ETSI TR 145 902 V13.0.0 (2016-01)

TECHNICAL REPORT

Digital cellular telecommunications system (Phase 2+); Flexible Layer One (FLO) (3GPP TR 45.902 version 13.0.0 Release 13)

Reference

RTR/TSGG-0145902vd00

Keywords

GSM

ETSI

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Foreword

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Introduction

A new type of physical layer is proposed for the GSM/EDGE Radio Access Network (GERAN): the flexible layer one (FLO). The main advantage of FLO is that the configuration of the physical layer (e.g. channel coding and interleaving) is specified at call setup. This means that the support of new services such as IP Multimedia Subsystem (IMS) services can be handled smoothly without having to specify new coding schemes in each release.

Through several enhancements such as reduced granularity and flexible interleaving, the radio bearers offered by FLO would not only fulfil the IMS requirements in terms of flexibility and performance, but also greatly improve the link level performance of real-time IMS services compared to GERAN Release 5.

The objective of this TR is to provide an overview of FLO, its architecture and study the impacts it has on the GERAN radio protocol stack.

1 Scope

The present document provides an overview of the flexible layer one, its architecture and studies the impacts it has on the GERAN radio protocol stack.

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.
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- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: 'Vocabulary for 3GPP Specifications'.

[2] 3GPP TS 22.101, 'Service Principles'.

[3] 3GPP TS 22.228, 'Service requirements for the IP Multimedia Core Network Subsystem'.

[4] 3GPP TS 23.107, 'QoS Concept and Architecture'.

[5] 3GPP TS 23.228, 'IP Multimedia Subsystem'.

[6] 3GPP TS 25.201, 'Physical layer - General description'.

[7] 3GPP TS 25.212, 'Multiplexing and channel coding (FDD)'.

[8] 3GPP TS 25.331, 'RRC Protocol Specification'.

[9] 3GPP TS 32.201, 'Specification of the 3GPP Confidentiality and Integrity Algorithms'.

[10] 3GPP TS 44.018: 'Radio Resource Control protocol'.

[11] 3GPP TS 44.118: 'Radio Resource Control protocol, Iu mode'.

[12] 3GPP TS 44.060: 'Radio Link Control/Medium Access Control protocol'.

[13] 3GPP TS 44.160: 'Radio Link Control/Medium Access Control protocol, Iu mode'.

[14] 3GPP TS 45.002: 'Multiplexing and multiple access on the radio path'.

[15] 3GPP TS 45.003: 'Channel Coding'.

[16] 3GPP TS 45.005: 'Radio transmission and reception'.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

Active Transport Channel: a transport channel is active during a TTI if it carries a transport block.

Dynamic attributes: for one transport channel, the values of the dynamic attributes are different among transport formats. They are configured by Layer 3 and can change on a TTI basis under the control of the MAC sublayer.

Empty Transport Format: a transport format such that no transport block is carried over the transport channel (i.e. the transport channel is inactive).

Empty Transport Format Combination: a transport format combination that is made up only of empty transport formats.

Inactive Transport Channel: a transport channel is inactive during a TTI if it does not carry a transport block (i.e. the transport block size is zero).

Radio Frame: The result of applying rate matching to a transport block along with its associated CRC that have first been channel encoded.

Radio Packet: The set of one or more radio frames together with the applicable coded TFCI that form the volume of payload that can be transmitted on a basic physical subchannel for any given TTI.

Semi-static attributes: for one transport channel, the values of the semi-static attributes are common to all transport formats. They are configured by Layer 3 and can only be changed by Layer 3 signalling.

Transport Block: block exchanged on a transport channel between the physical layer and the MAC sublayer.

Transport Channel: SAP between the physical layer and the MAC sublayer.

Transport Format: configuration of a transport channel, including for instance channel coding, CRC size, etc.

Transport Format Combination: allowed combination of transport format(s) of the different transport channels that are multiplexed together on a basic physical subchannel.

