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| 3GPP TR 26.858 V0.6.0 (2025-07) |
| Technical Report |
| 3rd Generation Partnership Project;Technical Specification Group SA4;Study on APIs for 3GPP Speech and Audio Codecs(Release 19) |
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For definitive guidance on drafting 3GPP TSs and TRs, see [3GPP TS 21.801](http://www.3gpp.org/DynaReport/21801.htm) supplemented by the 3GPP web page <http://www.3gpp.org/specifications-groups/delegates-corner/writing-a-new-spec>.

Ensure all blue guidance text is removed before submitting the TS/TR to the TSG for approval.

# Foreword

This clause is mandatory; do not alter the text in any way other than to choose between "Specification" and "Report".

This Technical Report 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:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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.

In drafting the TS/TR, pay particular attention to the use of modal auxiliary verbs! TRs shall not contain any normative provisions.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# Introduction

This clause is optional. If it exists, it shall be the second unnumbered clause.

# 1 Scope

This clause shall start on a new page.

The present document …

# 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 TR 21.905: "Vocabulary for 3GPP Specifications".

[c1] Codec Registry, W3C Draft Registry, 9 September 2024, <https://www.w3.org/TR/webcodecs-codec-registry>.

[c2] WebCodecs, W3C Working Draft, 8 July 2025, [https://www.w3.org/TR/webcodecs/#dictdef-audioencoderconfig](https://www.w3.org/TR/webcodecs/%22%20%5Cl%20%22dictdef-audioencoderconfig).

[c3] WebCodecs W3C Working Draft, 8 July 2025,  [https://www.w3.org/TR/webcodecs/#audio-decoder-config](https://www.w3.org/TR/webcodecs/%22%20%5Cl%20%22audio-decoder-config)

…

[x] <doctype> <#>[ ([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

It is preferred that the reference to 21.905 be the first in the list.

# 3 Definitions of terms, symbols and abbreviations

This clause and its three subclauses are mandatory. The contents shall be shown as "void" if the TS/TR does not define any terms, symbols, or abbreviations.

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Definition format (Normal)

**<defined term>:** <definition>.

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

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

Symbol format (EW)

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

Abbreviation format (EW)

<ABBREVIATION> <Expansion>

# 4 Interfaces of codecs and other processing blocks

# 5 Web Interfaces for codecs and other processing blocks

[

## 5.1 Introduction

## 5.2 WebCodecs API

### 5.2.1 Introduction

The WebCodecs API is a powerful web API that provides developers with low-level access to the individual frames of a video stream and chunks of audio. It is particularly useful for web applications that require full control over the way media is processed, such as video or audio editors, and video conferencing applciations.

The WebCodecs API provides access to codecs that are already in the browser, eliminating the need for additional software codecs and leveraging the existing hardware acceleration on the device. It gives access to raw video frames, chunks of audio data, image decoders, audio and video encoders, and decoders.

The WebCodecs API uses an asynchronous processing model. Each instance of an encoder or decoder maintains an internal, independent processing queue. Methods named configure(), encode(), decode(), and flush() operate asynchronously by appending control messages to the end of the queue, while methods named reset() and close() synchronously abort all pending work and purge the processing queue.

The WebCodecs API provides several interfaces:

- AudioDecoder: Decodes EncodedAudioChunk objects.

- VideoDecoder: Decodes EncodedVideoChunk objects.

- AudioEncoder: Encodes AudioData objects.

- VideoEncoder: Encodes VideoFrame objects.

- EncodedAudioChunk: Represents codec-specific encoded audio bytes.

- EncodedVideoChunk: Represents codec-specific encoded video bytes.

- AudioData: Represents unencoded audio data.

- VideoFrame: Represents a frame of unencoded video data.

- VideoColorSpace: Represents the color space of a video frame.

- ImageDecoder: Unpacks and decodes image data, giving access to the sequence of frames in an animated image.

- ImageTrackList: Represents the list of tracks available in the image.

- ImageTrack: Represents an individual image track.

The following table provides a simple example code for the usage of WebCodecs to demonstrate the functionality of the WebCodecs API:

|  |
| --- |
| // Create a new VideoDecoder and configure itconst init = { output: handleFrame, error: (e) => { console.log(e.message); },};const config = { codec: "hevc", codedWidth: 1280, codedHeight: 720};let decoder = new VideoDecoder(init);decoder.configure(config);// Create a new VideoEncoder and configure itlet encoder = new VideoEncoder({ output: (chunk) => { const buffer = new ArrayBuffer(chunk.byteLength); chunk.copyTo(buffer); chunks.push(buffer); }, error: (e) => console.error(e.message)});encoder.configure({ codec: 'hevc', width: 1280, height: 720, bitrate: 2000000, framerate: 25});// Encode every image as a frame track.requestFrame().then((frame) => { encoder.encode(frame, {keyFrame: true}); frame.close(); }); // Create a video from it encoder.flush().then(() => { const blob = new Blob(chunks, {type: 'video/webm; codecs=vp8'}); const url = URL.createObjectURL(blob); decoder.decode(new EncodedVideoChunk({ type: 'key', timestamp: 0, data: blob })); });}).catch((error) => { console.error("Error: ", error);}); |

A full example can be found under <https://bouazizi.dev/webcodecs/>

### 5.2.2 Codec Registration Procedure

The codec registration procedure for new codecs is defined by W3C in [2]. The registration request should define the EncodedAudioChunk or EncodedVideoChunk format as well as the configuration data format in AudioDecoderConfig or VideoDecoderConfig. These structures may be extended to carry codec-specific information.

The request must then be sent to the GitHub issue trucker of WebCodecs for evaluation.

### 5.2.3 Configuration Properties for 3GPP Speech and Audio Codecs

#### 5.2.3.1 Introduction

For 3GPP speech and audio codecs the configuration properties were extracted, based on the APIs in Annex <A>, to allow full configuration for application as WebCodecs.

#### 5.2.3.2 AudioEncoder Configuration

The WebCodecs AudioEncoder interface supports the configure() method allowing for tuning encoder configuration using the dictionary data structure AudioEncoderConfig. The AudioEncoderConfig API defined in [c2] allows for codec-specific extensions to this dictionary as shown below: -

|  |
| --- |
| dictionary AudioEncoderConfig { required DOMString codec; [EnforceRange] require] allows long sampleRate; [EnforceRange] required unsigned long numberOfChannels; [EnforceRange] unsigned long long bitrate; BitrateMode bitrateMode = "variable";}; |

The dicitionary with combinations of the paramaters (e.g. sampleRate, numberOfChannels but also other entries) can be validated using the isConfigSupported(config) method of Audio Encoder interface. Some of the encoder configuration elements may correspond to initialization time parameters (e.g. dtx or input format) while others are expected to be updated throughout the encoding session (e.g. ism/masa metadata in case of IVAS), it should not be necessary to provide all configuration data at all times. Thus, an encoder configuration with only the updated parameters can be provided to ease packing/parsing efforts.

The identified encoder and decoder configuration properties are listed in Tables 1 and 2, respectively.

Table 1: Encoder Configuration Properties

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Codec | Property | Description | Type | Default |
| AMR | bitRate | Bitrate in bits per second (e.g., 4750, 5150, 12200) | integer | 12200 |
| AMR | allowDtx | Enable Discontinuous Transmission (DTX) | boolean | false |
| AMR-WB | bitRate | Bitrate in bits per second (e.g., 6600, 8850, 23850) | integer | 23850 |
| AMR-WB | allowDtx | Enable Discontinuous Transmission (DTX) | boolean | false |
| AMR-WB+ | bitRate | Bitrate in bits per second (e.g., 8000, 16000, 24000) | integer | 24000 |
| AMR-WB+ | stereo | Enable stereo encoding | boolean | false |
| EVS | bitRate | Bitrate in bits per second (e.g., 9600, 13200, 24400) | integer | 13200 |
| EVS | bandwidth | Bandwidth mode (one of "NB", "WB", "SWB", "FB") | string | WB |
| EVS | dtx | DTX interval for adaptive SID (0 for adaptive intervals) | integer | 0 |
| EVS | partialCopyOffset | Offset for partial copies in channel-aware mode | integer | 3 |
| EVS | fecIndicator | FEC indicator for channel-aware mode (either "HI" or "LO") | string | HI |
| IVAS | inputFormat | Coded format for Immersive audio, one of (MONO, STEREO, BINAURAL, FOA\_PLANAR, HOA2\_PLANAR, HOA3\_PLANAR, FOA, HOA2, HOA3, MASA1, MASA2, ISM1, ISM2, ISM3, ISM4, ISM1\_EXTENDED\_METADATA, ISM2\_EXTENDED\_METADATA, ISM3\_EXTENDED\_METADATA, ISM4\_EXTENDED\_METADATA, MC\_5\_1, MC\_7\_1, MC\_5\_1\_2, MC\_5\_1\_4, MC\_7\_1\_4, OMASA\_ISM1\_1TC, OMASA\_ISM2\_1TC, OMASA\_ISM3\_1TC, OMASA\_ISM4\_1TC, OMASA\_ISM1\_2TC, OMASA\_ISM2\_2TC, OMASA\_ISM3\_2TC, OMASA\_ISM4\_2TC, OSBA\_ISM1\_FOA\_PLANAR, OSBA\_ISM2\_FOA\_PLANAR, OSBA\_ISM3\_FOA\_PLANAR, OSBA\_ISM4\_FOA\_PLANAR, OSBA\_ISM1\_FOA, OSBA\_ISM2\_FOA, OSBA\_ISM3\_FOA, OSBA\_ISM4\_FOA, OSBA\_ISM1\_HOA2\_PLANAR, OSBA\_ISM2\_HOA2\_PLANAR, OSBA\_ISM3\_HOA2\_PLANAR, OSBA\_ISM4\_HOA2\_PLANAR, OSBA\_ISM1\_HOA2, OSBA\_ISM2\_HOA2, OSBA\_ISM3\_HOA2, OSBA\_ISM4\_HOA2, OSBA\_ISM1\_HOA3\_PLANAR, OSBA\_ISM2\_HOA3\_PLANAR, OSBA\_ISM3\_HOA3\_PLANAR, OSBA\_ISM4\_HOA3\_PLANAR, OSBA\_ISM1\_HOA3, OSBA\_ISM2\_HOA3, OSBA\_ISM3\_HOA3, OSBA\_ISM4\_HOA3) | enum | "MONO" |
| IVAS | bandwidth | Bandwidth mode (one of "NB", "WB", "SWB", "FB") | enum | "FB" |
| IVAS | allowDtx | Enable Discontinuous Transmission (DTX) | boolean | false |
| IVAS | dtxInterval | DTX interval in frames for adaptive SID (0 for adaptive intervals, 3-100) | integer | 0 |
| IVAS | ismMetadata | Additional metadata specific to each ISM Objects (binary byte buffer) | ArrayBuffer | - |
| IVAS | masaMetadata | Additional metadata specific to parametric MASA metadata (binary byte buffer) | ArrayBuffer | - |

#### 5.2.3.3 AudioDecoder Configuration

Unlike AudioEncoderConfig, the AudioDecoderConfig does not expose an extension config per codec in the Web Codec API. The AudioDecoderConfig is generally defined in [c3] with just a “description” field which is defined as codec-specific bytes as shown below.

|  |
| --- |
| dictionary AudioDecoderConfig { required DOMString codec; [EnforceRange] required unsigned long sampleRate; [EnforceRange] required unsigned long numberOfChannels; AllowSharedBufferSource description;}; |

The identified decoder configuration properties are listed in Table 2, respectively.

