3GPP TS 26.102 V16.0.0 (2020-07)

Technical Specification

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Mandatory speech codec;

Adaptive Multi-Rate (AMR) speech codec;

Interface to Iu, Uu and Nb

(Release 16)

** 

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Keywords

GSM, UMTS, codec, LTE

***3GPP***

Postal address

3GPP support office address

650 Route des Lucioles - Sophia Antipolis

Valbonne - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet

http://www.3gpp.org

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Contents

Foreword [5](#__RefHeading___Toc517704974)

1 Scope [6](#__RefHeading___Toc517704975)

2 References [6](#__RefHeading___Toc517704976)

3 Definitions and abbreviations [7](#__RefHeading___Toc517704977)

3.1 Definitions [7](#__RefHeading___Toc517704978)

3.2 Abbreviations [8](#__RefHeading___Toc517704979)

4 General [8](#__RefHeading___Toc517704980)

5 RAB aspects [10](#__RefHeading___Toc517704981)

6 Iu Interface User Plane (RAN) [11](#__RefHeading___Toc517704982)

6.1 Frame structure on the Iu UP transport protocol [11](#__RefHeading___Toc517704983)

6.1.1 Initialisation [11](#__RefHeading___Toc517704984)

6.1.2 Time Alignment Procedure [11](#__RefHeading___Toc517704985)

6.2 Mapping of the bits [11](#__RefHeading___Toc517704986)

6.3 Frame handlers [13](#__RefHeading___Toc517704987)

6.3.1 Handling of frames from TC to Iu interface (downlink) [13](#__RefHeading___Toc517704988)

6.3.1.1 Frame Quality Indicator [13](#__RefHeading___Toc517704989)

6.3.1.2 Frame Type [13](#__RefHeading___Toc517704990)

6.3.1.3 Codec Mode Indication [13](#__RefHeading___Toc517704991)

6.3.1.4 Codec Mode Request [13](#__RefHeading___Toc517704992)

6.3.1.5 Optional internal 8 bits CRC [14](#__RefHeading___Toc517704993)

6.3.1.6 Mapping of Speech or Comfort Noise parameter bits [14](#__RefHeading___Toc517704994)

6.3.2 Handling of frames from Iu interface to TC (uplink) [14](#__RefHeading___Toc517704995)

6.3.2.1 Frame Quality Indicator [14](#__RefHeading___Toc517704996)

6.3.2.2 Frame Type [14](#__RefHeading___Toc517704997)

6.3.2.3 Codec Mode Indication [14](#__RefHeading___Toc517704998)

6.3.2.4 Codec Mode Request [15](#__RefHeading___Toc517704999)

6.3.2.5 Optional internal 8 bits CRC [15](#__RefHeading___Toc517705000)

6.3.2.6 Speech and Comfort noise parameter bits [15](#__RefHeading___Toc517705001)

7 Uu Interface User Plane (UE) [15](#__RefHeading___Toc517705002)

8 Nb Interface User Plane (CN) of a BICC-based Circuit Switched Core Network [16](#__RefHeading___Toc517705003)

8.1 Frame structure on the Nb UP transport protocol [16](#__RefHeading___Toc517705004)

8.1.1 Initialisation [16](#__RefHeading___Toc517705005)

8.1.2 Time Alignment Procedure [16](#__RefHeading___Toc517705006)

8.1.3 SID Frame Generation [16](#__RefHeading___Toc517705007)

8.2 Mapping of the bits [17](#__RefHeading___Toc517705008)

8.2.1 Mapping for AMR frames [17](#__RefHeading___Toc517705009)

8.2.2 Mapping for PCM Coded Speech [17](#__RefHeading___Toc517705010)

8.2.3 Mapping for GSM\_EFR frames [17](#__RefHeading___Toc517705011)

8.2.4 Mapping for GSM\_FR frames [18](#__RefHeading___Toc517705012)

8.2.5 Mapping for GSM\_HR frames [19](#__RefHeading___Toc517705013)

8.3 Frame handlers [20](#__RefHeading___Toc517705014)

9 Nb Interface User Plane (CN) of a SIP-I -based Circuit Switched Core Network [21](#__RefHeading___Toc517705015)

9.1 Overview [21](#__RefHeading___Toc517705016)

9.1.1 Time Alignment Procedure [21](#__RefHeading___Toc517705017)

9.1.2 SID Frame Generation [21](#__RefHeading___Toc517705018)

9.1.3 Initial Codec Mode [22](#__RefHeading___Toc517705019)

9.2 AMR [22](#__RefHeading___Toc517705020)

9.3 AMR-WB [23](#__RefHeading___Toc517705021)

9.4 GSM\_EFR [24](#__RefHeading___Toc517705022)

9.5 GSM\_FR [24](#__RefHeading___Toc517705023)

9.6 GSM\_HR [25](#__RefHeading___Toc517705024)

9.7 PCM [25](#__RefHeading___Toc517705025)

9.8 Telephone-Event [25](#__RefHeading___Toc517705026)

10 A-Interface User Plane over IP [25](#__RefHeading___Toc517705027)

10.1 Overview [25](#__RefHeading___Toc517705028)

10.1.1 Time Alignment Procedure [26](#__RefHeading___Toc517705029)

10.1.2 SID Frame Generation [26](#__RefHeading___Toc517705030)

10.1.3 Initial Codec Mode [26](#__RefHeading___Toc517705031)

10.2 AMR [27](#__RefHeading___Toc517705032)

10.3 AMR-WB [27](#__RefHeading___Toc517705033)

10.4 GSM\_EFR [28](#__RefHeading___Toc517705034)

10.5 GSM\_FR [28](#__RefHeading___Toc517705035)

10.6 GSM\_HR [28](#__RefHeading___Toc517705036)

10.7 PCM [28](#__RefHeading___Toc517705037)

Annex A (informative): Change history [29](#__RefHeading___Toc517705038)

# Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

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

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x the first digit:

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document specifies the mapping of the AMR generic frame format (3GPP TS 26.101) to the Iu Interface (3GPP TS 25.415 [7]), the Uu Interface and the Nb Interface (3GPP TS 29.415). It further specifies the mapping of Enhanced Full Rate (GSM\_EFR) coded speech and of PCM 64 kBit/s (ITU-T G.711 [9]) coded speech to the Nb Interface in a BICC-based circuit switched core network.

The present document also specifies the mapping of Full Rate (GSM\_FR) coded speech and of Half Rate (GSM\_HR) coded speech to the Nb Interface in a BICC-based circuit switched core network.

The present document also specifies the transport of the AMR Codec Types, the AMR-WB Codec Types, the GSM\_EFR Codec, the GSM\_FR Codec, the GSM\_HR Codec and the ITU-T G.711 Codec over the A-Interface over IP (3GPP TS 48.002 [11]) and the Nb-Interface in a SIP-I -based circuit switched core network (3GPP TS 23.231 [12]).

# 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. 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 TS 25.415: "Iu Interface CN-UTRAN User plane Protocols".

[2] 3GPP TS 26.101: "AMR Speech Codec, Frame structure".

[3] 3GPP TS 23.107: "QoS Concept and Architecture".

[4] 3GPP TS 46.051: "Enhanced Full Rate (EFR) speech processing functions; General Description"

[5] 3GPP TS 28.062: "Inband Tandem Free Operation (TFO) of speech codecs; Service description; Stage 3".

[6] 3GPP TS 23.153: "Out of band transcoder control, Stage 2".

[7] 3GPP TS 29.415: "Core Network Nb Interface User Plane Protocols".

[8] ITU-T I.366.2: "AAL type 2 service specific convergence sublayer for trunking".

[9] ITU-T Recommendation G.711: "Pulse code modulation (PCM) of voice frequencies".

[10] 3GPP TS 29.414: "Core Network Nb data transport and transport signalling".

[11] 3GPP TS 48.002: "Base Station System - Mobile-services Switching Centre (BSS - MSC) interface; Interface principles".

[12] 3GPP TS 23.231: "SIP-I based circuit-switched core network; Stage 2".

[13] 3GPP TS 29.007: "General requirements on interworking between the Public Land Mobile Network (PLMN) and the Integrated Services Digital Network (ISDN) or Public Switched Telephone Network (PSTN)".

[14] 3GPP TS 26.103: "Speech codec list for GSM and UMTS ".

[15] IETF RFC 3264 (2002): "An Offer/Answer Model with the Session Description Protocol (SDP)", J. Rosenberg and H. Schulzrinne.

[16] IETF RFC 3550 (2003): "RTP: A Transport Protocol for Real-Time Applications", H. Schulzrinne, S. Casner, R. Frederick and V. Jacobson.

[17] IETF RFC 3551 (2003): "RTP Profile for Audio and Video Conferences with Minimal Control", H. Schulzrinne and S. Casner.

[18] void

[19] IETF RFC 4566 (2006): "SDP: Session Description Protocol", M. Handley, V. Jacobson and C. Perkins.

[20] IETF RFC 4733 (2006): "RTP Payload for DTMF Digits, Telephony Tones, and Telephony Signals", H. Schulzrinne and T. Taylor.

[21] IETF RFC 4867 (2007): "RTP Payload Format and File Storage Format for the Adaptive Multi-Rate (AMR) and Adaptive Multi-Rate Wideband (AMR-WB) Audio Codecs", J. Sjoberg, M. Westerlund, A. Lakaniemi and Q. Xie.

[22] IETF RFC 5993 (2010) "RTP Payload Format for Global System for Mobile Communications Half Rate (GSM-HR)".

[23] 3GPP TS 46.010: "Full rate speech; Transcoding".

[24] 3GPP TS 46.020: "Half rate speech; Half rate speech transcoding".

[25] 3GPP TS 46.041: "Half rate speech; Discontinuous Transmission (DTX) for half rate speech traffic channels".

[26] 3GPP TS 48.060: "In-band control of remote transcoders and rate adaptors for full rate traffic channels".

