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1

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3rd Generation Partnership Project (3GPP); TDD multiplexing, channel coding and interleaving description;

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Contents

2 Intellectual Property Rights

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

3 Foreword

This TR describes multiplexing, channel coding and interleaving for UTRA Physical Layer TDD mode.

The baseline for this document is ETSI TR xx.10 V0.5.0 (UTRA TDD, multiplexing channel coding and interleaving description). Text added from ARIB Volume 3 is written with revision marks active.

In particular, rate detection, multirate transmission, parts of DTX and slotted mode in handover are new chapters in this document.

4 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.

5 References

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply;

b) publications without mention of a specific version, in which case the latest version applies.

6 Definitions and abbreviations

<Editor's note: This section covers TDD relevant abbreviations only.>

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

7

8 Status of this document

8.1 general

8.2 Transport channel coding/multiplexing

- Under study in AdHoc 4, currently combined from ETSI xx.10 and ARIB Volume 3.

8.2.1 CRC calculation

- Currently only input from ARIB Volume 3.

8.2.2 channel coding

- Under study in AdHoc 5, currently a combination of ETSI and ARIB original sources.

8.2.3 1st interleaving

- Under study in AdHoc 5.

8.2.4 rate matching

- A combination of ETSI xx.10 and ARIB Volume 3.

8.2.5 transport channel multiplexing

- Under study in AdHoc 4.

8.2.6 2nd interleaving

- Under study in AdHoc 5.

8.2.7 Discontinuous transmission

- Currently copied from ARIB Volume 3.

8.2.8 Multirate transmission

- Currently copied from ARIB Volume 3.

8.2.9 Rate detection

- Currently copied from ARIB Volume 3.

8.3 automatic repeat request

- study item (still to be decided whether this is within the layer 1 scope)

8.4 coding for layer 1 control

- Currently copied from ARIB Volume 3

8.5 Inter-frequency handover

- .Slotted mode added from ARIB Volume 3,

Annex A

- Examples on blind rate detection; text is from ARIB Volume 3.

9 Multiplexing, channel coding and interleaving

9.1 General

This section describes the services multiplexing, channel coding/interleaving and rate matching.

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.

? *< Editors Note : There is no limited number of multiplexed bursts within one time slot in ARIB.>*

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.

? *< Editors Note : One type of traffic burst is used in ARIB.>*

9.2 Transport-channel coding/multiplexing

<Editor’s note: the following chapter and bulletin point list was taken from ETSI xx.10.>

Figure Error! **Style not defined.-Error! Bookmark not defined.** 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}.

The following coding/multiplexing steps can be identified:

- Add CRC to each transport block
- Channel coding. This may include interleaving for turbo code
- Interleaving (two steps)
- Transport-channel multiplexing
- Mapping to physical channels

?

? *<Editor’s note: these following two paragraphs were taken from ARIB Volume 3.>*

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.

Cyclic Redundancy Check is applied as an error detection scheme.

<Editor’s note: the following text in square brackets was taken from ARIB Volume 3.>

[r forward error correction, either convolutional coding or Turbo coding is applied. Common transport channels nploy only convolutional coding. However, for dedicated transport channels, convolutional coding is used when aximal coding unit size is less than 320 bits while Turbo coding is used when maximal coding unit size is more than o ual to 320 bits. To offer efficient transmission, rate-matching scheme, such as repetition or puncturing, is applied.

r interleaving, Multi-stage Interleaving method (MIL) is applied to ensure higher performance both with nvolutional coding and Turbo coding. The channel MIL consists of two-step interleaving process; inter-frame MIL ıd intra-frame MIL. In the transmitter side, the inter-frame MIL is processed in advance of the intra frame MIL.As for roadcast channel (BCH), SFN information is combined with data stream from MAC layer. PI part is attached to pagin essage (MUI) in Paging channel (PCH).

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? *< Editors Note : In ARIB, RS is not used and maximal coding unit size is defined. Furthermore, MIL is applied for interleaving method.>*

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? The different steps are described in detail below.

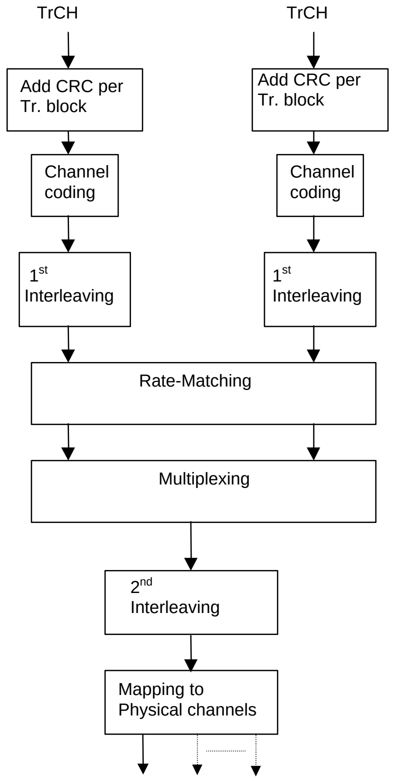

Figure Error! Style not defined.**-**Error! Bookmark not defined.. **Coding and multiplexing of transport channels**.

<Editor's note: Figure 7-1 is from ETSI xx.10 document>

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

ːimarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or severa ıysical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composit ransport Channels), which corresponds to having several parallel multiplexing chains as in Figure Error! **Style no efined.-Error! Bookmark not defined.**, resulting in several data stream, each mapped to one or several physica channels.

