be re-released with an identifying change of release date and an increase in version number as follows:

Version m.x.y

where:

- m indicates [major version number]
- x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- y the third digit is incremented when editorial only changes have been incorporated into the specification.

3 Scope

This 3GPP Report describes multiplexing, channel coding and interleaving for UTRA Physical Layer TDD mode.

Text without revision marks has been approved in the previous TSG-RAN WG1 meetings, while text with revision marks is subject to approval.

4 References

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

[1] TS S1.02 (V1.0.0): “UE capabilities”

[2] TS S1.11 (V1.0.0): “Transport channels and physical channels (FDD)”

[3] TS S1.12 (V1.0.0): “Multiplexing and channel coding (FDD)”

[4] TS S1.13 (V1.0.0): “Spreading and modulation (FDD)”

[5] TS S1.14 (V1.0.0): “Physical layer procedures (FDD)”

[6] TS S1.21 (V1.0.0): “Transport channels and physical channels (TDD)”

[7] TS S1.22 (V1.0.0): “Multiplexing and channel coding (TDD)”

[8] TS S1.23 (V1.0.0): “Spreading and modulation (TDD)”

[9] TS S1.24 (V1.0.0): “Physical layer procedures (TDD)”

[10] TS S1.31 (V1.0.0): “Measurements”

[11] TS S2.01 (V1.0.0): “Radio Interface Protocol Architecture”

5 Definitions, symbols and abbreviations

5.1 Definitions

For the purposes of the present document, the following definitions apply:

<defined term>: <definition>.

5.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol>   <Explanation>

5.3 Abbreviations

ARQ	Automatic Repeat on Request
BCCH	Broadcast Control Channel
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BS	Base Station
BSS	Base Station Subsystem
CA	Capacity Allocation
CAA	Capacity Allocation Acknowledgement
CBR	Constant Bit Rate
CCCH	Common Control Channel
CD	Capacity Deallocation
CDA	Capacity Deallocation Acknowledgement
CDMA	Code Division Multiple Access
CTDMA	Code Time Division Multiple Access
CRC	Cyclic Redundancy Check
DCA	Dynamic Channel Allocation
DCCH	Dedicated Control Channel
DL	Downlink
DRX	Discontinuous Reception
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FEC	Forward Error Control
FER	Frame Error Rate
GMSK	Gaussian Minimum Shift Keying
HCS	Hierarchical Cell Structure
JD	Joint Detection
L1	Layer 1
L2	Layer 2
LLC	Logical Link Control
MA	Multiple Access
MAC	Medium Access Control
MAHO	Mobile Assisted Handover
MO	Mobile Originated
MOHO	Mobile Originated Handover
MS	Mobile Station
MT	Mobile Terminated
NRT	Non-Real Time
PC	Power Control

PCH	Paging Channel
ODMA	Opportunity Driven Multiple Access
QoS	Quality of Service
QPSK	Quaternary Phase Shift Keying
RACH	Random Access Channel
RF	Radio Frequency
RLC	Radio Link Control
RRC	Radio Resource Control
RRM	Radio Resource Management
RT	Real Time
RU	Resource Unit
SCH	Synchronization Channel
SDCCH	Stand-alone Dedicated Control Channel
SP	Switching Point
TCH	Traffic channel
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
UL	Uplink
UMTS	Universal Mobile Telecommunications System
VBR	Variable Bit Rate

6 Multiplexing, channel coding and interleaving

6.1 General

Data stream from/to MAC and higher layers (Transport block / Transport block set) is encoded/decoded to offer transport services over the radio transmission link. Channel coding scheme is a combination of error detection, error correcting (including rate matching), and interleaving and transport channels mapping onto/splitting from physical channels.

In the UTRA-TDD mode, the total number of basic physical channels (a certain time slot one spreading code on a certain carrier frequency) per frame is given by the maximum number of time slots which is 16 and the maximum number of CDMA codes per time slot. This maximum number of codes is 8 in case the different codes within one time slot are allocated to different users in the uplink and is higher than 8 (e.g. 9 or 10) in the downlink or if several codes are allocated to one single user in the uplink.

~~The service classes given in the following represent only a selection of all possibilities which are conceivable.~~

~~Two types of traffic bursts are used. They are described in „Physical Channels“ section.~~

6.2 Transport-channel coding/multiplexing

Figure 6-1 illustrates the overall concept of transport-channel coding and 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}.

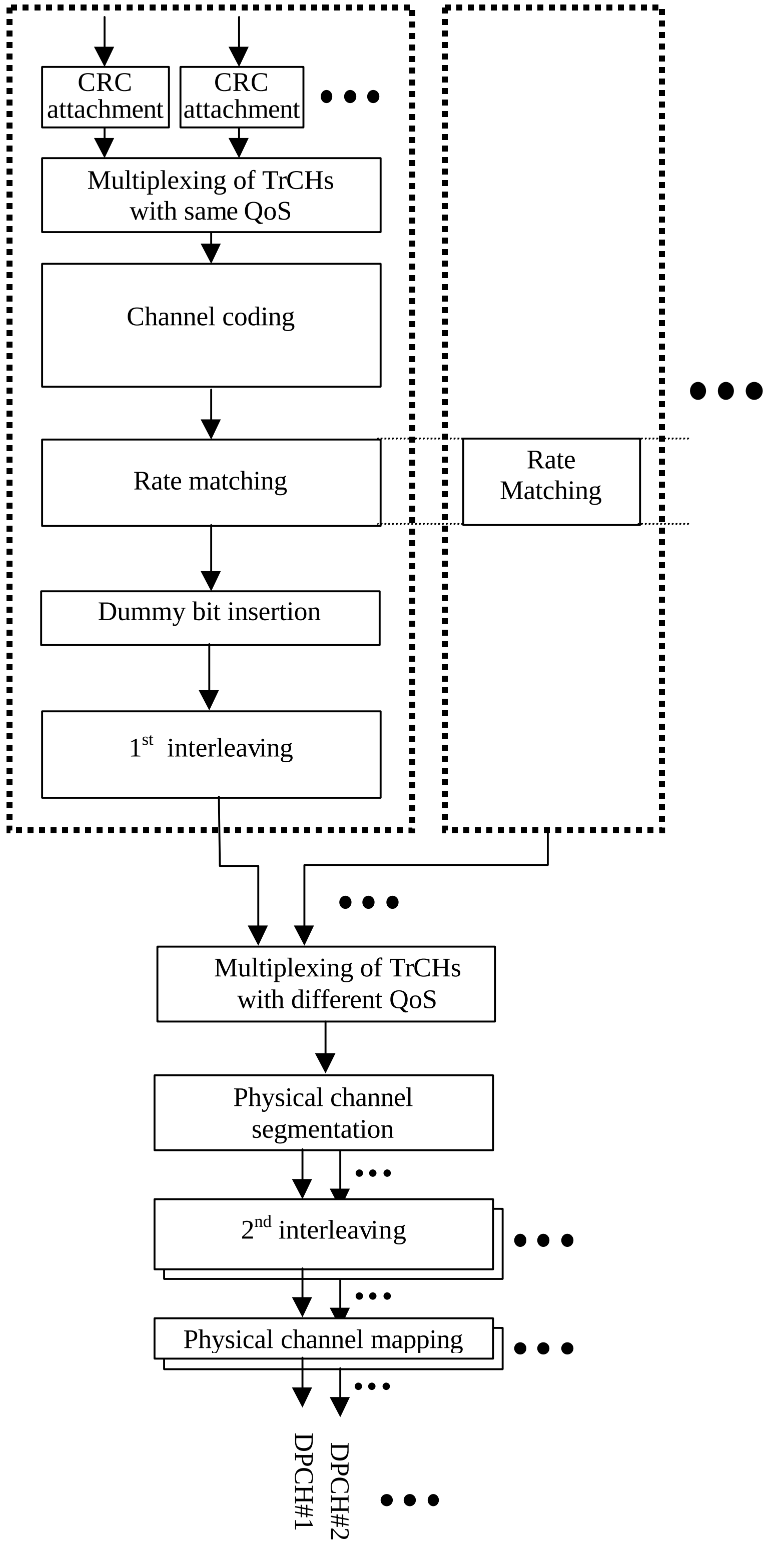
Two or more services having different Quality of Service (QoS) requirements are multiplexed into one or more physical channels using a physical channel segmentation unit, as shown in Fig 6-1.Rate matching is used to adjust the channel symbol rates (i.e., symbol rate after physical channel segmentation) to an optimum level, where minimum QoS requirement of each service is fulfilled with the same channel symbol energy. The rate matching uses the algorithm described in section 6.2.4.

