Source:	**TSG-S4**
Title:	**AMR Wideband Permanent project document WB-4: Design Constraints, v. 1.0**
Document for:	**Approval**
Agenda Item:	**5.4.3**

1. Introduction

This document lists design constraints for the AMR-WB speech codec development. The design constraints are a set of mandatory requirements that the codec proposal must fulfil to be suitable for 3G and GSM and to be considered in codec selection. Whenever it is not clearly specified, the constraints apply to the selection phase and to any preselection (qualification) phase of the AMR-WB development.

2. AMR-WB codec development constraints (summary table)

Development constraints		**Open issues, notes**
Complexity requirements[1]		WB = Wideband NB = Narrowband
Channel coding including possible control loop management algorithms	**GSM FR:** **A. wMOPS ≤ 5.7 wMOPS** **B. RAM ≤ 3.0 kwords** **C. ROM ≤ 4.5 kwords** **D. Program ROM ≤ 1.5 * Program ROM of AMR-NB FR ch. Codec)** (1.5 * 1 342 ETSI basic operators) **3G:** Existing generic 3G channel coding toolbox shall be used for channel coding. **GSM EDGE:** [t.b.a.] **GSM multi-slot:** [f.f.s.]	Are separate (higher) complexity requirements needed for higher rate GSM channels?
Speech coding (excluding VAD/DTX)	**E. wMOPS ≤ 40 wMOPS** (≈ 2.4 x wMOPS of AMR-NB sp. Codec: 16.75) **F. RAM ≤ 15 kwords** (≈ 2.8 × RAM of AMR-NB speech codec: 5.28 kwords) **G. ROM ≤ 18 kwords** (≈ 1.2 x ROM of AMR-NB speech codec: 14.57 kwords) **H. Program ROM ≤ 1.2*Program ROM of AMR-NB speech codec** (= 1.2 * 4 851 ETSI basic operators)	The complexity limit applies to the codec considered as a whole, including all modes.
Additional complexity for VAD/DTX operation (over speech coding complexity limits)	1.5 times the corresponding complexity of AMR-NB VAD/DTX with the more complex VAD Option (VAD2): **I. wMOPS ≤ 1.6 wMOPS** **J. RAM ≤ 149 words** **K. ROM ≤ 1004 words** **L. Program ROM ≤ 1.5 * Program ROM of AMR-NB VAD/DTX with the more complex VAD Option (VAD 2)** ([t.b.a.] ETSI basic operators)	
A-ter and Iu submultiplexing	At least one codec mode at AMR-WB shall be consistent with 16 kbit/s submultiplexing on the A-ter interface. This implies the constraint of providing at least one codec mode in AMR-WB operating at a source codec bit-rate below 14.4 kbit/s .	Bit-rate limitations due to EDGE A-ter?