Table 2: Decoder Configuration Elements

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Codec | Property | Description | Type | Default |
| AMR | None | AMR decoder does not require additional config options | N/A | N/A |
| AMR-WB | None | AMR-WB decoder does not require additional config options | N/A | N/A |
| AMR-WB+ | stereo | Enable stereo decoding | boolean | false |
| EVS | outputSampleRate | Output sample rate (8000, 16000, 32000, 48000) | integer | 16000 |

The 3GPP decoder can utilize output sample-rate and number of channels configuration from AudioDecoderConfig. However, there are additional configuration parameters that are needed for full support of IVAS decoder API. Some of these configurations is listed below:

Table 3: IVAS Decoder Specific Configuration Elements

|  |  |
| --- | --- |
| Parameter | Description |
| outputFormat | Output configuration (e.g. "MONO", "STEREO", "BINAURAL", "5\_1", "7\_1", "5\_1\_2", "5\_1\_4", "7\_1\_4", "LS\_CUSTOM", "EXT",…) |
| headTrackData | Head Tracking metadata like orientation and position (binary byte buffer) |
| customHRTF | Custom HRTF metadata (binary byte buffer) |
| customLoudspeaker | Custom loudspeaker setup data (binary byte buffer) |
| ivasConfigData | More data useful for IVAS decoding/rendering (binary byte buffer) |
| …. | … |

More IVAS specific parameters can be added to Table 3. ivasConfigData can be seen as a placeholder for any such parameters that are needed for decoding/rendering.

The description field of AudioDecoderConfig is a byte buffer which can take codec-specific data. It can be utilized to provide a key-value pair representation for IVAS decoder-specific configurations. A JSON representation can be used to provide extensibility and easy encapsulation in web-browser context to encode into the byte buffer. An example is shared below: -

### **Example of a IVAS Decoder using Binaural rendering with Head Tracking**

|  |
| --- |
| description = { "outputFormat": "BINAURAL", "headTrackData": {"w": 1.0, "x": 0.2, "y": 2.1, "z": 0.0}} |

As is the case with the IVAS encoder, since some of the IVAS decoder configuration elements may correspond to initialization-time parameters (e.g. custom HRTF) while others are expected to be updated throughout the session (e.g. head tracking data), it should not be necessary to provide all configuration parameters at once. Thus, a configuration with only the updated parameters can be provided to ease packing/parsing efforts.

NOTE: For time varying metadata configurations, where metadata may change on frame boundary, configure() calls should precede decode() calls.

### 5.2.4 AudioData

#### 5.2.4.1 IVAS Split Rendering Mode

IVAS in split rendering mode produces a bitstream output containing a reference binaural signal and additional metadata. In such a case, the AudioData output from the decoder should specify format field as “null” and numberOfChannels = 1, numberOfFrames = bitstream length in bytes. The caller of the WebCodec API should ensure that this output is correctly routed to necessary transport.

|  |
| --- |
| // Output AudioData buffer**dictionary** AudioDataInit { **required AudioSampleFormat** format; **required float** sampleRate; **[EnforceRange] required unsigned long** numberOfFrames; **[EnforceRange] required unsigned long** numberOfChannels; **[EnforceRange] required long long** timestamp; // microseconds **required BufferSource** data; **sequence<ArrayBuffer>** transfer = [];};//format = null to indicate bitstream (i.e. not PCM)//numberOfFrames = bitstream length in bytes//numberOfChannels = 1 |

]

## 5.3 WebRTC

### 5.3.1 Introduction

Editor’s Note: Should contain a better introduction of WebRTC in general.

Traditionally, WebRTC has bundled media capture, encoding/decoding, and transport into a single, convenient-to-use solution. This bundling enabled rapid development of browser-based real-time communication applications, hiding many of the details to application developers. Those details are usually only known to RTP and VoIP experts. Hiding them democratizes real-time communications, but comes with the limitations of a single solution trying to cover all applications.

Especially in the mobile communications domain the existing non-WebRTC solutions were always defined with the goal of highly efficient transmission to manage a large user-base with high QoE with reasonable operation costs. Therefore, 3GPP defined – and still is defining - a series of codecs that provided at their time the best quality when a call was made over the 3GPP networks. Those codecs however are not part of the general purpose WebRTC solution, which originates from the IETF/W3C domains with different optimization criteria than 3GPP.

Previous analysis of this situation was one the reasons for the FS\_ACAPI work item, to combine the two worlds of convenient-to-use WebRTC but using the codecs of 3GPP optimized for its networks. It was however also identified previously that simply extending WebRTC with the 3GPP codecs is non-trivial, as WebRTC implementations in the browsers come with their own limited set of codecs for WebRTC usage, not supporting otherwise available WebCodecs or the on-device 3GPP codecs when operating in 3GPP UEs. At the same time there were no interfaces other than the RTCPeerConnection APIs, forcing developers to use the high-level convenience APIs, bundling all the previously mentioned RTC key components.

### 5.3.2 WebRTC libraries

#### 5.3.2.1 Introduction

When WebRTC was defined it reflected the browser-focused API for Google’s “libwebrtc”. While this library is still the most influential one due to it being used in all browsers, other libraries surfaced that differ in terms of the language they’re written in but also feature set, sometimes addressing very special needs for e.g. server applications. This document will put a spotlight on the following libraries:

* libWebRTC
* pion
* Aiortc
* Sipsorcery
* Gstreamer
* webrtc-rs
* str0m
* libdatachannel
* Elixir

#### 5.3.2.3 Libwebrtc

Libwebrtc is the original WebRTC implementation, developed and maintained by Google in C++. It serves as the backbone for WebRTC in many browsers and is continuously updated to follow evolving standards and browser requirements.

#### 5.3.2.4 pion

The pion library is a lightweight and modular WebRTC implementation written in Go. It is popular among developers building media servers (e.g., LiveKit) and server-side RTC solutions, thanks to its ease of integration and active community.

#### 5.3.2.5 aiortc

aiortc is an asynchronous WebRTC (and ORTC) implementation for Python. It is designed for rapid prototyping, educational purposes, and lightweight real-time communication applications, making it a popular choice in the Python community.

#### 5.3.2.6 sipsorcery

sipsorcery is a .NET library written in C# that combines SIP (Session Initiation Protocol) and WebRTC capabilities. It is aimed at building robust communication solutions on Microsoft platforms.

#### 5.3.2.7 GStreamer

GStreamer is a comprehensive multimedia framework written primarily in C. It allows developers to construct complex media-handling pipelines for applications ranging from media players to real-time communication systems. Its modular, plugin-based architecture means that many codecs and processing components are available.

#### 5.3.2.8 webrtc-rs

webrtc-rs is a Rust implementation of WebRTC that leverages Rust’s memory safety and performance characteristics. Its design focuses on handling connection, signalling, and protocol aspects of WebRTC.

#### 5.3.2.9 Str0m

Str0m is another Rust-based library that provides WebRTC connection functionalities such as signalling, ICE, and DTLS. It is designed to be minimal and lightweight.

#### 5.3.2.10 libdatachannel

Despite its name, libdatachannel supports more than just data channels—it also enables media connections within a WebRTC context. It is written in C/C++ and is designed for efficiency and portability.

#### 5.3.2.11 Elixir WebRTC

The Elixir WebRTC implementations leverage the strengths of the Erlang VM, such as high concurrency and fault tolerance. Rather than embedding media processing, these implementations typically rely on external tools (for example, FFmpeg) for handling media.

#### 5.3.2.12 Summary

Table 4: Encoder Configuration Properties

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Library | Language | Project URL | Audio Codec Support | Notes |
| Libwebrtc | C++ | [webrtc.googlesource.com](https://webrtc.googlesource.com) / [webrtc.org](https://webrtc.org) | G.711, G.722, CNG, Opus, ISAC, PCM16, redundancy | Reference implementation maintained by Google. |
| pion | Go | [github.com/pion/webrtc](https://github.com/pion/webrtc) | G.711, G.722, Opus | Popular in media servers (e.g., LiveKit); modular and lightweight. |
| aiortc | Python | [github.com/aiortc/aiortc](https://github.com/aiortc/aiortc) | G.711, Opus | Asynchronous implementation ideal for prototyping and educational purposes. |
| sipsorcery | C# | [github.com/sipsorcery-org/sipsorcery](https://github.com/sipsorcery-org/sipsorcery) | G.711, G.722, G.729 (Opus available but not activated) | Integrates SIP and WebRTC for .NET applications. |
| GStreamer | C (plugins in various languages) | [gstreamer.freedesktop.org](https://gstreamer.freedesktop.org) | WebRTC plugins support raw audio, Opus (plus many others in full ecosystem) | A comprehensive media framework with a modular, plugin-based architecture. |
| webrtc-rs | Rust | [github.com/webrtc-rs/webrtc](https://github.com/webrtc-rs/webrtc) | None (requires external codec integration) | Focuses on WebRTC connection and signaling aspects; codec support must be added by users. |
| Str0m | Rust | [github.com/str0m/str0m](https://github.com/str0m/str0m) | None | Minimalist design with no media encoding/decoding support. |
| libdatachannel | C/C++ | [github.com/paullouisageneau/libdatachannel](https://github.com/paullouisageneau/libdatachannel) | None (developers must integrate codecs) | Emphasizes data channels; media transport is supported but not media processing. |
| Elixir WebRTC | Elixir | [github.com/elixir-webrtc](https://github.com/elixir-webrtc)  | None (relies on external tools like FFmpeg) | Leverages Erlang VM strengths; media handling is offloaded to external solutions. |

### 5.3.3 RTPTransport

Previously, WebRTC only exposed the very high-level APIs for IP/UDP/RTP transmission, while no lower level APIs at e.g. UDP level was provided in browsers. Alternative APIs such as WebSockets and the WebRTC Data Channel would also permit other ways of real-time transmission but no generic IP/UDP/RTP. Now RTPTransport exposes the RTP layer, thus enabling IP/UDP/RTP transmission in a custom manner.