[27] 3GPP TS 48.061: "In band control of remote transcoders and rate adaptors for half rate traffic channels".

[28] 3GPP TS 46.012: "Full rate speech; Comfort noise aspect for full rate speech traffic channels".

[29] 3GPP TS 46.022: "Half rate speech; Comfort noise aspects for half rate speech traffic channels".

[30] 3GPP TS 46.062: "Comfort noise aspects for Enhanced Full Rate (EFR) speech traffic channels".

[31] 3GPP TS 26.093: "Adaptive Multi-Rate (AMR) speech codec; Source controlled rate operation".

[32] 3GPP TS 26.193: "Adaptive Multi-Rate - Wideband (AMR-WB) speech codec; Source controlled rate operation".

[33] 3GPP TS 48.008: "Mobile Switching Centre - Base Station System (MSC-BSS) interface".

[34] 3GPP TS 48.103: "Base Station System – Media GateWay (BSS-MGW) interface; User Plane transport mechanism".

[35] 3GPP TS 45.009: "Radio Access Network; Link adaptation"

[36] 3GPP TS 46.060: "EFR Speech Codec; Speech Transcoding Functions"

# 3 Definitions and abbreviations

## 3.1 Definitions

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

**AMR Generic Frame Interface:** this interface transports the AMR IF1 generic frame as defined in 3GPP TS 26.101

## 3.2 Abbreviations

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

AAL2 ATM Adaptation Layer 2

ACS Active Codec Set

AMR Adaptive Multi-Rate

AoIP A-Interface user plane transport over RTP/UDP/IP

AS Access Stratum

ATM Asynchronous Transfer Mode

BFH Bad Frame Handling

CDMA Code Division Multiple Access

CMI Codec Mode Indication

CMR/CMC Codec Mode Request or Codec Mode Command

CN Core Network

DRC Downlink Rate Command

FDD Frequency Duplex Division

FQC Frame Quality Classification (Iu Interface)

FQI Frame Quality Indication (AMR IF1)

GSM Global System for Mobile communications

ITU-T International Telecommunication Union – Telecommunication standardisation sector

MGW Media GateWay

NboIP Nb-Interface user plane transport over RTP/UDP/IP when SIP-I is used on Nc

PCM Pulse Code Modulation, synonym for 64 kBit/s coded speech (see ITU-T G.711 [9])

PDC Personal Digital Communication

PLMN Public Land Mobile Network

QoS Quality of Service

RAB Radio Access Bearer

RAN Radio Access Network

RF Radio Frequency

RFC RAB sub-flow Combination

RFCI RFC Indicator

RFCS RFC Set

RX Receive

SCR Source Controlled Rate

SDU Source Data Unit

SID Silence Insertion Descriptor

SMpSDU Support Mode for Predefined SDU sizes

SPD SPeech Decoder

SPE SPeech Encoder

TC Transcoder

TDD Time Duplex Division

TDMA Time Division Multiple Access

TFO Tandem Free Operation

TrFO Transcoder Free Operation

TX Transmit

UE User Equipment (terminal)

URC Uplink Rate Command

# 4 General

The Iu-Interface is defined in two different variants for speech telephony,   
 a) for the ATM bearer with Iu-framing and   
 b) for the IP bearer with Iu-framing.

The Nb-Interface is defined in three different variants for speech telephony,  
 a) for the ATM bearer with Nb-framing in a BICC-based Core Network,  
 b) for the IP bearer with Nb-framing in a BICC-based Core Network and  
 c) for the IP bearer with RTP packetization in a SIP-I -based Core Network, also called NboIP.

The mapping of the AMR Speech Codec parameters to the Iu interface specifies the frame structure of the speech data exchanged between the RNC and the TC inside the MGW in case of normal operation. This mapping is independent from the radio interface in the sense that it has the same structure for both FDD and TDD modes of the UTRAN.

The mapping between the Speech Codec and the Radio Access Network within the UE is not an open interface and need not to be detailed.

The mapping on the Nb Interface in a BICC based Core Network is identical to the one on the Iu Interface in case of Transcoder Free Operation, with the MGW relaying the SDUs unaltered between Iu and Nb Interfaces.

PCM coded speech is mapped onto the Nb-Interface in packets of 40 octets (5ms packetization time) or 160 octets (20ms packetization time). With Nb-framing (i.e. in a BICC-based Circuit Switched Core Network, IP or ATM) the default packetization time for PCM-coded speech is 5ms; 20ms is an additional option. For NboIP (i.e. RTP packetization in a SIP-I -based Circuit Switched Core Network) the default packetization time for PCM-coded speech is 20ms; 5ms is an additional option.

The packetization time of PCM-coded speech for AoIP is 20ms without any other option.

For the 3GPP Codec Types (GSM\_FR, GSM\_HR, GSM\_EFR, AMR and AMR-WB) the framing is always 20ms and also the packetization time is 20ms in all versions of the Nb-Interface and the A-Interface over IP. The mapping of GSM\_FR, GSM\_HR and GSM\_EFR Speech Codec parameters is defined on the A Interface over IP and all versions of the Nb-Interface, but not on the Iu Interface.

# 5 RAB aspects

During the RAB Assignment procedure initiated by the CN to establish the RAB for AMR, the RAB parameters are defined. The AMR RAB is established with one or more RAB co-ordinated sub-flows with predefined sizes and QoS parameters. In this way, each RAB sub-flow Combination corresponds to one AMR frame type. For AMR, subject to operator tuning, the first RAB sub-flow (sub-flow 1) corresponds with the Class A bits. In case there are three RAB sub-flows, subject to operator tuning, the third RAB sub-flow (sub-flow 3) corresponds with the Class C bits. On the Iu interface, these RAB parameters define the corresponding parameters regarding the transport of AMR frames.

Some of the QoS parameters in the RAB assignment procedure are determined from the Bearer Capability Information Element used at call set up. These QoS parameters as defined in [3], can be set as follows:

Table 5-1: Example of mapping of BC IE into QoS parameters for UMTS AMR

| RAB service attribute | | | RAB service attribute value | | | Comments |
| --- | --- | --- | --- | --- | --- | --- |
| Traffic Class | | | Conversational | | |  |
| RAB Asymmetry Indicator | | | Symmetric, bidirectional | | | Symmetric RABs are used for uplink and downlink |
| Maximum bit rate | | | 12.2 / 10.2 / 7.95 / 7.4 / 6.7 / 5.9 / 5.15 / 4.75 kbit/s | | | This value depends on the highest mode rate in the RFCS |
| Guaranteed bit rate | | | 12.2 / 10.2 / 7.95 / 7.4 / 6.7 / 5.9 / 5.15 / 4.75 kbit/s | | | One of the values is chosen, depending on the lowest rate controllable SDU format (note 2) |
| Delivery Order | | | Yes | | | (note 1) |
| Maximum SDU size | | | 244 / 204 / 159 / 148 / 134 / 118 / 103 / 95  bits | | | Maximum size of payload field in Iu UP, according to the highest mode rate in the RFCS |
| Traffic Handling Priority | | | Not applicable | | | Parameter not applicable for the conversational traffic class. (note 1) |
| Source statistics descriptor | | | Speech | | | (note 1) |
| SDU Parameters | | | RAB sub-flow 1 (Class A bits) | RAB sub-flow 2 (Class B bits) | RAB sub-flow 3 (Class C bits) | The number of SDU, their number of RAB sub-flow and their relative sub-flow size is subject to operator tuning (note 3) |
|  | SDU error ratio | | 7 \* 10-3 | - | - | (note 3) |
|  | Residual bit error ratio | | 10-6 | 10-3 | 5 \* 10-3 | (note 3 – applicable for every sub-flow) |
|  | Delivery of erroneous SDUs | | yes | - | - | Class A bits are delivered with error indication; Class B and C bits are delivered without any error indication. |
|  | SDU format information 1-9 | |  |  |  | (note 4) |
|  |  | Sub-flow SDU size 1-9 | (note 5) | (note 5) | (note 5) |  |
| NOTE 1: These parameters apply to all UMTS speech codec types.  NOTE 2: The guaranteed bit rate depends on the periodicity and the lowest rate controllable SDU size.  NOTE 3: These parameters are subject to operator tuning.  NOTE 4: SDU format information has to be specified for each AMR core frame type (i.e. with speech bits and comfort noise bits) included in the RFCS as defined in [2].  NOTE 5: The sub-flow SDU size corresponding to an AMR core frame type indicates the number of bits in the class A, class B and class C fields. The assigned SDU sizes shall be set so that the SCR operation is always possible. | | | | | | |

The RAB parameters shall be set so that the SCR operation is always possible.

The conversational traffic class shall be used for the speech service, which is identified by the ITC parameter of the bearer capability information element in the SETUP message. This shall apply for all UMTS speech codec types.  
The parameters traffic class, transfer delay, traffic handling priority and source statistics descriptor shall be the same for all speech codec types applicable for UMTS.

# 6 Iu Interface User Plane (RAN)

The data structure exchanged on the Iu interface are symmetrical, i.e. the structure of the uplink data frames is identical to that of the downlink data frames.

## 6.1 Frame structure on the Iu UP transport protocol

### 6.1.1 Initialisation

At the initialisation of the SMpSDU mode of operation, several parameters are set by the CN. The initialisation procedure is described in [1].

- RFCS:

In the case of AMR, the RFCS corresponds to the Active Codec Set (ACS) plus potentially SCR authorised in the communication. Annex A of [1] gives an illustration of the usage of RFCI for AMR speech RAB. RFCS used in downlink may differ from that in uplink.

- Delivery of erroneous SDUs:

This parameter shall be set to YES. Erroneous speech frames may be used to assist the error concealment procedures. Therefore, according to [1], PDU type 0 (containing a payload CRC) shall be used for transport of AMR data.

### 6.1.2 Time Alignment Procedure

The TC should adjust the timing of the speech data transmission in downlink direction according to the time alignment frames sent by the RNC.

Time alignment procedure shall be dismissed in case of TFO and TrFO.