The following coding/multiplexing steps can be identified:

- Add CRC to each transport block

<Editor’s note: It should still be possible to code transport channels with same QoS separately. Combining several transport blocks from one or different transport channels before coding is a study item in Ad Hoc 5. Hence, a new name could perhaps be introduced for the block saying multiplexing of transport channels with the same QoS.>

- Possibility to multiplex transport channels with same QoS before coding.
- ~~Multiplexing of transport channels with the same QoS~~
- Channel coding.
- Rate matching
- ~~Dummy bit insertion~~
- Interleaving (two steps)
- Multiplexing of transport channels with different QoS.
- Physical channel segmentation
- Mapping to physical channels


CRC attachment
CRC attachment
Multiplexing of TrCHs with same QoS
Channel coding
Rate matching
Rate Matching
Dummy bit insertion
1st interleaving
Multiplexing of TrCHs with different QoS
Physical channel segmentation
2nd interleaving
Physical channel mapping
DPCH#1
DPCH#2

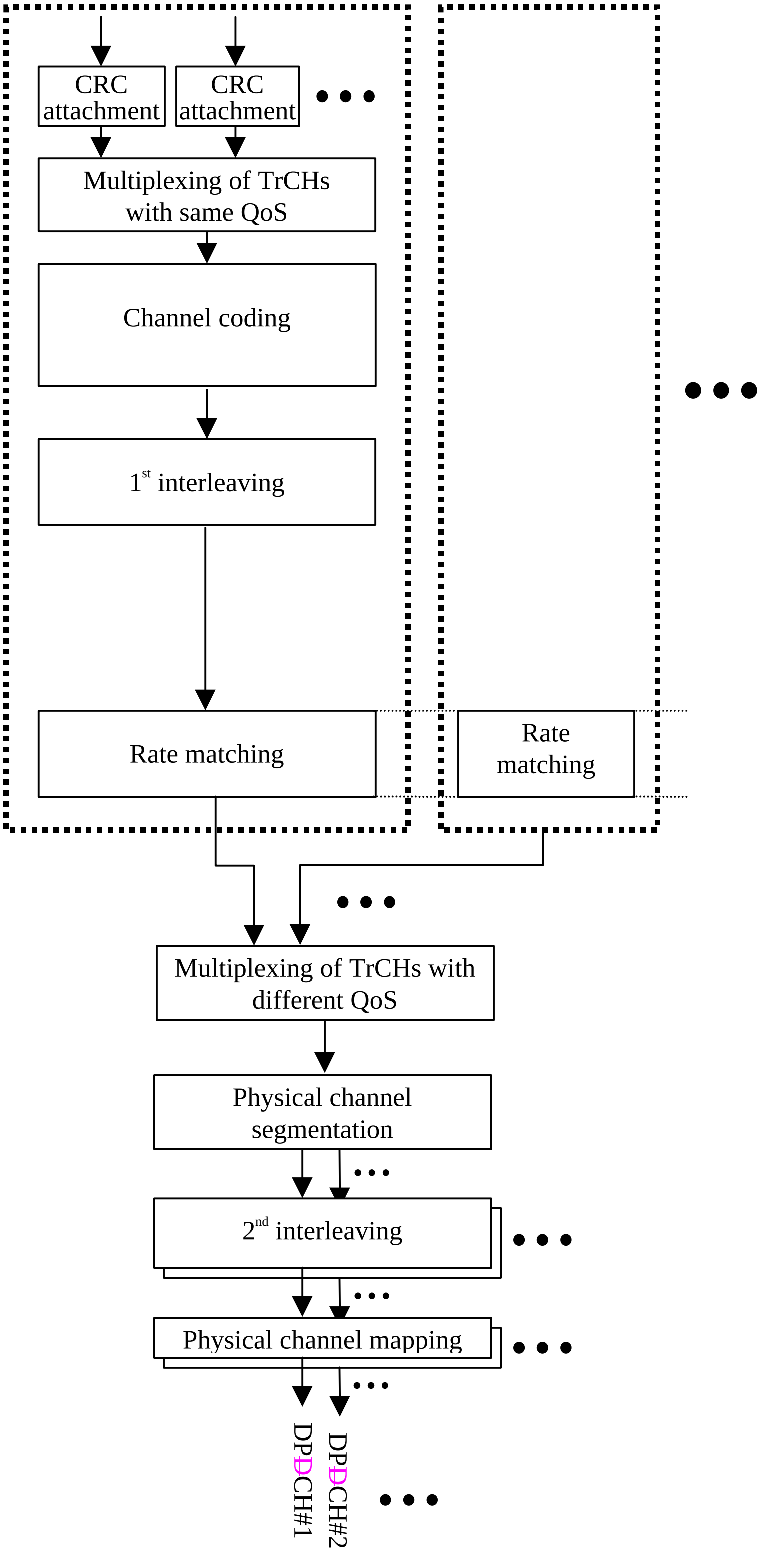


Figure 6–1. Transport channel multiplexing structure for uplink and downlink

Primarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or several physical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composite Transport Channels), which corresponds to having several parallel multiplexing chains as in Figure 6-1, resulting in several data streams, each mapped to one or several physical channels.

6.2.1 CRC calculation

Cyclic Redundancy Check is applied as an error detection scheme of transport blocks.

A 16-bit CRC code is applied to each transport block of all logical channels. Overall transport block is used to calculate the CRC for each transport block. Generator Polynomial is as follows:

$G_{CRC16}(X)= X^{16}+X^{12}+X^{5}+1$

The initial value of the CRC arithmetic calculator shall be “all 0”.

Output to the convolutional coder or Turbo coder shall be done from the most significant bit. ~~higher ones~~. ~~*<Editor’s note: Would ‘higher ones’ mean starting from most significant bit? >*~~

6.2.2 Channel coding

The following options are available for the transport-channel specific coding, see also Figure 6-2:

- Convolutional coding
- Turbo coding
- Service-specific coding, e.g. unequal error protection for some types of speech codecs.

