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Source: **TSG SA WG4**

Title: **Report from SA4 to SA#23 on PSS/MMS audio codec selection**

Agenda item: **7.4.3**

Document for: **Information**

Introduction

This document gives a report of the PSS/MMS Audio Codec selection.

1 PSS/MMS Audio Codec Selection Procedure and Conclusions

The audio codec selection procedure was performed on 3 candidates in the low-bitrate range and 2 candidates in the high-bitrate range. During steps 1 to 3 (and steps 6 to 8 respectively) of the selection process, the candidate codecs were anonymized as follows:

Low-bitrate range: Codec1 (aacPlus), Codec2 (AMR-WB+), Codec3 (enhanced aacPlus)

High-bitrate range: Codec1 (aacPlus), Codec2 (enhanced aacPlus)

The selection procedure was performed following the steps defined in the selection rules (SP-030675). The rules are repeated below, followed by a description of the conclusions of SA4 drawn after each of these steps:

Low Bit-Rate codec discussion (steps 1-5):

1. *The LBR Selection test results will be presented and analysed while keeping secret the identity of the LBR candidates. Each candidate will be informed of the code used for its own solution and its solution only. The Selection rules 2 and 3 defined in section 1 will be applied at this stage.*

    - The audio ad-hoc group reviewed the Global Analysis Lab report (S4-040099) which contained the information required to apply Selection Rules 2 and 3. Based on the data contained in the document, the group concluded that the Codec 1 has to be excluded from the further selection because it did not perform in line with Selection Rule 2.

2. *After the review and discussion of the test results (as specified for rule 3), TSG-SA4 will try to reach a consensus on a quality ranking of the LBR candidates.*

    - The tables in Annex 1 contain the Figures of Merit which were defined for Selection Rule 3 in the low-bitrate range.
    - Based on the FOMs, SA4 could draw the following conclusions:

    The preferred FoM is a multi-dimensional matrix and no consistent ranking of the codecs is possible according to the table entries.

    However, the following conclusions have been drawn by the group:

    - *At 14 kbps Codec 2 performs better than Codec 3.*
    - *At 24 kbps Codec 3 performs better than Codec 2.*
    - *At 18 kbps the ranking of the performance of Codec 2 compared to Codec 3 depends on the application and/or content-type:*
        - *Codec 3 performs better than Codec 2 in use case B (MMS)*
        - *Codec 2 performs better than Codec 3 in use case A (PSS)*
    - *Codec 3 is strong in music and speech over music content at 18 and 24 kbps.*
    - *Codec 2 is strong in speech and speech between music content at 14, 18, and 24 kbps.*
    - *Codec 3 performs worse than the reference for speech and speech-between-music content at rates 14 and 18 kbps.*

3. *Each LBR candidate will then present its solution and show the compliance with the PSS/MMS Audio Codec Design Constraints [1]. All candidates not compliant with all design constraints will be excluded according to the Selection rule 1 defined in section 1.*

    - All candidates were found to meet the design constraints. No candidate was excluded according to Selection Rule 1.
    - The enhanced AMR-WB candidate was also found to meet the design constraints established in the enhanced AMR-WB work item.

4. *The test results obtained by each LBR candidate will then be revealed.*

    - The identity of each candidate was revealed to the delegates.

5. *A discussion and review of the LBR candidate codec characteristics and test results will take place.*

    - No further conclusions beyond those described in Step 2 could be reached.

High Bit-Rate codec discussion (steps 6-10):

6. *The HBR Selection test results will be presented and analysed while keeping secret the identity of the HBR candidates. Each candidate will be informed of the code used for its own solution and its solution only. The Selection rules 2 and 3 defined in section 2 will be applied at this stage.*

   - The audio ad-hoc group reviewed the Global Analysis Lab report (S4-04028) which contained the information required to apply Selection Rules 2 and 3. Based on the data contained in the document, the group concluded that no codec has to be excluded according to Selection Rule 2.

7. *After the review and discussion of the test results (as specified for rule 3), TSG-SA4 will try to reach a consensus on a quality ranking of the HBR candidates.*

Tests	Operating condition	Codec1	Codec2
LR-A3	24 kbps, mono	75.0	75.8
LR-A4	24 kbps, stereo	55.3	67.1
1	32 kbps, stereo	75.8	84.9
2	48 kbps, stereo	82.0	81.5
3-1	32 kbps, stereo, 1% FER	66.2	72.9
3-2	32 kbps, stereo, 3% FER	56.3	62.3

   - Based on all FoMs, Codec 2 was found to be the best performer in the high bit-rate range. SA4 agreed on this quality ranking of candidates for the high bit-rate case.