## 6.2 Mapping of the bits

The mapping of the bits between the generic AMR frames and the PDU is the same for both uplink and downlink frames.

The following table gives the correspondence of the bit fields between the generic AMR frames at the TC interface and the PDU exchanged with the Iu transport layer.

Table 6-1: Mapping of generic AMR frames onto Iu PDUs

|  |  |  |
| --- | --- | --- |
| **PDU field** | Corresponding field within the  generic AMR frame | Comment |
| **PDU Type** | N/A | Type 0 |
| **Frame Number** | N/A |  |
| **FQC** | Frame Quality Indicator |  |
| **RFCI** | Frame Type |  |
| **Payload CRC** | N/A |  |
| **Header CRC** | N/A |  |
|  |  |  |
| **Payload Fields (N Sub-flows)** | Class A or SID payload  Class B  Class C |  |
| **SDU #1** | Most important speech bits come first | Mandatory |
| **SDU #2** | Next bits follow | Optional |
|  |  |  |
| **…** | … | Optional |
| **SDU #N** | Least important speech bits | Optional |

The number of RAB sub-flows, their corresponding sizes, and their attributes such as "Delivery of erroneous SDUs" shall be defined at the RAB establishment and signalled in the RANAP RAB establishment request, as proposed in clause 5. The number of RAB sub-flows is corresponding to the desired bit protection classes. The total number of bits in all sub-flows for one RFC shall correspond to the total number given in 3GPP TS 26.101, generic AMR frame, format IF1, for the corresponding Codec Mode, respectively Frame Type.

The class division and relative subjective importance of the encoded bits is given in 3GPP TS 26.101 and provides guidance for setting the number of bits in each RAB sub-flow.

The following two tables are examples of mapping of RAB sub-flows.

Table 6-2 gives three examples of sub-flow mapping.   
The RFCI definition is given in order of increasing SDU sizes.

- Example 1 describes Codec Type UMTS\_AMR, with all eight codec modes foreseen in the Active Codec Set (ACS) and provision for Source Controlled Rate operation (SCR). In this example, Blind Transport Format Detection is supported and the sub-flow mapping follows the 3GPP TS 26.101 class division.

- Example 2 describes Codec Type GSM\_EFR, with one codec mode, including SCR.

- Example 3 describes Codec Type FR\_AMR, including AMR SCR

Table 6-2: Example for AMR with SCR and three sub-flows, according to subjective class division indication of 3GPP TS 26.101

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| UMTS\_AMR | GSM\_EFR | FR\_AMR | RAB sub-flows | | | Total size of  bits/RAB sub-flows combination  (Mandatory) | Source rate |
| RFCI Example 1 | RFCI Example 2 | RFCI Example 3 | RAB sub-  flow 1  (Optional) | RAB sub-  flow 2  (Optional) | RAB sub-  flow 3  (Optional) |
| **2** |  | **2** | **42** | **53** | **0** | 95 | AMR 4,75 kbps |
| **3** |  |  | **49** | **54** | **0** | 103 | AMR 5,15 kbps |
| **4** |  | **3** | **55** | **63** | **0** | 118 | AMR 5,9 kbps |
| **5** |  | **4** | **58** | **76** | **0** | 134 | AMR 6,7 kbps |
| **6** |  |  | **61** | **87** | **0** | 148 | AMR 7,4 kbps |
| **7** |  |  | **75** | **84** | **0** | 159 | AMR 7,95 kbps |
| **8** |  | **5** | **65** | **99** | **40** | 204 | AMR 10,2 kbps |
| **9** | **2** |  | **81** | **103** | **60** | 244 | AMR 12,2 kbps |
| **1** |  | **1** | **39** | **0** | **0** | 39 | AMR SID |
|  | **1** |  | **43** | **0** | **0** | 43 | GSM-EFR SID |

Table 6-3 gives one example of sub-flow mapping that supports Equal Error Protection.  
The RFCI definition is given in order of increasing SDU sizes.

- Example 4 describes Codec Type PDC\_EFR and the corresponding Source Controlled Rate operation (SCR).

Table 6-3: Example of SDU sizes for PDC\_EFR with SCR and Equal Error Protection

|  |  |  |  |
| --- | --- | --- | --- |
| PDC\_EFR | RAB sub-flow | Total size of  bits/RAB sub-flows combination  (Mandatory) | Source rate |
| RFCI Example 4 | RAB sub-  Flow 1  (Mandatory) |
|  | **95** | 95 | AMR 4,75kbps |
|  | **103** | 103 | AMR 5,15kbps |
|  | **118** | 118 | AMR 5,9kbps |
| **2** | **134** | 134 | AMR 6,7kbps |
|  | **148** | 148 | AMR 7,4kbps |
|  | **159** | 159 | AMR 7,95kbps |
|  | **204** | 204 | AMR 10,2kbps |
|  | **244** | 244 | AMR 12,2kbps |
|  | **39** | 39 | AMR SID |
|  | **43** | 43 | GSM-EFR SID |
|  | **38** | 38 | TDMA-EFR SID |
| **1** | **37** | 37 | PDC-EFR SID |

## 6.3 Frame handlers

Iu PDU Frame handling functions are described in 3GPP TS 25.415 [1]. This sections describe the mandatory frame handling functions at the AMR Generic frame interface.

### 6.3.1 Handling of frames from TC to Iu interface (downlink)

The frames from the TC in generic AMR frame format IF1 are mapped onto the Iu PDU as follows.

#### 6.3.1.1 Frame Quality Indicator

The Frame Quality Indicator (FQI) from the TC is directly mapped to the Frame Quality Classification (FQC) of the Iu frame according to Table 6-4.

Table 6-4: FQI AMR to FQC Iu PDU mapping

|  |  |  |  |
| --- | --- | --- | --- |
| FQI AMR | FQI value (1 bit) | FQC PDU | FQC value (2 bit) |
| GOOD | 1 | GOOD | 00 |
| BAD | 0 | BAD | 01 |

#### 6.3.1.2 Frame Type

The received Frame Type Index l is mapped onto the RFCI j thanks to the assigned RFCS table: the correspondence between Codec Mode, Frame Type Index l and RFCI j is defined at RAB assignment.

#### 6.3.1.3 Codec Mode Indication

The Codec Mode Indication is not used.

#### 6.3.1.4 Codec Mode Request

Codec Mode Request (CMR) in downlink direction is forwarded to the rate control procedure when it changes, or when it is commanded so by the TC in case of TFO, see 3G TS 28.062.

#### 6.3.1.5 Optional internal 8 bits CRC

The internal AMR Codec CRC is not used on the Iu interface.

#### 6.3.1.6 Mapping of Speech or Comfort Noise parameter bits

Let us define the N payload fields of the N sub-flows for RFCI j as follows:

Ui(k) shall be the bits in sub-flow i, for k =1 to Mi

Mi shall be the size of sub-flow i, for i = 1 to N

d(k) shall be the bits of the speech or comfort noise parameters of the corresponding Frame Type l in decreasing subjective importance, as defined in the generic AMR frame format IF1, see TS 26.101 [2].

Then the following mapping in pseudo code applies:

U1(k) = d(k-1) with k = 1, … M1

U2(k) = d(k -1+ M1) with k = 1, … M2

U3(k) = d(k-1 + M2) with k = 1, … M3

…

UN(k) = d(k-1 + MN-1) with k = 1 … MN

### 6.3.2 Handling of frames from Iu interface to TC (uplink)

The uplink Iu frames are mapped onto generic AMR frames, format IF1, as follows.

#### 6.3.2.1 Frame Quality Indicator

At reception of Iu PDU the Iu frame handler function set the Frame Quality Classification according to the received FQC, Header-CRC check, and Payload-CRC check (see 25.415). AMR Frame Type and Frame Quality Indicator are determined according to the following table:

Table 6-5: FQC Iu PDU type 0 to AMR FQI and AMR Frame Type mapping

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| FQC | FQC value (2 bits) | Resulting FQI | FQI value (1 bit) | resulting Frame Type |
| GOOD | 00 | GOOD | 1 | from RFCI |
| BAD | 01 | BAD | 0 | NO\_DATA |
| BAD Radio | 10 | BAD | 0 | from RFCI |
| Reserved | 11 | BAD | 0 | Reserved |

#### 6.3.2.2 Frame Type

The received RFCI j is mapped onto the Frame Type Index l thanks to the RFCS table.

#### 6.3.2.3 Codec Mode Indication

The Codec Mode Indication is not used.

#### 6.3.2.4 Codec Mode Request

The received Downlink Rate Control command (DRC) is mapped onto the Codec Mode Request (CMR) towards the AMR Codec. In case a new DRC is received it is mapped into the corresponding CMR of the generic AMR frame format. It is remembered by the TC until the next DRC is received. In each new frame that is sent to the AMR Codec, the stored CMR is resent, in order to control the Codec Mode for the downlink direction.

#### 6.3.2.5 Optional internal 8 bits CRC

The internal AMR Codec CRC is not used on the Iu interface.

#### 6.3.2.6 Speech and Comfort noise parameter bits

The speech and Comfort noise parameter bits are mapped from the sub-flows to the payload of the generic AMR frames with the reverse function of clause 6.3.1.6.

# 7 Uu Interface User Plane (UE)

The interface between the UE AMR speech codec (see 3GPP TS 26.101) and the Radio Access Network is an internal UE interface and is not detailed. The mapping is corresponding to the mapping described in clause 6 for the Iu interface.

Even though the details of Uu interface are not detailed, there are some functional requirements for the UE that need to be considered, when an AMR codec type (i.e. UMTS AMR2) is being used in a conversational speech call. These requirements are related to the mapping of AMR Generic frame format handling functions. The requirements are

1) The set of available codec modes (bitrates) that the UE may use are configured by UTRAN. The UE shall select, from the configured set of codec modes, a mode that is supported by the current TX power conditions as defined in 3GPP TS25.133. The highest available mode should be used for best speech quality.