<Editor's note: the following paragraph was taken from ARIB Volume 3.>

/hen two or more services having different Quality of Service (QoS) requirements are multiplexed into one or more ıysical channels using a common physical channel mapping unit, as shown in Fig., service specific rate matching shall ɛ used to adjust the channel symbol rates (i.e., symbol rate after channel coding and service specific rate matching) to ı optimum level, where minimum QoS requirement of each service is fulfilled with the same channel symbol energy. he service specific rate matching uses the same algorithm that is used in the physical channel-mapping unit, and ɛscribed in section 7.2.4. The symbol rates after service specific rate matching shall be signaled to physical layer via ayer 3 messages.

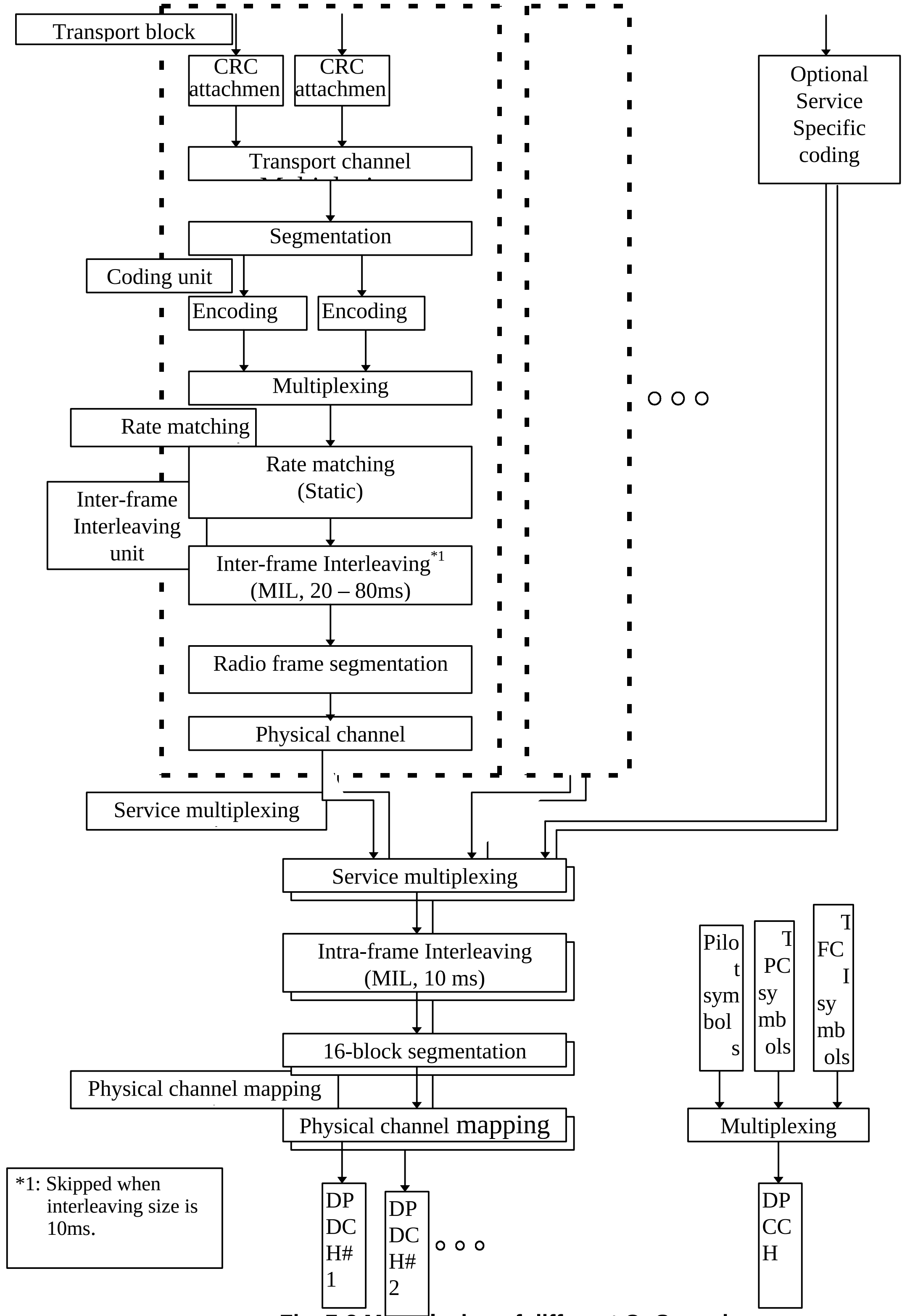

Fig. 7-2 Multiplexing of different QoS services

<Editor's note: Figure 7-2 is from ARIB Volume 3.>

9.2.1 CRC calculation

<Editor's note: In xx.10 there was not text on CRC, thus CRC chapter was taken from the ARIB Vol. 3 specification.>

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

9.2.1.1 Generator Polynomial

A 16-bit CRC code is applied to each transport block of all logical channels. 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". *<Editor's note: this bulletin point was moved from 7.2.1.3.>*

9.2.1.2 CRC Arithmetic Application Range

CRC for each transport block: overall Transport block

9.2.1.3 Usage of CRC Check Results

Editor's note:these remarks probably belong to L23 document.>

CRC for each transport block: judgement of retransmission required/not required in the retransmission protocol (layer2, layer 3 retransmission) of higher layer.
CRC for each DCH selective combining units: (i) outer-loop transmitter power control, (ii) reliability information for selective combining.
CRC for each DCH inner coding units: outer-loop transmitter power control
Inner coding units of RACH: layer 1 retransmission.
ditor's note: Description on Retransmission function shall be harmonised with MAC specification.]

Inner coding units of DCH: (i) outer-loop transmitter power control.
CRC for RACH inner coding units: Invalidate data of inner coding units.