8. *Each HBR candidate will then present its solution and show the compliance with the PSS/MMS Audio Codec Design Constraints [1]. All candidates not compliant with all design constraints will be excluded according to the Selection rule 1 defined in section 2.*

   - One set of design constraints was covering both the low- and the high-bitrate range. The group concluded, that no candidate had to be excluded according to Selection Rule 1.

9. *The test results obtained by each HBR candidate will then be revealed.*

   - The identity of each candidate was revealed to the delegates.

10. *A discussion and review of the HBR candidate codec characteristics and test results will take place.*

    - No further conclusions beyond those described in Step 7 could be reached.

Selection of PSS/MMS Audio codec(s) for low and high bit-rate ranges:

11. *SA4 will try to reach a consensus on codec(s) for the PSS/MMS default audio codec for low and high bit-rate range.*

    - After a discussion on the respective merits of the candidate codecs and after a collection of company preferences, SA4 agreed on the following selection of codecs:

Text on audio media-type into TS 26.234 (PSS, Rel-6):

7.3 Audio

If audio is supported, then one or both of the following two audio decoders should be supported for PSS:

Enhanced AAC+	[REF TBD]
AMR-WB+	[REF TBD]

Guidelines as to the usage of these decoders is provided in an informative Annex (TBD)

Annex:

Enhanced AAC+ has an optimal operating range from 18kbps upwards

AMR-WB+ has an optimal operating range up to 24kbps

Further information on the characteristics of these codecs can be found in the following Technical Report XXX

Notes:

The Enhanced AAC+ decoder also provides backwards compatibility with AAC which was recommended in Rel4 and 5

The AMR-WB+ decoder also supports decoding of AMR-WB bitstreams

List of Attachments:

- SP-030675: PSS/MMS Audio Codec and Extended AMR-WB, Selection Rules Version 2.0
- S4-030433: PSS/MMS Audio Codec Design Constraints and Performance Requirements Version 2.0

Annex 1: FOMs for the low-bitrate range

Codec 2

Preferred FoM

	m	s	sbm	som	average	min	max
A1 14 kbps, mono, use case A (PSS)	18.38	15.07	16.65	5.27	13.84	-1.40	26.67
A2 18 kbps, stereo, use case A (PSS)	12.69	2.72	9.88	1.97	6.82	-18.90	26.10
A3 24 kbps, mono, use case A (PSS)	8.74	21.53	11.42	11.35	13.26	-4.41	27.07
A4 24 kbps, stereo, use case A (PSS)	8.60	12.81	16.50	11.73	12.41	-4.60	26.57
B1 14 kbps, mono, use case B (MMS), 16 kHz	3.61	-1.48	5.48	-1.83	1.45	-10.20	13.53
B2 18 kbps, stereo, use case B (MMS)	11.61	-0.71	-3.14	2.54	2.58	-19.57	30.83
B3 14 kbps, mono, use case A (PSS), 3% FER	6.99	19.60	23.77	20.13	17.63	-0.76	32.80
B4 24 kbps, stereo, use case A (PSS), 3% FER	11.15	20.37	19.18	19.30	17.50	3.70	30.33
Average	10.22	11.24	12.47	8.81	10.68	-7.02	26.74
Min	-13.37	-11.43	-19.57	-18.90	-15.81	-19.57	
Max	30.83	27.69	32.80	30.33	30.41		32.80
FoM L1	28						
FoM L2	4						

Codec 3

Preferred FoM

	m	s	sbm	som	average	min	max
A1 14 kbps, mono, use case A (PSS)	17.55	-7.91	-6.24	6.91	2.58	-37.10	30.19
A2 18 kbps, stereo, use case A (PSS)	28.69	-19.66	-0.45	9.99	4.64	-36.37	42.20
A3 24 kbps, mono, use case A (PSS)	27.29	14.02	21.65	24.32	21.82	-15.40	42.00
A4 24 kbps, stereo, use case A (PSS)	33.18	6.26	3.81	28.39	17.91	-13.80	44.24
B1 14 kbps, mono, use case B (MMS), 16 kHz	7.75	-15.84	-11.19	-0.39	-4.92	-34.38	15.67
B2 18 kbps, stereo, use case B (MMS)	31.29	-8.61	-13.73	20.94	7.47	-27.83	46.00
B3 14 kbps, mono, use case A (PSS), 3% FER	2.99	5.26	10.35	19.31	9.48	-23.93	30.70
B4 24 kbps, stereo, use case A (PSS), 3% FER	31.35	10.28	11.74	35.05	22.10	-5.07	48.23
average	22.51	-2.03	1.99	18.06	10.14	-24.23	37.40
min	-23.93	-37.10	-27.83	-25.48	-28.59	-37.10	
max	46.00	33.48	40.97	48.23	42.17		48.23
FoM L1	23						
FoM L2	9						

