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| **Status** | **Contribution** |
| **Title** | **Profiling of range extension coding tools in HEVC Amd1** |
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# Introduction

This contribution provides a summary of the profiling issues raised in document JCTVC‑Q0051[5], in order to facilitate discussion of profiles for HEVC Amd1 in the JCT-VC parent bodies.

# Background

A Request for Amendment of HEVC [1] was issued in January 2013. This gave the following rationale for the amendment:

*“The purpose of this amendment of ISO/IEC 23008-2 is to provide the capability to support high fidelity video signals. In high end consumer and professional environment, larger sample accuracy and alternative chroma sampling structures such as 4:4:4 and 4:2:2 are used. This amendment is intended to extend the capability of ISO/IEC 23008-2 for those applications.”*

At the JCT-VC meeting in July 2013, five profiles were defined for inclusion in HEVC Amd1: Main 12, Main 4:2:2 10/12, and Main 4:4:4 10/12. However, there was no discussion on which tools would be appropriate to include in these profiles.

At the JCT-VC meeting in October 2013, there was some discussion on the profiling of range extension coding tools and it was agreed to exclude coding tools effective only for screen content coding (SCC) from Main 12 and Main 4:2:2 10/12 profiles. However, consensus could not be reached on tools for Main 4:4:4 10/12 profiles and the possible creation of a Main 4:4:4 8 bit profile, since sufficient time was not allocated to discuss all input documents related to the profiles of HEVC range extensions.

At the JCT-VC meeting in January 2014, it was agreed to add a 4:4:4 16bit all-intra profile, but consideration of other issues relating to 4:4:4 profiles was deferred until the 108th MPEG meeting.

The current document is intended to help focus on the issues that require decisions at parent body level. Details of results are available in document JCTVC-Q0051 [5]. Document JCTVC‑Q0051 is an update of document JCTVC-P0106 [4] which was submitted to the 16th JCT-VC meeting in San Jose, which is itself an update of document JCTVC-O0144 [3] which was submitted to the 15th JCT-VC meeting in Geneva. Unfortunately, it appeared to be impossible to find time to allow the presentation of these documents at either these meetings.

# Suggested process for selecting tools for new profiles

We suggest that a structured and requirements-led approach should be followed when defining new profiles of HEVC:

1. Parent bodies define the timescales for an amendment to HEVC and the applications to be addressed
2. JCT-VC specifies common test conditions that represent the typical characteristics of the applications selected by the parent bodies
3. Parent bodies define the structure of profiles to be added by the amendment
4. JCT-VC selects tools for the profiles that give a beneficial trade-off between performance and complexity when measured under the common test conditions

In the case of HEVC Amd1, the first two steps of the above process appear to have been followed, but the process then became less clear. In particular, some coding tools have been included in the DIS text that do not appear to give a beneficial trade-off between performance and complexity when measured under the common test conditions [2].

# Tools under consideration from JCT-VC Range Extension work

In addition to design improvements to properly support high bit-depth and extended colour formats, some range extension coding tools have been included in the draft text:

* implicit residual DPCM
* explicit residual DPCM
* residual rotation
* single context model for significance map coding in transform-skipped (TS) block
* intra block copy
* Golomb-Rice parameter adaptation
* cross component de-correlation
* CU-adaptive chroma QP offset
* CABAC bit alignment

In m32728, the coding gain and complexity of these additional coding tools are evaluated under the common test condition of HEVC range extensions [2]. In all the tests, the anchor is HM13.0-RExt6.0 and the tested condition is “coding tool off”.

A summary of the results is given in Tables 1 to 7 below. Please note that CU-adaptive chroma QP offset could not be tested since it has not been integrated into the reference software in time for testing in this contribution. CABAC bit alignment is not tested either, since it has been already agreed at the last meeting to enable this tool only in 4:4:4 16b all-intra profile.