The RTPTransport specification proposes to expose the RTP transport layer as a first-class API. This means that applications can now directly interact with the mechanisms for packetizing, transmitting, and receiving RTP packets. This includes:

* Separation of Concerns: By decoupling transport from media processing (i.e., encoding/decoding), developers can manage the network-level operations (like encryption, packet scheduling, and header management) separately from the codec logic.
* Flexibility in Signaling and Negotiation: The API allows for more granular control over how RTP parameters (payload types, header extensions, SSRC, etc.) are set up and negotiated.
* Low-level Access: Developers can inspect, manipulate, or even generate RTP packets, enabling more customized handling of the media stream.

As the requirements in 3GPP go beyond what the common codecs in WebRTC can offer, supporting 3GPP codecs is essential and would now be possible with RTPTransport if a codec is supported by a browser. Support for an additional codec in a browser may be achieved by a codec implemented as a WebCodec or a custom WebAssembly implementation. The latter is highly flexible as codecs may be easily tested, having a codec as a WebCodec would however permit usage of optimized variants available on the platform.

It should be noted that custom codecs with RTPTransport require corresponding payload format implementations as payload formats are codec-specifc and can’t be provided in a generic way. Thus, the output from a WebCodec or WASM encoding codec module needs to be packetized, and at receiver side also a corresponding depacketizer is necessary. While this is extra implementation effort (that is anyways required even for non-WebRTC based applications), the underlying transport for WebRTC will be re-used, including ICE for connectivity, DTLS for encryption, etc. It becomes also possible to support custom header extensions that wouldn’t be possible with the traditional, high-level WebRTC APIs. It becomes also possible to implement adaptive behavior for custom, codec-optimized congestion control or error correction strategies.

[

*Editor’s Note: The following clause is derived from agreed document S4-250580. It amey be necessary to add the need for normative work to the clauses on recommendations.*

## 5.4 Audio Format Support

### 5.4.1 Introduction

The 3GPP IVAS codec is a versatile immersive audio codec which supports multiple different coding formats, such as stereo, SBA, MASA, ISM, multichannel, OMASA and OSBA. As a new feature compared to earlier 3GPP voice codecs, some of the coding formats require associated essential audio metadata input to an IVAS encoder together with the audio data. Namely, MASA and OMASA formats require MASA metadata input and ISM, OMASA and OSBA formats require ISM metadata input in addition to the audio data. Additionally, IVAS decoder supports an external output (EXT) mode, where the decoder output comprises audio and metadata if the input bitstream to the decoder is encoded as MASA, ISM, OMASA or OSBA.

### 5.4.2 Audio Format Support in WebRTC

#### 5.4.2.1. Audio metadata support in WebRTC

The WebRTC API does not provide ways to input/output associated essential audio metadata to/from the audio codec. Moreover, the WebRTC implementation and internal APIs (e.g., the C++ API) does not contain relevant data structures for metadata handling and does not allow moving metadata between processing modules, e.g., from an audio capture (front-end) module to an encoder module.

#### 5.4.2.2. Multichannel and SBA format support in WebRTC

The WebRTC implementation, e.g., like the one in [3], presently allows a maximum of 8 audio channels to be used, with the following layouts being directly mappable to layouts supported by IVAS.

Table 5.4-1: Mapping between WebRTC channel layout and IVAS Multichannel channel layout

|  |  |  |  |
| --- | --- | --- | --- |
| WebRTC channel layout | WebRTC channel order | IVAS channel layout | IVAS channel order |
| MONO | Centre | Mono | Centre |
| STEREO | Left, Right | Stereo | Left, Right |
| 5\_1 | Left, Right, Centre, Side Left, Side Right | 5.1 (CICP6) | Left, Right, Centre, Side Left, Side Right |
| 7\_1 | Left, Right, Centre, Side Left, Side Right, Back L, Back Right | 7.1 (CICP12) | Left, Right, Centre, Side Left, Side Right, Back Left, Back Right |

The Stereo, 5.1 and 7.1 IVAS layouts expect the same channel order as in WebRTC, such that operation in these modes should be covered. Of the remaining standard multichannel audio layouts supported in IVAS, 5.1.2 could be plausibly supported in a *custom* WebRTC application if the application repurposes one of the other existing 8-channel formats (e.g. 7\_1\_WIDE\_BACK, which still has LFE as the 4th channel). It should be noted, however, that repurposing of layouts is not an interoperable solution. Additionally, the IVAS decoder supports integrated rendering to custom MC layouts up to 16 channels, with azimuth and elevation specified for each channel. There does not appear to be support for custom MC modes in WebRTC.

In the case of SBA, there is no explicit support for these formats in the WebRTC source. However, a custom application could similarly repurpose alternative WebRTC 4- 5- and 7-channel layouts to support certain SBA modes. One such repurposing scheme could work as follows:

Table 5.4-2: Custom mapping between WebRTC channel layout and IVAS SBA layout

|  |  |  |
| --- | --- | --- |
| WebRTC channel layout | WebRTC channel order | IVAS SBA format |
| SURROUND | Front Left, Front Right, Front Centre | Planar FOA |
| QUAD | Front Left, Front Right, Back Left, Back Right | FOA |
| 5\_0 | Left, Right, Centre, Side Left, Side Right | Planar HOA2 |
| 7\_0 | Left, Right, Centre, Side Left, Side Right, Back L, Back Right | Planar HOA3 |

In this way, there would at least be a clear differentiation between the modes used for MC and for SBA.

The following non-metadata IVAS input format modes remain unmappable in the WebRTC source code due to the 8-channel limitation: 5.1.4 (CICP16), 7.1.4 (CICP19), HOA2, HOA3.

### 5.4.3 Audio Format Support in WebCodecs

*Editor’s Note: Also document the current audio format support.*

Similar gaps as for WebRTC for metadata handling are present for the WebCodecs API.

]

# 6 Common APIs

## 6.1 Overview

In a typical smartphone UE there is not just a single place where all the codecs reside but codecs exist at multiple places - ranging from hardware to software implementations. In Figure 6.1 an example UE with codecs at multiple places is depicted to illustrate potential codec implementations and codec consumers.



Figure 6.1: Codecs and interfaces in an example UE

Low-Level Codec APIs:

* IF1 (HAL): Chipsets may provide codecs using a battery-efficient implementation that can be exposed to the running operation system using some Hardware Abstraction Layer.
* IF2 (OS Codec API): Operating systems may provide codecs to be used by applications runing on the operating system using an OS-specific API.
* IF3 (Browser Codec API): Browsers may provide codecs to be used internally by other components of the browser such as the WebRTC stack of the browser.
* IF4 (WebCodecs API): The codecs inside browsers with interface IF3 may be exposed using the common WebCodecs API.
* IF5 (In-Application Custom API): Native applications may come with their own custom codecs using an interface internal to the application.
* IF6 (WASM Codec): Web Applications may come with their own custom codec using e.g. WebAssembly using an interface internal to the Web application.

Application-specific APIs:

* IF7 (Voice Call API): Chipsets may provide call functionality using the codec but providing a higher-level API that keeps codec specifics opaque to the user.
* IF8 (WebRTC RTCPeerConnection API): Browsers may provide WebRTC functionality using the codecs built into a particular WebRTC stack that keeps codec specifics mostly opaque to the user

Codec consumers:

* The operating system may use the codecs provided by the hardware using the HAL (IF1) or come with its own codecs. Most codecs might be exposed using IF2.
* Browsers may use the operating system codecs (IF2), come with their own codecs (IF3) or implicitly provide codecs by providing e.g. WebRTC functionality (IF8).
* Web applications may use codecs available in the browser, exposed by IF4 or IF6, or alternatively employ the WebRTC API of IF8.
* Native applications may use the codecs provided by the operating system via IF2 or come with their own codecs in IF5.
* As a special native implementation, the caller app may use the voice call API (IF7) to provide the basic call functionality.

# 7 Recommendations for Potential Interfaces and Adapters

[

Editor’s Note: From S4-251327:

## 7.1 WebCodecs

The current IVAS API might require certain updates to map to the WebCodec API to allow for dynamic changes to formats. Necessary updates to the IVAS API to facilitate this mapping are FFS.

### 7.1.1 Limitations in WebCodec API for IVAS Encoder

#### 7.1.1.1 Codec Input with Audio + Metadata

While the AudioEncoderConfig() can be used to pass metadata on frame-by-frame basis as mentioned in clause 5.2.3.2, a dedicated metadata input, supporting codec specific metadata configurations, to the encode API may be a better solution. To support such use cases in WebCodecs, one of the following strategies could be followed: -

* Modify the encode() API in the Audio Encoder interface to allow a sequence of AudioData buffers as mentioned below.

undefined encode(sequence <AudioData> Data);

The AudioSampleFormat definition can be enhanced to include formats for metadata buffers. This sequence of Audio data buffers can then be used to input both PCM and metadata to the encoder.

* Implement a AudioEncoderMetadata in the encode() API in the Audio Encoder interface, as mentioned below, to allow passing a codec specific metadata to the encoder

undefined encode(AudioData data, AudioEncoderMetadata metadata);

### 7.1.2 Limitations in WebCodec API for IVAS Decoder

#### 7.1.2.1 Codec Output with Audio + Metadata

The callback from the AudioDecoder and the AudioEncoder interface have the following definition: -

|  |
| --- |
| **callback** AudioDataOutputCallback = undefined(AudioData output); |
| **callback** EncodedAudioChunkOutputCallback = undefined ( EncodedAudioChunk output,  optional EncodedAudioChunkMetadata metadata = {}); |

This implies that the AudioDecoder only supports a single AudioData output currently, while the AudioEncoder also provides a mechanism to return additional metadata output.

ISM, MASA and combined formats may produce additional metadata relevant for external rendering of the decoded audio data, which currently cannot be obtained due to lack of additional output buffer or metadata buffers. To support such use cases in WebCodecs, one of the following strategies could be followed: -

* Implement an optional DecodedAudioMetadata in the AudioDataOutputCallback analogous to EncodedAudioChunkMetadata in the encoder which is reported from EncodedAudioChunkOutputCallback to allow AudioMetadata as an additional output.

- Enhance the AudioDecoder interface to support multiple AudioData buffers which can be enumerated and used for additional metadata.

#### 7.1.2.2 Decoder output in EXT Output format

When configured in EXT output format mode, the encoded format of the bitstream should be reported from the decoder. Currently the AudioData output from the decoder cannot provide signalling for output format. A workaround can be that the sender and receiver negotiate a coded format using SDP, for example, and use this coded format throughout the session. To support dynamic format switching use-cases, additional DecodedAudioMetadata could be added to the WebCodec API.