9.2.1.4 CRC Transmission order

Output to the convolutional coder or Turbo coder shall be done from the higher ones.

<Editor's note: Would 'higher ones' mean starting from most significant bit? >

9.2.2 Channel coding

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

The following options are available for the transport-channel specific coding, see also Figure Error! **Style not defined.-Error! Bookmark not defined.**:

- Convolutional coding
- Outer Reed Solomon coding | Outer interleaving | Convolutional coding
- Turbo coding (FFS)
- Service-specific coding, e.g. unequal error protection for some types of speech codecs.

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? *< Editors Note : In ARIB, RS is not used and Turbo coding is not FFS.>*

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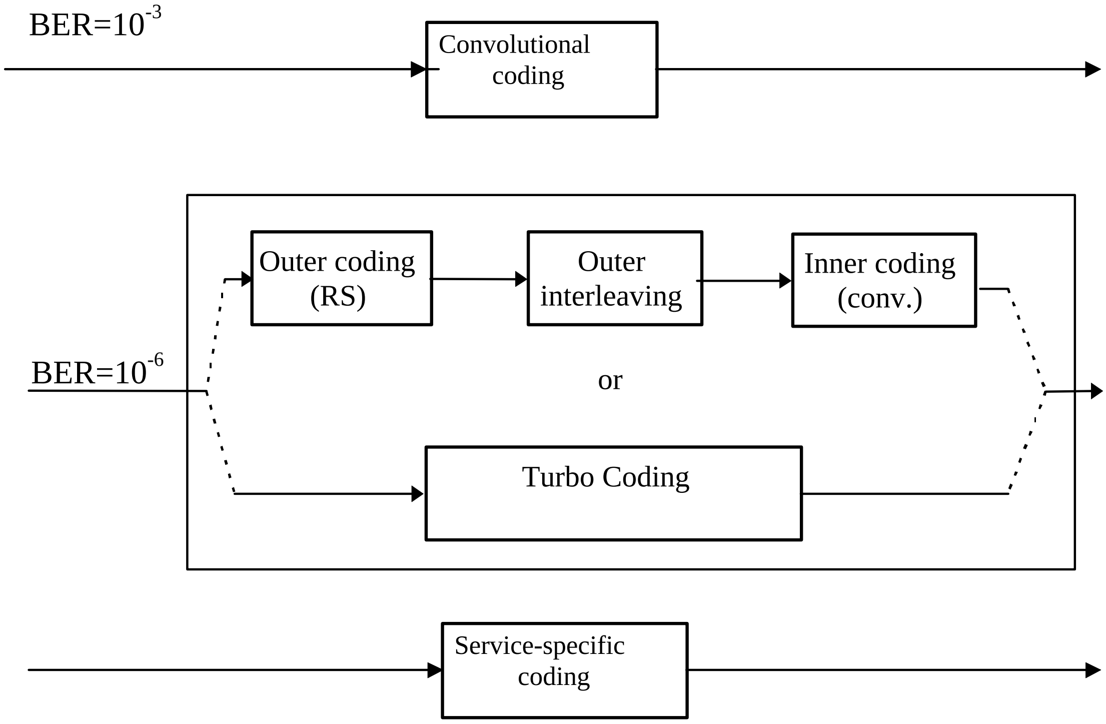

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Figure Error! Style not defined.**-**Error! Bookmark not defined.**. Channel coding in UTRA/TDD**.

<Editor's note: Figure 7-2 and the following three paragraphs were taken from ETSI xx.10 document.>

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.

For the RT services two levels of QoS (10^{-3} , 10^{-6}) have been considered as examples in Figure **Error! Style not defined.-Error! Bookmark not defined.**.

Only convolutional coding is used in case of BER=10^{-3}, while a concatenated code scheme (Reed-Solomon, outer interleaving and convolutional coding) or Turbo codes could be used to achieve BER=10^{-6}.

9.2.2.1 Convolutional coding

<Editor's note: the following paragraph was taken from ETSI xx.10 document. In ARIB TDD, convolutional coding rate is chosen as 1/2 or 1/3.>

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

9.2.2.1.1 Convolutional Coder

<Editor's note: The following description was taken from ARIB Volume 3. The output order and the initial value of the shift register were only defined in the ARIB specification.>

- The configuration of the convolutional coder is presented in Fig. 7-4.
- 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".

Table Error! Style not defined.**-**Error! Bookmark not defined. **Error Correction Coding Parameters**

Transport channel type (Maximum coding unit size)	Coding scheme (constraint length)	Coding rate
CCH	Convolutional code (K=9)	1/2
CH		
ACH		
ACH		
DCH (less than 32kbps)		1/2 or 1/3
DCH (equal or more than 32kbps)	Turbo code (K=3)	