Table 1. Performance of cross component de-correlation off vs. on (AHG5 CTC)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BD-rate Y | AI-MT | AI-HT | AI-SHT | RA-MT | RA-HT | LB-MT | LB-HT |
| RGB 4:4:4 | 25.6% | 19.6% | 13.9% | 18.6% | 14.4% | 16.1% | 12.5% |
| YCbCr 4:4:4 | 1.5% | 1.9% | 2.1% | 0.6% | 1.0% | 0.2% | 0.7% |
| YCbCr 4:2:2 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Overall | 9.0% | 7.2% | 5.3% | 6.4% | 5.1% | 5.4% | 4.4% |
| Enc Time[%] | 94% | 93% | 92% | 95% | 93% | 95% | 93% |
| Dec Time[%] | 101% | 101% | 101% | 101% | 100% | 99% | 99% |

Table 2. Performance of explicit residual DPCM off vs. on (AHG5 CTC)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BD-rate Y | AI-MT | AI-HT | AI-SHT | RA-MT | RA-HT | LB-MT | LB-HT |
| RGB 4:4:4 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:2:2 | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| Overall | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 95% | 95% | 96% | 87% | 89% | 89% | 90% |
| Dec Time[%] | 99% | 99% | 99% | 100% | 100% | 99% | 98% |

Table 3. Performance of Golomb-Rice group adaptation off vs. on (AHG5 CTC)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BD-rate Y | AI-MT | AI-HT | AI-SHT | RA-MT | RA-HT | LB-MT | LB-HT |
| RGB 4:4:4 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:2:2 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Overall | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | 99% | 99% | 99% | 99% | 99% | 99% |
| Dec Time[%] | 99% | 99% | 99% | 100% | 99% | 99% | 98% |

Table 4. Performance of implicit residual DPCM off vs. on (AHG5 CTC)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BD-rate Y | AI-MT | AI-HT | AI-SHT | RA-MT | RA-HT | LB-MT | LB-HT |
| RGB 4:4:4 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:2:2 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Overall | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | 99% | 99% | 99% | 99% | 99% | 99% |
| Dec Time[%] | 100% | 99% | 99% | 100% | 100% | 98% | 98% |

Table 5. Performance of intra block copy off vs. on (AHG5 CTC)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BD-rate Y | AI-MT | AI-HT | AI-SHT | RA-MT | RA-HT | LB-MT | LB-HT |
| RGB 4:4:4 | 0.7% | 0.4% | 0.2% | 0.5% | 0.2% | 0.3% | 0.1% |
| YCbCr 4:4:4 | 0.5% | 0.3% | 0.2% | 0.2% | 0.2% | 0.0% | 0.1% |
| YCbCr 4:2:2 | 0.4% | 0.3% | 0.2% | 0.2% | 0.1% | 0.0% | 0.0% |
| Overall | 0.5% | 0.3% | 0.2% | 0.3% | 0.1% | 0.1% | 0.1% |
| Enc Time[%] | 44% | 40% | 40% | 91% | 87% | 91% | 87% |
| Dec Time[%] | 100% | 100% | 99% | 100% | 99% | 98% | 98% |

Table 6. Performance of residual rotation off vs. on (AHG5 CTC)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BD-rate Y | AI-MT | AI-HT | AI-SHT | RA-MT | RA-HT | LB-MT | LB-HT |
| RGB 4:4:4 | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:4:4 | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| YCbCr 4:2:2 | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% |
| Overall | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | 100% | 100% | 99% | 99% | 99% | 99% |
| Dec Time[%] | 99% | 99% | 99% | 98% | 99% | 98% | 97% |

Table 7. Performance of single significance map context off vs. on (AHG5 CTC)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BD-rate Y | AI-MT | AI-HT | AI-SHT | RA-MT | RA-HT | LB-MT | LB-HT |
| RGB 4:4:4 | 0.0% | 0.1% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| YCbCr 4:4:4 | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| YCbCr 4:2:2 | 0.1% | 0.1% | 0.1% | 0.1% | 0.2% | 0.1% | 0.2% |
| Overall | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| Enc Time[%] | 99% | 99% | 99% | 99% | 99% | 99% | 99% |
| Dec Time[%] | 99% | 99% | 99% | 99% | 100% | 99% | 98% |

# Recommended profiling of range extension coding tools

The profiling in HEVC Amd1 is recommended to follow a similar process to that used for HEVC v1. As shown in the test results, cross component de-correlation is the only additional coding tool that provides a beneficial trade-off between performance and complexity when measured under the common test conditions.