<table>
<tr><td>Other constraints for bit-rates</td><td>The source codec shall be capable of operating at or below the primary rates of interest to ITU WB Question (currently bit-rates of 16 and 24 kbit/s).</td><td>Investigate the possible constraints due to multi-slot operation.</td></tr>
<tr><td>Codec mode</td><td><u>GSM FR:</u>
• Same signalling scheme as in AMR-NB shall be used. This is valid for codec mode and channel measurement signalling.
<u>GSM EDGE:</u>
• Same signalling scheme as in AMR-NB shall be used. This is valid for codec mode and channel measurement signalling.
<u>GSM multi-slot:</u>
• Same signalling scheme as in AMR-NB shall be used. This is valid for codec mode and channel measurement signalling. This constraint is to be confirmed at the next meeting.
<u>3G:</u>
• Same signalling scheme as in AMR-NB shall be used.
Channel coding (including possible control-loop management algorithms) is part of the codec proposal. The channel coding scheme shall be included for GSM FR, GSM EDGE, GSM multi-slot and 3G.</td><td>Note that there are no constraints for the number of codec modes. Nevertheless the number of codec modes allowed for each channel in selection/qualification tests may be restricted (see WB-8 "Test Plans for Each Phase").
Availability of error patterns must be confirmed.</td></tr>
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Channel mode	**GSM (FR, EDGE and multi-slot):** The AMR-WB codec will operate in GSM full-rate speech traffic channel, EGDE, and multi-slot channels. Channel mode handovers will be executed in the same way as existing intra-cell handovers. Handovers between AMR-WB FR and AMR-NB HR will mean switching between wideband speech services and the existing AMR HR narrowband speech services. The algorithm used to determine when and whether to perform an AMR handover will be specific to the BSS manufacturer. • Channel mode signalling: transmitted out of band on the radio interface • The up- and downlinks (of the same air-interface) shall use the same channel mode. • Channel mode control is located in the network.	**3G:** The AMR-WB will operate with spreading factors: 128, 64 and 32 (see 3G channel codec toolbox)	
Channel coding	**GSM (FR, EDGE and multi-slot):** The existing sets of convolutional polynomials defined in GSM 05.03 shall be used.	**3G:** Existing generic 3G channel coding toolbox shall be used. Error protection containing up to 3 bit-sensivity classes may be used.	
Tandem Free Operation (TFO)	The AMR-WB codec shall support Tandem Free Operation		
Voice Activity Detection (VAD) and comfort noise	The codec proponents shall provide the VAD and comfort noise encoding solution for the selection phase. The AMR-WB VAD/DTX will be that associated with the selected codec.		
Discontinuous Transmission (DTX)	**GSM FR:** The same DTX scheme (transport format, update frequency) as in AMR-NB shall be used **GSM EDGE:** Derived from the AMR-NB DTX **GSM multi-slot:** Derived from the AMR-NB DTX	**3G:** The same SCR-scheme (transport format, update frequency) as in AMR-NB shall be used.	

Active noise suppression in the selection/ qualification phase	In order to compare all solutions in the same conditions, and select the candidate with the best intrinsic quality, the noise suppressers would not be included during the selection phases, or that any noise suppresser integrated to a source codec shall be turned off for these tests. The selection and possible standardisation of a noise suppresser may then be addressed in a separate phase	
Transmission delay[2]	This constraint is set for the algorithmic transmission delay in GSM FR channel. The target is to keep the algorithmic round trip delay for wideband modes equal to the algorithmic round trip delay of the GSM AMR-NB FR. Nevertheless, some increase of algorithmic transmission delay is expected due to the higher source coding bit-rates in AMR-WB. See note 2 "Evaluation of algorithmic round-trip delay" for definition of the evaluation methodology and the relating constraint.	
Error concealment	Error concealment techniques of AMR-WB codec candidates shall only rely on soft-output information from the equaliser (in BTS only information that can be sent over Ater). This does not preclude any future exploitation of other radio channel parameters in the final AMR-WB system.	
Frame size	The frame size is constrained to be one of the possible values: 5ms, 10ms or 20 ms.	
Input sampling rate and audio bandwidth	The codec will operate on 16 kHz input sampling rate. The input signal bandwidth shall be 50 Hz to 7 kHz. It is required to make sure that no artifacts are caused by signals lying outide the range 50 Hz to 7 kHz.	Note that other bandwidths may be used for testing purposes.

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[1] The complexity requirements are valid for all phases of the AMR-WB development and are separate for channel coding, speech coding and DTX algorithms.

Notes:

1. Program ROM is computed as the number of basic instructions
2. The control loop management algorithms are intended to include all the additional algorithms beyond speech and channel codec that are needed for codec mode adaptation: channel metric estimation, adaptation algorithm, coding and decoding of the in-band signalling.

Complexity calculation rules:

The same complexity evaluation methodology as used in the past for GSM AMR narrowband standardisation (based on ETSI fixed-point basic operations) will be used for complexity evaluation of the AMR-WB codec. Detailed procedure for each phase is the following:

- **Qualification (if needed)**: Complexity evaluation may be based on floating point code. The results should nevertheless be presented as ETSI FOM, wMOPS, and memory figures even though they are allowed to be estimated from a floating-point code. Requirements shall be checked according to the assessment methodology given in AMR narrowband document AMR-9 (Complexity and delay assessment) [2].
- **Selection**: ETSI methodology based on fixed point code (Basic op. Counters, i.e. Worst observed case)
- **Verification/characterisation**: ETSI methodology based on fixed point code (Theoretical worst case)

Arithmetic used in codec proposals:

- **Qualification (if needed)**: Fixed point or floating point code
- **Selection**: Fixed point code (using ETSI set of basic operations)
- **Verification/characterisation**: Fixed-point code (using ETSI set of basic operations).