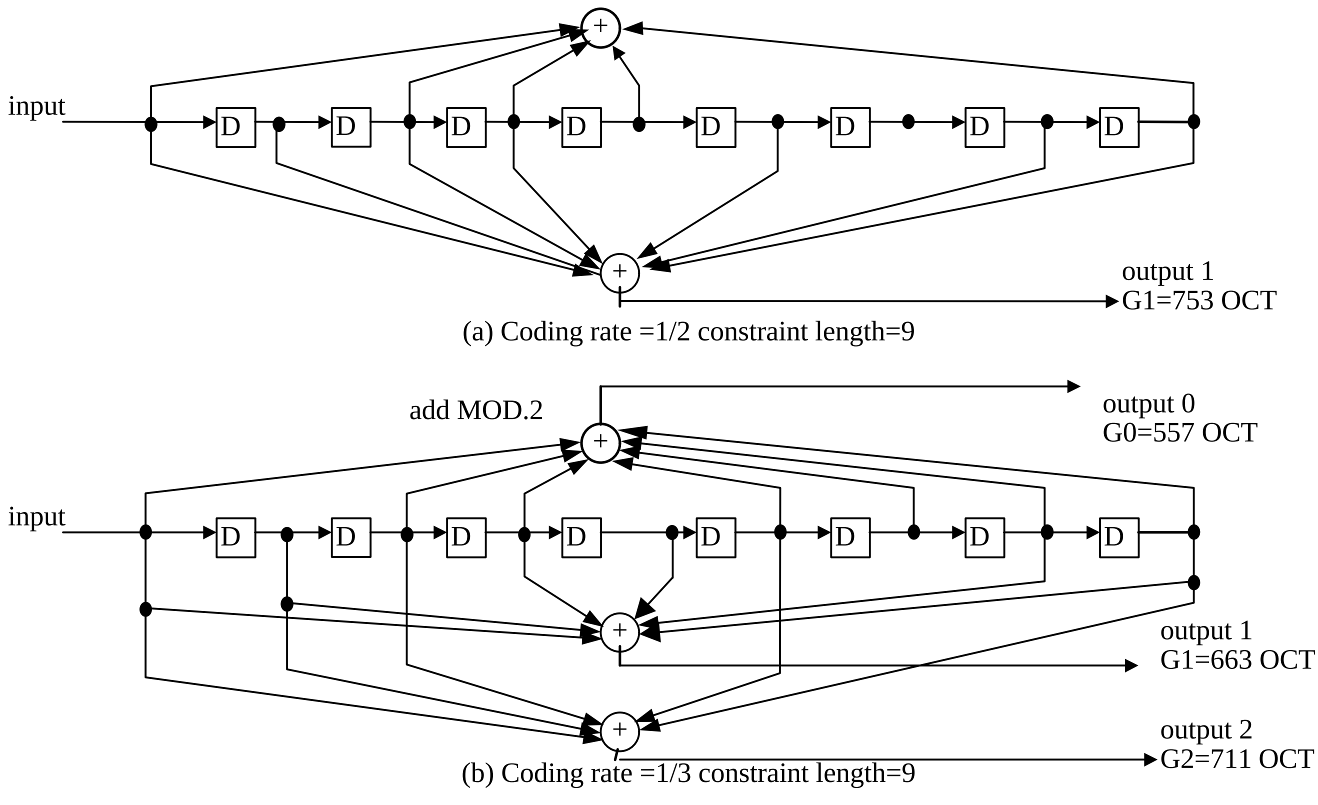


Fig. 7-4 Convolutional Coder

9.2.2.2 Outer Reed Solomon coding and outer interleaving

The outer RS coding, on GF(2^8) has different rate for different services. An outer interleaver to break the error burst at the output of the Viterbi decoder is needed in addition to an inner interleaver for breaking the error bursts due to fading.

? < Editor's Note : In ARIB, RS is not used.>

9.2.2.3 Turbo coding

<Editor's note: Turbo coding text is taken from ETSI. The decision of AdHoc5 is reflected here>

9.2.2.3.1 Turbo Coder

The parallel concatenated convolutional code (PCCC) with 8-state constituent encoders is described below. SCCC will be further evaluated equally with the 8-state PCCC.

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

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

where,

$$\mathrm{d(D)=1+D^2+D^3}$$

$$\mathrm{n(D)=1+D+D^3}.$$

Figure Error! Style not defined.**-**Error! Bookmark not defined.**. Structure of the 8 state PCCC encoder**

he 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 enerating matrix

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

he rate 2/3 is obtained by puncturing every other parity-check bit.
he inner code is a rate ½ systematic recursive convolutional code with the same previous generating matrix

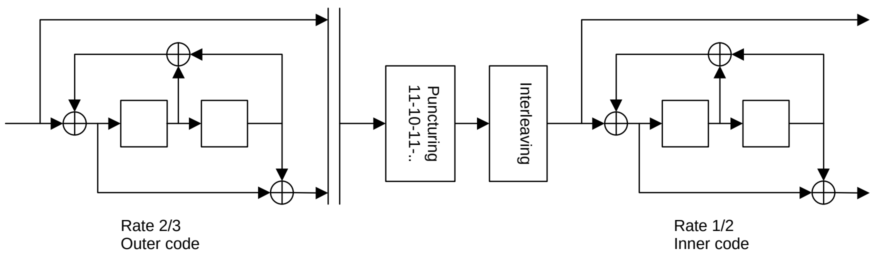


Figure Error! Style not defined.**-**Error! Bookmark not defined.**. Structure of the 4 state SCCC encoder**

Editor's note: for the sake of completeness also the ARIB turbo coder is depicted here. The concensus ecision in AdHoc 5 favors taking the ETSI scheme, however.>

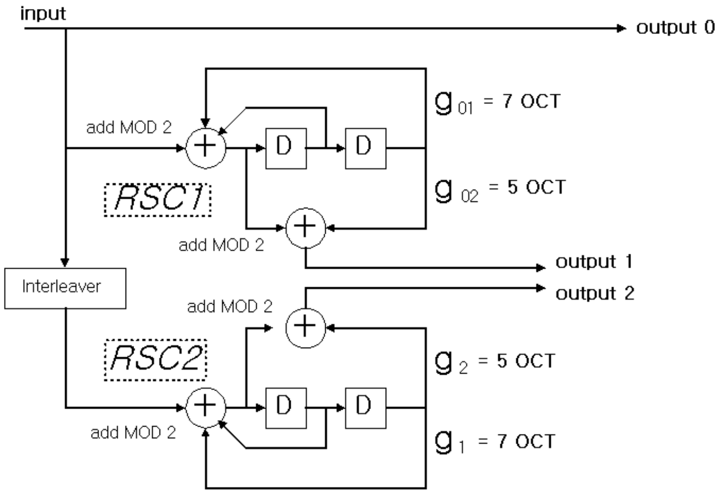
The configuration of Turbo coder is presented in Fig. 7-7.
The initial value of the shift registers of the coder shall be "all 0".
The output of the Turbo encoder is a sequence taken from output0, output1 and output2 using the puncturing patterns given in Table 7.2.2-2.