]

# 8 Recommendations for Potential Normative Work

Editor’s Note: Potential normative work includes the definition of WebCodec APIs for 3GPP’s speech/audio codecs, definition of a custom RTCPeerConnection based on RTPTransport, WebCodecs.

Annex A (informative):
Relevant C APIs of 3GPP Speech and Audio Codecs

## A.1 Introduction

The following clauses collect the interfaces to the 3GPP coding schemes.

## A.2 AMR

### A.2.1 General

### A.2.2 AMR Fixed-Point Code (TS 26.073)

#### A.2.2.1 General

#### A.2.2.2 Encoder API (cod\_amr.h)

/\*

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\* DEFINITION OF DATA TYPES

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

/\*-----------------------------------------------------------\*

 \* Coder constant parameters (defined in "cnst.h") \*

 \*-----------------------------------------------------------\*

 \* L\_WINDOW : LPC analysis window size. \*

 \* L\_NEXT : Samples of next frame needed for autocor. \*

 \* L\_FRAME : Frame size. \*

 \* L\_FRAME\_BY2 : Half the frame size. \*

 \* L\_SUBFR : Sub-frame size. \*

 \* M : LPC order. \*

 \* MP1 : LPC order+1 \*

 \* L\_TOTAL7k4 : Total size of speech buffer. \*

 \* PIT\_MIN7k4 : Minimum pitch lag. \*

 \* PIT\_MAX : Maximum pitch lag. \*

 \* L\_INTERPOL : Length of filter for interpolation \*

 \*-----------------------------------------------------------\*/

typedef struct {

 /\* Speech vector \*/

 Word16 old\_speech[L\_TOTAL];

 Word16 \*speech, \*p\_window, \*p\_window\_12k2;

 Word16 \*new\_speech; /\* Global variable \*/

 /\* Weight speech vector \*/

 Word16 old\_wsp[L\_FRAME + PIT\_MAX];

 Word16 \*wsp;

 /\* OL LTP states \*/

 Word16 old\_lags[5];

 Word16 ol\_gain\_flg[2];

 /\* Excitation vector \*/

 Word16 old\_exc[L\_FRAME + PIT\_MAX + L\_INTERPOL];

 Word16 \*exc;

 /\* Zero vector \*/

 Word16 ai\_zero[L\_SUBFR + MP1];

 Word16 \*zero;

 /\* Impulse response vector \*/

 Word16 \*h1;

 Word16 hvec[L\_SUBFR \* 2];

 /\* Substates \*/

 lpcState \*lpcSt;

 lspState \*lspSt;

 clLtpState \*clLtpSt;

 gainQuantState \*gainQuantSt;

 pitchOLWghtState \*pitchOLWghtSt;

 tonStabState \*tonStabSt;

 vadState \*vadSt;

 Flag dtx;

 dtx\_encState \*dtx\_encSt;

 /\* Filter's memory \*/

 Word16 mem\_syn[M], mem\_w0[M], mem\_w[M];

 Word16 mem\_err[M + L\_SUBFR], \*error;

 Word16 sharp;

} cod\_amrState;

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* DECLARATION OF PROTOTYPES

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*

\* Function : cod\_amr\_init

\* Purpose : Allocates memory and initializes state variables

\* Description : Stores pointer to filter status struct in \*st. This

\* pointer has to be passed to cod\_amr in each call.

 \* - initilize pointers to speech buffer

 \* - initialize static pointers

 \* - set static vectors to zero

\* Returns : 0 on success

\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

int cod\_amr\_init (cod\_amrState \*\*st, Flag dtx);

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*

\* Function : cod\_amr\_reset

\* Purpose : Resets state memory

\* Returns : 0 on success

\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

int cod\_amr\_reset (cod\_amrState \*st);

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*

\* Function : cod\_amr\_exit

\* Purpose : The memory used for state memory is freed

\* Description : Stores NULL in \*st

\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

void cod\_amr\_exit (cod\_amrState \*\*st);

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

 \* FUNCTION: cod\_amr\_first

 \*

 \* PURPOSE: Copes with look-ahead.

 \*

 \* INPUTS:

 \* No input argument are passed to this function. However, before

 \* calling this function, 40 new speech data should be copied to the

 \* vector new\_speech[]. This is a global pointer which is declared in

 \* this file (it points to the end of speech buffer minus 200).

 \*

 \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

int cod\_amr\_first(cod\_amrState \*st, /\* i/o : State struct \*/

 Word16 new\_speech[] /\* i : speech input (L\_FRAME) \*/

);

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

 \* FUNCTION: cod\_amr

 \*

 \* PURPOSE: Main encoder routine.

 \*

 \* DESCRIPTION: This function is called every 20 ms speech frame,

 \* operating on the newly read 160 speech samples. It performs the

 \* principle encoding functions to produce the set of encoded parameters

 \* which include the LSP, adaptive codebook, and fixed codebook

 \* quantization indices (addresses and gains).

 \*

 \* INPUTS:

 \* No input argument are passed to this function. However, before

 \* calling this function, 160 new speech data should be copied to the

 \* vector new\_speech[]. This is a global pointer which is declared in

 \* this file (it points to the end of speech buffer minus 160).

 \*

 \* OUTPUTS:

 \*

 \* ana[]: vector of analysis parameters.

 \* synth[]: Local synthesis speech (for debugging purposes)

 \*

 \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

int cod\_amr(cod\_amrState \*st, /\* i/o : State struct \*/

 enum Mode mode, /\* i : AMR mode \*/

 Word16 new\_speech[], /\* i : speech input (L\_FRAME) \*/

 Word16 ana[], /\* o : Analysis parameters \*/

 enum Mode \*usedMode, /\* o : used mode \*/

 Word16 synth[] /\* o : Local synthesis \*/

);

#### A.2.2 3 Decoder (dec\_amr.h)

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* LOCAL VARIABLES AND TABLES

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

/\*---------------------------------------------------------------\*

 \* Postfilter constant parameters (defined in "cnst.h") \*

 \*---------------------------------------------------------------\*

 \* L\_FRAME : Frame size. \*

 \* PIT\_MAX : Maximum pitch lag. \*

 \* L\_INTERPOL : Length of filter for interpolation. \*

 \* M : LPC order. \*

 \*---------------------------------------------------------------\*/

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* DEFINITION OF DATA TYPES

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

typedef struct{

 /\* Excitation vector \*/

 Word16 old\_exc[L\_SUBFR + PIT\_MAX + L\_INTERPOL];

 Word16 \*exc;

 /\* Lsp (Line spectral pairs) \*/

 /\* Word16 lsp[M]; \*/ /\* Used by CN codec \*/

 Word16 lsp\_old[M];

 /\* Filter's memory \*/

 Word16 mem\_syn[M];

 /\* pitch sharpening \*/

 Word16 sharp;

 Word16 old\_T0;

 /\* Memories for bad frame handling \*/

 Word16 prev\_bf;

 Word16 prev\_pdf;

 Word16 state;

 Word16 excEnergyHist[9];

 /\* Variable holding received ltpLag, used in background noise and BFI \*/

 Word16 T0\_lagBuff;

 /\* Variables for the source characteristic detector (SCD) \*/

 Word16 inBackgroundNoise;

 Word16 voicedHangover;

 Word16 ltpGainHistory[9];

 Bgn\_scdState\* background\_state;

 Word16 nodataSeed;

 Cb\_gain\_averageState \*Cb\_gain\_averState;

 lsp\_avgState \*lsp\_avg\_st;

 D\_plsfState\* lsfState;

 ec\_gain\_pitchState\* ec\_gain\_p\_st;

 ec\_gain\_codeState\* ec\_gain\_c\_st;

 gc\_predState\* pred\_state;

 ph\_dispState\* ph\_disp\_st;

 dtx\_decState\* dtxDecoderState;

} Decoder\_amrState;

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* DECLARATION OF PROTOTYPES

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*

\* Function : Decoder\_amr\_init

\* Purpose : Allocates initializes state memory

\* Description : Stores pointer to filter status struct in \*st. This

\* pointer has to be passed to Decoder\_amr in each call.

\* Returns : 0 on success

\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

int Decoder\_amr\_init (Decoder\_amrState \*\*st);

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*

\* Function : Decoder\_amr\_reset

\* Purpose : Resets state memory

\* Returns : 0 on success

\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

int Decoder\_amr\_reset (Decoder\_amrState \*st,enum Mode mode);

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*

\* Function : Decoder\_amr\_exit

\* Purpose : The memory used for state memory is freed

\* Description : Stores NULL in \*s

\* Returns : void

\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

void Decoder\_amr\_exit (Decoder\_amrState \*\*st);

/\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*

\* Function : Decoder\_amr

\* Purpose : Speech decoder routine.

\* Returns : 0

\*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\*/

int Decoder\_amr (

 Decoder\_amrState \*st, /\* i/o : State variables \*/

 enum Mode mode, /\* i : AMR mode \*/

 Word16 parm[], /\* i : vector of synthesis parameters

 (PRM\_SIZE) \*/

 enum RXFrameType frame\_type, /\* i : received frame type \*/

 Word16 synth[], /\* o : synthesis speech (L\_FRAME) \*/

 Word16 A\_t[] /\* o : decoded LP filter in 4 subframes

 (AZ\_SIZE) \*/

);

### A.2.3 AMR Floating-Point Code (TS 26.104)

#### A.2.3.1 General

#### A.2.3.2 Encoder (interf\_enc.h)

/\*

 \* Encodes one frame of speech

 \* Returns packed octets

 \*/

int Encoder\_Interface\_Encode( void \*st, enum Mode mode, short \*speech,

#ifndef ETSI

 unsigned char \*serial, /\* max size 31 bytes \*/

#else

 short \*serial, /\* size 500 bytes \*/

#endif

 int forceSpeech ); /\* use speech mode \*/

/\*

 \* Reserve and init. memory

 \*/

void \*Encoder\_Interface\_init( int dtx );

/\*

 \* Exit and free memory

 \*/

void Encoder\_Interface\_exit( void \*state );

#endif

#### A.2.3.3 Decoder (interf\_dec.h)

/\*

 \* Conversion from packed bitstream to endoded parameters

 \* Decoding parameters to speech

 \*/

void Decoder\_Interface\_Decode( void \*st,

#ifndef ETSI

 unsigned char \*bits,

#else

 short \*bits,

#endif

 short \*synth, int bfi );

/\*

 \* Reserve and init. memory

 \*/

void \*Decoder\_Interface\_init( void );