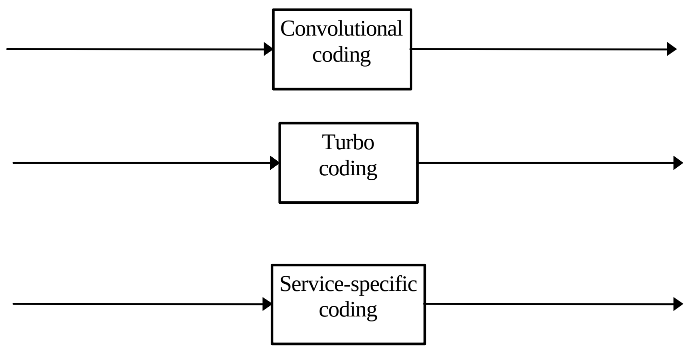


Figure 6-2. Channel coding in UTRA/TDD.

~~*<Editor’s note: Figure 6–2 was aligned with S1.12.>*~~
In Real Time (RT) services a FEC coding is used, instead Non Real Time (NRT) services could be well managed with a proper combination of FEC and ARQ.

~~6.2.2.1 Convolutional coding~~

~~The convolutional coding rates change according to the rates of different services. The convolutional coding rates from 1/4 to 1 have been chosen such that the complete system will be able to use as much as possible the same decoding structure.~~

Table Error! No text of specified style in document.**-**Error! Unknown switch argument. **Error Correction Coding Parameters**

Transport channel type (Maximum coding unit size)	Coding scheme (constraint length)	Coding rate
BCH	Convolutional code (K=9)	1/2
PCH		
FACH		
RACH		[2/3, 7/8] *<Editor's note: the values in square brackets have not yet been approved.>*
DCH (less than or equal to 32kbps)		1/2 or 1/3
DCH (more than 32kbps)	Turbo code ~~(K=3)~~	

6.2.2.2 Convolutional Coding

- The configuration of the convolutional coder is presented in Fig. 6-3.
- The output from the convolutional coder shall be done in the order starting from output0, output1 and output2. (When coding rate is 1/2, output is done up to output 1).
- The initial value of the shift register of the coder shall be "all 0".

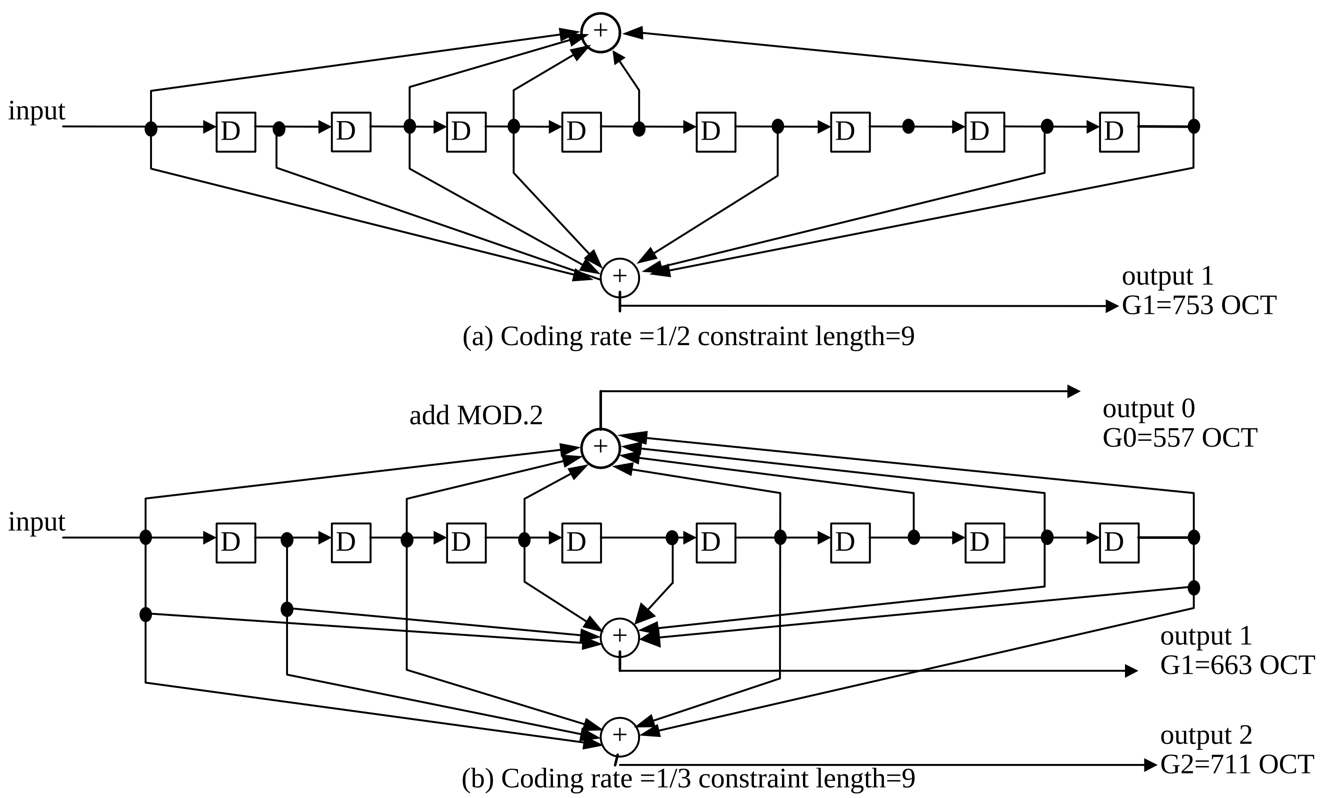


Fig. 6-4~~3~~ Convolutional Coder

6.2.2.3 Turbo coding

6.2.2.3.1 Turbo Coder

<Editor's note: 8-state PCCC was adopted as a working assumption for the turbo codec.>

For data services requiring quality of service between 10^{-3} and 10^{-6} BER inclusive, parallel concatenated convolutional code (PCCC) with 8-state constituent encoders is used. If data services requiring quality of service below 10^{-6} BER are to be specified, the possibility of adopting serial concatenated convolutional code (SCCC) with 4-state constituent encoders for those services should be considered for further study.

The transfer function of the 8-state constituent code for PCCC is

$$G(D)=\left[1, \frac{n(D)}{d(D)}\right]$$

where,

$$d(D)=1+D^2+D^3$$

$$n(D)=1+D+D^3.$$

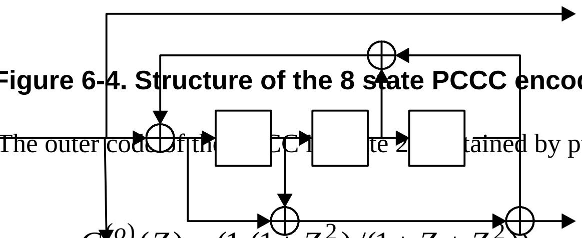


Figure 6-4. Structure of the 8 state PCCC encoder

The SCCC is a rate 1/3 SCCC, The outer code of the SCCC is a rate 2/3 obtained by puncturing a rate ½ code with generating matrix

$$G^{(o)}(Z) = (1, (1+Z^2)/(1+Z+Z^2))$$

The rate 2/3 is obtained by punct[illegible] parity-check bit.
The inner code is a rate ½ systematic recursive convolutional code with the same previous generating matrix