Computational Complexity FOMs:

Decoder (mono/stereo)

	Peak WMOPS	Average WMOPS	RAM +ROM (KW)	PROM (KW)
AAC+	12.47 / 17.69	11.12 / 16.20	21.3 / 22.7	6.8 / 6.5
AMR-WB+	8.6 / 15.5	7.1 / 14.2	22.6 / 27.3	4.0 / 4.9
CT	11.39 / 21.63	10.30 / 20.45	22.6 / 26.7	6.7 / 8.0

MMS Encoder (stereo)

	Peak WMOPS	Average WMOPS	RAM +ROM (KW)	PROM (KW)
AAC+	44.09	36.67	40.7	14.3
AMR-WB+	38.3	34.4	36.1	6.8
CT	29.85	27	43.7	14.4

PSS Encoder (stereo)

	Peak WMOPS	Average WMOPS	RAM +ROM (KW)
AAC+	44.09	36.67	40.7
AMR-WB+	62.0	60.9	40
CT	29.85	27	43.7

3GPP SA4 #26 ***Tdoc. S4-030433***
May 5-9, 2003, Paris, France

Title: PSS/MMS Audio Codec Selection, Design Constraints and Performance Requirements – Version 2.0

Source: TSG SA-4 [1]

[1] Editor:
Oliver Kunz
Coding Technologies

Tel: +49 911 928 9112
Fax: +49 911 928 9199
E-mail: kunz@codingtechnologies.com

1 Introduction

This document is related to the Rel.6 work item “Packet Switched Streaming” and contains the performance requirements and design constraints for the selection of the audio codec for PSS/MMS in Rel.6. The subjective quality evaluation procedures are described in the “PSS/MMS Audio Codec Selection Test Plan” (S4-030377).

1.1 Background

At SA-4 #24, the PSM SWG agreed that the establishment of mandatory audio codecs for PSS in Rel.6 would be desirable (see [1]). Based on this decision, the following language was included into the living document of TS 26.234 Rel-6:

> SA4 PSM was in agreement that the selection of a mandatory codec for audio in PSS and MMS (and MBMS ffs) would be desirable in the context of Rel.6. The group acknowledged that in the lower bitrate audio range (12 kbit/s to <32 kbit/s, as defined in the S4-020660) there were two contenders being presented, namely aacPlus and the proposed Wideband AMR Extension presented as a work item to SA4. In the higher bitrate audio range, the group agreed that at the present moment, aacPlus and AAC appear to be the contenders in that field.

The list of candidate codecs was closed on March 31st, 2003. The current list of candidates can be found in S4-030316. Furthermore, the current draft of the design constraints for the AMR-WB+ work item (see [3]) sets the maximum bitrate for the AMR-WB+ codec to 24kbit/s.

1.2 Document structure

Given the information presented in section 1.1, it appears sensible to treat the two bitrate ranges separately in the context of this document. The use cases in the two bitrate ranges can be expected to be different. In order to allow some flexibility in defining the exact breaking point between the low and the high bitrate range (should this become necessary in the context of creating final language in TS 26.234 Rel-6), it was agreed to introduce an area of overlap of the two bitrate ranges between 24kbit/s and 32kbit/s. This will be achieved by defining test cases at 24kbit/s for both the low and the high bitrate range.

Section 2 lists the design constraints, which are identical for both bitrate ranges.

Section 3 lists the performance requirements, detailed by bitrate range.

2 Design constraints and objectives for the codecs

Table 2.1 lists the design constraints which the codecs will have to comply with. It also lists a number of objectives which are considered relevant in the selection process.

