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Title: Multiplexing, channel coding and interleaving for TDD

Introduction

During the last weeks there was a detailed discussion in the ad hoc group 4 regarding service multiplexing issues for FDD. Although TDD and FDD should be designed as similar to each other as possible, there are certain items, which cannot be treated identically for both modes due to the different transmission scheme on the air interface and its impact on the resource allocation.

In this paper those relevant items are identified and a working assumption for TDD is proposed whenever the FDD-scheme cannot be directly adopted.

For all other items, which are not explicitly treated here, the FDD-solution can be used, which does not mean that such an agreed solution already exists in all cases. Moreover, the exact wording regarding the proposed changes in the description [2] must be partly changed to match with TDD and will be provided if the text proposal is available.

Multiplexing Features for TDD

All items for which TDD has special requirements are listed in table 1. In the following, some comments are given regarding these proposals:

The TDD multiplexing scheme (section 7.2 in S1.22) differs from FDD due to the fact, that for TDD discontinuous transmission is an inherent system feature. Consequently, the FDD-downlink scheme as depicted in figure 1 can be taken for TDD uplink (UL) and downlink (DL) as well, since this scheme enables a more effective rate matching, which can be treated independent of the 1st interleaving. However, the scheme used for FDD UL, which supports dynamic rate matching, should be kept for further discussions, since it might be useful to restrict puncturing exclusively to those frames, in which actually a high data rate is transmitted. However, this item is also still open for FDD, therefore no final decision for TDD should be taken.

For the convolutional coding (7.2.2.1) it is proposed to use rates of 1/3 and 1/2 as for FDD. Additionally, since due to the slot structure the time diversity gain is lower, for TDD also the code rates 2/3 and 7/8 should be possible. The usage of the coding schemes depends on the RLC protocol operation.

Referring to the Rate Matching method itself in section 7.2.4 it is proposed as working assumption for TDD to use only static rate matching in UL and DL as for FDD DL. This means, the individual matching factor for each service depends on both, the required power balancing and the peak rate of the sum of all services. It should be for further study, whether the application of dynamic rate matching in certain frames should be retained as an option, see above. However, this is no TDD-specific discussion and the possible benefits are independent of the transmission mode.

Regarding Traffic Channel multiplexing (7.2.5) it is important for TDD that more than one Coded Composite Transport Channel (CCTrCh) is supported, to offer the possibility for an individual mapping of bearers to certain resources. This option was already agreed in WG2 also for FDD [4], where it especially may enable an earlier deployment of high-end terminals based on code-multiplexing, as proposed during WG1 ad hoc n08 discussions.

For TDD the mapping of the CCTrCh to the physical channels depends on whether the TFCI is used or not. With TFCI, floating starting points within each slot are used, this means dependent on the actual blocksizes of all bearers the individual

starting points are not fixed. If no TFCI is transmitted, then fixed starting points for all bearers may be used to facilitate blind rate detection.

The 2nd interleaving for TDD according to section 7.2.6 is carried out for all data to be transmitted during one radio frame but independently for each CCTrCh.

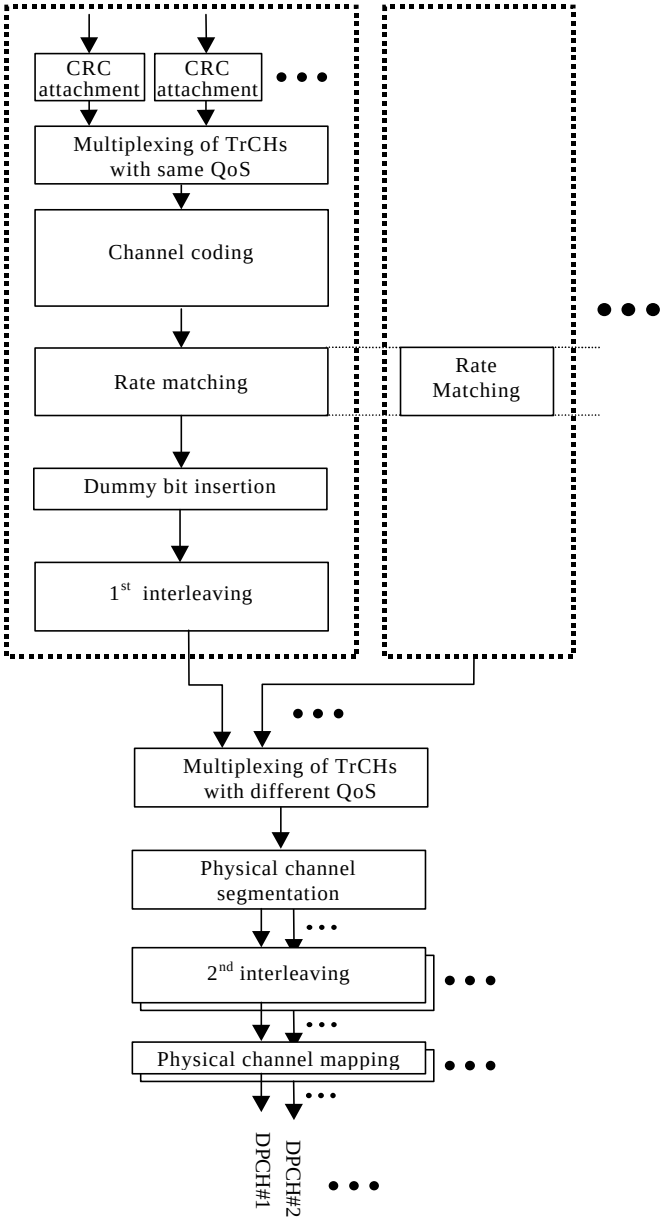

Figure 1: Transport channel multiplexing for TDD regarding a single CCTrCh

Referring to discontinuous transmission for TDD (7.2.7) it is proposed that DTX will be used both for UL and DL, if the data rate after static rate matching does not fit the transmission rate.