the case of coding rate=1/3, the output pattern from the Turbo encoder shall be:

utput0, output1, output2, output0, output1, output2,. ...

the case of coding rate=1/2, the output pattern from the Turbo encoder shall be:

output0, output1, output0, output2, output0, output1, output0, output2, ...



Constraint length=3

Fig. 7-7 Turbo Coder

Table 7.2.2- 2 Puncturing patterns for Turbo coder

(1: output, 0: punctured)

output 0	1	1
output 1	1	1
output 2	1	1

(a) Coding rate = 1/3

output 0	1	1
output 1	1	0
output 2	0	1

(b) Coding rate = 1/2

9.2.2.3.2 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.

9.2.2.3.3 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)

9.2.2.3.4 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"

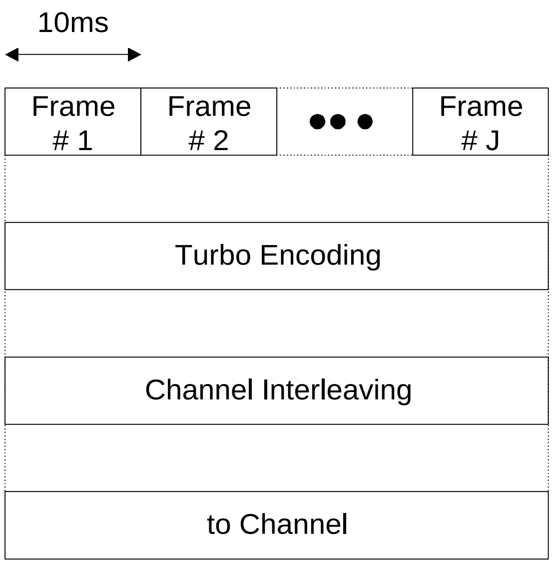


Figure Error! Style not defined.**-8. Frame Combining**

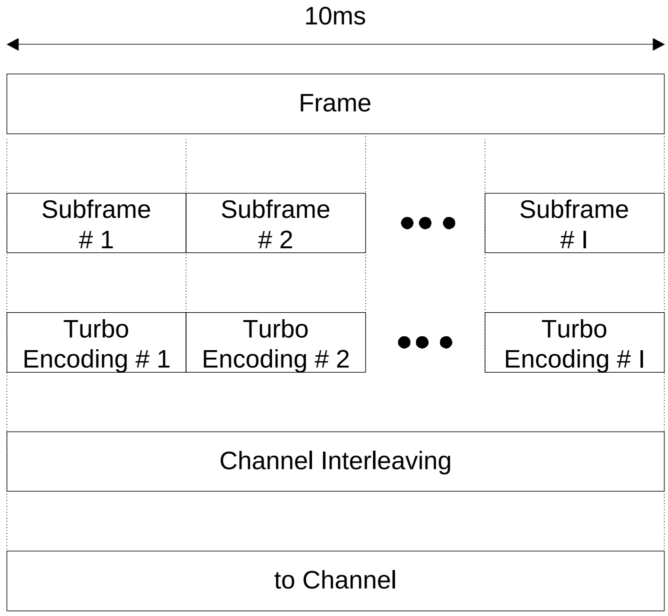


Figure Error! Style not defined.**-9. Frame Segmentation**

9.2.2.4 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.>

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.

9.2.3 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. >*

he channel interleaver has the interleaving pattern obtained by using Multi-stage Interleaving Method (MIL). The ıannel MIL consists of two-step interleaving process; inter-frame MIL and intra-frame MIL. In the transmitter side, the ter-frame MIL is processed in advance of the intra frame MIL as shown in Figure 7-2.

9.2.4 Rate matching

<Editor's note: The following two paragraphs were taken from ARIB Volume 3.>

Static rate matching is applied to downlink channels. In this scheme, ratio of rate matching is determined by the size of each transport blocks and mapping position of each transport channels to a radio frame is settled even when the rate of the other transport channels are varied. When rate of a transport channel is reduced from its maximum rate, this lead some punctured bits (not transmitted bits) in a radio frame.

<Editor's note: Dynamic rate matching is maybe not needed for TDD because it is impossible for TDD uplink to perform continuous transmission.>

Dynamic rate matching means service specific rate matching as described in. 7.2. In this case, the ratio of each rate matching is varied with size of each transport blocks and rate of the other transport channels. Mapping position of each transport channels to a radio frame is varied according to the share of each transport channels in a radio frame so as to fulfill a radio frame with valid data bits.