2) The lowest configured codec mode is always to be considered supported.

3) When the codec mode is being adapted during a call, the used mode should be changed in a step-by-step fashion within the configured set of codec modes, i.e. by stepping one mode up or down within the configured set. This avoids disruptions on AMR decoding in GSM side, if TFO or TrFO operation is ongoing.

NOTE: In case of modification of the maximum rate (e.g. by the RNC), it takes a short time period until the speech frames sent by the UE to the Radio Access Network comply with the modified maximum rate. To facilitate optimization of performance (for instance avoiding problems like audio gaps due to discarded packets) in sending direction from the UE to the network when changing mode as requested, it is a good implementation practice to allow adaptation of the UE Encoder to take effect, and to maintain currently used rate for the next few frames after the information about the rate adaptation has been sent to the UE Encoder.

# 8 Nb Interface User Plane (CN) of a BICC-based Circuit Switched Core Network

The data structures exchanged on the Nb interface are symmetrical, i.e. the structures of the sent and received data frames are identical.

The Nb-Interface is defined in a BICC-based Core Network in two different variants, a) for the ATM bearer with Nb-framing, b) for the IP bearer with Nb-framing. The Nb-framing and the use of PDU Type 0 for the speech payload and PDU Type 14 [7] for AMR Rate Control is common for both versions of the Nb-Interface here. These two versions also share the principle of "Nb\_Init", where the Nb-Interface is initialized on User Plane level and where the Initial Codec Mode for AMR and/or AMR-WB is signalled.

## 8.1 Frame structure on the Nb UP transport protocol

Delivery of erroneous SDUs for AMR- and AMR-WB-coded speech, as well as for GSM\_FR-, GSM\_HR-, GSM\_EFR-coded speech and for PCM-coded speech on the Nb-Interface shall be set to: "YES" in a BICC-based Circuit Switched Core Network. Erroneous speech frames may be used to assist the error concealment procedures. Therefore, according to [1] and [7], PDU Type 0 (with payload CRC) shall be used for the transport of AMR, AMR-WB, GSM\_FR, GSM\_HR and GSM\_EFR coded speech on the Nb interface.   
PDU Type 0 (with payload CRC) shall be used for the transport of PCM coded speech on the Nb interface, too.

### 8.1.1 Initialisation

The initialisation procedure is used for support mode. At the initialisation several parameters are set by the CN. The initialisation procedure for the Nb Interface is described in [7].

### 8.1.2 Time Alignment Procedure

The handling of Time Alignment on the Nb Interface is described in [7].

The Time alignment procedure shall be dismissed in case of TFO and TrFO.

### 8.1.3 SID Frame Generation

All 3GPP Codec Types include a standardized Discontinuous Transmission (DTX) with Voice Activity Detection, Silence Description (by SID frames) and Comfort Noise Generation to fill the speech pauses. If speech inactivity is detected by the Encoder, then (speech) frames are not transmitted, but the transmission is suspended in order to save battery life time in the mobile station, reduce interference on the radio interface and reduce load on all links. The receiving Decoder fills these transmission pauses with Comfort Noise to minimize the contrast between pauses and active speech. Silence Descriptor (SID) frames need to be send during speech inactivity to keep the Comfort Noise decently well aligned with the background noise at sender side. This is especially important at the onset of the next talkspurt and therefore SID frames should not be too old, when speech starts again.

The generation of SID frames for the AMR and AMR-WB families of Codecs is determined by the Speech Encoder as specified in TS 26.093 [31], respectively TS 26.193 [32]. The radio subsystem does not influence this timing! SID frames come during speech pauses in uplink and downlink about every 160ms. Also an AMR Encoder in the Media Gateway generates and sends SID frames about every 160ms.

The generation of SID frames for GSM\_FR, GSM\_HR and GSM\_EFR in the GSM radio network is determined by the GSM mobile station and the GSM radio subsystem, not primarily by the Speech Encoder! SID frames come during speech pauses in uplink from the mobile station about every 480ms. In downlink to the mobile station, when they are generated by the Speech Encoder of the GSM radio subsystem, SID frames are sent every 20ms to the GSM base station, which then picks only one every 480ms for downlink radio transmission. For other applications, like transport over Nb, it is more appropriate to send the SID frames less often than every 20ms, but 480ms may be too sparse. As a compromise it is recommended that an Encoder in the Media Gateway should generate and send SID frames every 160ms.

## 8.2 Mapping of the bits

### 8.2.1 Mapping for AMR frames

The mapping of the bits between the generic AMR frames and the PDU for the Nb Interface is identical to the mapping on the Iu Interface. In case of TrFO the MGW relays the AMR frames from the Iu Interface unaltered to the Nb Interface and vice versa, as described in [7].

### 8.2.2 Mapping for PCM Coded Speech

The mapping for the PCM coded speech in 5ms frames on the Nb Interface shall be as defined in Table 8-1.

Table 8-1: Mapping of PCM Coded Speech in 5 ms frames onto Nb PDU, Type 0

|  |  |
| --- | --- |
| **PDU field** | Comment |
| PDU Type | Type 0 (with Payload CRC) |
| Frame Number | as defined in [7] |
| FQC | set to "good", i.e. value 0 |
| RFCI | initialise by MGW, see [7], one value required |
| Header CRC | as defined in [7] |
| Payload CRC | as defined in [7] |
|  |  |
| Payload Field | 320 bits of PCM coded speech, in accordance with [8]. |

The mapping for the PCM coded speech in 20ms frames on the Nb Interface shall be as defined in Table 8-2.

Table 8-2: Mapping of PCM Coded Speech in 20ms frames onto Nb PDU, Type 0

|  |  |
| --- | --- |
| **PDU field** | Comment |
| PDU Type | Type 0 (with Payload CRC) |
| Frame Number | as defined in [7] |
| FQC | set to "good", i.e. value 0 |
| RFCI | initialised by MGW, see [7], one value required |
| Header CRC | as defined in [7] |
| Payload CRC | as defined in [7] |
|  |  |
| Payload Field | 4x320 bits of PCM coded speech, in accordance with [8]. |

5ms is the default packetization time to be supported for PCM encoded speech over Nb in a BICC based Core Network. 20ms is an additional optional packetization time for PCM encoded speech in a BICC based Core Network over IP Nb bearer that may be negotiated during bearer establishment as specified in [10].

NOTE: the use of 20ms packetization time will result in some call scenarios in higher delays over the speech path compared to the 5ms packetization time. This potentially higher delay should be taken into account in the overall end to end (ear to mouth) delay budget.

### 8.2.3 Mapping for GSM\_EFR frames

The mapping of the bits between the generic GSM\_EFR frames and the PDUs for the Nb Interface follows the same principles as the mapping of AMR frames. The PDU for the GSM\_EFR speech frame is identical to the PDU for AMR Mode 12.2 kbps.

The PDU for the GSM\_EFR SID frame is similar to the PDU for AMR SID, with 43 instead of 39 bits in the payload field. The contents of GSM\_EFR SID is the Comfort Noise Parameter set (s(i)) as defined in [36]. The Comfort noise parameters are computed as described in [30] by the GSM\_EFR speech encoder and are denoted as s(i) = {*s*(1),*s*(2),...,s(38), s(87),s(88),…,s(91)}. The notation *s*(*i*) follows that of [36] (Table 6). The notation *d*(*j*) = {d(1) … d(43)} of the SID frame is local to the present document and is formed as defined by the pseudo code below.

for *j* = 1 to 38  
*d*(*j*) := *s*(*j*); /\* LSP parameters in *s*(1) to *s*(38) \*/;

for *j* = 39 to 43  
 *d*(*j*) := *s*(*j*+48); /\* fixed codebook gain parameter in *s*(87)-*s*(91) \*/

The payload within the PDU shall be the vector *d(j)* constructed above. The first bit in the vector *d(j)* shall be supplied first in the payload within the PDU.

NOTE: The Payload field for Nb frames for GSM\_EFR in a BICC-based Circuit Switched Core Network is filled differently to the RTP payload according to RFC3551 [17], used in AoIP and NboIP.

### 8.2.4 Mapping for GSM\_FR frames

The mapping of GSM\_FR-coded speech in 20ms frames on the Nb Interface shall be as defined in Table 8.2.4.1.

Table 8.2.4.1: Mapping of GSM\_FR-coded speech in 20ms frames onto Nb PDU, Type 0

|  |  |
| --- | --- |
| **PDU field** | Comment |
| PDU Type | Type 0 (with Payload CRC) |
| Frame Number | as defined in [7] |
| FQC | see below |
| RFCI | initialise by MGW, see [7], two values required (Speech and SID) |
| Header CRC | as defined in [7] |
| Payload CRC | as defined in [7] |
|  |  |
| Payload Field | 264 bits if Nb PDU contains a speech frame, see below.  42 bits if Nb PDU contains a SID frame, see below. |

**Payload field with speech frame:**The 260 bits of GSM\_FR-coded speech (b1…b260) are defined in TS 46.010, chapter 1.7. They and a "signature" are copied into the 33 octets of the Payload field as follows. The four most significant bits (bit 8….5) of the first octet (octet 1) of the Nb Payload field are set to a "signature" of 0b1101 = 0xD. Then the four most significant bits (b6…b3) of the first GSM\_FR parameter (LAR 1) are copied into the next bits (bit 4…1) of the first octet. The two least significant bits of the first GSM\_FR parameter (LAR 1) are copied into the next octet (octet 2) into the 2 MSBs (bit 8…7), and so on. Each GSM\_FR parameter is copied bit by bit with its most significant bit first. The least significant bit of the last GSM\_FR parameter (b258 of RPE-pulse no.13) is placed in the LSB (bit 1) of octet 33.