/\*

 \* Exit and free memory

 \*/

void Decoder\_Interface\_exit( void \*state );

## A.3 AMR-WB

### A.3.2 AMR-WB Fixed-Point (TS 26.173)

#### A.3.2.1 General

#### A.3.2.2 Encoder (main.h)

void Init\_coder(void \*\*spe\_state);

void Close\_coder(void \*spe\_state);

void coder(

 Word16 \* mode, /\* input : used mode \*/

 Word16 speech16k[], /\* input : 320 new speech samples (at 16 kHz) \*/

 Word16 prms[], /\* output: output parameters \*/

 Word16 \* ser\_size, /\* output: bit rate of the used mode \*/

 void \*spe\_state, /\* i/o : State structure \*/

 Word16 allow\_dtx /\* input : DTX ON/OFF \*/

);

void Reset\_encoder(void \*st, Word16 reset\_all);

Word16 encoder\_homing\_frame\_test(Word16 input\_frame[]);

#### A.3.2.3 Decoder (main.h)

void Init\_decoder(void \*\*spd\_state);

void Close\_decoder(void \*spd\_state);

void decoder(

 Word16 mode, /\* input : used mode \*/

 Word16 prms[], /\* input : parameter vector \*/

 Word16 synth16k[], /\* output: synthesis speech \*/

 Word16 \* frame\_length, /\* output: lenght of the frame \*/

 void \*spd\_state, /\* i/o : State structure \*/

 Word16 frame\_type /\* input : received frame type \*/

);

void Reset\_decoder(void \*st, Word16 reset\_all);

Word16 decoder\_homing\_frame\_test(Word16 input\_frame[], Word16 mode);

Word16 decoder\_homing\_frame\_test\_first(Word16 input\_frame[], Word16 mode);

### A.3.3 AMR-WB Floating-Point (TS 26.204):

#### A.3.3.1 General

#### A.3.3.2 Encoder (enc.h)

Word16 E\_MAIN\_init(void \*\*spe\_state);

void E\_MAIN\_reset(void \*st, Word16 reset\_all);

Word16 E\_MAIN\_encode(Word16 \* mode, Word16 input\_sp[], Word16 prms[],

 void \*spe\_state, Word16 allow\_dtx);

void E\_MAIN\_close(void \*\*spe\_state);

#### A.3.3.3 Decoder (dec.h)

void D\_MAIN\_reset(void \*st, Word16 reset\_all);

Word32 D\_MAIN\_init(void \*\*spd\_state);

void D\_MAIN\_close(void \*\*spd\_state);

Word32 D\_MAIN\_decode(Word16 mode, Word16 prms[], Word16 synth16k[],

 void \*spd\_state, UWord8 frame\_type);

## A.4 EVS

### A.4.1 General

### A.4.2 Example API in S4-211541

#### A.4.1 Encoder

//! Creates the EVS encoder state.

DLL\_PUBLIC

Encoder\_State\* EVS\_cod\_open();

//! Configures the EVS encoder - needs to be called after EVS\_cod\_open().

/\*! @param[in] st encoder state

 \* @param[in] inSampleRate sample rate of the audio samples to encode: 8000, 16000, 32000, 48000

 \* @param[in] bandwidth audio bandwith to encode: NB=8000, WB=16000, SWB=32000, FB=48000

 \* @param[in] bitrate codec bitrate in bits per second, e.g. 9600, 13200, 24400

 \* @param[in] dtx flag to enable DTX: 0=DTX off, 1=DTX on

 \* @param[in] partialCopyOffset offset of partial copies in case of channel aware mode (bitrate=13200): 0 (no CA), 2, 3 (default), 5, 7

 \* @return 0 if successful

 \*/

DLL\_PUBLIC

int EVS\_cod\_configure(Encoder\_State \*st, uint32\_t inSampleRate, uint32\_t bandwidth, uint32\_t bitrate, int dtx, uint32\_t partialCopyOffset);

//! Switches the codec mode - can be called between encoding two frames.

/\*! @param[in] st encoder state

 \* @param[in] bandwidth audio bandwith to encode: NB=8000, WB=16000, SWB=32000, FB=48000

 \* @param[in] bitrate codec bitrate in bits per second, e.g. 9600, 13200, 24400

 \* @param[in] dtx flag to enable DTX: 0=DTX off, 1=DTX on

 \* @param[in] partialCopyOffset offset of partial copies in case of channel aware mode (bitrate=13200): 0 (no CA), 2, 3 (default), 5, 7

 \* @return 0 if successful

 \*/

DLL\_PUBLIC

int EVS\_cod\_switchMode(Encoder\_State \*st, uint32\_t bandwidth, uint32\_t bitrate, int dtx, uint32\_t partialCopyOffset);

//! Encodes one frame of audio samples.

/\*! @param[in] st encoder state

 \* @param[in] samples input signal to encode

 \* @param[in] nSamples number of input samples - must equal 20ms

 \* @param[out] bitstream buffer to store the bitstream

 \* @param[out] nBitstreamBytes number of bytes written to the bitstream buffer

 \* @param[out] isSid flag if the current frame was encoded as SID

 \* @return 0 if successful

 \*/

DLL\_PUBLIC

int EVS\_cod\_encode(Encoder\_State \*st, const int16\_t \*samples, uint32\_t nSamples, uint8\_t \*bitstream, uint32\_t \*nBitstreamBytes, int \*isSid);

//! Returns the encoder delay and its time scale.

/\*! @param[in] st encoder state

 \* @param[out] nSamples delay in samples

 \* @param[out] timeScale time scale of nSamples

 \* @return 0 if successful \*/

DLL\_PUBLIC

int EVS\_cod\_delay(Encoder\_State \*st, uint32\_t \*nSamples, uint32\_t \*timeScale);

//! Destructs the EVS encoder state and frees the memory.

DLL\_PUBLIC

void EVS\_cod\_close(Encoder\_State \*st);

//! Returns a string containing the version number of the EVS codec (e.g. 12.1.0).

DLL\_PUBLIC

const char \* EVS\_cod\_version();

#### A.4.2 Decoder

struct Decoder\_State;

typedef struct Decoder\_State Decoder\_State;

typedef enum

{

 EVS\_BITSTREAM\_FORMAT\_NON\_VOIP,

 EVS\_BITSTREAM\_FORMAT\_VOIP\_G192\_RTP,

 EVS\_BITSTREAM\_FORMAT\_VOIP\_RTPDUMP

} BitstreamFormat;

//! Creates the EVS decoder state.

DLL\_PUBLIC

Decoder\_State\* EVS\_dec\_open();

//! Configures the EVS decoder - needs to be called after EVS\_dec\_open().

/\*! @param[in] st decoder state

 \* @param[in] bitstreamFormat bitstream format (G.192/MIME/VOIP\_G192\_RTP/VOIP\_RTPDUMP)

 \* @param[in] outSampleRate sample rate of the audio samples to create in Hz: 8000, 16000, 32000, 48000

 \* @param[out] frameSize the number of samples created in one call to EVS\_dec\_decode() or EVS\_dec\_conceal()

 \* @return 0 if successful

 \*/

DLL\_PUBLIC

int EVS\_dec\_configure(Decoder\_State \*st, BitstreamFormat bitstreamFormat, uint32\_t outSampleRate, uint32\_t \*frameSize);

//! Decodes one bitstream frame.

/\*! @param[in] st decoder state

 \* @param[in] bitstream buffer containing the bitstream

 \* @param[in] partialCopy flag if the partial copy contained in the bitstream should be decoded

 \* @param[out] nBits number of bits in the bitstream buffer

 \* @param[out] samples one frame of decoded signal

 \* @param[out] bandwidth for information: outputs the current bandwidth of the bitstream

 \* @return 0 if successful

 \*/

DLL\_PUBLIC

int EVS\_dec\_decode(Decoder\_State \*st, const uint8\_t \*bitstream, uint32\_t nBits, int partialCopy,

 int16\_t \*samples, uint32\_t \*bandwidth);

//! Creates audio samples for one missing frame (PLC or DTX).

/\*! @param[in] st decoder state

 \* @param[out] samples one frame of decoded signal

 \* @return 0 if successful

 \*/

DLL\_PUBLIC

int EVS\_dec\_conceal(Decoder\_State \*st, int16\_t \*samples);

//! Returns the decoder delay and its time scale.

/\*! @param[in] st decoder state

 \* @param[out] nSamples delay in samples

 \* @param[out] timeScale time scale of nSamples

 \* @return 0 if successful \*/

DLL\_PUBLIC

int EVS\_dec\_delay(Decoder\_State \*st, uint32\_t \*nSamples, uint32\_t \*timeScale);

//! Destructs the EVS decoder state and frees the memory.

DLL\_PUBLIC

void EVS\_dec\_close(Decoder\_State \*st);

//! Checks if a frame contains a partial copy and gets its offset.

DLL\_PUBLIC

int EVS\_dec\_previewFrame(const uint8\_t \*bitstream, uint32\_t nBitstreamBytes, int \*rfNoData, uint32\_t \*partialCopyOffset);

//! Returns a string containing the version number of the EVS codec (e.g. 12.1.0).