<Editor's note:the following paragraph and bulletin points were taken from ETSI xx.10 document.>

The rate matching applies repetition and puncturing of the different transport channels. 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, maximum puncturing factor will require further discussion.>*

9.2.4.1 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)

[$= \begin{cases} 0.2 & \text{for downlink} \\ 0.0 & \text{for uplink} \end{cases}$]

<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
```

9.2.5 Transport-channel multiplexing

<Editor's note: the following paragraph and Figure 7-8 were taken from ETSI xx.10 document.>

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. 7-10.

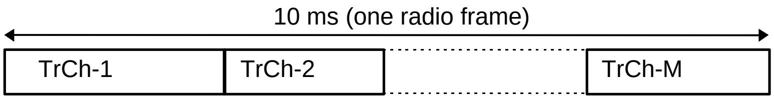


Figure Error! Style not defined.**-10. Transport channel multiplexing**.

<Editor's note: the following chapter was taken from ARIB Volume 3.>

When more than one transport channel has been allocated to one user the following multiplexing principles must be followed:

1. Transport channels with same E_b/N_o requirement are multiplexed into one physical code channel. Only when the aggregate bit rate of the transport channels exceeds the transmission capability of the one physical code channel multicode transmission is used.
2. Transport channels that use turbo coding with 10-80 ms channel interleaving (target BER $\leq 10^{-6}$) are multiplexed with transport channels that utilize convolutional coding and 10 ms channel interleaving (target BER $\leq 10^{-3}$) into one physical code channel. Only when the aggregate bit rate of the transport channels exceeds the transmission capability of the one physical code channel multicode transmission is used.

9.2.6 2nd interleaving

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

? < Editors Note : In ARIB, Intra-frame MIL is carried out. >

9.2.7 Discontinuous transmission (DTX)

<Editor's note: DTX in S1.22 apparently pertains to speech services. The header needs to be reworded in order to avoid confusion. There is no figure available for TDD case in the ARIB Volume 3.>

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

9.2.7.1 DTX within a radio frame

9.2.7.1.1 Transmission

- If transport data is less than the number of DPDCH bits in a radio frame, the DPDCH transmission can be turn off for data absent. This situation can be occurred when the DPDCH carries DCH(s) to which a DTCH for voice information and/or a DCCH(s) are mapped. (Although Rate matching described in 7.2.4 can be applied to fulfil the

DPDCH, the downlink transmission is not needed to be continuous. *<Editor's note: these parentheses can perhaps be removed since neither link has continuous transmission in TDD.>*)

- The transmission of the DPDCH symbols shall be ON, only if there is data to transmit. If there is no data, the transmission shall be OFF.
- Pilot 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. ?

9.2.7.1.2 Reception

- When the DPDCH carries DCH(s) to which DCCH(s) are mapped, there is no need to judge whether there is data or not, and the ordinary processing shall be performed.
- When the DPDCH carries DCH(s) to which a DTCH for voice information is mapped, the method shown in Table 7.2.7-1 shall be performed to judge whether there is voice and/or control information. The symbol average received power in Table 7.2.7-1 is the received power average value of all corresponding symbols within the radio frame.