**Payload field with SID frame:**The GSM\_FR SID frames are defined in chapter 5.2 of [28] and in chapter 1.7 of [23] and are denoted as   
b(i) = {b(1),b(2),...,b(36), b(48),b(49),...,b(53)}. Each GSM\_FR SID parameter is copied bit by bit with its most significant bit first. The notation *d*(*j*) = {d(1) … d(42)} of the SID frame is local to the present document and is formed by the pseudo code below.

for *j* = 1 to 36  
*d*(*j*) := *b*(*j*); /\* averaged log area coefficients in *b*(1) to *b*(36) \*/;

for *j* = 37 to 42  
*d*(*j*) := *b*(*j*+11); /\* averaged block amplitude values in *b*(48)-*b*(53) \*/

The payload within the PDU shall be the vector *d(j)* constructed above. The first bit in the vector *d(j)* shall be supplied first in the payload within the PDU.

NOTE: The Payload field for Nb frames for GSM\_FR containing SID frame in a BICC-based Circuit Switched Core Network is filled differently to the Payload field in RTP Packets according to RFC3551 [17], used in AoIP and NboIP.

**FQC:**  
The FQC (see Nb UP [7]) is set by the MGW depending on the call case:

1) FQC is set to "good", i.e. value 0, if the GSM\_FR-compression and coding is performed within the MGW

2) FQC is set to "good", i.e. value 0, if GSM\_FR-coded speech is received without frame quality indication

3) FQC is derived from the input frame, if FQC or a similar frame quality indication is specified there.  
In case of GSM\_FR-coded speech received via TFO frames (see TS 28.062 [5]) the FQC is derived from the "Bad Frame Indication" (BFI) of these TFO frames. Speech frames and SID frames marked with BFI set to "good" shall be sent with FQC set to "good", i.e. value 0. Speech frames and SID frames marked with BFI set to "bad" shall not be sent in order to save bandwidth on Nb.

### 8.2.5 Mapping for GSM\_HR frames

The mapping of GSM\_HR-coded speech in 20ms frames on the Nb Interface shall be as defined in Table 8.2.5.1.

Table 8.2.5.1: Mapping of GSM\_HR-coded speech in 20ms frames onto Nb PDU, Type 0

|  |  |
| --- | --- |
| **PDU field** | Comment |
| PDU Type | Type 0 (with Payload CRC) |
| Frame Number | as defined in [7] |
| FQC | see below |
| RFCI | initialise by MGW, see [7], two values required (Speech and SID) |
| Header CRC | as defined in [7] |
| Payload CRC | as defined in [7] |
|  |  |
| Payload Field | 112 bits if Nb PDU contains a Speech frame, see below.  33 bits if Nb PDU contains a SID frame, see below. |

**Payload field with speech frame:**  
The 112 bits of GSM\_HR-coded speech (b1…b112) are defined in TS 46.020, Annex B, in the order of occurrence. The first bit (b1) of the first parameter is placed in bit 8 (the MSB) of the first octet (octet 1) of the Nb Payload field; the second bit is placed in bit 7 of the first octet and so on. The last bit (b112) is placed in the LSB (bit 1) of octet 14.

NOTE 1:The Payload field for Nb frames for GSM\_HR with speech frame in a BICC-based Circuit Switched Core Network is identical to the "speech data section" of the RTP payload. It is done according to [22], used in AoIP and NboIP.

**Payload field with SID frame:**The GSM\_HR SID frames are defined in [24] and [29] and are denoted as b(i) = {b(1),b(2),...,b(33)}. The notation *d*(*j*) = {d(1) … d(33)} of the SID frame is local to the present document and is formed by the pseudo code as follows.

for *j* = 1 to 5  
*d*(*j*) := *b*(*j*); /\* R0 parameter in *b*(1) to *b*(5) \*/;

for *j* = 6 to 16  
*d*(*j*) := *b*(*j*); /\* LPC1 parameter in *b*(6)-*b*(16) \*/

for *j* = 17 to 25  
*d*(*j*) := *b*(*j*); /\* LPC2 parameter in *b*(17)-*b*(25) \*/

for *j* = 26 to 33  
*d*(*j*) := *b*(*j*); /\* LPC3 parameter in *b*(26)-*b*(33) \*/

The payload within the PDU shall be the vector *d(j)* constructed above. The first bit in the vector *d(j)* shall be supplied first in the payload within the PDU.

NOTE 2:The Payload field for Nb frames for GSM\_HR with SID frame in a BICC-based Circuit Switched Core Network is not filled in the same way as the "speech data section" of the RTP payload used in AoIP and NboIP. For both AoIP and NboIP packing is according to [22].

**FQC:**  
The FQC (see Nb UP [7]) is set by the MGW depending on the call case:

1) FQC is set to "good", i.e. value 0, if the GSM\_HR-compression and coding is performed within the MGW.

2) FQC is set to "good", i.e. value 0, if GSM\_HR-coded speech is received without frame quality indication.

3) FQC is derived from the input frame, if FQC or a similar frame quality indication is specified there.  
In case of GSM\_HR-coded speech received via TFO frames (see TS 28.062 [5]) the FQC is derived from the "Extended control bits" (XC1 to XC5) for 8kbps submultiplexing (specified in TS 48.061, chapter 5.2.4.1.1 and partly reprinted here for ease of reading) as defined in table 8.2.5.2.

Table 8.2.5.2: The FQC for GSM\_HR-coded Nb frames derived from TFO frames

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **FQC** | **XC1** | **XC2** | **XC3** | **XC4** | **XC5** | **Meaning** (in Abis frames with 8kbps submultiplexing) |
| good | 0 | 0 | 0 | 0 | 0 | Good speech frame with UFI = 0   (BFI=0, SID=0, TAF=1)   (BFI=0, SID=0, TAF=0) |
| bad\* | 0 | 0 | 0 | 0 | 1 | Unreliable speech frame (if speech decoder is in speech decoding mode)  or unusable frame (if speech decoder is in comfort noise insertion mode) with UFI = 1   (BFI=0, SID=0, TAF=1)   (BFI=0, SID=0, TAF=0) |
| good | 0 | 0 | 0 | 1 | 0 | Valid SID frame with UFI = 0   (BFI=0, SID=2, TAF=1)   (BFI=0, SID=2, TAF=0) |
| bad | 0 | 0 | 0 | 1 | 1 | Invalid SID frame with UFI = 1   (BFI=0, SID=2, TAF=1)   (BFI=0, SID=2, TAF=0) |
| bad | 0 | 1 | 0 | 0 | 0 | Invalid SID frame at TAF=0 with UFI = 0  (BFI=0, SID=1, TAF=0)   (BFI=1, SID=1, TAF=0)   (BFI=1, SID=2, TAF=0) |
| bad | 0 | 1 | 0 | 0 | 1 | Invalid SID frame at TAF=0 with UFI = 1  (BFI=0, SID=1, TAF=0)  (BFI=1, SID=1, TAF=0)  (BFI=1, SID=2, TAF=0) |
| bad | 0 | 1 | 0 | 1 | 0 | Invalid SID frame at TAF=1 with UFI = 0  (BFI=0, SID=1, TAF=1)  (BFI=1, SID=1, TAF=1)  (BFI=1, SID=2, TAF=1) |
| bad | 0 | 1 | 0 | 1 | 1 | Invalid SID frame at TAF=1 with UFI = 1  (BFI=0, SID=1, TAF=1)  (BFI=1, SID=1, TAF=1)  (BFI=1, SID=2, TAF=1) |
| bad\* | 0 | 1 | 1 | 0 | 0 | Bad speech frame or unusable frame at TAF = 0 with UFI = 0  (BFI=1, SID=0, TAF=0) |
| bad\* | 0 | 1 | 1 | 0 | 1 | Bad speech frame or unusable frame at TAF = 0 with UFI = 1  (BFI=1, SID=0, TAF=0) |
| bad\* | 0 | 1 | 1 | 1 | 0 | Bad speech frame or unusable frame at TAF = 1 with UFI = 0  (BFI=1, SID=0, TAF=1) |
| bad\* | 0 | 1 | 1 | 1 | 1 | Bad speech frame or unusable frame at TAF = 1 with UFI = 1  (BFI=1, SID=0, TAF=1) |

Speech frames and SID frames marked in Table 8.2.5.2 with FQC set to "good", i.e. value 0, shall be sent.   
Frames marked in Table 8.2.5.2 with FQC set to "bad\*" or "bad" shall not be sent in order to save bandwidth on Nb.

NOTE 3**:** the abbreviations "UFI" (unreliable frame indication), "BFI" (bad frame indication), "SID" (Silence Descriptor) and "TAF" (Time Alignment Flag) are defined in 3GPP TS 46.041 [25].

## 8.3 Frame handlers

Nb PDU Frame handling functions are described in [7].

# 9 Nb Interface User Plane (CN) of a SIP-I -based Circuit Switched Core Network

## 9.1 Overview

The SIP-I -based Circuit Switched Core Network is specified in 3GPP TS 23.231 [12]. The User Plane in this Core Network is further specified in 3GPP TS 29.414 [10]. RTP is specified in IETF RFC 3550 [16].

RTP is used in a SIP-I -based Circuit Switched Core Network as framing protocol at the Nb-Interface (without Nb-framing protocol). The rules for the usage of RTP and RTCP in 3GPP TS 29.414 [10] are applicable in combination with further Codec-specific rules provided in the present specification.

Table 9.1.1 lists the applicable 3GPP Codec Types for a SIP-I -based Circuit Switched Core Network. Codecs for data transport are described in 3GPP TS 29.007 [13].