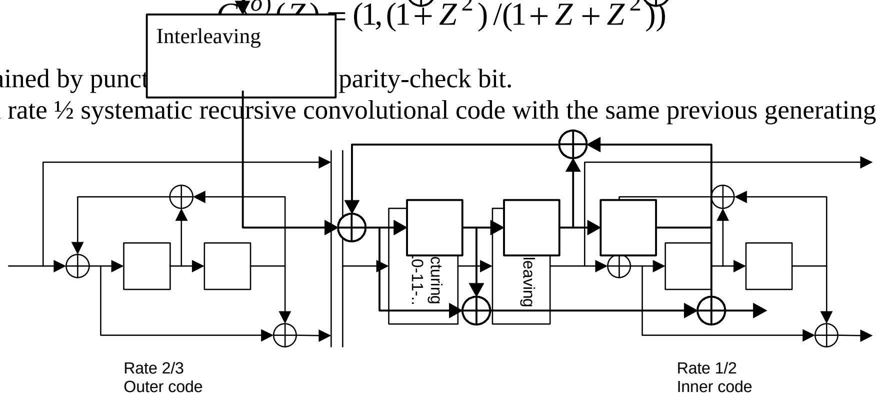


Figure 6-5. Structure of the 4 state SCCC encoder

6.2.2.3.2 Trellis termination in Turbo code

<Editor's note: this text on trellis termination reflects the AdHoc 5 consensus. ARIB scheme of CBP was removed from the merged specification based on AdHoc 5 discussion. >

The conventional method of trellis termination is used in which the tail bits are taken from the shift register feedback after all information bits are encoded. Tail bits are added after the encoding of information bits.

6.2.2.3.3 Turbo code internal interleaver

<Editor’s note: this text on internal interleaver reflects the AdHoc 5 consensus on interleavers to be studied further. In ARIB Volume 3 MIL interleaver was chosen but interleaver patterns were TBD.>

Interleaver is TBD. The complexity and flexibility of the interleaver proposals are for further study.

The following interleaver schemes are under study.

- Multiple stage interleaver (MIL)
- Galois field interleaver (GF)
- 2 dimensional algebraic interleaver (AL-N)
- 1 dimensional algebraic interleaver (AL-C) (single padding and matching constituent encoders)

6.2.2.3.4 Adaptive QoS processing in turbo code

<Editor’s note: This content is described only in ARIB specs. This issue is a study item in Ad Hoc 5.>

- In high-speed data mode (e.g. N x 64kbps mode), the turbo encoder/decoder can process combined frames, where the number of frames “J” in a combined (super) frame can be varied from 1 to 8 (i.e. 10ms to 80 ms).

- In very high-speed data mode where the size of frame is very long, the turbo encoder/decoder can process segmented frame in order to reduce the decoder complexity. The number of segmented (sub) frames is denoted by “I”

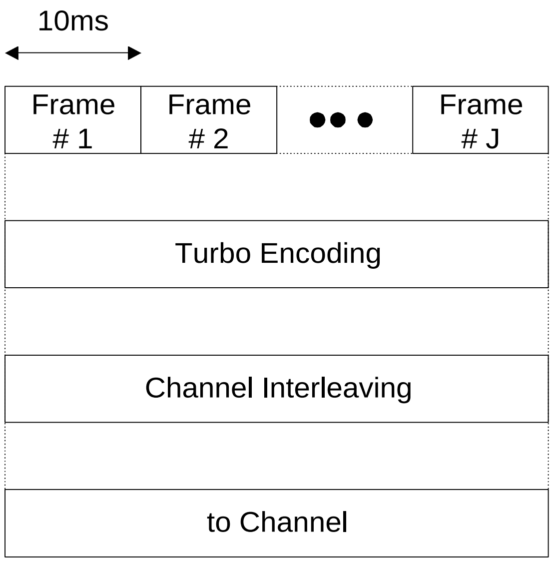


Figure 6-7. Frame Combining

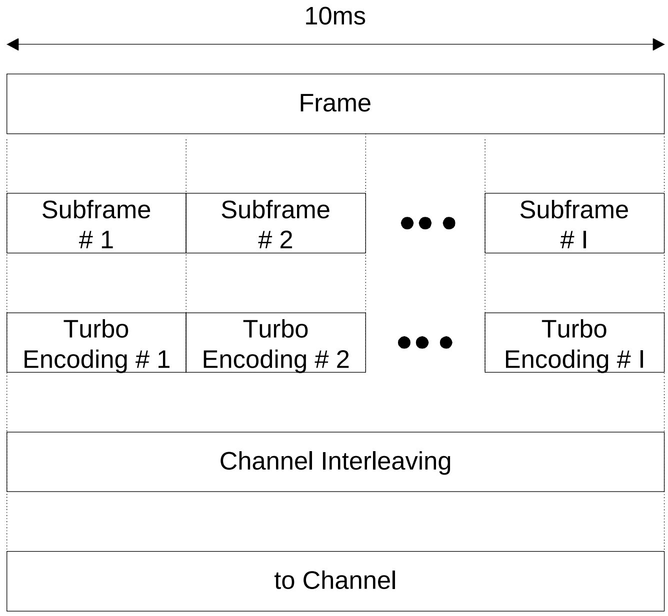


Figure 6-8. Frame Segmentation

6.2.2.4 Service specific coding

<Editor's note: the description in ETSI and ARIB is basically the same. The following text is a merge of the two descriptions.>

<Editor's note: The application of service specific coding is still under discussion in AdHoc #4.>
In addition to standard channel coding options a service specific encoder can be used. In the simplest case it can mean that there is no channel coding at all. A more typical example is an unequal-error-protection channel code for a specific speech codec.

6.2.3 1st interleaving

<Editor's note: the following paragraph was taken from ETSI xx.10 document.>

1st interleaving is carried out on a per-transport-channel basis. The exact interleaver structure is TBD.

< Editors Note : In ARIB, Inter-frame MIL is carried out as described in the following paragraph.Interleaving patterns were defined as TBD in ARIB TDD text so none are depicted here. >

The channel interleaver has the interleaving pattern obtained by using Multi-stage Interleaving Method (MIL). The channel MIL consists of two-step interleaving process; inter-frame MIL and intra-frame MIL. In the transmitter side, the inter-frame MIL is processed in advance of the intra frame MIL as shown in Figure 6-1.

6.2.4 Rate matching

~~Static rate matching is applied to both uplink and downlink channels, i.e. the applied rate matching factors are fixed during one transmission time interval. When rate of a transport channel is reduced from its maximum rate, this lead some punctured bits (not transmitted bits) in a radio frame.~~

For each combination of rates of the different transport channels, a puncturing/repetition factor is assigned to each transport channel. The set of puncturing/repetition factors is determined based on following criteria:

- desired transmission quality requirements of each transport channel is fulfilled and not significantly exceeded. This means that required transmission power to meet quality requirements for all transport channels is as low as possible.
- on uplink and downlink, the total number of allocated resource units should be minimised
- the puncturing factors should not exceed a certain maximum puncturing factor, specific for each transport channel.