Criteria	Design Constraint	Design Objective
Computational Complexity[2]	Server-based stereo Encoder (PSS and/or MMS): A. wMOPS ≤ 8 * AMR-WB[3] codec B. RAM+ROM ≤ 160 kWords Low-complexity mono encoder for MMS: A. wMOPS ≤ 1.2 * AMR-WB codec B. RAM+ROM ≤ 40 kWords C. PROM ≤ 3.5 * AMR-WB codec Low-complexity stereo encoder for MMS: A. wMOPS ≤ 2 * AMR-WB codec B. RAM+ROM ≤ 65 kWords C. PROM ≤ 3.5 * AMR-WB codec Decoder: A1. wMOPS ≤ 3 * AMR-WB decoder (to create mono output out of either mono or stereo input bitstream) A2. wMOPS ≤ 4 * AMR-WB decoder (for stereo) B. RAM + ROM ≤ 40 kWords C. PROM ≤ 3 * AMR-WB codec	Low decoder complexity is an advantage. PROM ≤ 2.5 * AMR-WB codec PROM ≤ 2.5 * AMR-WB codec
Configurability	Multiple bitrates in both mono and stereo	Flexible adjustment of bitrate
Switching between bitrates	Bitrate switching within the same sampling rate and number of channels shall be possible.	
Encoder sampling rates	The encoder shall support 16kHz input sampling rate The encoder shall not require input at any sampling rate other than (in kHz): 16, 22.05, 24, 32, 44.1, 48	
Decoder capability	The decoder shall not require the terminal to support output at sampling rates other than (in kHz): 16, 22.05, 24, 32, 44.1, 48 The decoder shall support output sampling rates of (in kHz): 8, 16	
Variable bitrate coding		Support of DTX or variable bitrate coding
Error concealment	Shall only rely on the information that a frame was lost	

Table 2.1 Design constraints

[2] Computational complexity will be evaluated based on floating point source code, using the tools described in Tdoc. S4-030301

[3] All AMR-WB complexity figures as described in Tdoc. S4-030302

3 Performance requirements

3.1.1 Performance requirements for the lower bitrate range

Table 2.2 lists the performance requirements against which the codecs complying with the design constraints will be evaluated in terms of audio quality and error robustness.
Table 2.3 lists the content types to be taken into account in the audio quality evaluation process

Criteria	Performance Requirement	Performance Objective
Audio quality	No worse than the better of AMR-WB and MPEG-4 AAC LC at the same bitrate in any test case based on the average performance over music, mixed content and speech, and better in at least one test case. Test cases covered shall be 14kbit/s mono, 18kbit/s stereo, 24kbit/s mono and 24kbit/s stereo	Maximum performance across all relevant bitrates and content types
Error Robustness	At 3% frame-loss rate[4] no worse than the better of AMR-WB and MPEG-4 AAC-LC at the same bitrate and frame loss rate in any test case based on the average performance over music, mixed content and speech. Test cases covered shall be 14kbit/s mono and 24kbit/s stereo.	At 5% frame-loss rate no worse than the better of AMR-WB and MPEG-4 AAC-LC at the same bitrate and frame loss rate in any test case based on the average performance over music, mixed content and speech. Test cases covered shall be 14kbit/s mono and 24kbit/s stereo.

Table 3.1 Performance requirements in the low bitrate range

Content type	Description	Relative value
Mixed content 1	Speech over music	25%
Music	Classical and popular music with and without vocals	25%
Speech only	Clean speech and speech with background noise	25%
Mixed content 2	Speech in between music	25%

Table 3.2 Content types for lower bitrate range

3.1.2 Performance requirements for the higher bitrate range

Table 2.4 lists the performance requirements against which the codecs complying with the design constraints will be evaluated in terms of audio quality and error robustness.
Tables 2.5 lists the content types to be taken into account in the audio quality evaluation process for the bitrates above 24kbit/s (for the 24kbit/s cases, please refer to section 2.2.1).

[4] Random frame loss at the given rate is assumed. To be able to compare codecs, X% frame loss rate means on the average X lost frames out of 100 frames regardless of frame length.

Criteria	Performance Requirement	Performance Objective
Audio quality	Better than AAC in all test cases. Test cases are 24kbit/s mono, 24kbit/s stereo, 32kbit/s stereo and 48kbit/s stereo.	Maximum performance across all relevant bitrates and content types
Error Robustness	At 1% frame-loss rate no worse than MPEG-4 AAC-LC at the same frame loss rate, tested at 32 kbit/s stereo.	At 3% frame-loss rate no worse than MPEG-4 AAC-LC at the same frame loss rate, tested at 32 kbit/s stereo.

Table 3.3 Performance requirements for the higher bitrate range

Content types	Description	Relative value
Music	Music with and without vocals	100%

Table 3.4 Content type taken into account for test cases in the higher bitrate range

4 References

[1] TSG-S4 PSM SWG Chairman, *Report on TSG-S4 PSM SWG during SA4#24 meeting,* Tdoc S4-020731

[2] Ericsson (Rapporteur), *PSS R6 Time Plan version 1.0*, Tdoc S4-030098

[3] AMR-WB+ AHG, *Draft AMR-WB+ Design Constraints*, Tdoc S4-030098

[4] ITU, *Method for the subjective assessment of intermediate quality level of coding systems,* Recommendation ITU-R BS.1534

[5] Ericsson (Editor), *Draft AMR-WB+ Test and Processing Plan (WB+-x) Version 0.1*, Tdoc S4-030052