Table 9.1.1 Supported Codec Types in a SIP-I -based Circuit Switched Core Network

|  |  |  |  |
| --- | --- | --- | --- |
| **Payload Type Name** | **References** | **Remarks** | **Support** |
| audio/AMR | IETF RFC 4867 [21] | Applicable for FR\_AMR, HR\_AMR, OHR\_AMR, UMTS\_AMR and UMTS\_AMR2 | Mandatory.  Not all AMR Configurations are mandatory. Some Configurations are preferred, see below. |
| audio/AMR-WB | IETF RFC 4867 [21] | Applicable for FR\_AMR-WB, OHR\_AMR-WB, OFR\_AMR-WB, UMTS\_AMR-WB | Optional. AMR-WB is mandatory, if WB speech is supported.  Not all WB Configurations are mandatory, see below |
| audio/GSM\_EFR | IETF RFC 3551 [17] | Useful if an A-interface over IP is attached or TFO is used. | Optional |
| audio/GSM\_FR | IETF RFC 3551 [17] | Useful if an A-interface over IP is attached or TFO is used. | Optional |
| audio/GSM\_HR | IETF RFC 5993 [22] | Useful if an A-interface over IP is attached or TFO is used. | Optional |
| audio/PCMA | IETF RFC 3551 [17] | ITU-T G.711 Alaw | Mandatory |
| audio/PCMU | IETF RFC 3551 [17] | ITU-T G.711 ulaw | Mandatory |
| audio/telephone-event | IETF RFC 4733 [20] | Used to transport DTMF | Mandatory |

The RTP "Payload Type" number for the Nb-Interface is either static (for PCMA, PCMU and GSM\_FR) or determined by the MSC-S (dynamic Payload Type).

### 9.1.1 Time Alignment Procedure

Time Alignment (and AMR Phase Alignment) is not specified in a SIP-I -based Circuit Switched Core Network.

### 9.1.2 SID Frame Generation

All 3GPP Codec Types include standardized Discontinuous Transmission (DTX) with Voice Activity Detection, Silence Description (by SID frames) and Comfort Noise Generation to fill the speech pauses. If speech inactivity is detected by the Encoder, then (speech) frames are not transmitted, but the transmission is suspended in order to save battery life time in the mobile station, reduce interference on the radio interface and reduce load on all links. The receiving Decoder fills these transmission pauses with Comfort Noise to minimize the contrast between pauses and active speech. Silence Descriptor frames need to be send during speech inactivity to keep the Comfort Noise decently well aligned with the background noise at sender side. This is especially important at the onset of the next talkspurt and therefore SID frames should not be too old, when speech starts again.

The generation of SID frames for the AMR and AMR-WB families of Codecs is determined by the Speech Encoder as specified in TS 26.093 [31], respectively TS 26.193 [32]. The radio subsystem does not influence this timing! SID frames come during speech pauses in uplink and downlink about every 160ms. Also an AMR Encoder in the Media Gateway generates and sends SID frames about every 160ms.

The generation of SID frames for GSM\_FR, GSM\_HR and GSM\_EFR in the GSM radio network is determined by the GSM mobile station and the GSM radio subsystem, not primarily by the Speech Encoder! SID frames come during speech pauses in uplink from the mobile station about every 480ms. In downlink to the mobile station, when they are generated by the Speech Encoder of the GSM radio subsystem, SID frames are sent every 20ms to the GSM base station, which then picks only one every 480ms for downlink radio transmission. For other applications, like transport over Nb, it is more appropriate to send the SID frames less often than every 20ms, but 480ms may be too sparse. As a compromise it is recommended that an Encoder in the Media Gateway should generate and send SID frames every 160ms.

### 9.1.3 Initial Codec Mode

NOTE: At the Nb-Interface in a SIP-I -based Core Network, direct RTP packetization without Nb-framing is applied. Therefore the use of PDU Type 0 for the speech payload and PDU Type 14 [7] for AMR Rate Control is here not applicable. Also the principle of "Nb\_Init" is not applicable for a SIP-I -based Core Network.

The Initial Codec Mode for AMR and AMR-WB shall be derived by pre-defined rules from the AMR Configuration (Active Codec Set), see TS 45.009 [35], chapter 3.4.3 "Initial Codec Mode Selection at Call Setup and Handover".

Start of extract from TS 45.009 [35] for information and ease of reading:

"If the Initial Codec Mode is not signalled, then the default Initial Codec Mode is given by the following implicit rule. If the Active Codec Set contains:

1 mode, then this shall be the Initial Codec Mode;

2 or 3 modes, then the Initial Codec Mode shall be the most robust mode of the set (with lowest bit rate);

4 modes, then the Initial Codec Mode shall be the second most robust mode of the set (with second lowest bit rate."

End of extract from TS 45.009 [35].

In case of FR\_AMR (Set 1), i.e. Config-NB-Code 1, see below, this is the AMR Mode with 5.90kbps.

## 9.2 AMR

AMR (FR\_AMR, HR\_AMR, OHR\_AMR, UMTS\_AMR and UMTS\_AMR2) shall be packed according to IETF RFC 4867 [21].

The AMR Codec Types can be used in conversational speech telephony services in a number of different Codec Configurations. The set of preferred AMR Codec Configurations is defined in TS 28.062 [5], Table 7.11.3.1.3-2. One of these preferred Configurations, **Config-NB-Code 1**, is recommended for TFO-TrFO harmonisation between GSM and UMTS networks. This Configuration shall be supported in a SIP-I based circuit switched core network to ensure interoperability with an AoIP-based BSS. However, it is recommended that nodes in the core network support all AMR modes for maximum interoperability.

The bandwidth efficient mode of RFC 4867 shall be used. CRC and robust sorting shall not be applied.

To avoid delay, a single frame (Speech or SID\_FIRST or SID\_UPDATE or ONSET) shall be included in one RTP packet, Interleaving (redundancy) shall not be used, and a packetization time of 20ms shall be applied. No\_Data frames should not be sent, except when needed for urgent Rate Control.

Nodes in the core network (e.g. MGWs) transcoding between AMR and some other Codec shall observe the following rules:

- An AMR Encoder (sender) in the core network shall obey an AMR Codec Mode change period of 40ms, i.e. Codec Mode changes by the AMR Encoder (sender) in this core network node are only permissible at every second frame. This ensures maximum interoperability with any AMR receiver.

- An AMR Decoder (receiver) shall, however, be able to accept Codec Mode changes at any time.   
Variations of the Codec Mode period in receive direction may happen due to handover or other events during a conversation. The UMTS\_AMR Codec Type (only allowed in R99 UTRAN-only terminals) may change its Codec Mode any time. Other application of the AMR Codec Types (e.g. MTSI) may perform Codec Mode changes any time. This ensures maximum interoperability with any AMR sender.

- An AMR Encoder shall only change the Codec Mode to a neighbouring mode of the defined AMR Configuration (one step up or one step down), regardless which Rate Control command it receives. If necessary the AMR Encoder shall apply several Codec Mode changes in a row, if the received Rate Control command requests a change of more than one step. This ensures maximum interoperability with any AMR receiver, especially within GSM terminals.

- An AMR Decoder (receiver) shall, however, be able to accept Codec Mode changes in any step size. Variations of the Codec Mode in receive direction may happen due to handover or other events during a conversation. Other application of the AMR Codec Types (e.g. MTSI) may perform any Codec Mode changes. This ensures maximum interoperability with any AMR sender.

- DTX (SCR) shall be supported in send and receive direction.

AMR Rate Control shall use the CMR bits inside the RTP payload, both, in send and receive direction. RTCP shall not be used for AMR Rate Control in a CS core network.

Rate Control Commands coming from an Nb-Interface of a BICC-based Core Network, or an Iu-Interface, or an IMS-Interface, or an general VoIP-Interface, shall be converted to CMR and shall be send continuously inside RTP packets together with the next Speech or SID\_FIRST or SID\_UPDATE or ONSET frame.

NOTE: In a SIP-I -based Circuit Switched Core Network no Nb-framing is applied and so also no "PDU Type 14" [7] exists for Rate Control Commands.

It is allowed to send an artificially inserted No\_Data frame to transport an urgent CMR in RTP. Please note that a GSM radio subsystem connected via AoIP can not send No\_Data frames across the radio interface and will typically ignore such No\_Data frames. The use of No\_Data frames for CMR is especially helpful inside the Core Network at call setup to control the downlink mode for the Encoder inside the terminating MGW for the compression of the ringback tone or an announcement, when the originating MGW still blocks the speech path in forward direction to prevent fraud.

## 9.3 AMR-WB

AMR-WB (FR\_AMR-WB, OHR\_AMR-WB, OFR\_AMR-WB, UMTS\_AMR-WB) shall be packed according to IETF RFC 4867 [21].

The AMR-WB Codec Types can be used in conversational speech telephony services in a number of different Codec Configurations. The set of AMR-WB Codec Configurations is defined in TS 26.103 [14], Table 5.7-1. One of these Configurations, **Config-WB-Code** 0, shall be supported by all nodes supporting the AMR-WB codec in a SIP-I based circuit switched core network to ensure interoperability. However, it is recommended that nodes in the core network support all AMR-WB modes for maximum interoperability.

The bandwidth efficient mode of RFC 4867 [21] shall be used. CRC and robust sorting shall not be applied.

To avoid delay, a single frame (Speech or SID\_FIRST or SID\_UPDATE or ONSET) shall be included in one RTP packet, Interleaving (redundancy) shall not be used, and a packetization time of 20ms shall be applied. No\_Data frames should not be sent, except when needed for urgent Rate Control.

Nodes in the core network (e.g. MGWs) transcoding between AMR-WB and some other Codec shall observe the following rules:

- An AMR-WB Encoder (sender) in the core network shall obey an AMR-WB Codec Mode change period of 40ms, i.e. Codec Mode changes by the AMR-WB Encoder (sender) in this core network node are only permissible at every second frame. This ensures maximum interoperability with any AMR-WB receiver.

- An AMR-WB Decoder (receiver) shall, however, be able to accept Codec Mode changes at any time.   
Variations of the Codec Mode period in receive direction may happen due to handover or other events during a conversation. Other application of the AMR-WB Codec Types (e.g. MTSI) may perform Codec Mode changes any time. This ensures maximum interoperability with any AMR-WB sender.