<Editor's note:~~ the above bulleting point is in square brackets since there is already one solution in ARIB. However,~~ ~~m~~Maximum puncturing factor will require further discussion.>

6.2.4.1 Rate matching algorithm

<Editor's note: the rate matching algorithms in ETSI and ARIB are similar. However, in ARIB the maximum amount of puncturing allowed is already defined.>

Let's denote:

$S_N = \{N_1, N_2, \ldots, N_L\}$ = ordered set (in ascending order from left to right) of allowed number of bits per block

N_C = number of bits per matching block

$S_0 = \{d_1, d_2, \ldots, d_{N_C}\}$ = set of N_C data bits

P = maximum amount of puncturing allowed (tentatively 0.2, for further study)

[
P= 0.2: for forward-link
0.2: for reverse-link
]

<Editor's note: values for P taken from ARIB Volume 3. These may need to be reconsidered in WG1 discussion.>

The rate matching rule is as follows:

find N_i and N_{i+1} so that $N_i \le N_C < N_{i+1}$

$$if\left(\frac{N_i}{N_C} > 1 - P\right)$$

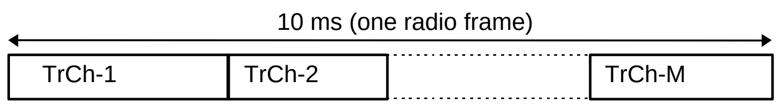
```
y = NC-Ni

e =  NC              -- initial error between current and desired puncturing ratio
                     -- this offset is flexible, e.g. e = 2Nc
m = 1            -- index of current bit
do while m <= NC
e = e – 2 * y            -- update error
if e <= 0 then           -- check if bit number m should be punctured
puncture bit m from set S0
e = e + 2*NC         -- update error
end if
m = m + 1                --  next bit
end do
else
y = Ni+1-NC

e = NC           -- initial error between current and desired puncturing ratio
                     -- this offset is flexible, e.g. e = 2Nc
m = 1                -- index of current bit
do while m <= NC
e = e – 2 * y            -- update error
do while e <= 0          -- check if bit number m should be repeated
repeat bit m from set S0
e = e +  2*NC    -- update error
enddo
m = m + 1                --  next bit
end do
end if
```

6.2.5 Multiplexing of transport channels with different QoS

The coded transport channels are serially multiplexed within one radio frame. The output after the multiplexer (before the 2nd interleaver) will thus be according to Fig. 6-9. Several CCTrCHs are supported.



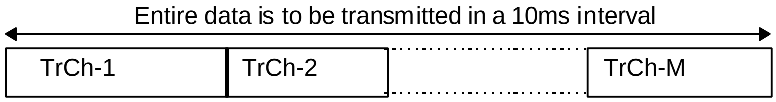


Figure 6-9. Transport channel multiplexing.

6.2.6 Physical channel segmentation

<Editor's note: Physical channel segmentation will depend upon the QoS parameters of the different transport channels in each CCTrCH. It will be necessary to specify what are the parameters expected from L2 for it.>

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

6.2.7 2nd interleaving

The 2nd interleaving is carried out over one radio frame (10 ms) and is applied to the multiplexed set of transport channels.

6.2.8 Physical channel mapping

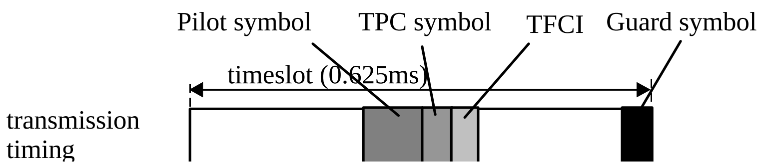
~~If transport data is less than the capacity of a dedicated physical channel, the transmission of the dedicated physical channel can be discontinuous.~~

<Editor's note: "Downlink discontinuous transmission" was renamed and was moved here. Ad Hoc4 conclusions are included with regard to the mapping position of transport channels.>

- ~~If the total bit rate after transport channel multiplexing is not identical to the total channel bit rate of the allocated dedicated physical channels, discontinuous transmission is used, i.e. dummy channel bits with zero power are inserted.~~
- If transport data is less than the number of DPCH bits in a radio frame, dynamic rate matching is applied to ensure that all resource units which belong to one user are either completely filled with data or empty.~~the DPCH transmission can be turn off for data absent. This situation can be occurred when the DPCH carries DCH(s) to which a DTCH for voice information and/or a DCCH(s) are mapped.~~
- The transmission of the DPCH symbols shall be ON, only if there is data to transmit. If there is no data, the transmission shall be OFF.
- For transport channels not relying on TFCI for rate detection (blind rate detection), the positions of the transport channels within the frame should be fixed.
- For transport channels relying on TFCI for rate detection, the positions of the transport channels should be non-fixed.
- ~~Midamble and TPC symbols are always transmitted regardless of the data existence.~~
- ~~The information to notify whether voice and/or control information exist or not shall not be transmitted.~~

6.2.9 Multicode Transmission

- For multi-code transmission several codes within one or several timeslots can be allocated for each user independently for uplink and downlink. Those resource units are negotiated by means of higher layers at the beginning of a transmission dependent on the individual services.
- For one user within a certain timeslot there is only one midamble code.
- Dependent on the actual amount of data to be transmitted not all resource units which are allocated to a certain link are used continuously. If no data is transmitted within a time slot during a frame, then also the midamble will be omitted



~~**Fig. 6-10 Spreading code in multi-code transmission**~~

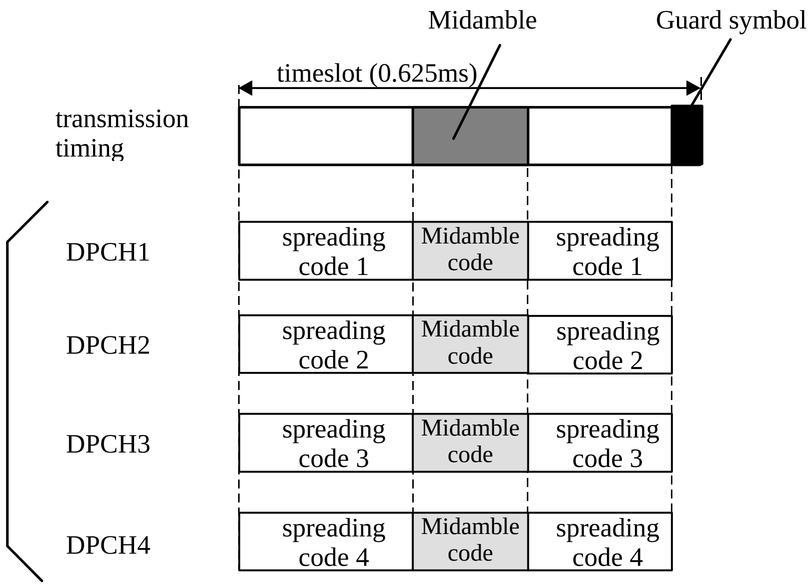
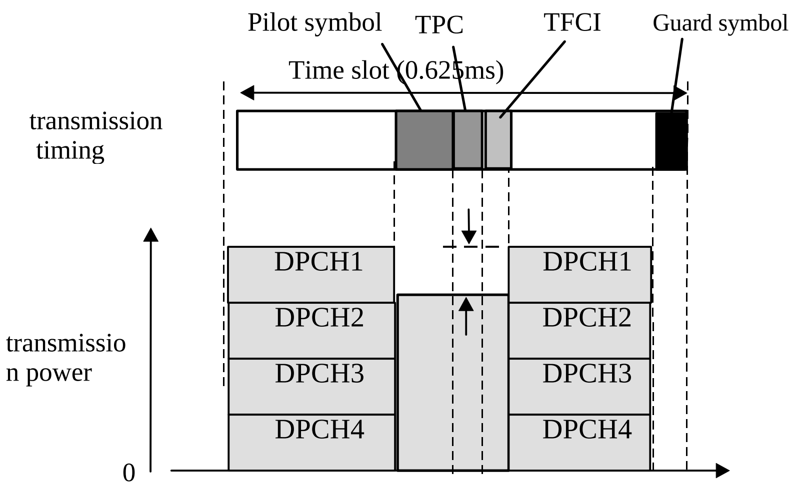