[6] Ericsson, *PSM low bit rate audio codec selection criteria,* Tdoc S4-030158

Technical Specification Group Services and System Aspects **TSGS#22(03)0675**

Meeting #22, Maui, Hawaii, USA, 15-18 December 2003 **Agenda Item: 7.4.3**

3GPP TSG SA4 #29 Tdoc S4-(03)0837

Tampere, Finland, 24-28 November 2003

Source: **TSG-SA4**

Title: **PSS/MMS Audio Codec and Extended AMR-WB, Selection Rules Version 2.0**

Introduction

This document contains a permanent document on Selection Rules for PSS/MMS Audio Codec and AMR-WB+. This document was prepared based on permanent document on Selection Rules used earlier in 3GPP for AMR-WB codec selection. (Since no separate permanent document exists this time for Selection Deliverables, a list of required selection deliverables is included in Annex A of this proposed permanent document.)

For permanent documents of AMR-WB Selection Phase, see http://www.3gpp.org/ftp/tsg_sa/WG4_CODEC/AMR-Wideband/Perm_Docs_Selection_Phase.

1. PSS/MMS Low-Bit Rate Audio Codec (LBRAC) Selection Rules

Three basic rules are defined. The first two rules are eliminating rules intended to exclude all candidates failing to demonstrate full compliance with the PSS/MMS Audio Codec Design Constraints defined in [1] or presenting test results too far below the expected performance level. The third rule is not exactly a rule but a primary selection of Figures of Merit according to which the candidate performances will be compared as part of the Selection test results analysis. These multiple criteria are intended to provide a good picture of the relative performances of the proposed solutions.

Each rule is further described in the following sections:

PSS/MMS LBRAC Selection Rule 1:

Any candidate (including AMR-WB+) not compliant with all design constraints defined in [1] will be excluded. In the case when the AMR-WB+ candidate fulfils the PSS/MMS audio codec design constraints and wins the selection based on the rules defined in this document but fails to fulfil the AMR-WB+ design constraints, the adoption of AMR-WB+ codec as the default PSS/MMS low bit-rate audio codec will be determined in TSG-SA4 group.

PSS/MMS LBRAC Selection Rule 2:

Any candidate not meeting the performance requirements [1] will be excluded. In order to meet the performance requirements, a candidate must be better than the reference at least in one test case (a test case being defined by its bitrate and mono/stereo configuration). A candidate must never be worse than the reference in any test case in experimental block A. However, up to one failure is accepted in quality comparison under stressed operating conditions (experimental block B). In each test case independently, the reference is selected as either AMR-WB or MPEG-4 AAC LC whichever performs better on the average over all tested items.

Denoting the AAC-LC performance in test case K and for item i (N is the total number of tested items) by $P_{AAC}(K,i)$, and respectively, the AMR-WB performance by $P_{AMRWB}(K,i)$, then the reference performance is understood as:

$$R(K) = \max\left(\frac{1}{N}\sum_{i=1}^{N} P_{AAC}(K,i), \frac{1}{N}\sum_{i=1}^{N} P_{AMRWB}(K,i)\right).$$

According to the content type weighting specified in [1], the experimental results for mixed content (speech over music and speech between music) are counted twice.

"Better than" and "no worse than" are defined at the 95% confidence level for performance measures defined above.

The score is understood as a MUSHRA score averaged across the replications of the sub-experiments (different laboratories) in each operational mode and operational condition.

PSS/MMS LBRAC Selection Rule 3: Figures of Merit:

A number of Figures of Merit (FoM) will be used to analyse and compare the performance of the candidates. Corresponding rankings will be prepared and provided for information only. None of the Figures of Merit listed below is intended to serve as single selection criteria.

The candidates will be ranked according to the following metrics:

Preferred quality FoM:

For each test case *K* and content type *T* = {music, speech over music, speech between music, speech} a delta performance score is calculated as the difference between the codec performance $\overline{P}_C(K,T)$ and the performance of a quality reference $R_Q(K,T)$:

$$\Delta_C(K,T) = \overline{P}_C(K,T) - R_Q(K,T)$$

The quality reference is calculated according to:

$$R_Q(K,T) = \frac{1}{N_T} \sum_{i \in I_T} \max(P_{AAC}(K,i), P_{AMRWB}(K,i)),$$

where I_T denotes the set of N_T items belonging to content type *T*.

The candidate codec performance is calculated according to:

$$\overline{P}_C(K,T) = \frac{1}{N_T} \sum_{i \in I_T} P_C(K,i)$$

.

The delta performance scores are arranged in a matrix where the different content types are given across the columns while the test cases are across the rows. Negative delta scores will be highlighted in red in order to indicate cases where the reference performance it is not met.