DLL\_PUBLIC

const char \* EVS\_dec\_version();

## A.5 eAAC+

### A.5.1 eAAC+ Floating-Point (TS 26.410)

#### A.5.1.1 AAC Encoder (aacenc.h)

/\* here we distinguish between stereo and the mono only encoder \*/

#ifdef MONO\_ONLY

#define MAX\_CHANNELS 1

#else

#define MAX\_CHANNELS 2

#endif

#define AACENC\_BLOCKSIZE 1024 /\*! encoder only takes BLOCKSIZE samples at a time \*/

#define AACENC\_TRANS\_FAC 8 /\*! encoder short long ratio \*/

#define AACENC\_PCM\_LEVEL 1.0 /\*! encoder pcm 0db refernence \*/

/\*-------------------------- defines --------------------------------------\*/

#define BUFFERSIZE 1024 /\* anc data \*/

/\*-------------------- structure definitions ------------------------------\*/

typedef struct {

 int sampleRate; /\* audio file sample rate \*/

 int bitRate; /\* encoder bit rate in bits/sec \*/

 int nChannelsIn; /\* number of channels on input (1,2) \*/

 int nChannelsOut; /\* number of channels on output (1,2) \*/

 int bandWidth; /\* core coder audio bandwidth in Hz \*/

} AACENC\_CONFIG;

struct AAC\_ENCODER;

/\*

 \* p u b l i c a n c i l l a r y

 \*

 \*/

/\*-----------------------------------------------------------------------------

 functionname: AacInitDefaultConfig

 description: gives reasonable default configuration

 returns: ---

 ------------------------------------------------------------------------------\*/

void AacInitDefaultConfig(AACENC\_CONFIG \*config);

/\*---------------------------------------------------------------------------

 functionname:AacEncOpen

 description: allocate and initialize a new encoder instance

 returns: AACENC\_OK if success

 ---------------------------------------------------------------------------\*/

int AacEncOpen

( struct AAC\_ENCODER\*\* phAacEnc, /\* pointer to an encoder handle, initialized on return \*/

 const AACENC\_CONFIG config /\* pre-initialized config struct \*/

);

int AacEncEncode(struct AAC\_ENCODER \*hAacEnc,

 float \*timeSignal,

 unsigned int timeInStride,

 const unsigned char \*ancBytes, /\*!< pointer to ancillary data bytes \*/

 unsigned int \*numAncBytes, /\*!< number of ancillary Data Bytes, send as fill element \*/

 unsigned int \*outBytes, /\*!< pointer to output buffer \*/

 int \*numOutBytes /\*!< number of bytes in output buffer \*/

 );

/\*---------------------------------------------------------------------------

 functionname:AacEncClose

 description: deallocate an encoder instance

 ---------------------------------------------------------------------------\*/

void AacEncClose (struct AAC\_ENCODER\* hAacEnc); /\* an encoder handle \*/

#### A.5.1.2 SBR Encoder (sbr\_main.h)

#define MAX\_TRANS\_FAC 8

#define MAX\_CODEC\_FRAME\_RATIO 2

#define MAX\_PAYLOAD\_SIZE 256

typedef struct

{

 int bitRate;

 int nChannels;

 int sampleFreq;

 int transFac;

 int standardBitrate;

} CODEC\_PARAM;

typedef enum

{

 SBR\_MONO,

 SBR\_LEFT\_RIGHT,

 SBR\_COUPLING,

 SBR\_SWITCH\_LRC

}

SBR\_STEREO\_MODE;

typedef struct sbrConfiguration

{

 CODEC\_PARAM codecSettings;

 int SendHeaderDataTime;

 int crcSbr;

 int detectMissingHarmonics;

 int parametricCoding;

 int tran\_thr;

 int noiseFloorOffset;

 unsigned int useSpeechConfig;

 int sbr\_data\_extra;

 int amp\_res;

 int ana\_max\_level;

 int tran\_fc;

 int tran\_det\_mode;

 int spread;

 int stat;

 int e;

 SBR\_STEREO\_MODE stereoMode;

 int deltaTAcrossFrames;

 float dF\_edge\_1stEnv;

 float dF\_edge\_incr;

 int sbr\_invf\_mode;

 int sbr\_xpos\_mode;

 int sbr\_xpos\_ctrl;

 int sbr\_xpos\_level;

 int startFreq;

 int stopFreq;

 int usePs;

 int psMode;

 int freqScale;

 int alterScale;

 int sbr\_noise\_bands;

 int sbr\_limiter\_bands;

 int sbr\_limiter\_gains;

 int sbr\_interpol\_freq;

 int sbr\_smoothing\_length;

} sbrConfiguration, \*sbrConfigurationPtr ;

unsigned int

IsSbrSettingAvail (unsigned int bitrate,

 unsigned int numOutputChannels,

 unsigned int sampleRateInput,

 unsigned int \*sampleRateCore);

unsigned int

AdjustSbrSettings (const sbrConfigurationPtr config,

 unsigned int bitRate,

 unsigned int numChannels,

 unsigned int fsCore,

 unsigned int transFac,

 unsigned int standardBitrate);

unsigned int

InitializeSbrDefaults (sbrConfigurationPtr config

 );

typedef struct SBR\_ENCODER \*HANDLE\_SBR\_ENCODER;

int

EnvOpen (HANDLE\_SBR\_ENCODER\* hEnvEncoder,

 float \*pCoreBuffer,

 sbrConfigurationPtr params,

 int \*coreBandWith

 );

void

EnvClose (HANDLE\_SBR\_ENCODER hEnvEnc);

int

SbrGetXOverFreq(HANDLE\_SBR\_ENCODER hEnv,

 int xoverFreq );

int

SbrGetStopFreqRaw(HANDLE\_SBR\_ENCODER hEnv);

int

EnvEncodeFrame (HANDLE\_SBR\_ENCODER hEnvEncoder,

 float \*samples,

 float \*pCoreBuffer,

 unsigned int timeInStride,

 unsigned int \*numAncBytes,

 unsigned char \*ancData);

#### A.5.1.3 Resampler (iir32resample.h)

int

IIR32Resample( float \*inbuf,

 float \*outbuf,

 int inSamples,

 int outSamples,

 int stride);

int

IIR32GetResamplerFeed( int blockSizeOut);

void

IIR32Init( void);

#### A.5.1.4 AAC Decoder (aacdecoder.h)

enum {

 AAC\_DEC\_OK = 0x0,

 AAC\_DEC\_UNSUPPORTED\_FORMAT,

 AAC\_DEC\_DECODE\_FRAME\_ERROR,

 AAC\_DEC\_INVALID\_CODE\_BOOK,

 AAC\_DEC\_UNSUPPORTED\_WINDOW\_SHAPE,

 AAC\_DEC\_PREDICTION\_NOT\_SUPPORTED\_IN\_LC\_AAC,

 AAC\_DEC\_UNIMPLEMENTED\_PCE,

 AAC\_DEC\_UNIMPLEMENTED\_DSE,

 AAC\_DEC\_UNIMPLEMENTED\_LFE,

 AAC\_DEC\_UNIMPLEMENTED\_CCE,

 AAC\_DEC\_UNIMPLEMENTED\_GAIN\_CONTROL\_DATA,

 AAC\_DEC\_UNIMPLEMENTED\_EP\_SPECIFIC\_CONFIG\_PARSE,

 AAC\_DEC\_UNIMPLEMENTED\_CELP\_SPECIFIC\_CONFIG\_PARSE,

 AAC\_DEC\_UNIMPLEMENTED\_HVXC\_SPECIFIC\_CONFIG\_PARSE,

 AAC\_DEC\_OVERWRITE\_BITS\_IN\_INPUT\_BUFFER,

 AAC\_DEC\_CANNOT\_REACH\_BUFFER\_FULLNESS

};

typedef struct AAC\_DECODER\_INSTANCE \*AACDECODER;

#define FRAME\_SIZE 1024

/\* initialization of aac decoder \*/

AACDECODER CAacDecoderOpen(HANDLE\_BIT\_BUF pBs,

 SBRBITSTREAM \*streamSBR,

 float \*pTimeData);

int CAacDecoderInit(AACDECODER self,

 int samplingRate,

 int bitrate);

/\* aac decoder \*/

int CAacDecoder\_DecodeFrame(AACDECODER aacDecoderInstance,

 int \*frameSize,

 int \*sampleRate,

 int \*numChannels,

 char \*channelMode,

 char errorStatus

 );

#### A.5.1.5 SBR Decoder (sbrdecoder.h)

#define SBR\_EXTENSION 13 /\* 1101 \*/

#define SBR\_EXTENSION\_CRC 14 /\* 1110 \*/

#define MAXNRELEMENTS 2

#define MAXNRSBRCHANNELS MAXNRELEMENTS

#ifdef MONO\_ONLY

#define MAXNRQMFCHANNELS 1

#else

#define MAXNRQMFCHANNELS MAXNRSBRCHANNELS

#endif

#define MAXSBRBYTES 269

typedef enum

{

 SBRDEC\_OK = 0,

 SBRDEC\_CONCEAL,

 SBRDEC\_NOSYNCH,

 SBRDEC\_ILLEGAL\_PROGRAM,

 SBRDEC\_ILLEGAL\_TAG,

 SBRDEC\_ILLEGAL\_CHN\_CONFIG,

 SBRDEC\_ILLEGAL\_SECTION,

 SBRDEC\_ILLEGAL\_SCFACTORS,

 SBRDEC\_ILLEGAL\_PULSE\_DATA,

 SBRDEC\_MAIN\_PROFILE\_NOT\_IMPLEMENTED,

 SBRDEC\_GC\_NOT\_IMPLEMENTED,

 SBRDEC\_ILLEGAL\_PLUS\_ELE\_ID,

 SBRDEC\_CREATE\_ERROR,

 SBRDEC\_NOT\_INITIALIZED

}

SBR\_ERROR;

typedef enum

{

 SBR\_ID\_SCE = 0,

 SBR\_ID\_CPE,

 SBR\_ID\_CCE,

 SBR\_ID\_LFE,

 SBR\_ID\_DSE,

 SBR\_ID\_PCE,

 SBR\_ID\_FIL,

 SBR\_ID\_END

}

SBR\_ELEMENT\_ID;

typedef struct

{

 int ElementID;

 int ExtensionType;

 int Payload;

 unsigned char Data[MAXSBRBYTES];

}

SBR\_ELEMENT\_STREAM;

typedef struct

{

 int NrElements;

 int NrElementsCore;

 SBR\_ELEMENT\_STREAM sbrElement[MAXNRELEMENTS]; /\* for the delayed frame \*/

}

SBRBITSTREAM;

typedef struct SBR\_DECODER\_INSTANCE \*SBRDECODER;

SBRDECODER openSBR (int sampleRate, int samplesPerFrame, int bDownSample, int bApplyQmfLp) ;

SBR\_ERROR applySBR (SBRDECODER self,

 SBRBITSTREAM \* Bitstr,

 float \*TimeData,

 int \*numChannels,

 int frameOK,

 int bDownSample,

 int bBitstreamDownMix);

### A.5.2 eAAC+ Fixed-Point (TS 26.411)

#### A.5.2.1 AAC Encoder (aacenc.h)

/\* here we distinguish between stereo and the mono only encoder \*/

#ifdef MONO\_ONLY

#define MAX\_CHANNELS 1

#else

#define MAX\_CHANNELS 2

#endif

#define AACENC\_BLOCKSIZE 1024 /\*! encoder only takes BLOCKSIZE samples at a time \*/

#define AACENC\_TRANS\_FAC 8 /\*! encoder short long ratio \*/

#define AACENC\_PCM\_LEVEL 1.0 /\*! encoder pcm 0db refernence \*/

/\*-------------------------- defines --------------------------------------\*/

/\*-------------------- structure definitions ------------------------------\*/

struct AAC\_ENCODER;

typedef struct {

 Word32 sampleRate; /\* audio file sample rate \*/

 Word32 bitRate; /\* encoder bit rate in bits/sec \*/

 Word16 nChannelsIn; /\* number of channels on input (1,2) \*/

 Word16 nChannelsOut; /\* number of channels on output (1,2) \*/

 Word16 bandWidth; /\* targeted audio bandwidth in Hz \*/

} AACENC\_CONFIG;