Fig. 6-10 Spreading code and Midamble in multi-code transmission



~~**Fig. 6-11 Transmission power in multi-code transmission**~~

~~*<Editor's note: the original text is taken from ARIB and current TDD concept is not correctly described.>*~~

- ~~When 1 Radio Link consists of multiple dedicated physical channels (spreading codes), transmission shall be performed as described below, and pilot aided coherent detection and transmitter power control, etc. shall be performed comprehensively for all the dedicated physical channels in 1 Radio Link. When multiple Radio Links were allocated for one MS, pilot aided coherent detection and transmitter power control shall be performed independently for each Radio Link.~~
- ~~The frame timing and scrambling code phase shall be matched at all dedicated physical channels in one Radio Link. Also, the symbol rate of the multiple physical channels designated within one Radio Link shall all be the same.~~
- ~~In all of the dedicated physical channels within one Radio Link, the spreading codes used at one particular dedicated physical channel shall be used only for the pilot symbol and the TPC symbol part. (See Fig. 6-10)~~
- ~~Transmission power of pilot symbols and TPC symbols in 1 Radio Link might be transmitted at a different transmission power from that multiplied by the number of dedicated physical channels in 1 Radio Link for the transmission power by symbols other than the pilot symbols and TPC symbols. (See Fig. 6-11)~~
- ~~Generally, δ shall be settled around the value which sets the power of DPCCH part to be one-N th of the DPDCH part, where N is the number of dedicated physical channels in a radio link. But basically, there is no regulation about the difference δ of transmission power.~~
- ~~Mobile Station should reflect the difference δ in target received SIR for closed-loop transmission power control.~~

6.2.10 Rate detection

~~*<Editor's note: the section on rate detection was taken from ARIB Volume 3.>*~~

Two kinds of rate detection can be employed; explicit rate detection and blind rate detection. ~~In the~~With explicit rate detection, transmitter side transmits Transport Format Combination Indicator (TFCI), and receiver side detects transport format combination using TFCI. In case of ~~the~~ blind rate detection, transmitter side does not transmit TFCI, and receiver side uses the ~~detect~~possible transport format combinations ~~using some~~ as a priori information.

~~, e.g. received power ratio of DPDCH to DPCCH, CRC check results.~~

~~For uplink, the blind rate detection is an operator option. For downlink, services to be applied blind rate detection shall be specified.~~

6.2.10.1 Blind Rate Detection

~~Two kinds of blind rate detection are employed. Examples of these methods are given in Annex A.~~

Blind rate detection may be performed in the receiver by trying all possible combinations of the transport format.

6.2.10.2 Explicit Rate Detection

6.2.10.2.1 Transport Format Combination Indicator

Transport Format Combination Indicator (TFCI) informs the receiver of the number of bits in each frame of each of the services currently in use. As soon as a certain bit-rate is known, the number of code channels, the spreading factor and the puncturing/repetition rate is immediately known from the rules described in section 6.2.4.

This document therefore only explains the mapping from TFCI bits to TFCI service rate combinations.

A connection may in general include the variable-rate services S_1, S_2, …, S_K. Each service S_i has a set of possible transport format combination indicators $TF_{i,1}$,$TF_{i,2}$,…$TF_{i,Li}$:

S_1: $TF_{1,1}$, … , $TF_{1,L1}$

S_2: $TF_{2,1}$, … , $TF_{2,L2}$

…

S_K: $TF_{K,1}$, … , $TF_{K,LK}$

This gives L=L1xL2x…xLK service rate combinations, and thus it is required that L is less than or equal to 64 with the default TFCI word or 1024 with the extended TFCI word.

These service rate combinations shall be mapped to a certain service rate combination number, *m*, in the following way:

```
For j=K:-1:1,
  SRC[j]= m MOD L[j];
  m = m DIV L[j];
End;
```

From this pseudo-code, given a service rate combination number, i.e. a certain combination of TFCI bits, *m*, SRC contains the rates of each of the K services. The integer values used for *m* shall be consecutive, starting from 0. Note that this code gives the mapping rule from *m* to SRC, i.e. the rule used in the receiving side. The mapping rule from SRC to *m*, i.e. the transmitting side rule, is [TBD].

6.3 Automatic Repeat Request (ARQ)

<Editor's note: this chapter is unchanged from ETSI xx.10 document.>

The details of the UTRA ARQ schemes are not yet specified. Therefore, the impact on layer 1, e.g. if soft combining of retransmitted packets is to take place, is not yet fully specified.

6.4 Coding for layer 1 control

6.4.1 Coding of Transport-format-combination indicator (TFCI)

<Editor's note: TFCI text is taken from ARIB Volume 3. In ETSI TDD, the slot structure contains a variable number of TFCI bits (See last version of xx.09). The following text should be taken as an example for 32 transmitted TFCI bits. The interleaving is taken from FDD mode, different interleaving might be necessary for TDD.>

Encoding of the TFCI bits depends on the number of them. If there are at most 6 bits of TFCI the channel encoding is done as described in section **Error! Unknown switch argument.**. Correspondingly, if the TFCI word is extended to 7-10 bits the channel encoding is done as explained in the section **Error! Unknown switch argument.**. When decoding, default TFCI words are assumed.

6.4.1.1 Default TFCI word

If the number of TFCI bits is 6 or less a biorthogonal (32, 6) block code is used. The code words of the biorthogonal (32, 6) code are from two mutually biorthogonal sets, $S_{C_5} = \{C_5(0), C_5(1),.., C_5(31)\}$ and its binary complement, $\bar{S}_{C_5} = \{\bar{C}_5(0), \bar{C}_5(1),.., \bar{C}_5(31)\}$. Words of set S_{C5} are from the level 5 of the code three, which is generated, using the short code generation method defined in chapter 6.2 of S1.23. The mapping of information bits to code words is shown in the Table 6.3.1- 1.

Table 6.3.1- Error! Unknown switch argument. **Mapping of information bits to code words for biorthogonal (32, 6) code.**

Information bits	Code word
000000	$C_5(0)$
000001	$\overline{C_5(0)}$
000010	$C_5(1)$
...	...
111101	$\overline{C_5(30)}$
111110	$C_5(31)$
111111	$\overline{C_5(31)}$

6.4.1.2 Extended TFCI word

If the number of TFCI bits is 7-10 the TFCI information field is split into two words of length 5 bits as shown in the Fig. 6- 12.

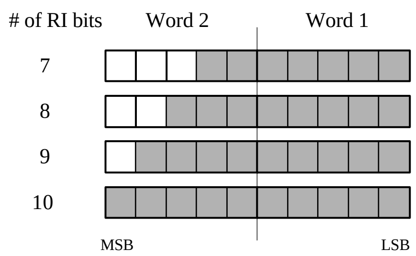


Fig. 6- 12 Mapping of TFCI bits to two words.