- An AMR-WB Encoder shall only change the Codec Mode to a neighbouring mode of the defined AMR-WB Configuration (one step up or one step down), regardless which Rate Control command it receives. If necessary the AMR-WB Encoder shall apply several Codec Mode changes in a row, if the received Rate Control command requests a change of more than one step. This ensures maximum interoperability with any AMR-WB receiver, especially within GSM terminals.

- An AMR-WB Decoder (receiver) shall, however, be able to accept Codec Mode changes in any step size. Variations of the Codec Mode in receive direction may happen due to handover or other events during a conversation. Other application of the AMR-WB Codec Types (e.g. MTSI) may perform any Codec Mode changes. This ensures maximum interoperability with any AMR-WB sender.

- DTX (SCR) shall be supported in send and receive direction.

AMR-WB Rate Control shall use the CMR bits inside the RTP payload, both, in send and receive direction. RTCP shall not be used for AMR-WB Rate Control in a CS core network.

Rate Control Commands coming from an Nb-Interface of a BICC-based Core Network, or an Iu-Interface, or an IMS-Interface, or an general VoIP-Interface, shall be converted to CMR and shall be send continuously inside RTP packets together with the next Speech or SID\_FIRST or SID\_UPDATE or ONSET frame.

NOTE: In a SIP-I -based Circuit Switched Core Network no Nb-framing is applied and so also no "PDU Type 14" [7] exists for Rate Control Commands.

It is allowed to send an artificially inserted No\_Data frame to transport an urgent CMR in RTP. Please note that a GSM radio subsystem connected via AoIP can not send No\_Data frames across the radio interface and will typically ignore such No\_Data frames. The use of No\_Data frames for CMR is especially helpful on the AoIP-Interface in uplink and inside the Core Network at call setup to control the downlink mode for the Encoder inside the terminating MGW for the compression of the ringback tone or an announcement, when the originating MGW still blocks the speech path in forward direction to prevent fraud.

## 9.4 GSM\_EFR

GSM\_EFR shall be packed according to IETF RFC 3551 [17].

The coding of SID frames is based on the coding of Speech frames by setting the 95 bits of the so called "SID-Codeword" all to "1", see TS 46.062 [30].

To avoid delay, a single frame (Speech or SID) shall be included in one RTP packet, Interleaving (redundancy) shall not be used, and a packetization time of 20 ms shall be applied. No\_Data frames shall not be sent.

DTX shall be supported in send and receive direction.

GSM\_EFR frames received from some interface (e.g. a GSM radio interface via TFO) with a bad frame indication set to "bad" shall not be forwarded on the Nb-Interface in a SIP-I -based Circuit Switched Core Network, but silently discarded.

NOTE: RFC 3551 [17] does not support the concept of Bad Frame Indication.

## 9.5 GSM\_FR

GSM\_FR shall be packed according to IETF RFC 3551 [17].

The coding of SID frames is based on the coding of Speech frames by setting the 95 bits of the so called "SID-Codeword" all to "0", see TS 46.012 [28].

To avoid delay, a single frame (Speech or SID) shall be included in one RTP packet, Interleaving (redundancy) shall not be used, and a packetization time of 20ms shall be applied. No\_Date frames shall not be sent.

DTX shall be supported in send and receive direction.

GSM\_FR frames received from some interface (e.g. a GSM radio interface via TFO) with a bad frame indication set to "bad" shall not be forwarded on the Nb-Interface in a SIP-I based Circuit Switched Core Network, but silently discarded.

NOTE: RFC 3551 [17] does not support the concept of Bad Frame Indication.

## 9.6 GSM\_HR

GSM\_HR shall be packed according to [22].

The options specified in [22] are not applied inside the Circuit Switched Core Network, but set to pre-defined values as follows:  
A single frame (Speech or SID) shall be included in one RTP packet, FEC and Interleaving (redundancy) shall not be used, Encryption shall not be used, a packetization time of 20ms shall be applied. No\_Data frames shall not be sent.

DTX shall be supported in send and receive direction.

GSM\_HR frames received from some interface (e.g. a GSM radio interface via TFO) with a bad frame indication set to "bad" shall not be forwarded on the Nb-Interface in a SIP-I -based Circuit Switched Core Network, but silently discarded.

NOTE: [22] does not support the concept of Bad Frame Indication.

## 9.7 PCM

PCMU and PCMA shall be packed according to IETF RFC 3551 [17].

The PCM packetization time for a SIP-I -based Core Network is negotiated via SDP. The mandatory, default value is 20ms; 5ms is one other, optional value; no other packetization time shall be used. To avoid delay, a single frame of length equal to the packetization time shall be included in one RTP packet, Interleaving (redundancy) shall not be used.

The usage of DTX for PCM-coded speech is not recommended for NboIP.

## 9.8 Telephone-Event

Telephony-Event (DTMF) shall be encoded according to IETF RFC 4733 [20].

The audio/telephone-event payload type in IETF RFC 4733 [20] with default events and default rate shall be used to encode DTMF, if compressed speech is used in a SIP-I -based Core Network. Only in case of PCM-coded speech on NboIP the Telephone-Event is optional, i.e. also inband DTMF tones may be used (see TS 23.231 [12]).

# 10 A-Interface User Plane over IP

## 10.1 Overview

The A interface User Plane over IP (AoIP) is standardised in the 3GPP TS 48-series (mainly in TS 48.008) [33] for the Control Plane and in TS 48.103 [34] for the User Plane).

For AoIP the same Codecs as described in Clause 9 are applicable, except telephone-event, see table 10.1.1. Those Codecs shall also be applied in the same manner as described in Clause 9, unless otherwise specified in the present Clause 10.

Table 10.1.1 Supported Codec Types for the A interface User Plane over IP

|  |  |  |  |
| --- | --- | --- | --- |
| **Payload Type Name** | **References** | **Remarks** | **Support** |
| audio/AMR | IETF RFC 4867 [21] | Applicable for FR\_AMR, HR\_AMR, OHR\_AMR | Optional.  Not all AMR Configurations are mandatory. Some Configurations are preferred, see chapter 9. |
| audio/AMR-WB | IETF RFC 4867 [21] | Applicable for FR\_AMR-WB, OHR\_AMR-WB, OFR\_AMR-WB | Optional.  AMR-WB is mandatory, if WB speech is supported.  Not all AMR-WB Configurations are mandatory, see chapter 9 |
| audio/GSM\_EFR | IETF RFC 3551 [17] |  | Optional |
| audio/GSM\_FR | IETF RFC 3551 [17] |  | Mandatory |
| audio/GSM\_HR | IETF RFC 5993 [22] |  | Optional |
| audio/PCMA | IETF RFC 3551 [17] | ITU-T G.711 Alaw | Optional |
| audio/PCMU | IETF RFC 3551 [17] | ITU-T G.711 ulaw | Optional |

The RTP "Payload Type" for AoIP is pre-determined by 3GPP TS 48.103 [34] for all Codec Types (static payload type).

### 10.1.1 Time Alignment Procedure

Time Alignment (and AMR Phase Alignment) is not specified for AoIP.

### 10.1.2 SID Frame Generation

All 3GPP Codec Types include standardized Discontinuous Transmission (DTX) with Voice Activity Detection, Silence Description (by SID frames) and Comfort Noise Generation to fill the speech pauses. If speech inactivity is detected by the Encoder, then (speech) frames are not transmitted, but the transmission is suspended in order to save battery life time in the mobile station, reduce interference on the radio interface and reduce load on all links. The receiving Decoder fills these transmission pauses with Comfort Noise to minimize the contrast between pauses and active speech. Silence Descriptor frames need to be send during speech inactivity to keep the Comfort Noise decently well aligned with the background noise at sender side. This is especially important at the onset of the next talk spurt and therefore SID frames should not be too old, when speech starts again.

The generation of SID frames for the AMR and AMR-WB families of Codecs is determined by the Speech Encoder as specified in TS 26.093 [31], respectively TS 26.193 [32]. The radio subsystem does not influence this timing! SID frames come during speech pauses in uplink and downlink about every 160ms. Also an AMR Encoder in the Media Gateway generates and sends SID frames about every 160ms.

The generation of SID frames for GSM\_FR, GSM\_HR and GSM\_EFR in the GSM radio network is determined by the GSM mobile station and the GSM radio subsystem, not primarily by the Speech Encoder! SID frames come during speech pauses in uplink from the mobile station about every 480ms. In downlink to the mobile station, when they are generated by the Speech Encoder of the GSM radio subsystem, SID frames are sent every 20ms to the GSM base station, which then picks only one every 480ms for downlink radio transmission. For other applications, like transport over the A-Interface, it is more appropriate to send the SID frames less often than every 20ms, but 480ms may be too sparse. As a compromise it is recommended that an Encoder in the Media Gateway should generate and send SID frames every 160ms.

### 10.1.3 Initial Codec Mode

The Initial Codec Mode for AMR and AMR-WB shall be derived by pre-defined rules from the AMR Configuration (Active Codec Set), see TS 45.009 [35], chapter 3.4.3 "Initial Codec Mode Selection at Call Setup and Handover".

Start of extract from TS 45.009 [35] for information and ease of reading:

"If the Initial Codec Mode is not signalled, then the default Initial Codec Mode is given by the following implicit rule. If the Active Codec Set contains:

1 mode, then this shall be the Initial Codec Mode;

2 or 3 modes, then the Initial Codec Mode shall be the most robust mode of the set (with lowest bit rate);

4 modes, then the Initial Codec Mode shall be the second most robust mode of the set (with second lowest bit rate."

End of extract from TS 45.009 [35].

In case of FR\_AMR (Set 1), i.e. Config-NB-Code 1, see below, this is the AMR Mode with 5.90 kbps.

## 10.2 AMR

AMR (FR\_AMR, HR\_AMR, OHR\_AMR) shall be packed according to IETF RFC 4867 [21].