In addition to the item-wise delta scores per test cases, average, minimum and maximum delta scores will be given both across content type and test case.

The minimum and maximum delta score is understood as worst, respectively, best observed score across all items separately in content types and in test cases in which the reference is taken as maximum of the performances of AAC-LC and AMR-WB for the respective items at the given content types and test cases.

In order to provide a global overview further composite scores are derived such as average, minimum and maximum scores across the complete set of test cases and content types.

An overview of the complete matrix of scores is given in table 1:

Content type Operating condition	Music	Speech over music	Speech between music	Speech	Average	Min per item	Max per item
14 kbps, mono, use case A (PSS)							
18 kbps, stereo, use case A (PSS)							
24 kbps, mono, use case A (PSS)							
24 kbps, stereo, use case A (PSS)							
14 kbps, mono, use case B (MMS), 16 kHz inp. and outp. sampling rate							
18 kbps, stereo, use case B (MMS)							
14 kbps, mono, use case A (PSS), 3% FER							
24 kbps, stereo, use case A (PSS), 3% FER							
Average							
Min per item							Not used
Max per item						Not used	

FoM L1:

The number of positive delta MUSHRA table entries.

FoM L2:

The number of negative delta MUSHRA table entries.

FoM L3a-L3e:

Figure of Merit for computational complexity and memory are:

- The peak-WMOPS (measured for the worst observed frame)
- Average-WMOPS (measured over the test material)
- RAM (in kWords measured for the worst test case)
- ROM (in kWords measured for the worst test case)
- Program ROM (number of instructions measured for the worst test case)

2 Set of Rules for High-Bit Rate Audio Codec (HBRAC) Selection Rules

Three basic rules are defined. The first two rules are eliminating rules intended to exclude all candidates failing to demonstrate full compliance with the PSS/MMS Audio Codec Design Constraints defined in [1] or presenting test results too far below the expected performance level. The third rule is not exactly a rule but a primary selection of Figures of Merit according to which the candidate performances will be compared as part of the Selection test results analysis. These multiple criteria are intended to provide a good picture of the relative performances of the proposed solutions.

Each rule is further described in the following sections:

PSS/MMS HBRAC Selection Rule 1:

Any candidate not compliant with all Design Constraints defined in [1] will be excluded.

PSS/MMS HBRAC Selection Rule 2:

Any candidate not meeting the performance requirements defined in [1] will be excluded.

PSS/MMS HBRAC Selection Rule 3 Figure of Merits:

A number of Figures of Merit (FoM) will be used to analyse and compare the performance of the candidates. Corresponding rankings will be prepared and provided for information only. None of the Figures of Merit listed below is intended to serve as single selection criteria.

Preferred quality FoM:

For each test case *K* a delta performance score is calculated as the difference between the codec performance $\overline{P}_C(K)$ and the performance of a reference codec $\overline{P}_R(K)$:

$$\Delta_C(K) = \overline{P}_C(K) - \overline{P}_R(K)$$

The quality reference is calculated according to:

$$\overline{P}_R(K) = \frac{1}{N}\sum_{i \in I} P_R(K,i),$$

where *I* denotes the set of *N* test items.

The candidate codec performance is calculated according to:

$$\overline{P}_C(K) = \frac{1}{N}\sum_{i \in I} P_C(K,i).$$

The delta performance scores are arranged in a vector according to the test cases. Negative delta scores will be highlighted in red in order to indicate cases where the reference performance it is not met.

In addition to the item-wise delta scores per test cases, average, minimum and maximum delta scores will be given across test cases.

The minimum and maximum delta score is understood as worst, respectively, best observed score across all items in test cases in which the reference is AAC-LC.

In order to provide a global overview further composite scores are derived such as average, minimum and maximum scores across the complete set of test cases.

An overview of the complete matrix of scores is given in table 2:

Content type Operating condition	Audio	Min per item	Max per item
24 kbps, mono, use case A (PSS)			
24 kbps, stereo, use case A (PSS)			
32 kbit/s, stereo, use case A (PSS)			
32 kbps, stereo, use case B			
48 kbps, stereo, use case A (PSS)			
48 kbps, stereo, use case B			
32 kbps, stereo, use case A (PSS), 1% FER			
32 kbps, stereo, use case A (PSS), 3% FER			
Average			
Min per item			Not used
Max per item		Not used	

Informative quality FoM:

For informative quality FoM each test case *K* a delta performance score is calculated as the difference between the codec performance $\overline{P}_C(K)$ and the performance of a informative reference codec $\overline{P}_{IR}(K)$:

$$\Delta_C(K) = \overline{P}_C(K) - \overline{P}_{IR}(K)$$

The quality informative reference is calculated according to:

$$\overline{P}_{IR}(K) = \frac{1}{N}\sum_{i \in I} P_{IR}(K,i),$$

where *I* denotes the set of *N* test items.