Both of the words are encoded using biorthogonal (16, 5) block code. The code words of the biorthogonal (16, 5) code are from two mutually biorthogonal sets, $S_{C_4} = \{C_4(0), C_4(1),..., C_4(15)\}$ and its binary complement, $\bar{S}_{C_4} = \{\bar{C}_4(0), \bar{C}_4(1),..., \bar{C}_4(15)\}$. Words of set S_{C_4} are from the level 4 of the code three, which is generated, using the short code generation method defined in chapter 3.2.4.2.2.1.1.1. The mapping of information bits to code words is shown in theTable 6.3.1-2.

Table 6.3.1- 2 Mapping of information bits to code words for biorthogonal (16, 5) code.

Information bits	Code word
00000	$C_4(0)$
00001	$\overline{C_4(0)}$
00010	$C_4(1)$
...	...
11101	$\overline{C_4(14)}$
11110	$C_4(15)$

11111	$\overline{C_4(15)}$

6.4.1.3 Interleaving of TFCI

6.4.1.3.1 Default TFCI word

As only one code word for TFCI of maximum length of 6 bits is needed no channel interleaving for the encoded bits are done. Instead, the bits of the code word are directly mapped to the slots of the radio frame as depicted in the Fig.6- 13.

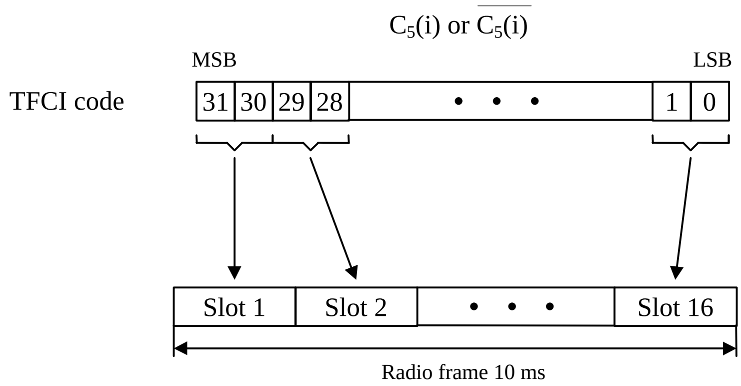


Fig.6- 13. Time multiplexing of code words of (32, 6) code to the slots of the radio frame.

6.4.1.3.2 Extended TFCI word

After channel encoding of the two 5 bit TFCI words there are two code words of length 16 bits. They are interleaved and mapped to DPCCH as shown in the Fig. 6- 1. Note that $b_{1,i}$ and $b_{2,i}$ denote the bit *i* of code word 1 and code word 2, respectively.

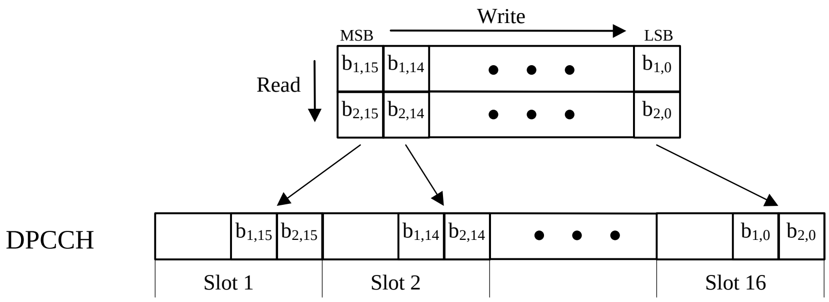


Fig. 6- 14 Interleaving of TFCI code word

6.5 Inter-frequency handover

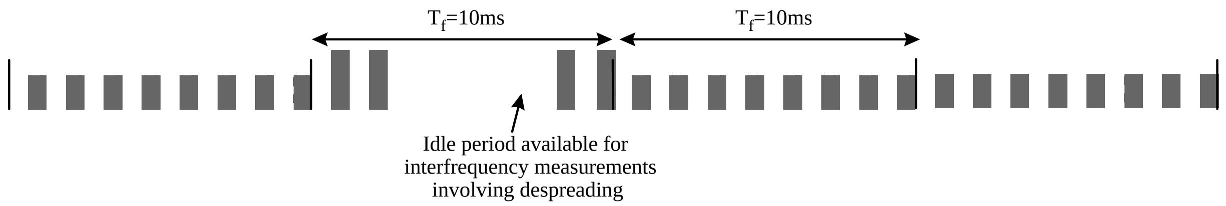
~~*<Editor's note: text in this chapter is taken from ARIB Volume 3.>*~~

6.5.1 Slotted mode

With TDD , in most cases slotted mode is not needed, since discontinuous transmission, which enables measurements at other frequencies, is an inherent system feature.

For high rate services higher layer algorithms have to provide a sufficient large measurement window.

~~The principle of the slotted downlink transmission approach is illustrated in Fig. 6-15. When the slotted mode is performed, the information normally transmitted during a 10 ms frame is compressed in time, either by code puncturing or by changing the coding rate R=1/3 into R=1/2 as similar to the FDD mode. In this way, a large number of slots are created, during which the mobile-station receiver is idle and can be used for inter-frequency measurements. Note that the idle slot is created without any loss of data as the number of information bits per frame is kept constant, while the processing gain is reduced by either reducing the spreading factor or increasing the coding rate. As illustrated in Fig. 6-11, the momentary transmitter power is increased in the slotted frame in order to keep the quality (BER, FER, etc.) unaffected by the reduced processing gain.~~



~~**Fig. 6-15 Downlink slotted mode transmission**~~

7 Annex A Blind rate detection

<Editor's note: text in Annex A is taken from ARIB Volume 3.>

7.1 Blind Rate Detection using Received Power Ratio

- This method is used for dual transport format case (the possible data rates, 0 and full rate, and only transmitting CRC for full rate).
- The rate detection is done using average received power ratio of DPDCH to DPCCH.
  Pc: Received Power per bit of DPCCH calculated from all pilot and TPC bits per slot over 10ms frame.
  Pd: Received Power per bit of DPDCH calculated from *X* bits per slot over 10ms frame.
  X: the number of DPDCH bits per slot when transport format corresponds to full rate.
  T: Threshold of average received power ratio of DPDCH to DPCCH for rate detection.

If *Pd/Pc >T* then

"TX_ON"

else

"TX_OFF"

7.2 Blind Rate Detection using CRC

- This method is used for multiple transport format case (the possible data rates: 0, …, (full rate)/r, …, full rate, and always transmitting CRC for all transport formats).
- At the transmitter, the variable-rate DCH data to be transmitted is block-encoded using a cyclic redundancy check (CRC) and then convolutionally encoded . It is necessary that the CRC parity bits are mapped on the head position (or certain position) in a frame as shown in Fig.A-1.
- The receiver knows only the possible transport formats (or the possible end bit position $\{n_{end}\}$ by Layer-3 negotiation (See Fig.A-1). The receiver performs Viterbi-decoding on the soft decision sample sequence. The correct trellis path of the Viterbi-decoder ends at the zero state at the correct end bit position.
- Blind rate detection method by using CRC traces back the surviving trellis path ending at the zero state (hypothetical trellis path) at each possible end bit position to recover the data sequence. Each recovered data sequence is then error-detected by CRC and if there is no error, the recovered sequence is declared to be correct.
- The following variable is defined:

$$s(n_{end}) = -10 \log ((a_0(n_{end}) - a_{min}(n_{end})) / (a_{max}(n_{end}) - a_{min}(n_{end}))) \text{ [dB]} \qquad \text{(Eq. 1)}$$

where $a_{max}(n_{end})$ and $a_{min}(n_{end})$ are, respectively, the maximum and minimum path-metric valuse among all survivors at end bit position n_{end}, and $a_0(n_{end})$ is the path-metric value at zero state.