/\*-----------------------------------------------------------------------------

functionname: AacInitDefaultConfig

description: gives reasonable default configuration

returns: ---

------------------------------------------------------------------------------\*/

void AacInitDefaultConfig(AACENC\_CONFIG \*config);

/\*---------------------------------------------------------------------------

functionname:AacEncOpen

description: allocate and initialize a new encoder instance

returns: AACENC\_OK if success

---------------------------------------------------------------------------\*/

Word16 AacEncOpen (struct AAC\_ENCODER\*\* phAacEnc, /\* pointer to an encoder handle, initialized on return \*/

 const AACENC\_CONFIG config); /\* pre-initialized config struct \*/

Word16 AacEncEncode(struct AAC\_ENCODER \*hAacEnc,

 Word16 \*timeSignal,

 const UWord8 \*ancBytes, /\*!< pointer to ancillary data bytes \*/

 Word16 \*numAncBytes, /\*!< number of ancillary Data Bytes, send as fill element \*/

 UWord8 \*outBytes, /\*!< pointer to output buffer \*/

 Word32 \*numOutBytes /\*!< number of bytes in output buffer \*/

 );

/\*---------------------------------------------------------------------------

functionname:AacEncClose

description: deallocate an encoder instance

---------------------------------------------------------------------------\*/

void AacEncClose (struct AAC\_ENCODER\* hAacEnc); /\* an encoder handle \*/

#### A.5.2.2 SBR Encoder (sbr\_main.h)

/\* core coder helpers \*/

#define MAX\_TRANS\_FAC 8

#define MAX\_CODEC\_FRAME\_RATIO 2

#define MAX\_PAYLOAD\_SIZE 128

typedef struct

{

 Word32 bitRate;

 Word16 nChannels;

 Word32 sampleFreq;

 Word16 transFac;

 Word32 standardBitrate;

} CODEC\_PARAM;

typedef enum

{

 SBR\_MONO,

 SBR\_LEFT\_RIGHT,

 SBR\_COUPLING,

 SBR\_SWITCH\_LRC

}

SBR\_STEREO\_MODE;

typedef struct sbrConfiguration

{

 /\*

 core coder dependent configurations

 \*/

 CODEC\_PARAM codecSettings; /\*!< Core coder settings, to be set from core coder \*/

 Word16 SendHeaderDataTime; /\*!< SBR-Header send update frequency in msec \*/

 Word16 crcSbr; /\*!< Flag: usage of SBR-CRC \*/

 Word16 detectMissingHarmonics; /\*!< Flag: usage of missing harmonics detection \*/

 Word16 parametricCoding; /\*!< Flag: usage of parametric coding tool \*/

 /\*

 core coder dependent tuning parameters

 \*/

 Word32 tran\_thr; /\*!< SBR transient detector threshold (\* 100) \*/

 Word32 noiseFloorOffset; /\*! Noise floor offset \*/

 UWord16 useSpeechConfig; /\*!< Flag: adapt tuning parameters according to speech \*/

 /\*

 core coder independent configurations

 \*/

 Word16 sbrFrameSize; /\*!< SBR frame size in samples, will be calculated from core coder settings \*/

 Word16 sbr\_data\_extra; /\*!< Flag usage of data extra \*/

 Word16 amp\_res; /\*!< Amplitude resolution \*/

 Word32 ana\_max\_level; /\*!< Noise insertion maximum level \*/

 Word16 tran\_fc; /\*!< Transient detector start frequency \*/

 Word16 tran\_det\_mode; /\*!< Transient detector mode \*/

 Word16 spread; /\*!< Flag: usage of SBR spread \*/

 Word16 stat; /\*!< Flag: usage of static framing \*/

 Word16 e; /\*!< Number of envelopes when static framing is chosen \*/

 SBR\_STEREO\_MODE stereoMode; /\*!< SBR stereo mode \*/

 Word16 deltaTAcrossFrames; /\*!< Flag: allow time-delta coding \*/

 Word16 sbr\_invf\_mode; /\*!< Inverse Filtering mode \*/

 Word16 sbr\_xpos\_mode; /\*!< Transposer mode \*/

 Word16 sbr\_xpos\_ctrl; /\*!< Transposer control \*/

 Word16 sbr\_xpos\_level; /\*!< Transposer 3rd order level \*/

 Word16 startFreq; /\*!< The start frequency table index \*/

 Word16 stopFreq; /\*!< The stop frequency table index \*/

 Word16 usePs; /\*!< Flag: usage of parametric stereo \*/

 Word32 psMode;

 /\*

 header\_extra1 configuration

 \*/

 Word16 freqScale; /\*!< Frequency grouping \*/

 Word16 alterScale; /\*!< Scale resolution \*/

 Word16 sbr\_noise\_bands; /\*!< Number of noise bands \*/

 /\*

 header\_extra2 configuration

 \*/

 Word16 sbr\_limiter\_bands; /\*!< Number of limiter bands \*/

 Word16 sbr\_limiter\_gains; /\*!< Gain of limiter \*/

 Word16 sbr\_interpol\_freq; /\*!< Flag: use interpolation in freq. direction \*/

 Word16 sbr\_smoothing\_length; /\*!< Flag: choose length 4 or 0 (=on, off) \*/

} sbrConfiguration, \*sbrConfigurationPtr ;

UWord32

IsSbrSettingAvail (UWord32 bitrate,

 UWord16 numOutputChannels,

 UWord32 sampleRateInput,

 UWord32 \*sampleRateCore);

UWord32

AdjustSbrSettings (const sbrConfigurationPtr config,

 UWord32 bitRate,

 UWord16 numChannels,

 UWord32 fsCore,

 UWord16 transFac,

 UWord32 standardBitrate);

UWord32

InitializeSbrDefaults (sbrConfigurationPtr config);

typedef struct SBR\_ENCODER \*HANDLE\_SBR\_ENCODER;

Word32

EnvOpen (HANDLE\_SBR\_ENCODER\* hEnvEncoder,

 sbrConfigurationPtr params,

 Word16 \*coreBandWith /\*\*< encoder (lowband) bandwith in Hz \*/

 );

void

EnvClose (HANDLE\_SBR\_ENCODER hEnvEnc);

Word32

SbrGetXOverFreq(HANDLE\_SBR\_ENCODER hEnv,

 Word32 xoverFreq );

Word32

SbrGetStopFreqRaw(HANDLE\_SBR\_ENCODER hEnv);

Word32

EnvEncodeFrame (HANDLE\_SBR\_ENCODER hEnvEncoder,

 Word16 \*samples, /\*!< time samples, always interleaved \*/

 Word16 \*pCoreBuffer,

 UWord16 timeInStride,

 Word16 \*numAncBytes,

 UWord8 \*ancData);

#### A.5.2.3 Resample (downsample\_FIR.h)

#define BUFFER\_SIZE\_2\_1 64

#define BUFFER\_SIZE\_3\_2 128

typedef struct

{

 const Word16 \*coeffFIR; /\*! pointer to filter coeffs \*/

 Word16 noOffCoeffs; /\*! number of filter coeffs \*/

 Word16 delayLine[BUFFER\_SIZE\_2\_1]; /\*! ringbuffer 1 input delay line \*/

} FIR\_FILTER\_2\_1;

typedef struct

{

 const Word16 \*coeffFIR; /\*! pointer to filter coeffs \*/

 Word16 noOffCoeffs; /\*! number of filter coeffs \*/

 Word16 delayLine[BUFFER\_SIZE\_3\_2]; /\*! ringbuffer 1 input delay line \*/

} FIR\_FILTER\_3\_2;

typedef struct

{

 FIR\_FILTER\_2\_1 firFilter; /\*! fir filter instance \*/

 Word32 fIn; /\*! input fs \*/

 Word32 fOut ; /\*! output fs \*/

 Word32 delay; /\*! delay input vs. output in samples \*/

} RESAMPLER\_FIR\_2\_1;

typedef struct

{

 FIR\_FILTER\_3\_2 firFilter; /\*! fir filter instance \*/

 Word32 fIn; /\*! input fs \*/

 Word32 fOut ; /\*! output fs \*/

 Word32 delay; /\*! delay input vs. output in samples \*/

} RESAMPLER\_FIR\_3\_2;

Word32 InitResampler\_firDown2(RESAMPLER\_FIR\_2\_1 \*ReSampler\_fir, /\*!< pointer to downsampler instance \*/

 Word32 fIn, /\*!< Input Sampling frequency \*/

 Word32 fOut); /\*!< Output Sampling frequency \*/

Word32 InitResampler\_firDown3(RESAMPLER\_FIR\_3\_2 \*ReSampler\_fir, /\*!< pointer to downsampler instance \*/

 Word32 fIn, /\*!< Input Sampling frequency \*/

 Word32 fOut); /\*!< Output Sampling frequency \*/

Word32 InitResampler\_firUp2(RESAMPLER\_FIR\_2\_1 \*ReSampler\_fir, /\*!< pointer to downsampler instance \*/

 Word32 fIn, /\*!< Input Sampling frequency \*/

 Word32 fOut); /\*!< Output Sampling frequency \*/

Word32 InitResampler\_firDown32(RESAMPLER\_FIR\_2\_1 \*ReSampler\_firUp2, /\*!< pointer to downsampler instance \*/

 RESAMPLER\_FIR\_3\_2 \*ReSampler\_firDown3, /\*!< pointer to downsampler instance \*/

 Word32 fIn, /\*!< Input Sampling frequency \*/

 Word32 fOut); /\*!< Output Sampling frequency \*/

Word32 Resample\_firDown2(RESAMPLER\_FIR\_2\_1 \*ReSampler\_fir, /\*!< pointer to downsampler instance \*/

 Word16 \*inSamples, /\*!< pointer to input samples \*/

 Word16 numInSamples, /\*!< number of input samples \*/

 Word16 inStride, /\*!< increment of input samples \*/

 Word16 \*outSamples, /\*!< pointer to output samples \*/

 Word16 \*numOutSamples, /\*!< pointer to number of output samples \*/

 Word16 outStride /\*!< increment of output samples \*/

 );

Word32 Resample\_firUp2(RESAMPLER\_FIR\_2\_1 \*ReSampler\_fir, /\*!< pointer to downsampler instance \*/

 Word16 \*inSamples, /\*!< pointer to input samples \*/

 Word16 numInSamples, /\*!< number of input samples \*/

 Word16 inStride, /\*!< increment of input samples \*/

 Word16 \*outSamples, /\*!< pointer to output samples \*/

 Word16 \*numOutSamples, /\*!< pointer tp number of output samples \*/

 Word16 outStride /\*!< increment of output samples \*/

 );