Table 7.2.7-1 Decision Method for With/Without Voice Information/ Control Information

Information type	with information	without information
Voice information	(At least one) CRC in DCH transport block is OK, or the power ratio of Pilot & TPC symbol average received power to the average symbol received power for DCH is less than P_{DTX} dB.	(At least one) CRC in DCH transport block is NG, and the power ratio of the Pilot & TPC symbol average received power to the average symbol received power for DCH is P_{DTX} dB or more.
Control information	(At least one) CRC in DCH transport block is OK.	(At least one) CRC in DCH transport block is NG.

9.2.8 Multirate transmission

<Editor's note: the chapter on multirate transmission was taken from ARIB Volume 3. There is some text on multicode transmission also in S1.21>

9.2.8.1 Variable Rate Transmission

<Editor's note: There was a mistake in version 0.0.1 since both uplink and downlink schemes were taken from ARIB Volume 3 FDD text. Uplink text was removed in this version. TDD format is similar only to FDD downlink, which is described below.>

- The timing of each variable rate DCH on physical channel is determined on the basis of the highest data rate case by Layer-3 negotiation. The head bit position of each variable rate DCH is fixed during the data rate changes. *(See Physical Channel Mapping)*
- Rate matching is always performed using the common rule which is done by assuming that all variable rate DCHs are the highest data rate. *(See 7.2.4. Repetition and Puncturing Rules)*
- Discontinuous transmission according to the data rate is applied for downlink DPDCH. (See 7.2.7 Discontinuous transmission (DTX) [needs changes/supplements concerned with the case of multiple variable rate DCH])
- Rate detection is performed either by use of blind rate detection using CRC (See 7.2.9.1 Blind Rate Detection), or by use of explicit Transport Format Combination Indicator (TFCI). Independent blind rate detection can be performed for each variable rate DCH. (The rate detection scheme (blind detection or TFCI) of each variable rate DTCH can be selected independently according to the required service quality.)

9.2.8.2 Multicode Transmission

<Editor's note: There was a mistake in version 0.0.1 since both uplink and downlink schemes were taken from ARIB Volume 3 FDD text. Uplink text was removed in this version. TDD format is similar only to FDD downlink, which is described below.>

- 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. 7-11)
- 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. 7-12)
- 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.

Fig. 7-11 Spreading code in multi-code transmission

Fig. 7-12 Transmission power in multi-code transmission

9.2.9 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 explicit rate detection, transmitter side transmits Transport Format Combination Indicator (TFCI), and receiver side detects transport format combination using TFCI. In the blind rate detection, transmitter side does not transmit TFCI, and receiver side detect transport format combination using some 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.

9.2.9.1 Blind Rate Detection

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

9.2.9.2 Explicit Rate Detection

9.2.9.2.1 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 7.2.4.

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].

9.3 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.