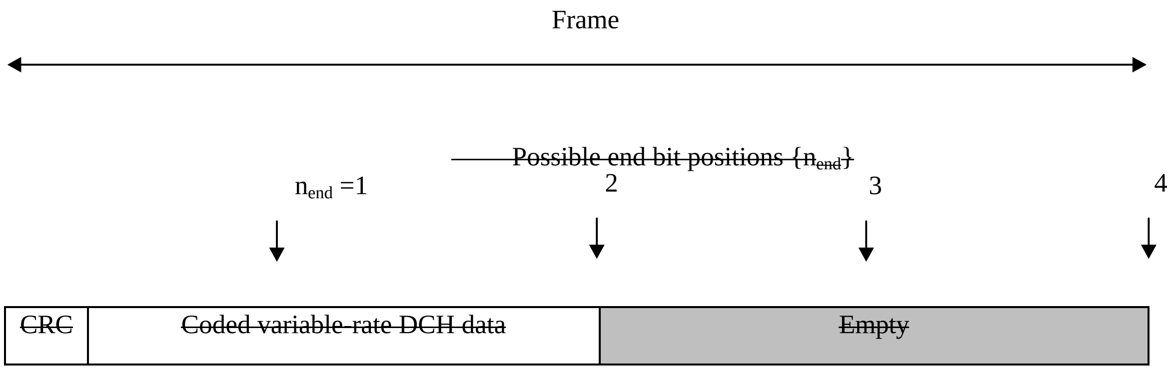
- In order to reduce the probability of false detection (this happens if the selected path is wrong but the CRC misses the error detection), a path selection threshold D is introduced. D determines whether the hypothetical trellis path connected to the zero state should be traced back or not at each end bit position n_{end}. If the hypothetical trellis path connected to the zero state that satisfies

$$s(n_{end}) =< D \qquad \text{(Eq. 2)}$$

is found, the path is traced back to recover the frame data, where D is the path selection threshold and a design parameter.

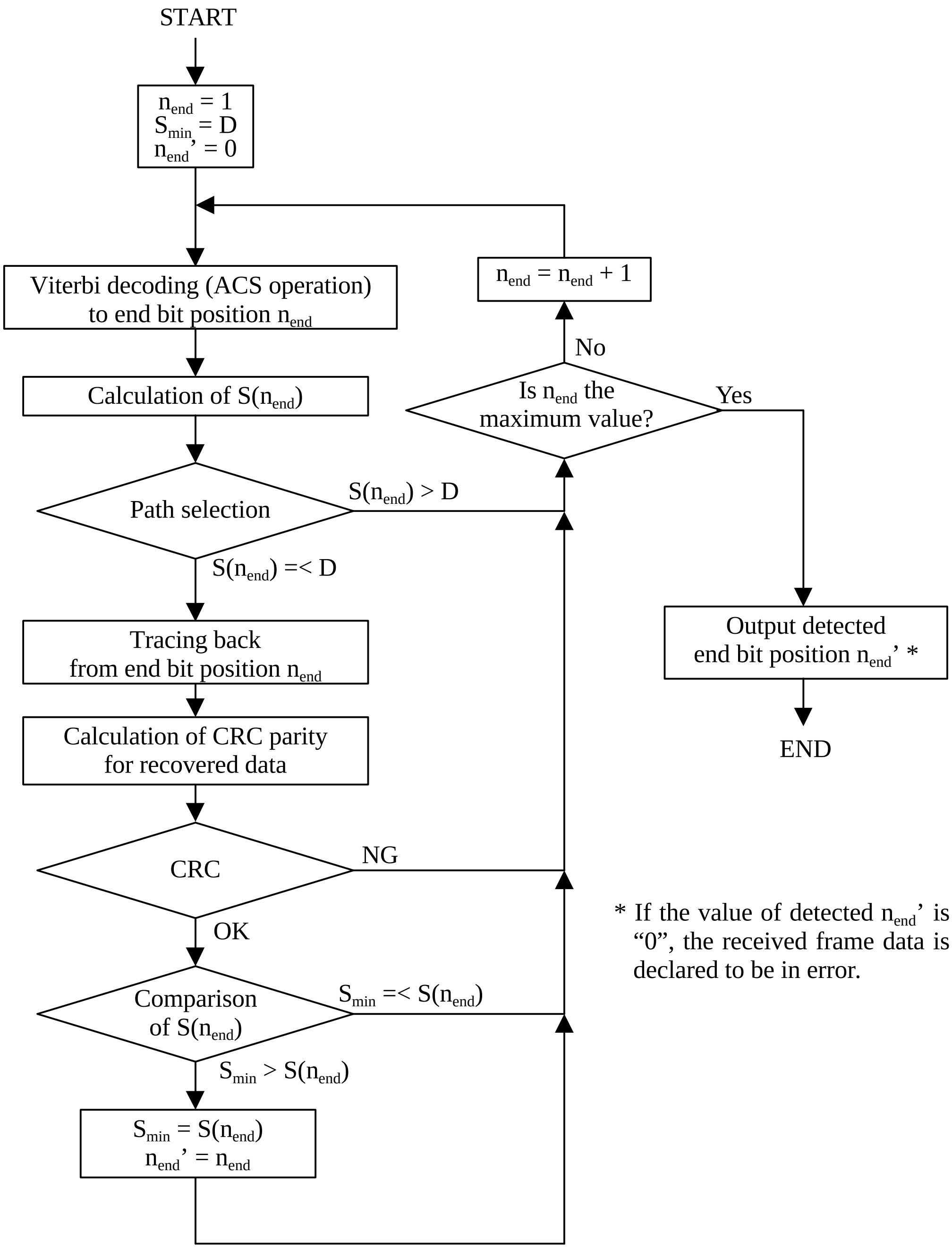
- If more than one end bit positions satisfying Eq. 2 are found, the end bit position which has minimum value of $s(n_{end})$ is declared to be correct.
- If no path satisfying Eq. 2 is found even after all possible end bit positions have been exhausted, the received frame data is declared to be in error.

Fig. A-2 shows the procedure of blind rate detection using CRC.



~~**Fig. A-1 An example of variable rate data format**~~

~~(Number of possible transport formats = 4, transmitted end bit position n_{end} = 2)~~



* If the value of detected n_{end}' is "0", the received frame data is declared to be in error.

~~Fig. A-2 Basic processing flow of blind rate detection~~

8 History

Document history		
v0.0.1	1999-02-12	Document created based on the documents Tdoc UMTS (xx.10) V0.5.0 and ARIB Volume 3 Version 1.0-1.0.
V0.0.2	1999-02-18	Document updated based on comments in the TSG-RAN WG1 e-mail reflector.
V0.1.0	1999-02-26	This version was approved at WG1#2 as the initial merge of ARIB and ETSI documents.
V0.1.1	1999-03-03	Document updated based on Adhoc decisions and technical comments made at WG1#2.
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V1.0.2	1999-03-24	Corrections made based on feedback in WG1#3 meeting.
V1.0.3	1999-04-13	Proposed changes for harmonisation with S1.12 and reflecting the TDD working assumption

The editor for 3GPP RAN WG1 S1.22 Multiplexing, channel coding and interleaving description (TDD), is:

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