2 Evaluation of algorithmic round-trip delay

The MS-to-MS algorithmic round-trip delay evaluation of a codec mode is based, as for the GSM HR, EFR and AMR standardisation, on four codec dependent algorithmic delay contributors :

- analysis frame length delay (T_{sample}): duration of the segment of PCM speech operated on by the speech transcoder.
- interleaving and de-interleaving delay (T_{rftx}): time required for transmission of a speech frame over the air interface due to interleaving and de-interleaving.
- uplink Abis delay (T_{Abisu}): time needed to transmit the minimum amount of bits over the Abis interface that are required at the speech decoder to synthesise the first output sample.
- downlink Abis delay (T_{Abisd}): time required to transmit all the speech frame data bits over the Abis interface in the downlink direction that are required to encode one speech frame.

The formula used for round-trip delay evaluation is the following:

$$D_{round\text{-}trip} = 2(T_{sample} + T_{rftx}) + T_{Abisu} + T_{Abisd}$$

The proponents must compute and provide figures for each component of the round trip delay for following configurations :

- highest delay of full-rate modes with 16kbps sub-multiplexing scheme ;
- highest delay of full-rate modes without 16kbps sub-multiplexing scheme

The delay constraints for the GSM TCH/FR channel is defined as follow:

Let's define the algorithmic round trip delay with two components

$$D_{round\text{-}trip} = 2(T_{sample} + T_{rftx}) + T_{Abisu} + T_{Abisd}$$

$$D_{round\text{-}trip} = D_{rt1} + D_{rt2}$$

With

$D_{rt1} = 2(T_{sample} + T_{rftx})$ **,** the algorithmic round trip delay without the Abis-Ater interface component, and

$D_{rt2} = T_{Abisu} + T_{Abisd}$ **,** the algorithmic round trip delay component over the Abis-Ater interface.

The reference are the maximum D_{rt1} and D_{rt2} delays for the AMR narrow-band. I.e. taken from the GSM 06.75 v7.1.0 we have :

D_{rt1} (ref)= $2(T_{sample} + T_{rftx})$ = 125 ms for FR-12.2 kbps AMR mode

D_{rt2} (ref)= $T_{Abisu} + T_{Abisd}$ = 24.25 ms for FR-12.2 kbps AMR mode

All AMR WB candidates shall comply with the following:

D_{rt1} (WB) <= D_{rt1} (ref) ; for scenarii A (GSM full-rate traffic channel (22.8 kbit/s gross bit-rate) with an additional constraint of 16 kbit/s A-ter sub-multiplexing) and B (GSM full-rate traffic channel (22.8 kbit/s gross bit-rate), and

D_{rt2} (WB) <= D_{rt2} (ref) + 5 ms ; for scenario A.

The Abis delays (uplink and downlink) should be computed with a similar methodology as the one used in the GSM Recommendations 03.05 for the GSM FR, and 06.55 for the GSM EFR.

For the qualification and the selection phases the proponents must justify how the delay figures were computed. To that purpose, they can base the Abis delays on either type of TRAU frames (existing FR, HR and AMR TRAU frames, or new TRAU frames format proposed for AMR-WB).

REFERENCES

[1] "Adaptive Multi-Rate Wideband (AMR-WB) Feasibility Study Report", version 1.0.0, Source: SMG11, ETSI TC SMG Tdoc SMG P-99-429, Meeting #29, 23-25 June, 1999, Miami (FL), USA

[2] "Reproduction of AMR narrowband document AMR-9 (Complexity and delay assessment)", v1.3, Tdoc S4/SMG11 71/00.

DOCUMENT HISTORY

VERSION	SOURCE
v0.1	Initial version by editor (October 1999) Editor: Kari Järvinen, Nokia; Mailing address: Nokia Research Center, P.O. Box 100 (Visiokatu 1), FIN-33721 Tampere, Finland; Email: kari.ju.jarvinen@nokia.com; Tel:+358 3272 5854; Mobile: +358 50 555 0 999; Fax: +358 3272 5888
v0.2	AMR-WB subgroup during SMG11#12 (October 1999)
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