**Source:** Nokia, Ericsson

**Title:** Additional information on AMR-WB+ performance

# Agenda item: 8

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# Summary

This document gives additional information on the AMR-WB+ audio codec performance in various operation conditions. AMR-WB+ with flexible codec control is compared against Enhanced aacPlus (EAAC+) codec available from Coding Technologies in low rate applications using MUSHRA methodology.

Results indicate that the flexible codec control with increased audio bandwidth improves the subjective quality of the AMR-WB+ codec especially in music content.

# Introduction

A subjective listening tests have been conducted to characterize the performance of the AMR-WB+. Tests have been conducted using the same high quality procedures that have been used to perform the official selection tests. Two listening laboratories conducted tests independently. The results from Nokia listening test laboratory in Finland and Ericsson listening test laboratory in Sweden were combined. Both laboratories performed testing with the same material.

# Source material

Tests have been performed using the material Nokia and Ericsson provided for the 3GPP PSS/MMS audio codec selection phase testing. Two different sets of material were utilised. Both sets consisted of 12 test and 4 practice items. Same material was used in both test laboratories.

# Processing

Processing of the source material has been done according to the low rate audio selection test and processing plan [1]. Only the tested codecs were different. Main processing has been done using concatenated material. All the processing has been done using the very same tools (up/down sampling, file concatenation etc.) that were used in the processing phase of the official low rate test A4.

# Test conditions

|  |  |  |
| --- | --- | --- |
| **Main Codec Conditions** |  |  |
| Candidates | 3 | AMR-WB+@14kbps, 18kbps & 24kbps E-AAC+ @16 kbps, 18 kbps & 24 kbps |
| Use case | 1 | A (PSS) |
| Error Conditions | 1 | No errors |
| Mono/Stereo | 1 | Stereo |
|  |  |  |
| **Codec references** |  |  |
| Codec references | 1 | AMR-WB+ @24 kbps use case A |
| Input sampling rate | 1 | 24 kHz |
| Input characteristics |  |  |
| Number of input channels | 2 | Stereo |
| Number of output channels | 2 | Stereo |
|  |  |  |
| **Other references** |  |  |
| Open Reference | 1 | Original signal |
| Hidden Reference | 1 | Original signal |
| Anchors | 2 | 3.5 kHz and 7 kHz low-pass filtered original signal |
|  |  |  |
| **Common Conditions** |  |  |
| Stimulus type |  | Sound item |
| Radio Channels | 0 | Clean |
| Number of audio items | 12 |  |
| Input sampling rate |  | 48 kHz |
| Number of input channels | 2 | Stereo |
| Output sampling rate |  | Unspecified |
| Number of output channels | 2 | Stereo |
| Listening Level | 1 | To be chosen by subject |
| Listening laboratories | 2 | Nokia and Ericsson listening test laboratories |
| Listeners | 46 | Experienced listeners (Nokia 26, Ericsson 20) |
| Presentation randomizations | 46 | One for each listener |
| Rating Scale | 1 | Continuous quality scale |
| Listening System | 1 | Binaural high-quality headphones |
| Listening Environment |  | Room Noise: Hoth Spectrum at 30dBA (as defined by ITU-T, Recommendation P.800, Annex A, section A.1.1.2.2.1 Room Noise, with table A.1 and Figure A.1) |

Table 1: Overview of the test conditions for low rate tests (A4)

# Listening sessions

## Nokia listening test laboratory

### Presentation sequences

All listeners listened their sound items and each trial of the item in unique order.

### Listeners

All the listeners were native finish speakers with prior experience in MUSHRA test methodology. They were all tested before listening with audiometer to have normal hearing (to fulfil ISO Standard 389 requirements).

### Listening environment

Listeners were placed in high quality, acoustically isolated booths. Six identical booths with internal dimensions of 1.4 x 1.1 x 2.1m were used. The background noise-rating curve of each booth fulfils the ISO NR15 requirement. The reverberation times within the booths are <300ms above 315Hz one-third octave bands. No discernible flutters are audible within the booths [2].

### Environmental noise

Environmental noise was fed into the booths with the required Hoth spectrum to represent typical room noise at the required 30dBA level (as defined by ITU-T, Recommendation P.800 [4]). Two loudspeaker units (type: Genelec 1029A) per booth were used. Speakers were positioned so that the sound pressure level was 30 dBA above the centre of the seat of subject's chair.

### Testing facility

The listening test was controlled by remote PCs with a keyboard, mouse and an LCD screen in the booths. Six machines were used to play the samples to the listeners and to collect their answers. Each one is furnished with a high quality digital sound card (type: RME DIGI 96/8 PRO), providing 44.1kHz or 48kHz output at a resolution of 24 bits. The digital audio output signals were subsequently fed to a Studer D19 24bit multi-channel digital to analogue converter employing an AES/EBU bus. A Symmetrix 304 headphone amplifier was used. Samples were presented binaurally to the listeners over high quality Sennheiser HD580 headphones.

