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Technical Report

UMTS Terrestrial Radio Access Network (UTRAN); UTRA TDD, multiplexing, channel coding and interleaving description (UMTS XX.10 version 1.0.0)

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Universal Mobile Telecommunications System

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Special Mobile Group (SMG).
The present document describes multiplexing, channel coding and interleaving for UTRA Physical Layer TDD mode.
The contents of the present document are subject to continuing work within SMG2 and SMG2 UMTS layer 1 expert group and may change following approval by either of these two groups.

1 Scope

This Technical Report describes multiplexing, channel coding and interleaving for UTRA Physical Layer TDD mode. Text without revision marks has been approved in the previous SMG2 Layer 1 expert group meetings, while text with revision marks is subject to approval.

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] Reference 1.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document the following terms and definitions apply:
Definition 1: to be completed

3.2 Abbreviations

For the purposes of the present document the following terms and definitions apply:
<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

4 Status of this document

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working assumption

4.2.1 CRC calculation

study item

4.2.2 channel coding

proposal

4.2.3 1st interleaving

study item

4.2.4 rate matching

working assumption

4.2.5 transport channel multiplexing

working assumption

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study item

4.3 automatic repeat request

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

4.4 coding for layer 1 control

study item

5 Multiplexing, channel coding and interleaving

5.1 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.
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.

5.2 Transport-channel coding/multiplexing

Figure 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}.
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.

The different steps are described in detail below.

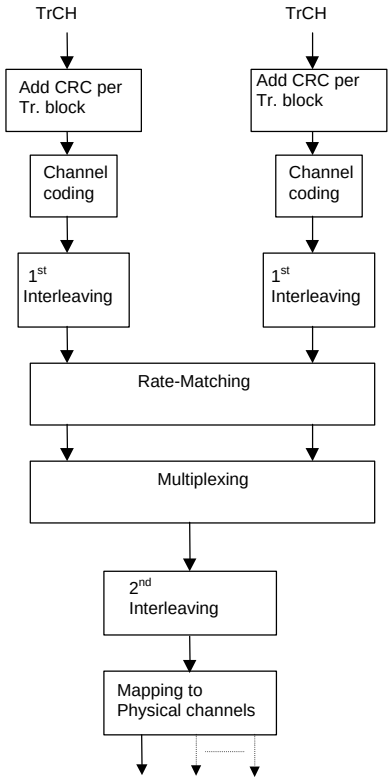

Figure 1: Coding and multiplexing of transport channels

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 1, resulting in several data stream, each mapped to one or several physical channels.

5.2.1 CRC calculation

[No text available]

5.2.2 Channel coding

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

- 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.