9.4 Coding for layer 1 control

9.4.1 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 0. Correspondingly, if the TFCI word is extended to 7-10 bits the channel encoding is done as explained in the section 0. When decoding, default TFCI words are assumed. If using extended TFCI words, it shall be informed beforehand via a Layer-3 message.

9.4.1.1 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, $S_{C_6} = \{C_6(0), C_6(1), \ldots, C_6(31)\}$ and its binary complement, $\overline{S}_{C_6} = \{\overline{C}_6(0), \overline{C}_6(1), \ldots, \overline{C}_6(31)\}$. Words of set S_{C_6} are from the level 5 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 the Table 7.4.1- 1.

Table 7.4.1- 1 Mapping of information bits to code words for biorthogonal (32, 6) code.

Information bits	Code word
000000	$C_6(0)$
000001	$\overline{C_6(0)}$
000010	$C_6(1)$
...	...
111101	$\overline{C_6(30)}$
111110	$C_6(31)$
111111	$\overline{C_6(31)}$

9.4.1.2 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. 7- 11.

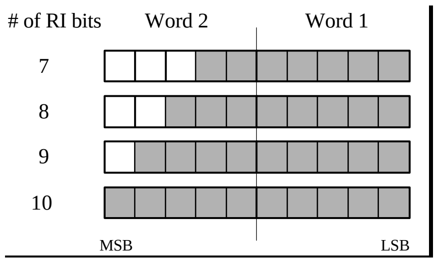


Fig. 7- 13 Mapping of TFCI bits to two words.

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, $S_{C_5} = \{C_5(0), C_5(1), \ldots, C_5(15)\}$ and its binary complement, $\overline{S}_{C_5} = \{\overline{C}_5(0), \overline{C}_5(1), \ldots, \overline{C}_5(15)\}$. Words of set S_{C_5} 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 the Table 7.4.1- .

Table 7.4.1- 2 Mapping of information bits to code words for biorthogonal (16, 5) code.

Information bits	Code word
00000	$C_5(0)$
00001	$\overline{C_5(0)}$
00010	$C_5(0)$
...	...
11101	$\overline{C_5(14)}$
11110	$C_5(15)$
11111	$\overline{C_5(15)}$

9.4.1.3 Interleaving of TFCI

9.4.1.3.1 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.7- 14.

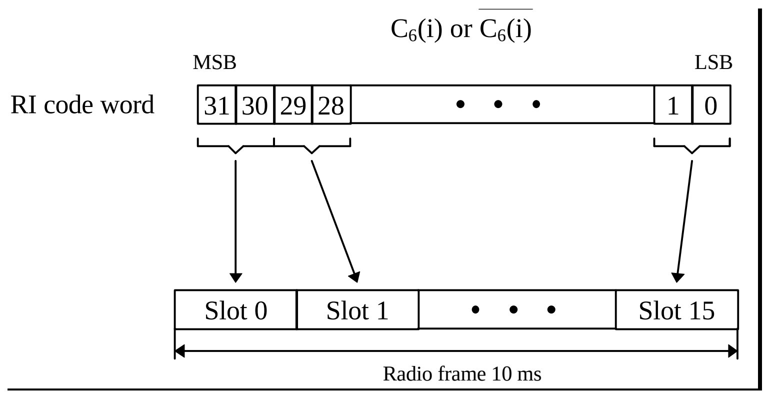


Fig.7- 14. Time multiplexing of code words of (32, 6) code to the slots of the radio frame.

9.4.1.3.2 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.7- 1. Note that $b_{1,i}$ and $b_{2,i}$ denote the bit *i* of code word 1 and code word 2, respectively.

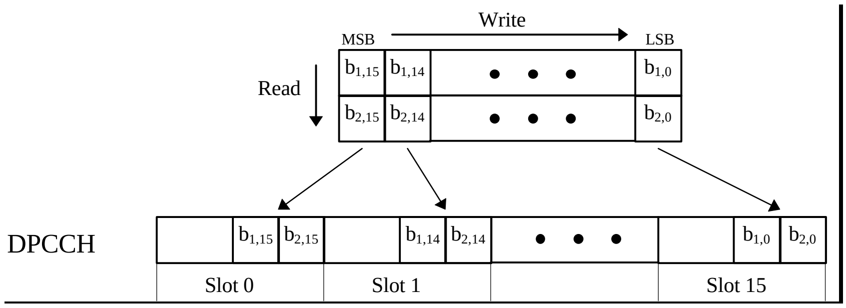


Fig.7- 15 Interleaving of TFCI code word

9.5 Inter-frequency handover

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

9.5.1 Slotted mode

The principle of the slotted downlink transmission approach is illustrated in Fig.7-16. 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.7-12, 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.

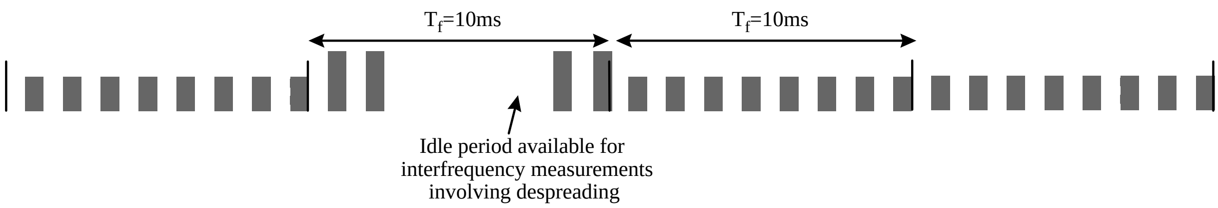


Fig. 7-16 Downlink slotted mode transmission

10

11 Annex A Blind rate detection

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

11.1 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"

11.2 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 [Turbo-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 [Turbo-decoding] on the soft decision sample sequence. The correct trellis path of the Viterbi-decoder [Turbo-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:

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

  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.

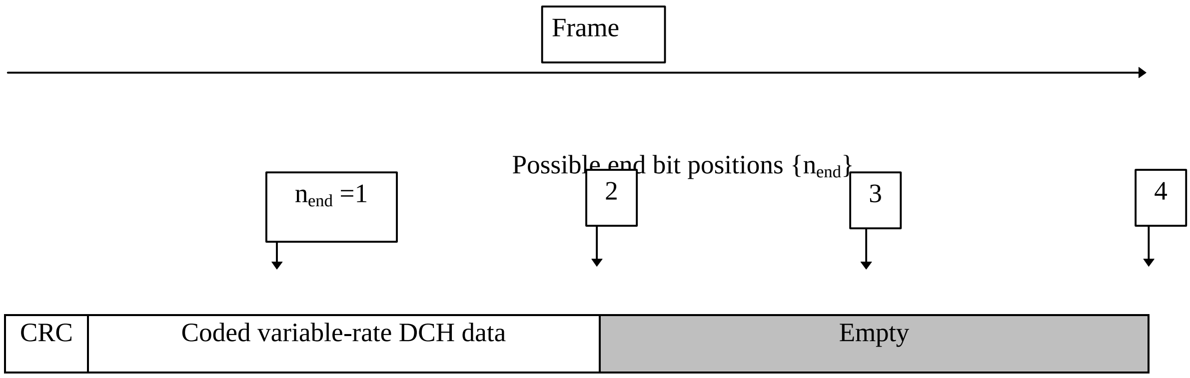


Fig. A-1 An example of variable rate data format

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

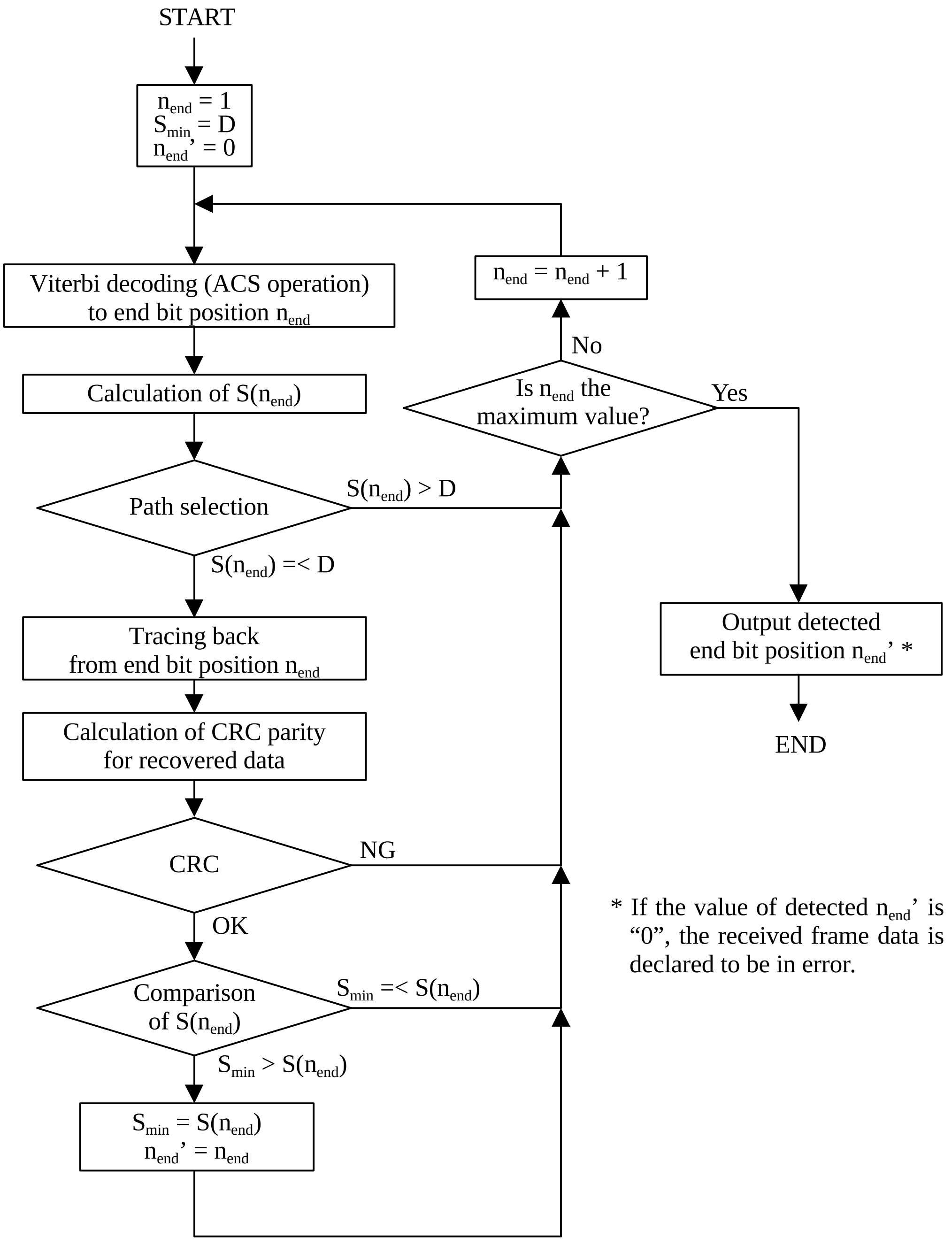


Fig. A-2 Basic processing flow of blind rate detection

13 History

Document history		
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