The candidate codec performance is calculated according to:

$$\overline{P}_C(K) = \frac{1}{N}\sum_{i \in I} P_C(K,i).$$

The delta performance scores are arranged in a vector according to the test cases. Negative delta scores will be highlighted in red in order to indicate cases where the reference performance it is not met.

In addition to the item-wise delta scores per test cases, average, minimum and maximum delta scores will be given across test cases.

The minimum and maximum delta score is understood as worst, respectively, best observed score across all items in test cases in which the informative reference is RealAudio @ 32 and 48 kbit/s stereo.

In order to provide a global overview further composite scores are derived such as average, minimum and maximum scores across the complete set of test cases.

An overview of the complete matrix of scores is given in table 3:

Content type Operating condition	Audio	Min per item	Max per item
32 kbit/s, stereo, use case A (PSS)			
32 kbps, stereo, use case B			
48 kbps, stereo, use case A (PSS)			
48 kbps, stereo, use case B			
Average			
Min per item			Not used
Max per item		Not used	

FoM H1:

The number of positive delta MUSHRA table entries.

FoM H2:

The number of negative delta MUSHRA table entries.

FoM H3a-H3e:

Figure of Merit for computational complexity and memory are:

- The peak-WMOPS (measured for the worst observed frame)
- Average-WMOPS (measured over the test material)
- RAM (in kWords measured for the worst test case)
- ROM (in kWords measured for the worst test case)
- Program ROM (number of instructions measured for the worst test case)

3 PSS/MMS Audio Codec Selection Procedure

The selection procedure will consist of the following steps:

Low Bit-Rate codec discussion (steps 1-5):

1. The LBR Selection test results will be presented and analysed while keeping secret the identity of the LBR candidates. Each candidate will be informed of the code used for its own solution and its solution only. The Selection rules 2 and 3 defined in section 1 will be applied at this stage.
2. After the review and discussion of the test results (as specified for rule 3), TSG-SA4 will try to reach a consensus on a quality ranking of the LBR candidates.
3. Each LBR candidate will then present its solution and show the compliance with the PSS/MMS Audio Codec Design Constraints [1]. All candidates not compliant with all design constraints will be excluded according to the Selection rule 1 defined in section 1.
4. The test results obtained by each LBR candidate will then be revealed.
5. A discussion and review of the LBR candidate codec characteristics and test results will take place.

High Bit-Rate codec discussion (steps 6-10):

6. The HBR Selection test results will be presented and analysed while keeping secret the identity of the HBR candidates. Each candidate will be informed of the code used for its own solution and its solution only. The Selection rules 2 and 3 defined in section 2 will be applied at this stage.
7. After the review and discussion of the test results (as specified for rule 3), TSG-SA4 will try to reach a consensus on a quality ranking of the HBR candidates.
8. Each HBR candidate will then present its solution and show the compliance with the PSS/MMS Audio Codec Design Constraints [1]. All candidates not compliant with all design constraints will be excluded according to the Selection rule 1 defined in section 2.
9. The test results obtained by each HBR candidate will then be revealed.
10. A discussion and review of the HBR candidate codec characteristics and test results will take place.

Selection of PSS/MMS Audio codec(s) for low and high bit-rate ranges:

11. SA4 will try to reach a consensus on codec(s) for the PSS/MMS default audio codec for low and high bit-rate range.

In addition to the above selection procedure, all candidates have to provide the Selection Deliverables as defined in Annex A. All LBR and HBR candidates not compliant with the required deliverables will be excluded (before Step 1).

References:

[1] S4-030433 “PSS/MMS Audio Codec Selection, Design Constraints and Performance Requirements – Version 2.0”

[2] AMR-WB+ permanent document; Design Constraints (Last version approved by TSG-SA4)

[3] AMR-WB+ permanent document; Performance Requirement (Last version approved by TSG-SA4)

[4] PSS/MMS Audio Codec and AMR-WB+ permanent document; Time Plan (Last version approved by TSG-SA4)

[5] PSS/MMS Audio Codec and AMR-WB+ permanent document; AMR-WB+ and PSS/MSS low-rate audio selection test and processing plan (Last version approved by TSG-SA4)

Annex A: Selection Deliverables for PSS/MMS Audio Codec and Extended AMR-WB

1. Introduction

This Annex lists the deliverables for the selection phase for PSS/MMS Audio Codec and Extended AMR-WB. The deliverables are all items the candidates must provide in order to enter into the selection contest.