Considering that the primary goal of HEVC Amd1 is to support bit-depth higher than 10 bits and non-4:2:0 colour formats, it is suggested to include only cross component de-correlation and possibly CU-adaptive chroma QP offset in Main 4:4:4 10/12. CU-adaptive chroma QP offset is proposed to be considered only in 4:4:4 profiles, since its benefit in terms of fine encoder-side rate control for chroma is limited in 4:2:2. It is also suggested to include Golomb-Rice parameter adaptation only in 4:4:4 16b all-intra profile, since its major benefit in terms of coding efficiency is observed only at high bit-depth. CABAC bit alignment is included only in the 4:4:4 16b all-intra profile. The recommended mapping between profiles and coding tools is summarized in Table 8.

Table 8. Mapping of coding tools onto Main profiles and initial TM for SC profiles

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Range extension coding tools** | **Main 12** | **Main 4:2:2** | | **Main 4:4:4** | | **4:4:4 All-Intra 16** | **TM1 for SC 4:4:4** | |
| **10** | **12** | **10** | **12** | **8** | **10** |
| Implicit RDPCM | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | ✓ | ✓ |
| Explicit RDPCM | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | ✓ | ✓ |
| Residual rotation | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | ✓ | ✓ |
| Single ctx for TS | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | ✓ | ✓ |
| Intra block copy | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | ✓ | ✓ |
| Rice parm. adapt. | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | ✓ | ✓ | ✓ |
| Cross comp. de-cor. | 🗶 | 🗶 | 🗶 | ✓ | ✓ | ✓ | ✓ | ✓ |
| CU chroma QP offset | 🗶 | 🗶 | 🗶 | **?** | **?** | **?** | ✓ | ✓ |
| CABAC bit alignment | 🗶 | 🗶 | 🗶 | 🗶 | 🗶 | ✓ | 🗶 | 🗶 |

Regarding SC coding tools, it is suggested to develop SC 4:4:4 Profiles, based on the evaluation results of the responses to the call for proposals for coding of screen content. It is suggested that all of the coding tools in the draft RExt text should be included in the initial test model for this new activity.

# Conclusion

In this contribution, it is suggested that the decision process for profiling for HEVC Amd1 should follow a similar process to that used for HEVC v1:

1. Parent bodies define the timescales for an amendment to HEVC and the applications to be addressed
2. JCT-VC specifies common test conditions that represent the typical characteristics of the applications selected by the parent bodies
3. Parent bodies define the structure of profiles to be added by the amendment
4. JCT-VC selects tools for the profiles that give a beneficial trade-off between performance and complexity when measured under the common test conditions

Based on the coding gain and complexity trade-off for the additional range extension coding tools, evaluated under HEVC range extension common test condition, it is suggested that only cross component de-correlation and CU-adaptive chroma QP offset are included in Main 4:4:4 10/12 profiles that are included in Amd 1 and which will be sent out for FDAM ballot in April 2014.

It is suggested that SC 4:4:4 profiles should also be developed, based on the evaluation results of the responses to the call for proposals for coding of screen content. It would be appropriate to include all the coding tools considered in this proposal in the initial test model for this new activity.

# References

1. MPEG Video and JCT-VC, “Request for ISO/IEC 23008-2:201X/Amd.1”, ISO/IEC document JTC1/SC29/WG11/N13344, Jan. 2013
2. C. Rosewarne, K. Sharman, D. Flynn, “Common test conditions and software reference configurations for HEVC range extensions,” Document of Joint Collaborative Team on Video Coding, JCTVC-P1006, Jan. 2014
3. S. Lee, E. Alshina, C. Kim, K. McCann, “AHG5 and AHG8: Recommended profiling of range extension coding tools”, Document of Joint Collaborative Team on Video Coding, JCTVC-O0144, Oct. 2013
4. S. Lee, E. Alshina, C. Kim, K. McCann, “AHG5: Recommended profiling of range extension coding tools,” Document of Joint Collaborative Team on Video Coding, JCTVC-P0106, Jan. 2014
5. S. Lee, E. Alshina, C. Kim, K. McCann, “AHG5: Recommended profiling of range extension coding tools”, Document of Joint Collaborative Team on Video Coding, JCTVC-Q0051, Mar. 2014