Transport Format Combination Indicator: layer one header that indicates the transport format combination that has been selected for each radio packet.

Transport Format Combination Set: set of allowed transport format combinations on a basic physical subchannel.

Transport Format Indicator: index identifying a particular transport format within the transport format set.

Transport Format Set: set of all transport formats defined for a particular transport channel.

Transmission Time Interval: rate at which transport blocks are exchanged between the physical layer and the MAC sublayer on a transport channel.

3.2 Abbreviations

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

ADCH	Associated Dedicated CHannel
CCTrCH	Coded Composite Transport CHannel
CDCH	Control-plane Dedicated CHannel
CTFC	Calculated Transport Format Combinations
DCH	Dedicated CHannel
FLO	Flexible Layer One
GERAN	GSM/EDGE Radio Access Network
IMS	IP Multimedia Subsystem
MAC	Medium Access Control
QoS	Quality of Service
PDU	Protocol Data Unit
RAN	Radio Access Network
RLC	Radio Link Control
RRC	Radio Resource Control
RT	Real Time
SDU	Service Data Unit
SAP	Service Access Point
TB	Transport Block

TBF	Temporary Block Flow
TF	Transport Format
TFI	Temporary block Flow Identity
TFS	Transport Format Set
TFIN	Transport Format INdicator
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TFCS	Transport Format Combination Set
TrCH	Transport Channel
TTI	Transmission Time Interval
UDCH	User-plane Dedicated CHannel
UTRAN	Universal Terrestrial Radio Access Network

Other abbreviations used in the present document are listed in 3GPP TR 21.905.

4 Motivation

The need for a flexible layer one for the Release 6 of GERAN is driven by the introduction of IMS services. For an efficient support of IMS services, requirements are set on the radio bearer service of the RAN (see 3GPP TS 22.101, 3GPP TS 22.228, 3GPP TS 23.228 and 3GPP TS 23.107):

- the radio bearers should be flexible enough to efficiently deploy any IP multimedia applications;
- the radio bearers should allow the transport of several flows in parallel (e.g. text and video);
- the radio bearers should satisfy the user in a spectral efficient manner;
- the radio bearer should support the UMTS QoS concept and architecture.

So as to fulfil these requirements in an efficient manner, a flexible layer one is needed. Thanks to the flexible layer one optimised support of real time IMS services is made possible in GERAN.

5 Requirements

The flexible layer one should:

- fulfil most of the IMS requirements in terms of radio bearer service attributes;
- support the multiplexing of parallel flows on to a basic physical subchannel;
- provide an optimisation of spectral efficiency through the support of different interleaving depths, unequal error protection/detection, reduced channel coding rate granularity and support of 8PSK and GMSK modulations;
- provide an efficient support of real time IMS services;
- be applicable to both modes of operation: *A/Gb mode* and *Iu mode*;
- minimize the impacts on the radio protocols;
- minimize the overhead introduced by the radio protocol stack;
- not introduce an unfeasible number of test configurations;
- be future proof;
- within reason, be compatible with legacy transceiver implementations.

6 Overview of FLO

6.1 General

In GERAN Release 5, the MAC sublayer is responsible for the mapping between the logical channels (traffic or control channels) and the basic physical channels (see 3GPP TS 45.002). The logical channels are the channels the physical layer offers to the MAC sublayer. Until now these logical channels and the mapping to the basic physical channel have been fully specified in 3GPP TS 45.002.

A different approach has been taken in UTRAN, where instead of providing logical channels the physical layer offers Transport Channels (TrCH), which can be used by the MAC sublayer (see 3GPP TS 25.201). A transport channel is used to transmit one data flow with a given QoS over the radio interface. A number of transport channels can be active at the same time and multiplexed at the physical layer. The transport channels are configured at call setup by the network.

With FLO, the concept of transport channels used in UTRAN can be reused in GERAN i.e. the physical layer offers one or several transport channels to the MAC sublayer.