## Ericsson listening test laboratory

### Presentation sequences

All listeners listened their sound items and each trial of the item in unique order.

### Listeners

The listening panel was selected from experienced listeners inside Ericsson. A pre-screening procedure was used were previous performance in intermediate quality audio listening tests served as an indication of the listeners’ ability to judge anchors and references in a correct way, as well as the ability to repeatedly grade in a consistent manner. The listeners, both male and female, were between 25 to 45 years of age and had all had previous experience of audio listening tests using the MUSHRA methodology.

### Listening environment

The listening environments were two listening labs, which both conformed to the standard requirements.

### Environmental noise

Environmental noise was fed into the booths with the required Hoth spectrum to represent typical room noise at the required 30dBA level (as defined by ITU-T, Recommendation P.800 [3]).

### Testing facility

Open-back circum-aural headphones were used (Sennheiser HD600) and the listeners could individually adjust the listening level to their preference. The audio was fed from the computer to the listener using M-audio USB Duo sound cards.

The MUSHRA software has been developed in-house. It has a similar GUI as the CRC-SEAQ software shown in the test plan although there is a possibility to show the waveform of the current test item. The waveform is rendered from the open reference clip, thus showing no information about the encoded clips. The software performs both inter-item and intra-item randomization of the test sequence, and provides a raw output of the test results into individual listener output files.

# AMR-WB+ codec

The flexible control of AMR-WB+ is utilised in the experiment. The core and stereo rates and internal sampling frequency (ISF) are set according to Table 2. To compare the performance of the flexible codec control the configuration utilised in PSS/MMS codec selection is included.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Codec** | **Core** | **Stereo** | **ISF** |
| **1** | AMR-WB+ 14kbps | 10.4 | 3.6 | 25.6 |
| **2** | AMR-WB+ 18kbps | 13.6 | 4.4 | 25.6 |
| **3** | AMR-WB+ 24kbps | 16.8 | 4.4 | 28.8 |
| **4** | AMR-WB+ 24 kbps (PSS) | Configuration utilised in PSS/MMS selection tests | | |

Table 2: AMR-WB+ codec configuration

# Test results

Results in numerical format are given in Table 3, and in graphical format in Figure 1.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Condition** | **Music** | **SoM** | **S** | **SbM** | **Total** |
| **1** | Direct | 98.93 | 98.77 | 99.28 | 98.68 | 98.98 |
| **2** | Low-pass (BW=7.0kHz) | 50.54 | 53.39 | 55.36 | 56.17 | 53.56 |
| **3** | Low-pass (BW=3.5kHz) | 27.03 | 28.91 | 29.91 | 31.85 | 29.11 |
| **4** | EAAC+ 16kbps | 57.65 | 55.23 | 48.62 | 51.25 | 53.17 |
| **5** | EAAC+ 18kbps | 63.26 | 63.09 | 53.72 | 55.72 | 58.79 |
| **6** | EAAC+ 24kbps | 82.37 | 77.27 | 67.95 | 68.57 | 74.41 |
| **7** | AMR-WB+ 14kbps | 53.27 | 54.63 | 56.66 | 65.38 | 56.64 |
| **8** | AMR-WB+ 18kbps | 64.35 | 66.60 | 68.65 | 74.10 | 67.78 |
| **9** | AMR-WB+ 24kbps | 73.62 | 77.75 | 79.13 | 78.67 | 76.99 |
| **10** | AMR-WB+ 24kbps (PSS) | 64.63 | 70.98 | 74.52 | 77.78 | 71.18 |

Table 3: A4 test results in numerical format (46 listeners)

Figure 1: Overall A4 test results in graphical format (46 listeners)

# Conclusion

Test results indicate that the AMR-WB+ with flexible codec control provides significant performance improvement. Compared to the AMR-WB+ 24 kbps stereo mode utilised in the PSS/MMS audio codec selection tests, the 24 kbps mode with higher internal sampling frequency, and thus, with higher audio bandwidth, provides significantly better audio quality. The results also indicate that the performance of AMR-WB+ e.g. in music does not saturate at low rates. This applies for both mono and stereo application. Hence, flexible codec control proves to be useful.

# References

[1] S4-030824 “Low-Rate Audio Selection Test and Processing Plan”

[2] M. Kylliäinen et al.; “Compact high performance listening spaces.” Euronoise, Naples, 2003.

[3] ITU-T, Recommendation P.800