The delivery dates for all selection deliverables are based on schedule assumptions given in the permanent document on codec selection and development [4]. In case of any discrepancy of the dates, the dates as indicated in [4] prevail.

2. List of Deliverables

The candidates participating to the selection phase must provide the following deliverables:

- Binding declaration to submit a candidate codec
- Codec executable(s)
- Technical descriptions (including draft Specifications - to be distributed only by the winning proponent(s))
- Report covering the design constraints
- IPR declaration
- Optional additional information

Each item is described in the following sections.

In addition, for the verification phase (after the selection phase), the winning proponent(s) must submit the ANSI-C source code of selected codec(s) to verification labs (under NDA).

2.1 Binding declaration to submit a candidate codec

The candidates must make the binding declaration (commitment to funding the selection phase) by 31st May 2003.

2.2 Executable

The candidates must deliver to ETSI copies of their executable by October 30 2003. It is the responsibility of the candidates to be sure that the executable will effectively be delivered by the due date. ETSI will register the executable delivery date for each candidate and will report the effective delivery date to SA4. ETSI will not check the correct operation of the files delivered.

The executables will be used by the host laboratories to create the samples used in the listening tests.

2.3 Technical descriptions

The candidates must provide by February 18 2004 a technical description of their codec through SA4 reflector. The description should contain sufficient details to allow analysis of the solution.

Each candidate shall also provide a report through SA4 reflector by February 18 2004 showing that the proposal fulfils all design constraints. This includes a complexity evaluation based on the floating-point code: Worst Observed Frame for the codec, memory (RAM and data ROM) and Program ROM estimates based on the floating-point implementation. The Worst Observed Frame figure must be computed from the complete database of material used for the selection phase.

In addition, each proponent shall have developed a draft version of the specification, but this is not a required deliverable before selection. Immediately following the selection at the SA4 meeting, the selected candidate(s) must publish this detailed description by providing a soft copy of the document to the SA4 secretary, who will make it available to meeting delegates and upload it onto the ETSI and 3GPP FTP sites. All SA4 organizations are then invited to comment and review the draft specification at the SA4 selection meeting (and in possible subsequent Audio Codec ad-hoc meeting). Note that this draft specification does not yet need to contain the ANSI-C source code of the codec.

The format of the specification is as described below:

- Detailed technical description of the encoder and decoder

- ANSI-C source code of the tested encoder and decoder

2.4 Source C-code (for the tested codec mode)

The winning company/companies must deliver a copy of their ANSI C-Code to the companies participating into verification work.

The compiled version of the source C-Code, the executable delivered to ETSI (see Section 2.2) and the executable used for processing shall give identical and bit-exact versions of all samples used for the selection testing. This version of the code should allow a third party to re-process the samples in order to check the integrity of the material used for the selection tests.

This C-code will be used to check the complexity estimates of the proposal. To that purpose, the candidate must also provide the following information for the solution:

1) Data RAM

- For each source file, enumeration of static variables, types and their associated length;
- Function call path leading to largest scratch RAM usage and list of temporary variables active in that case

2) Data ROM

- for each source file, enumeration of tables, types and their associated length

3) Program ROM

- list of source files (.c, .h)
- number of pure instruction C lines for each .c file

4) wMOPS

- The C source code should contain instrumentation and counters for basic operations, data move, logical operations and arithmetic tests.
- Sample and experiment condition that produced the highest wMOPS figure

Upon approval of the codec specification at TSG-SA, MCC will make the ANSI-C code available by including a soft-copy of the code into the approved specification. The ANSI-C code will be provided to TSG-SA#23 by the winning company/companies. The ANSI-C code provided to TSG-SA#23 shall be the same that was submitted to verification phase.

2.5 IPR Declaration

The candidates must provide by February 18 2004 a mutually acceptable declaration of IPR. Formal IPR declaration shall be submitted.

Candidates are advised to discuss the form of this IPR statement with the corresponding 3GPP Organisational Partner well in advance of this date, to define what is mutually acceptable, e.g. ETSI Legal Adviser (see below).

Mr. Stephane Tronchon
ETSI Legal Adviser
ETSI / PT SMG
650 Route des Lucioles
06921 Sophia Antipolis Cedex
France
Email: stephane.tronchon@etsi.org

A copy of the statement must be sent to Mr. Paolo Usai at the following address: paolo.usai@etsi.org

2.6 Optional additional information

The candidates are free to provide any additional information likely to help in the evaluation of their proposal by February 18 2004.

References

See reference list in the main body of this document.