The AMR Codec Types can be used in conversational speech telephony services in a number of different Codec Configurations. The set of preferred AMR Codec Configurations is defined in TS 28.062 [5], Table 7.11.3.1.3-2. One of these preferred Configurations, **Config-NB-Code 1**, is recommended for TFO-TrFO harmonisation between GSM and UMTS networks. This Configuration shall be supported in an AoIP supporting BSS and an AoIP supporting Circuit Switched Core Network to ensure interoperability. However, it is recommended that a BSS and Circuit Switched Core Network supports all AMR modes for maximum interoperability.

The bandwidth efficient mode of RFC 4867 [21] shall be used. CRC and robust sorting shall not be applied.

To avoid delay, a single frame (Speech or SID\_FIRST or SID\_UPDATE or ONSET) shall be included in one RTP packet, Interleaving (redundancy) shall not be used, and a packetization time of 20ms shall be applied. No\_Data frames should not be sent downlink across AoIP, except to transport an urgent CMR in RTP. The use of No\_Data frames for CMR is especially helpful on the AoIP-Interface in uplink and inside the Core Network at call setup to control the downlink mode for the Encoder inside the terminating MGW for the compression of the ringback tone or an announcement, when the originating MGW still blocks the speech path in forward direction to prevent fraud.

Please note that a GSM radio subsystem can not send No\_Data frames across the radio interface and will typically ignore such No\_Data frames in downlink direction.

DTX (SCR) shall be supported in send and receive direction.

AMR Rate Control shall use the CMR bits inside the RTP payload, both, in send and receive direction. RTCP shall not be used for AMR Rate Control in a CS network.

## 10.3 AMR-WB

AMR-WB (FR\_AMR-WB, OHR\_AMR-WB, OFR\_AMR-WB) shall be packed according to IETF RFC 4867 [21].

The AMR-WB Codec Types can be used in conversational speech telephony services in a number of different Codec Configurations. The set of AMR-WB Codec Configurations is defined in TS 26.103 [14], Table 5.7-1. One of these Configurations, **Config-WB-Code** **0,** shall be supported by all nodes supporting the AMR-WB codec in an AoIP-supporting BSS and an AoIP-supporting Circuit Switched Core Network to ensure interoperability. However, it is recommended that nodes in the Core Network support all AMR-WB modes for maximum interoperability.

The bandwidth efficient mode of RFC 4867 [21] shall be used. CRC and robust sorting shall not be applied.

To avoid delay, a single frame (Speech or SID\_FIRST or SID\_UPDATE or ONSET) shall be included in one RTP packet, Interleaving (redundancy) shall not be used, and a packetization time of 20ms shall be applied. No\_Data frames should not be sent downlink across AoIP, except to transport an urgent CMR in RTP. The use of No\_Data frames for CMR is especially helpful on the AoIP-Interface in uplink and inside the Core Network at call setup to control the downlink mode for the Encoder inside the terminating MGW for the compression of the ringback tone or an announcement, when the originating MGW still blocks the speech path in forward direction to prevent fraud.

Please note that a GSM radio subsystem can not send No\_Data frames across the radio interface and will typically ignore such No\_Data frames in downlink direction.

DTX (SCR) shall be supported in send and receive direction.

AMR-WB Rate Control shall use the CMR bits inside the RTP payload, both, in send and receive direction. RTCP shall not be used for AMR-WB Rate Control in a Circuit Switched Core Network.

## 10.4 GSM\_EFR

GSM\_EFR shall be packed according to IETF RFC 3551 [17].

The coding of SID frames is based on the coding of Speech frames by setting the 95 bits of the so called "SID-Codeword" all to "1", see TS 46.062 [30].

To avoid delay, a single frame (Speech or SID) shall be included in one RTP packet, Interleaving (redundancy) shall not be used, and a packetization time of 20 ms shall be applied. No\_Data frames shall not be sent.

DTX shall be supported in send and receive direction.

NOTE: RFC 3551 [17] does not support the concept of Bad Frame Indication. Therefore missing GSM\_EFR frames in the AoIP downlink direction (e.g. discarded by a network node due to the missing bad frame indication) need to be properly treated within the BSS before sending downlink on the radio interface. Details are not specified.

## 10.5 GSM\_FR

GSM\_FR shall be packed according to IETF RFC 3551 [17].

The coding of SID frames is based on the coding of Speech frames by setting the 95 bits of the so called "SID-Codeword" all to "0", see TS 46.012 [28].

To avoid delay, a single frame (Speech or SID) shall be included in one RTP packet, Interleaving (redundancy)shall not be used, and a packetization time of 20 ms shall be applied. No\_Data frames shall not be sent.

DTX shall be supported in send and receive direction.

NOTE: RFC 3551 [17] does not support the concept of Bad Frame Indication. Therefore missing GSM\_EFR frames in the AoIP downlink direction (e.g. discarded by a network node due to the missing bad frame indication) need to be properly treated within the BSS before sending downlink on the radio interface. Details are not specified.

## 10.6 GSM\_HR

GSM\_HR shall be packed according to [22].

The options specified in [22] are not applied on AoIP, but set to pre-defined values as follows:  
A single frame (Speech or SID) shall be included in one RTP packet, FEC and Interleaving (redundancy) shall not be used, Encryption shall not be used, a packetization time of 20ms shall be applied. No\_Data frames shall not be sent.

DTX shall be supported in send and receive direction.

NOTE: [22] does not support the concept of Bad Frame Indication. Therefore missing GSM\_HR frames in the AoIP downlink direction (e.g. discarded by a network node due to the missing bad frame indication) need to be properly treated within the BSS before sending downlink on the radio interface. Details are not specified.

## 10.7 PCM

PCMU and PCMA shall be packed according to IETF RFC 3551 [17].

A packetization time of 20ms shall be applied for PCM on AoIP. The packetization time is not negotiated for AoIP. To avoid delay, a single frame of 20ms shall be included in one RTP packet, Interleaving (redundancy) shall not be used.

The usage of DTX for PCM-coded speech is not allowed on AoIP.

Annex A (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Change history | | | | | | | |
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 1999-12 | 6 | SP-99563 |  |  | Approved at TSG-SA#6 Plenary |  | 3.0.0 |
| 2000-03 | 7 | SP-000025 | 001 | 3 | Introduction of QoS parameters used at RAB assignment | 3.0.0 | 3.1.0 |
| 2000-03 | 7 | SP-000025 | 002 |  | Introduction of different RFCS set on Iu User Plane | 3.0.0 | 3.1.0 |
| 2000-03 | 7 | SP-000025 | 003 | 2 | Introduction of Time Alignment | 3.0.0 | 3.1.0 |
| 2000-12 | 10 | SP-000575 | 005 | 1 | AMR interface to Iu | 3.1.0 | 3.2.0 |
| 2001-03 | 11 | SP-010103 | 006 | 2 | Removal of TFO and TrFO from Release 99, and removal of Initial Time Alignment | 3.2.0 | 3.3.0 |
| 2001-03 | 11 | SP-010103 | 008 | 1 | Introduction of TFO and TrFO | 3.3.0 | 4.0.0 |
| 2002-06 | 16 |  |  |  | Version for Release 5 | 4.0.0 | 5.0.0 |
| 2002-12 | 18 | SP-020689 | 012 | 2 | Correction of RAB parameter assignment for AMR | 5.0.0 | 5.1.0 |
| 2003-03 | 19 | SP-030087 | 015 | 2 | AMR Rate Adaptation of Rel-5 | 5.1.0 | 5.2.0 |
|  |  |  |  |  |  |  |  |
| 2004-04 | 25 | SP-040645 | 016 | 1 | Mapping of GSM\_EFR SID on Nb Interface | 5.2.0 | 6.0.0 |
|  |  |  |  |  |  |  |  |
| 2005-12 | 30 | SP-050791 | 0017 |  | 20 ms packetisation time for PCM coded speech over IP Nb | 6.0.0 | 7.0.0 |
| 2006-06 | 32 | SP-060358 | 0018 | 1 | Supplement of 20 ms packetisation time for PCM coded speech over IP Nb | 7.0.0 | 7.1.0 |
| 2008-06 | 41 | SP-080475 | 0019 | 2 | Addition of CS over IP User Plane | 7.1.0 | 8.0.0 |
| 2008-06 | 41 | SP-080475 | 0020 | 1 | Nb-framing for GSM\_FR and GSM\_HR | 7.1.0 | 8.0.0 |
| 2008-12 | 42 | SP-080678 | 0021 | 3 | Corrections to CS over IP User Plane | 8.0.0 | 8.1.0 |
| 2009-09 | 45 | SP-090568 | 0023 | 1 | Clarification of RAB sub-flow numbering for AMR | 8.1.0 | 8.2.0 |
| 2009-12 | 46 | SP-090703 | 0024 | 1 | Correction of payload field size for mapping of GSM FR on Nb interface | 8.2.0 | 8.3.0 |
| 2009-12 | 46 |  |  |  | Version for Release 9 | 8.3.0 | 9.0.0 |
| 2010-03 | 47 | SP-100018 | 0026 |  | Corrections and clarifications of Nb frames | 9.0.0 | 9.1.0 |
| 2011-03 | 51 | SP-110034 | 0028 |  | Correction of reference for GSM-HR payload format | 9.1.0 | 9.2.0 |
| 2011-03 | 51 |  |  |  | Version for Release 10 | 9.2.0 | 10.0.0 |
| 2012-09 | 57 | SP-120508 | 0029 | 2 | Clarification of Text Regarding Bit Protection Classes and RAB sub-flows | 10.0.0 | 11.0.0 |
| 2014-09 | 65 |  |  |  | Version for Release 12 | 11.0.0 | 12.0.0 |
| 2015-12 | 70 |  |  |  | Version for Release 13 | 12.0.0 | 13.0.0 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2016-09 | 73 | SP-160601 | 0031 | 1 | F | Clarification to avoid rate adaptation quality issues in uplink for UTRAN | 14.0.0 |
| 2018-06 | 80 |  |  |  |  | Version for Release 15 | 15.0.0 |
| 2020-07 | - | - | - | - | - | Update to Rel-16 version (MCC) | **16.0.0** |