In case of multicode/-slot transmission the occurrence of DTX again depends of the usage of the TFCI for indicating a special Transport Format: With TFCI, only one of the assigned resource units may be partly filled with data. All other resource units either do not contain any data or are filled completely. Without TFCI, the DTX-periods may be located in any of the assigned resource units.

In section 7.2.8 (Multirate transmission) the description of variable rate transmission can be copied from FDD-DL, but the wording regarding DTX must be adapted to TDD as described above. The text and the figures in the paragraph regarding multicode transmission is not precise and must be adopted to TDD.

It is proposed that the transmission of packet data by means of automatic repeat request (7.3) for TDD is performed by means of hybrid ARQ type II, which has shown best performance in simulations [3]. The usage of other ARQ-schemes is optionally.

Concerning the TFCI coding (7.4.1), for TDD this parameter should have a variable length of 0 to 10 bits to adopt to various service requirements and is transmitted adjacent to the midamble since this offers highest detection reliability. In case of multicode transmission only one resource unit contains the TFCI.

Due to the inherent discontinuous transmission with TDD, for the time being no slotted mode (section 7.5.1) needs to be defined, since in most cases terminals use only few time slots. For high-end terminals, dependent on the bearers to be transmitted, the DCA-algorithm can provide a measurement window of sufficient size. As a possible alternative, which is still under discussion also for FDD, those mobiles may need a second receiver.

Item in spec. S1.22	Topic	FDD recommendations	TDD recommendations
7.2	coding/multiplexing	- ETSI scheme for uplink For further discussions: specified for downlink as an - Whether ARIB scheme should be option or not	- ARIB scheme (with rate 1^{st} interleaving) for uplink and downlink For further discussion: - ETSI scheme (with rate matching after 1^{st} interleaving) for UL and DL as an additional option
7.2.2.1	Convolutional coding	Working assumption: see S1.12	Proposed working assumption: - Same coding scheme as FDD for coding rates 1/2 and 1/3 - Additional coding rates of 7/8 and 2/3
7.2.4	Rate Matching	Working assumption: - In DL the applied rate matching factors are fixed (static matching) - in UL these factors can be adapted each frame to the current data rate (dynamic matching)	Proposed working assumption: - In UL and DL the applied rate matching factors are fixed (static matching)
7.2.5	Transport-channel multiplexing	Working assumption: - code multiplexing is not supported for UL - For transport channels not relying on TFCI for rate detection (blind rate detection), the starting 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 could be fixed or non-fixed	Proposed working assumption: - Several CCTrCh are supported - For transport channels not relying on TFCI for rate detection (blind rate detection), the starting positions of the transport channels within the frame could be fixed or non-fixed. - For transport channels relying on TFCI for rate detection, the positions of the transport channels should be non-fixed
7.2.6	2^{nd} interleaving	Working assumption: see S1.12	Proposed working assumption: - CCTrCh-specific

7.2.7	Discontinuous transmission (DTX)	Working assumptions: - DTX is used only for DL - DTX-periods can be located either within a frame if fixed positions are used, or at the end of a frame in case of floating starting points	Proposed working assumption: - DTX is used for UL and DL - DTX-periods may be located at the beginning and at the end of a slot
7.2.8	Multirate transmission	Working assumption: see S1.12	Proposed working assumption: - Variable rate transmission can be taken from FDD-DL FFS: - The DTX must be described TDD-specific - Adapting wording and figures for multicode transmission to TDD
7.3	Automatic repeat request (ARQ)	Working assumption: not specified Note: According to the Liaison Statement from TSG RAN WG2 to WG1 also for FDD hybrid ARQ type II/III mechanism in the downlink would be supported.	Proposed working assumption: - hybrid ARQ type II
7.4.1	Transport-format-combination indicator (TFCI)	Working assumption: see S1.12	Already approved as working assumption: - The length of the TFCI is variable - The TFCI is located around the midamble - In case of multicode/-slot transmission the TFCI will be transmitted only in one resource unit Proposed working assumption: - The length of the TFCI should be variable between 0 and 10 bits FFS: The exact TFCI coding for TDD
7.5.1	Slotted mode	Working assumption: see S1.12	Proposed working assumption: - in most cases Slotted Mode is not needed - for high rate NRT-services DCA-algorithm (layer 2) can provide measurement window - dual receiver high end mobiles

Table 1: Identified items in S1.22 with special TDD-requirements

Conclusions

In this paper those items referring to the topic Service Multiplexing were identified and discussed which must be considered separately for FDD and TDD due to the different transmission schemes on the air interface. For most of these items detailed proposals were made which should be included in the S.1.22 specification.

References

[1] R1-99050 S1.12 Multiplexing and Channel Coding (FDD)
[2] R1-99055 S1.22 Multiplexing and Channel Coding (TDD)
[3] SMG2 UMTS-L23 Tdoc 436/98 ‘Comparison of Hybrid ARQ Types I and II for TDD Mode’
[4] 3GPP RAN S2.02 V0.0.1 ‘Services provided by the physical layer’