Word32 Resample\_firDown32(RESAMPLER\_FIR\_2\_1 \*ReSampler\_firUp2, /\*!< pointer to downsampler instance \*/

 RESAMPLER\_FIR\_3\_2 \*ReSampler\_firDown3, /\*!< pointer to downsampler instance \*/

 Word16 \*inSamples, /\*!< pointer to input samples \*/

 Word16 numInSamples, /\*!< number of input samples \*/

 Word16 inStride, /\*!< increment of input samples \*/

 Word16 \*outSamples, /\*!< pointer to output samples \*/

 Word16 \*numOutSamples, /\*!< pointer tp number of output samples \*/

 Word16 outStride /\*!< increment of output samples \*/

 );

#### A.5.2.4 AAC Decoder (aacdecoder.h)

typedef enum {

 AAC\_DEC\_OK = 0x0,

 AAC\_DEC\_UNSUPPORTED\_FORMAT,

 AAC\_DEC\_DECODE\_FRAME\_ERROR,

 AAC\_DEC\_INVALID\_CODE\_BOOK,

 AAC\_DEC\_UNSUPPORTED\_WINOW\_SHAPE,

 AAC\_DEC\_PREDICTION\_NOT\_SUPPORTED\_IN\_LC\_AAC,

 AAC\_DEC\_UNIMPLEMENTED\_CCE,

 AAC\_DEC\_UNIMPLEMENTED\_PCE,

 AAC\_DEC\_UNIMPLEMENTED\_LFE,

 AAC\_DEC\_UNIMPLEMENTED\_GAIN\_CONTROL\_DATA,

 AAC\_DEC\_OVERWRITE\_BITS\_IN\_INPUT\_BUFFER,

 AAC\_DEC\_CANNOT\_REACH\_BUFFER\_FULLNESS,

 AAC\_DEC\_TNS\_RANGE\_ERROR,

 AAC\_DEC\_TNS\_ORDER\_ERROR

}

AAC\_DEC\_STATUS;

typedef struct AAC\_DECODER\_INSTANCE \*AACDECODER;

#define FRAME\_SIZE 1024

/\* initialization of aac decoder \*/

AACDECODER CAacDecoderOpen(HANDLE\_BIT\_BUF hBitBufCore,

 SBRBITSTREAM \*streamSbr,

 Word32 samplingRate);

/\* aac decoder \*/

Word16 CAacDecoder\_DecodeFrame(AACDECODER aacDecoderInstance,

 Word16 \*frameSize,

 Word32 \*sampleRate,

 Word8 \*channelMode,

 Word16 \*numChannels,

 Word16 \*timeData,

 Flag frameOK

);

#### A.5.2.5 SBR Decoder (sbrdecoder.h)

#define SBR\_EXTENSION 13 /\* 1101 \*/

#define SBR\_EXTENSION\_CRC 14 /\* 1110 \*/

#define MAXNRELEMENTS 2

#define MAXNRSBRCHANNELS 2

#define MAXSBRBYTES 269

#define SBRDEC\_OK 0

typedef enum

{

 SBR\_ID\_SCE = 0,

 SBR\_ID\_CPE,

 SBR\_ID\_CCE,

 SBR\_ID\_LCS,

 SBR\_ID\_LFE,

 SBR\_ID\_DSE,

 SBR\_ID\_PCE,

 SBR\_ID\_FIL,

 SBR\_ID\_END

}

SBR\_ELEMENT\_ID;

typedef struct

{

 Word16 elementID; /\*!< ID\_SCE (mono) or ID\_CPE (stereo) \*/

 Word16 extensionType; /\*!< e.g. SBR\_EXTENSION or SBR\_EXTENSION\_MPEG \*/

 Word16 sizePayload; /\*!< length of data \*/

 Word8 \*pData; /\*!< Pointer to actual data \*/

}

SBR\_ELEMENT\_STREAM;

typedef struct

{

 Word16 nrElements; /\*!< Number of valid SBR streams \*/

 SBR\_ELEMENT\_STREAM sbrElement[MAXNRELEMENTS];

}

SBRBITSTREAM;

typedef struct SBR\_DECODER\_INSTANCE \*SBRDECODER;

SBRDECODER openSBR (Word32 sampleRate, Word16 samplesPerFrame, Flag bDownSample, Flag bApplyQmfLp) ;

Word16 applySBR (SBRDECODER self,

 SBRBITSTREAM \*Bitstr,

 Word16 \*TimeData,

 Word16 \*numChannels,

 Flag frameOK,

 Flag bDownSample,

 Flag bBitstreamDownMix);

## A.6 AMR-WB+

### A.6.1 AMR-WB+ Fixed-Point (TS 26.273)

#### A.6.1.1 Encoder (enc\_if\_fx.h)

#define L\_FRAME16k 320 /\* Frame size at 16kHz \*/

#define NB\_SERIAL\_MAX 61 /\* max serial size \*/

int E\_IF\_encode\_fx(void \*st, Word16 mode, Word16 \*speech,

 UWord8 \*serial, Word16 dtx);

void \*E\_IF\_init\_fx(void);

void E\_IF\_exit\_fx(void \*state);

void E\_IF\_encode\_first\_fx(void \*st, Word16 \*speech);

#### A.6.1.2 Decoder (dec\_if\_fx.h)

#define NB\_SERIAL\_MAX 61 /\* max serial size \*/

#define L\_FRAME16k 320 /\* Frame size at 16kHz \*/

#define \_good\_frame 0

#define \_bad\_frame 1

#define \_lost\_frame 2

#define \_no\_frame 3

void D\_IF\_decode\_fx(void \*st, UWord8 \*bits, Word16 \*synth, Word16 bfi);

void \* D\_IF\_init\_fx(void);

void D\_IF\_exit\_fx(void \*state);

### A.6.2 AMR-WB+ Floating-Point (TS 26.304)

#### A.6.2.1 Encoder (proto\_func.h)

void init\_coder\_amrwb\_plus(Coder\_State\_Plus \* st, int num\_chan, int fscale, short use\_case\_mode, short full\_reset);

int coder\_amrwb\_plus\_stereo(float channel\_right[], /\* input: used on mono and stereo \*/

 float channel\_left[], /\* input: used on stereo only \*/

 int codec\_mode, /\* input: AMR-WB+ mode (see cnst.h) \*/

 int L\_frame, /\* input: 80ms frame size \*/

 short serial[], /\* output: serial parameters \*/

 Coder\_State\_Plus \* st, /\* i/o : coder memory state \*/

 short useCaseB, int bwe\_flag, /\* 32kHz NBWE \*/

 int StbrMode);

int coder\_amrwb\_plus\_mono(float channel\_right[], /\* input: used on mono and stereo \*/

 int codec\_mode, /\* input: AMR-WB+ mode (see cnst.h) \*/

 int L\_frame, /\* input: 80ms frame size \*/

 short serial[], /\* output: serial parameters \*/

 Coder\_State\_Plus \* st, /\* i/o : coder memory state \*/

 short useCaseB, int bwe\_flag /\* 32kHz NBWE \*/

 );

void coder\_amrwb\_plus\_mono\_first(float channel\_right[], /\* input: used on mono and stereo \*/

 int n\_channel, /\* input: 1 or 2 (mono/stereo) \*/

 int L\_frame, /\* input: frame size \*/

 int L\_next, /\* input: lookahead \*/

 int bwe\_flag, /\* for 32kHz NBWE \*/

 Coder\_State\_Plus \* st /\* i/o : coder memory state \*/

 );

int coder\_amrwb\_plus\_first(float channel\_right[], /\* input: used on mono and stereo \*/

 float channel\_left[], /\* input: used on stereo only \*/

 int n\_channel, /\* input: 1 or 2 (mono/stereo) \*/

 int L\_frame, /\* input: frame size \*/

 int L\_next, /\* input: lookahead \*/

 int bwe\_flag, /\* AriL: for 32kHz NBWE \*/

 Coder\_State\_Plus \* st /\* i/o : coder memory state \*/

 );

#### A.6.2.2 Decoder (proto\_func.h)

void init\_decoder\_amrwb\_plus(Decoder\_State\_Plus \* st, int num\_chan, int fscale, short full\_reset);

int decoder\_amrwb\_plus(int codec\_mode, /\* input: AMR-WB+ mode (see cnst.h) \*/

 short serial[], /\* input: serial parameters (4x20ms) \*/

 int bad\_frame[], /\* input: bfi (bad\_frame[4]) \*/

 int L\_frame, /\* input: frame size of synthesis \*/

 int n\_channel, /\* input: 1 or 2 (mono/stereo) \*/

 float channel\_right[], /\* (o): used on mono and stereo \*/

 float channel\_left[], /\* (o): used on stereo only \*/

 Decoder\_State\_Plus \* st, /\* i/o : decoder memory state \*/

 int fscale,

 int StbrMode,

 int mono\_dec\_stereo,

 short upsamp\_fscale);

void decoder\_amrwb\_plus\_1(float \*chan\_right,

 float \*chan\_left,

 int \*mod,

 int \*param,

 int \*prm\_hf\_right,

 int \*prm\_hf\_left,

 int \*nbits\_AVQ,

 int codec\_mode,

 int \*bad\_frame,

 int \*bad\_frame\_hf,

 float \*AqLF,

 float \*synth,

 int \*pitch,

 float \*pit\_gain, Decoder\_State\_Plus \* st, int n\_channel, int L\_frame, int bwe\_flag,

 int mono\_dec\_stereo);

## A.7 IVAS

tbd

Annex B (informative):
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2024-05 | SA4#128 | S4-241215 |  |  |  | Initial version | 0.1.0 |
| 2024-11 | SA4#130 | S4-242146 |  |  |  | Addition of WebCodec configuration properties based on S4-241968 | 0.2.0 |
| 2024-11 | SA4#130 | S4-242239 |  |  |  | Editorial work on clause numbering in Annexes | 0.2.1 |
| 2025-02 | SA4#131 | S4-250315 |  |  |  | Addition of WebRTC clauses based on S4-250211, S4-250216 | 0.3.0 |
| 2025-02 | SA4#131 | S4-240387 |  |  |  | Editorial fixes | 0.3.1 |
| 2025-04 | SA4#131-bis-e | S4-250703 |  |  |  | Addition of clause on audio format support based on S4-250580 | 0.4.0 |
| 2025-04 | SA4#131-bis-e | S4-250748 |  |  |  | Editorial fixes | 0.4.1 |
| 2025-05 | SA4#132 | S4-250920 |  |  |  | Addition of clauses on Audio Formats in WebRTC and Common APIs based on S4-251054 and S4-250927 | 0.5.0 |