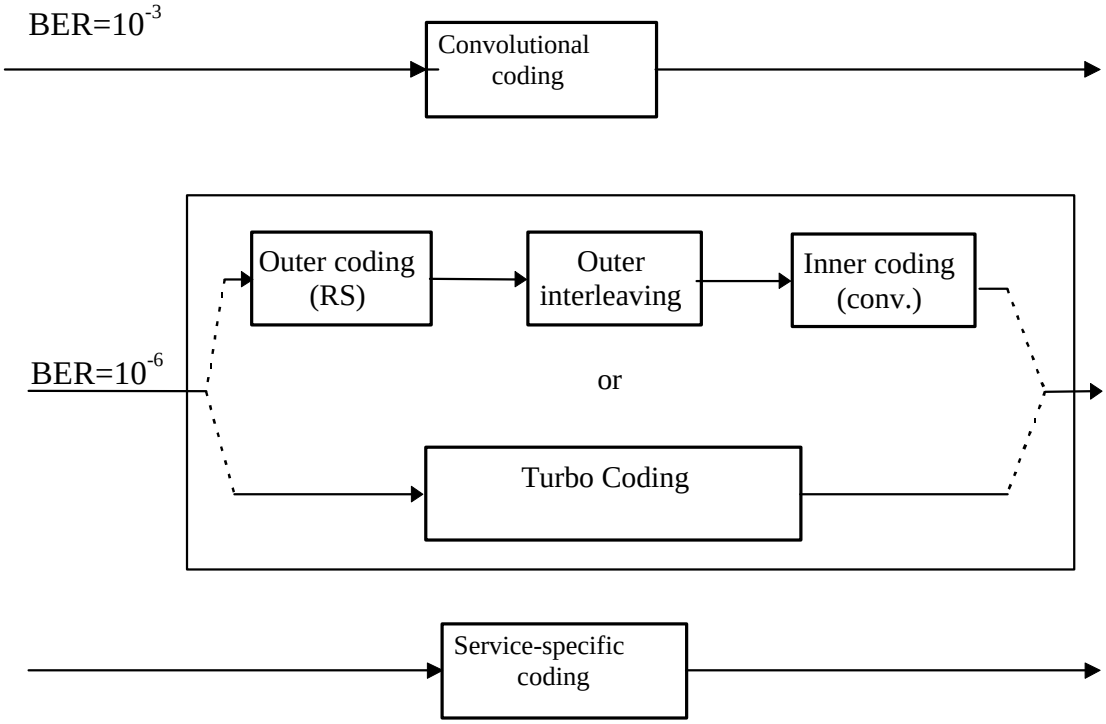

Figure 2: Channel coding in UTRA/TDD

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 2.
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}.

5.2.2.1 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.

5.2.2.2 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.

5.2.2.3 Turbo coding

[FFS]

5.2.2.4 Service specific coding

The service-specific-coding option allows for additional flexibility of the UTRA layer 1 by allowing for additional coding schemes, in addition to the standard coding schemes listed above. One example is the use of unequal-error-protection coding schemes for certain speech-codecs.

5.2.3 1st interleaving

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

5.2.4 Rate matching

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.

5.2.4.1 Rate matching algorithm

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)

The rate matching rule is as follows:

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

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

$y = N_C - N_i$

$e = N_C$ -- *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 <= N_C
e = e – 2 * y -- update error
if e <= 0 then -- check if bit number m should be punctured
puncture bit m from set S_0
e = e + 2*N_C -- update error
end if
m = m + 1 -- next bit
end do

else

$y = N_{i+1} - N_C$

$e = N_C$ -- *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 <= N_C
e = e – 2 * y -- update error
do while e <= 0 -- check if bit number m should be repeated
repeat bit m from set S_0
e = e + 2*N_C -- update error
enddo
m = m + 1 -- next bit
end do
end if

5.2.5 Transport-channel multiplexing

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 Figure 3.

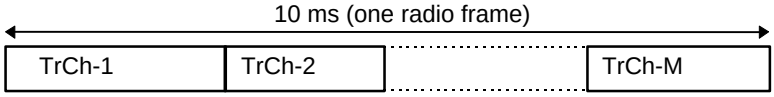

Figure 3: Transport channel multiplexing

5.2.6 2nd interleaving

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

5.3 Automatic Repeat Request (ARQ)

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.

5.4 Coding for layer 1 control

5.4.1 Transport-format-indicator coding

[FFS]

History

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v0.1	1998-06-08	Document created based on the documents Tdoc SMG 899/97, Tdoc SMG2 UMTS-L1 36/98 and Tdoc SMG2 UMTS L1 87/98. Approved by SMG2 #26 (Sunne, Sweden) for ITU submission only.
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v0.2.1	1998-07-01	Updated due to comments via e-mail reflector prior to submission to SMG2 UMTS Ad-Hoc #6 (Stratford, July 6. - 8.)
v0.3.0	1998-08-17	'UTRA Physical Layer Description, TDD part' was split into several subdocuments; xx.xx. This new subdocument xx.10 contains chapter 9 of the former TDD master document v.0.2.1. Only editorial modifications are made (adding foreword, scope).
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