6.2 Principles of FLO

With FLO, the physical layer of GERAN offers one or several transport channels to the MAC sublayer. Each of these transport channels can carry one data flow providing a certain Quality of Service (QoS). A number of transport channels can be multiplexed and sent on the same basic physical subchannel at the same time.

The configuration of a transport channel i.e. the number of input bits, channel coding, interleaving etc. is denoted the Transport Format (TF). As in UTRAN, a number of different transport formats can be associated to one transport channel. The configuration of the transport formats is completely controlled by the RAN and signalled to the MS at call setup. In both the MS and the BTS, the transport formats are used to configure the encoder and decoder units. When configuring a transport format, the RAN can choose between a number of predefined CRC lengths and block lengths.

On transport channels, transport blocks (TB) are exchanged between the MAC sublayer and the physical layer on a transmission time interval (TTI) basis. For each TTI a transport format is chosen and indicated through the transport format indicator (TFIN). In other words, the TFIN tells which transport format to use for that particular transport block on that particular TrCH during that particular TTI. When a transport channel is inactive, the transport format with a transport block size of zero (empty transport format) is selected.

Only a limited number of combinations of the transport formats of the different TrCHs are allowed. A valid combination is called a Transport Format Combination (TFC). The set of valid TFCs on a basic physical subchannel is called the Transport Format Combination Set (TFCS). The TFCS is signalled through the Calculated Transport Format Combinations (CTFC).

In order to decode the received sequence the receiver needs to know the active TFC for a radio packet. This information is transmitted in the Transport Format Combination Indicator (TFCI) field. This field is basically a layer 1 header and has the same function as the stealing bits in GSM. Each of the TFC within a TFCS are assigned a unique TFCI value and when a radio packet is received this is the first to be decoded by the receiver. From the decoded TFCI value the transport formats for the different transport channels are known and the actual decoding can start.

In case of multislot operation, there shall be one FLO instance for each basic physical subchannel. Each FLO instance is configured independently by Layer 3 and as a result gets its own TFCS. The number of allocated basic physical subchannels depends on the multislot capabilities of the MS.

6.3 Evolution from Release 5

In GERAN Release 5, logical channels are offered by the physical layer to the MAC sublayer. With FLO, transport channels are offered by the physical layer to the MAC sublayer.

In GERAN Release 5, speech frames, RLC/MAC blocks, data frames and blocks of info bits are exchanged on logical channels between the physical layer and the MAC sublayer. With FLO, transport blocks are exchanged on transport channels between the physical layer and the MAC sublayer.

In GERAN Release 5, a fixed set of coding schemes are standardized for each logical channel in 3GPP TS 45.003. With FLO, transport formats are configured at call setup for each transport channel.

In GERAN Release 5, only one logical channel can be sent per radio block. With FLO, the transport format combinations allow a number of transport channels to be multiplexed within the same radio block.

In GERAN Release 5, the coding scheme and/or the content of the radio block is indicated by the stealing bits. With FLO, the TFC and thereby the active transport formats of the TrCHs is indicated by the TFCI.

6.4 Limitations

The following assumptions are made in order to limit the complexity of FLO:

- FLO shall be used on dedicated channels only, maintaining the 26-multiframe structure for which the SACCH shall be treated as a separate logical channel based on Release 5 format;
- All TrCHs shall use the same TTI: the same length as in GSM/GPRS of Release 5, i.e. 20ms;
- FLO shall provide at most 8 transport channels per basic physical subchannel;
- FLO shall support a maximum of 4 active transport channels per radio packet per basic physical subchannel;
- The size of the TFCI shall be limited to 5 bits, allowing a maximum of 32 different TFCs per basic physical subchannel;
- A maximum of 32 different TFs is allowed per TrCH;
- One RLC PDU cannot be mapped across multiple basic physical subchannels.

6.5 Protocol architecture

6.5.1 Iu mode

Figure 1 below illustrates the protocol architecture in conjunction with FLO in *Iu mode*: