Joint Collaborative Team on Video Coding (JCT-VC)
of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11
5th Meeting: Geneva, CH, 16-23 March 2011

Document: JCTVC-E600 (v3~~2~~)

Title:	**Meeting report of the fifth meeting of the Joint Collaborative Team on Video Coding (JCT-VC), Geneva, CH, 16-23 March 2011**
Status:	Report Document from Chairs of JCT-VC
Purpose:	Report

Author(s) or Contact(s):

Gary Sullivan
Microsoft Corp.
1 Microsoft Way
Redmond, WA 98052 USA
Tel: +1 425 703 5308
Email: garysull@microsoft.com

Jens-Rainer Ohm
Institute of Communications Engineering
RWTH Aachen University
Melatener Straße 23
D-52074 Aachen
Tel: +49 241 80 27671
Email: ohm@ient.rwth-aachen.de

Source: Chairs

Summary

The Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T WP3/16 and ISO/IEC JTC 1/SC 29/WG 11 held its fifth meeting during 16-23 March 2011 at the ITU-T premises in Geneva, CH. The JCT-VC meeting was held under the chairmanship of Dr. Gary Sullivan (Microsoft/USA) and Dr. Jens-Rainer Ohm (RWTH Aachen/Germany).

The JCT-VC meeting sessions began at approximately 10:30 on Wednesday 16 March 2011. Meeting sessions were held on all days (including weekend days) until the meeting was closed at approximately 13:50 on Wednesday 23 March. Approximately 225 people attended the JCT-VC meeting, and approximately 500 input documents were discussed. The meeting took place in a co-located fashion with a meeting of of ITU-T SG16 – one of the two parent bodies of the JCT-VC. The subject matter of the JCT-VC meeting activities consisted of work on the new next-generation video coding standardization project now referred to as High Efficiency Video Coding (HEVC).

The primary goals of the meeting were to review the work that was performed in the interim period since the fourth JCT-VC meeting in implementing the 2nd HEVC Test Model (HM2) and editing the 2nd HEVC specification Working Draft (WD2), review results from Core Experiments (CE), review technical input documents, further develop Working Draft and HEVC Test Model (HM), and plan a new set of Core Experiments (CEs) for further investigation of proposed technology.

The JCT-VC produced three particularly important output documents from the meeting: the HEVC Test Model 3 (HM3), the HEVC specification Working Draft 3 (WD3), and a document specifying common conditions and software reference configurations for HEVC coding experiments. Moreover, 12 documents describing the planning of CEs were drafted.

For the organization and planning of its future work, the JCT-VC established 20 "Ad Hoc Groups" (AHGs) to progress the work on particular subject areas. The next JCT-VC meeting will be held during 14-22 July 2011 under WG 11 auspices in Torino (Turin), IT. Subsequent meetings are planned to be held during 22-30 November 2011 under ITU-T auspices in Geneva, CH, and 1-10 February 2012 under WG 11 auspices in San José, USA.

The document distribution site http://phenix.it-sudparis.eu/jct/ was used for distribution of all documents.

The reflector to be used for discussions by the JCT-VC and all of its AHGs is the JCT-VC reflector: jct-vc@lists.rwth-aachen.de. For subscription to this list, see http://mailman.rwth-aachen.de/mailman/listinfo/jct-vc.

1 Administrative topics

1.1 Organization

The ITU-T/ISO/IEC Joint Collaborative Team on Video Coding (JCT-VC) is a group of video coding experts from the ITU-T Study Group 16 Visual Coding Experts Group (VCEG) and the ISO/IEC JTC 1/ SC 29/ WG 11 Moving Picture Experts Group (MPEG). The parent bodies of the JCT-VC are ITU-T WP3/16 and ISO/IEC JTC 1/SC 29/WG 11.

The Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T WP3/16 and ISO/IEC JTC 1/ SC 29/ WG 11 held its fifth meeting during 16-23 March 2011 at ITU-T premises in Genva, CH. The JCT-VC meeting was held under the chairmanship of Dr. Gary Sullivan (Microsoft/USA) and Dr. Jens-Rainer Ohm (RWTH Aachen/Germany).

1.2 Meeting logistics

The JCT-VC meeting sessions began at approximately 10:30 on Wednesday 16 March 2011. Meeting sessions were held on all days (including weekend days) until the meeting was closed at approximately 13:50 on Wednesday 23 March. Approximately 225 people attended the JCT-VC meeting, and approximately 500 input documents were discussed. The meeting took place in a co-located fashion with a meeting of ITU-T SG16 – one of the two parent bodies of the JCT-VC. The subject matter of the JCT-VC meeting activities consisted of work on the new next-generation video coding standardization project now referred to as High Efficiency Video Coding (HEVC).

Information regarding logistics arrangements for the meeting had been provided at http://www.itu.int/ITU-T/studygroups/com16/ and http://www.itu.int/events/.

1.3 Primary goals

The primary goals of the meeting were to review the work that was performed in the interim period since the fourth JCT-VC meeting in producing the 2nd HEVC Test Model (HM) software and editing the 2nd HEVC specification Working Draft (WD2), review results from Core Experiments (CEs), review technical input documents, and establish third versions of the Working Draft (WD3) and HEVC Test Model (HM3).

1.4 Documents and document handling considerations

1.4.1 General

The documents of the JCT-VC meeting are listed in Annex A of this report. The documents can be found at http://phenix.it-sudparis.eu/jct/.

Registration timestamps, initial upload timestamps, and final upload timestamps are listed in Annex A of this report.

Document registration and upload times and dates listed in Annex A and in headings for documents in this report are in Paris/Geneva time. Dates mentioned for purposes of describing events at the meeting (rather than as contribution registration and upload times) follow the local time at the meeting facility.

Decisions made by the group that affect the normative content of the draft standard are identified in this report by prefixing the description of the decision with the string "Decision:".

This meeting report is based primarily on notes taken by the chairs and projected for real-time review by the participants during the meeting discussions. The preliminary notes were also circulated publicly by ftp during the meeting on a daily basis. Considering the high workload of this meeting and the large number of contributions, it should be understood by the reader that 1) some notes may appear in abbreviated form, 2) summaries of the content of contributions are often based on abstracts provided by contributing proponents without an intent to imply endorsement of the views expressed therein, and 3) the depth of discussion of the content of the various contributions in this report is not uniform. Generally, the report is written to include as much discussion of the contributions and discussions as is feasible in the interest of aiding study, although this approach may not result in the most polished output report.

1.4.2 Late and incomplete document considerations

The formal deadline for registering and uploading non-administrative contributions had been announced as Friday, 11 March 2011.

Non-administrative documents uploaded after 23:59 in Paris/Geneva time Saturday March 12 were considered "officially late".

Most documents in this category were CE reports or cross-verification reports, which are somewhat less problematic than late proposals for new action (and especially for new normative standardization action).

At this meeting, we had a substantial amount of late document activity. This may have been partly due to the relatively short time available between the prior meeting and this meeting. The group strived to be conservative when discussing and considering the content of late documents, although no objections were raised regarding allowing some discussion in such cases. Corrective action was planned to try to improve the timely availability of contributions for better consideration at future meetings. This included planning for a earlier cutoff time for late document classification for the next meeting, so that documents that arrive on time can be more carefully studied and more easily distinguished from further late arrivals.

All contribution documents with registration numbers JCTVC-E438 to JCTVC-E505 were registered after the "officially late" (and therefore also uploaded late). Some documents in this range include break-out activity reports that were generated during the meeting and are therefore considered report documents rather than late contributions.

In many cases, contributions were also revised after the initial version was uploaded. The contribution document archive website retains prior versions in such cases. The timing of late document availability for contributions is generally noted in the section discussing each contribution in this report.

The following other technical proposal contributions were also uploaded late:

- JCTVC-E220 (a technical proposal) [Sony]
- JCTVC-E316 (a technical proposal reporting core experiment results) [Qualcomm]
- JCTVC-E358 (a technical proposal reporting core experiment results) [Motorola Mobility]
- JCTVC-E359 (a technical proposal) [Motorola Mobility]
- JCTVC-E361 (a technical proposal) [Motorola Mobility]
- JCTVC-E362 (a technical proposal) [Motorola Mobility]
- JCTVC-E363 (a technical proposal) [Motorola Mobility]
- JCTVC-E364 (a technical proposal) [Motorola Mobility]
- JCTVC-E365 (an information document containing experiment analysis) [Motorola Mobility, NEC, I2R, TI]
- JCTVC-E373 (a technical proposal reporting core experiment results) [Huawei & HiSilicon, Qualcomm, Samsung, Technicolor]

- JCTVC-E417 (a technical proposal reporting core experiment results) [SKKU, SK Telecom]
- JCTVC-E436 (a technical proposal) [HKUST]
- JCTVC-E437 (a technical proposal) [Sharp]

The following other documents not proposing normative technical content were uploaded late:

- JCTVC-E139 (offering test material for screen content coding)
- JCTVC-E425 (a non-normative fast encoding technique description)
- JCTVC-E426 (an experiment report)

The following intended cross-verification document was reported verbally, but was never actually uploaded:

- JCTVC-E182

The following other cross-verification reports were submitted late:

- JCTVC-E065
- JCTVC-E067
- JCTVC-E093
- JCTVC-E149
- JCTVC-E150
- JCTVC-E151
- JCTVC-E152
- JCTVC-E153
- JCTVC-E178
- JCTVC-E180
- JCTVC-E205
- JCTVC-E248
- JCTVC-E259
- JCTVC-E261
- JCTVC-E282
- JCTVC-E310
- JCTVC-E311
- JCTVC-E352
- JCTVC-E355
- JCTVC-E357
- JCTVC-E389
- JCTVC-E405
- JCTVC-E410
- JCTVC-E414

- JCTVC-E415
- JCTVC-E416
- JCTVC-E423
- JCTVC-E427
- JCTVC-E434

The following document registrations were later cancelled or otherwise never discussed or provided:

- JCTVC-E094
- JCTVC-E135
- JCTVC-E167
- JCTVC-E254
- JCTVC-E293
- JCTVC-E306
- JCTVC-E457

Ad hoc group activity and results reports, break-out activity reports, and information documents containing results of experiments requested during the meeting are not included in the above list, as these are considered administrative report documents.

As a general policy, missing documents were not to be presented, and late documents (and substantial revisions) could only be presented when sufficient time for studying was given after the upload. An exception is applied for AHG reports and CE summaries, which can only be produced after availability of other input docs. There were no objections raised by the group regarding presentation of late contributions.

"Placeholder" contribution documents that were basically empty of content, with perhaps only a brief abstract and some indication of an intent to provide a more complete submission as a revision, were considered unacceptable and rejected in the document management system, as has been agreed since the third meeting.

The initial uploads of the following contribution documents were rejected as "placeholders" and were not corrected until after the upload deadline:

- JCTVC-E124 (corrected 2011-03-13 03:20:03) [Samsung]
- JCTVC-E159 (corrected 2011-03-14 03:10:53) [LGE]
- JCTVC-E189 (corrected 2011-03-13 13:13:04) [NEC]
- JCTVC-E191 (corrected 2011-03-15 07:05:35) [NEC]
- JCTVC-E238 (corrected 2011-03-13 23:39:06) [TI]
- JCTVC-E295 (corrected 2011-03-15 20:07:26) [Huawei]
- JCTVC-E349 (never corrected) [Qualcomm]
- JCTVC-E360 (corrected 2011-03-14 04:07:05) [Qualcomm]
- JCTVC-E382 (corrected 2011-03-13 21:09:00) [Sony]
- JCTVC-E385 (corrected 2011-03-14 07:06:35) [Sony]

The initial upload of the following contribution appeared as if it might be borderline in terms of "placeholder" acceptability of the initial uploaded version, which was not improved until after the upload deadline, but the document was not rejected as a placeholder:

- JCTVC-E199 (corrected 2011-03-13 13:05:47) [Sony]

A few contributions had some problems relating to IPR declarations in the initial uploaded versions (missing declarations, declarations saying they were from the wrong companies, etc.). These issues were corrected by later uploaded versions in all cases (to the extent of the awareness of the chairs).

1.4.3 Measures to facilitate the consideration of contributions

It was agreed that, due to the increasingly high workload for this meeting, the group would try to rely more extensively on summary CE reports. For other contributions, it was agreed that generally presentations should not exceed 2 slides and 5 minutes to achieve a basic understanding of a proposal – with further review only if requested by the group. For cross-verification contributions, it was agreed that the group would ordinarily only review cross-checks for proposals that appear promising.

When considering cross-check contributions, it was agreed that, to the extent feasible, the following data should be collected:

- Subject (including document number).
- Whether common conditions were followed.
- Whether the results are complete.
- Whether the results match those reported by the contributor (within reasonable limits, such as minor compiler/platform differences).
- Whether the contributor studied the algorithm and software closely and has demonstrated adequate knowledge of the technology.
- Whether the contributor independently implemented the proposed technology feature, or at least compiled the software themselves.
- Any special comments and observations made by the cross-check contributor.

1.4.4 Outputs of the preceding meeting

The report documents of the previous meeting, particularly the meeting report JCTVC-D500, the HEVC Test Model (HM) JCTVC-D502, and the Working Draft (WD) JCTVC-D503, were approved. The HM reference software produced by the AHG on software development and HM software technical evaluation was also approved.

1.5 Attendance

The list of participants in the JCT-VC meeting can be found in Annex B of this report.

The meeting was open to those qualified to participate either in ITU-T WP3/16 or ISO/IEC JCT 1/ SC 29/ WG 11 (including experts who had been personally invited by the Chairs as permitted by ITU-T or ISO/IEC policies).

Participants had been reminded of the need to be properly qualified to attend. Those seeking further information regarding qualifications to attend future meetings may contact the Chairs.

1.6 Agenda

The agenda for the meeting was as follows:

- IPR policy reminder and declarations

- Contribution document allocation
- Reports of Ad Hoc group activities
- Reports of Core Experiment activities
- Review of results of previous meeting
- Consideration of contributions and communications on HEVC project guidance
- Consideration of HEVC technology proposal contributions
- Consideration of information contributions
- Coordination activities
- Future planning: Determination of next steps, discussion of working methods, communication practices, establishment of coordinated experiments, establishment of AHGs, meeting planning, refinement of expected standardization timeline, other planning issues
- Other business as appropriate for consideration

1.7 IPR policy reminder

Participants were reminded of the IPR policy established by the parent organizations of the JCT-VC and were referred to the parent body web sites for further information. The IPR policy was summarized for the participants.

The ITU-T/ITU-R/ISO/IEC common patent policy shall apply. Participants were particularly reminded that contributions proposing normative technical content shall contain a non-binding informal notice of whether the submitter may have patent rights that would be necessary for implementation of the resulting standard. The notice shall indicate the category of anticipated licensing terms according to the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form. Contributions of software source code for incorporation into the Reference Software for the standard shall be provided with a suitable copyright disclaimer header text in a form acceptable to the parent bodies to enable publication of the source code and to enable users of the software to copy the software and use it for research and standardization purposes and as a basis for the development of products (while the submitter separately retains any associated patent rights for licensing to be conducted outside of ITU-T/ITU-R/ISO/IEC). New developments regarding the software copyright disclaimer header text are further discussed elsewhere in this report.

This obligation is supplemental to, and does not replace, any existing obligations of parties to submit formal IPR declarations to ITU-T/ITU-R/ISO/IEC.

Participants were also reminded of the need to formally report patent rights to the top-level parent bodies (using the common reporting form found on the database listed below) and to make verbal and/or document IPR reports within the JCT-VC as necessary in the event that they are aware of unreported patents that are essential to implementation of a standard or of a draft standard under development.

Some relevant links for organizational and IPR policy information are provided below:

- http://www.itu.int/ITU-T/ipr/index.html (common patent policy for ITU-T, ITU-R, ISO, and IEC, and guidelines and forms for formal reporting to the parent bodies)
- http://ftp3.itu.int/av-arch/jctvc-site (JCT-VC contribution templates)
- http://www.itu.int/ITU-T/studygroups/com16/jct-vc/index.html (JCT-VC general information and founding charter)
- http://www.itu.int/ITU-T/dbase/patent/index.html (ITU-T IPR database)
- http://www.itscj.ipsj.or.jp/sc29/29w7proc.htm (JTC 1/ SC 29 Procedures)

The chairs invited participants to make any necessary verbal reports of previously-unreported IPR in draft standards under preparation, and opened the floor for such reports: No such verbal reports were made.

1.8 Communication practices

The documents for the meeting can be found at http://phenix.it-sudparis.eu/jct/. For the first two JCT-VC meetings, the JCT-VC documents had been made available at http://ftp3.itu.int/av-arch/jctvc-site, and documents for the first two JCT-VC meetings remain archived there. That site was also used for distribution of the contribution document template and circulation of drafts of this meeting report.

JCT-VC email lists are managed through the site http://mailman.rwth-aachen.de/mailman/options/jct-vc, and to send email to the reflector, the email address is jct-vc@lists.rwth-aachen.de. Only members of the reflector can send email to the list.

It was emphasized that reflector subscriptions and email sent to the reflector must use their real names when subscribing and sending messages and must respond to inquiries regarding their type of interest in the work.

For the case of CE documents and AHG reports, email addresses of participants and contributors may be obscured or absent (and will be on request), although these will be available (in human readable format – possibly with some "obscurification") for primary CE coordinators and AHG chairs.

1.9 Terminology

Some terminology used in this report is explained below:

- **AHG**: Ad hoc group.
- **AI**: All-intra.
- **AIF**: Adaptive interpolation filtering.
- **AIS**: Adaptive intra smoothing.
- **ALF**: Adaptive loop filter.
- **AMP**: Asymmetric motion partitioning.
- **AMVR**: Adaptive motion vector resolution.
- **AVC**: Advanced video coding – the video coding standard formally published as ITU-T Recommendation H.264 and ISO/IEC 14496-10.
- **BD**: Bjøntegaard-delta – a method for measuring percentage bit rate savings at equal PSNR or decibels of PSNR benefit at equal bit rate (e.g., as described in document VCEG-M33 of April 2001).
- **BoG**: Break-out group.
- **BR**: Bit rate.
- **CABAC**: Context-adaptive binary arithmetic coding.
- **CBF**: Coded block flag(s).
- **CE**: Core experiment – a coordinated experiment conducted after the 3rd or 4th meeting.
- **DCT**: Discrete cosine transform (sometimes used loosely to refer to other transforms with conceptually similar characteristics).
- **DCTIF**: DCT-derived interpolation filter.
- **DIF**: Directional interpolation filter.

- **DF**: Deblocking filter.
- **DT**: Decoding time.
- **ET**: Encoding time.
- **GPB**: Generalized P/B – a not-particularly-well-chosen name for B pictures in which the two reference picture lists are identical.
- **HE**: High efficiency – a set of coding capabilities designed for enhanced compression performance (contrast with LC). Often loosely associated with RA.
- **HEVC**: High Efficiency Video Coding – the video coding standardization initiative under way in the JCT-VC.
- **HM**: HEVC Test Model – a video coding design containing selected coding tools that constitutes our draft standard design – now also used especially in reference to the (non-normative) encoder algorithms (see WD and TM).
- **IBDI**: Internal bit-depth increase – a technique by which lower bit depth (8 bits per sample) source video is encoded using higher bit depth signal processing, ordinarily including higher bit depth reference picture storage (ordinarily 12 bits per sample).
- **JM**: Joint model – the primary software codebase developed for the AVC standard.
- **LC**: Low complexity – a set of coding capabilities designed for reduced implementation complexity (contrast with HE). Often loosely associated with LD.
- **LCEC**: Low-complexity entropy coding.
- **LD**: Low delay – a set of coding conditions designed to enable interactive real-time communication, with less emphasis on ease of random access (contrast with RA). Often loosely associated with LC.
- **LUT**: Look-up table.
- **MC**: Motion compensation.
- **MDDT**: Mode-dependent directional transform.
- **MPEG**: Moving picture experts group (WG 11, the parent body working group in ISO/IEC JCT 1/ SC 29, one of the two parent bodies of the JCT-VC).
- **MRG**: block merging mode for CUs.
- **MV**: Motion vector.
- **NAL**: Network abstraction layer (as in AVC).
- **NB**: National body (usually used in reference to NBs of the WG 11 parent body)
- **OBMC**: Overlapped block motion compensation.
- **PCP**: Parallelization of context processing.
- **PIPE**: Probability interval partitioning entropy coding (roughly synonymous with V2V for most discussion purposes, although the term PIPE tends to be more closely associated with proposals from Fraunhofer HHI while the term V2V tends to be more closely associated with proposals from RIM).
- **QP**: Quantization parameter.
- **QT**: Quadtree.
- **RA**: Random access – a set of coding conditions designed to enable relatively-frequent random access points in the coded video data, with less emphasis on minimization of delay (contrast with LD). Often loosely associated with HE.

- **R-D**: Rate-distortion.
- **RDO**: Rate-distortion optimization.
- **RDOQ**: Rate-distortion optimized quantization.
- **ROT**: Rotation operation for low-frequency transform coefficients.
- **RQT**: Residual quadtree.
- **SEI**: Supplemental enhancement information (as in AVC).
- **TE**: Tool Experiment – a coordinated experiment conducted after the 1st or 2nd JCT-VC meeting.
- **TM**: Test Model – a video coding design containing selected coding tools; as contrasted with the TMuC, see HM.
- **TMuC**: Test Model under Consideration – a video coding design containing selected proposed coding tools that are under study by the JCT-VC for potential inclusion in the HEVC standard.
- **TPE**: Transform precision extension.
- **UDI**: Unified directional intra.
- **Unit types**:
  - **CU**: coding unit.
  - **LCU**: (formerly LCTU) largest coding unit (synonymous with TB).
  - **PU**: prediction unit, with four shape possibilities.
    - **2Nx2N**: having the full width and height of the CU.
    - **2NxN**: having two areas that each have the full width and half the height of the CU.
    - **Nx2N**: having two areas that each have half the width and the full height of the CU.
    - **NxN**: having four areas that each have half the width and half the height of the CU.
  - **TB**: tree block (synonymous with LCU – LCU seems preferred).
  - **TU**: transform unit.
- **V2V**: variable-length to variable-length prefix coding (roughly synonymous with PIPE for most discussion purposes, although the term PIPE tends to be more closely associated with proposals from Fraunhofer HHI while the term V2V tends to be more closely associated with proposals from RIM).
- **VCEG**: Visual coding experts group (ITU-T Q.6/16, the relevant rapporteur group in ITU-T WP3/16, which is one of the two parent bodies of the JCT-VC).
- **WD**: Working draft – the draft HEVC standard corresponding to the HM.
- **WG**: Working group (usually used in reference to WG 11, a.k.a. MPEG).

1.10 Liaison activity

The JCT-VC did not send or receive formal liaison communications at this meeting.

1.11 Opening remarks

It was noted that the Tōhoku earthquake and tsunami in Japan, a tragic event of historic proportions, had struck on 11 March – the Friday preceding the meeting, and this had affected the ability of some members to attend or to arrive on time, including some leading members who had been involved in coordination work and submitted multiple contributions. Accomodations were made so that T. Yamakage of Toshiba (AHG chair for post-processing filter and coordinator of CE8) could attend remotely by teleconference for part of the meeting. S.-I. Sekiguchi of Mitsubishi Electric, was delayed but able to attend.

It was noted that a new ITU-T Recommendation for objective perceptual multimedia video quality measurement of HDTV for digital cable television in the presence of a full reference had recently been approved as Rec. ITU-T J.341 (approval 2011-01-13). Moreover, a new ITU-T Recommendation for objective multimedia video quality measurement of HDTV for digital cable television in the presence of a reduced reference was consented during the meeting as Rec. ITU-T J.342 (approval 2011-04-29). These new Recommendations, as well as the prior Rec. ITU-T J.247 (approval 2008-08-13) on objective perceptual multimedia video quality measurement in the presence of a full reference, could potentially be useful in the work of the JCT-VC.

1.12 Contribution topic overview

The approximate subject categories and quantity of contributions per category for the meeting were summarized and categorized into "tracks" (A, B, or P) for "parallel session A", "parallel session B", or "Plenary" review, as follows. Discussions on topics categorized as "Track A" were primarily chaired by Jens-Rainer Ohm, and discussions on topic categorized as "Track B" were primarily chaired by Gary Sullivan.

- AHG reports (18) Track P (1st P session Wednesday, also Sunday p.m. and others)
- Project development, status, and guidance (2) Track P
- CE summary reports (14) – Reviewed with individual CE-related contributions
- CE1: Decoder-side motion vector derivation (9) Track A
- CE2: Flexible motion partitioning (6) Track A
- CE3: Interpolation filtering for MC (luma/chroma) (18) Track A
- CE4: Slice boundary processing and slice granularity (11) Track A
- CE5: Low complexity entropy coding improvement (16) Track B
- CE6: Intra prediction improvement (37) Track B
- CE7: Alternative transforms (17) Track B
- CE8: Non-deblocking loop filtering (25) Track A
- CE9: MV coding and skip/merge operation (19) Track A
- CE10: Core transfoms (11) Track B
- CE11: Coefficient scanning and coding (15) Track B
- CE12: Deblocking filter (19) Track A
- CE13: Sample adaptive offset (4) Track A
- CE14: Intra mode coding (7) Track B
- Project planning & NB comments (0) Track P
- Clarifications and bug fix issues (4) Track A

- HM settings and common test conditions (0) Track P
- Test material (3) Track A
- Application-specific topics (4) Track A
- Loop filtering (12) Track A
- Block structures and partitioning (15) Track B
- Motion compensation and interpolation filters (13) Track A
- Motion vector coding (36) Track A
- Inter mode coding (9) Track A
- High-level syntax and slice structure (26) Track B
- Quantization (15) Track B
- PCM mode (5) Track B
- Entropy coding and transform coefficient coding (22) Track A
- Intra prediction and mode coding (16) Track B
- Transforms (5) Track B
- IBDI and memory compression (4) Track A
- Parsing robustness and error resilience (12) Track A
- Complexity analysis (2) Track A

2 AHG reports

The activities of *ad hoc* groups that had been established at the prior meeting are discussed in this section.

JCTVC-E001 JCT-VC AHG report: Project management [G. J. Sullivan, J.-R. Ohm (AHG chairs)] [uploaded on 16th]

Reviewed in Track P.

The work of the JCT-VC overall had proceeded well in the interim period. A large amount of discussion was carried out on the group email reflector. All report documents from the preceding meeting had been made available, particularly including the following:

- The meeting report (JCTC-D500_r1)
- Request for Video Test Material for "Screen Content" Coding Experiments (JCTVC-D501)
- The HM 2 encoder description (JCTVC-D502_r1)
- The HEVC Working Draft (JCTVC-D503_r1) [delivered later than originally planned – 10 March]
- The HM encoder description (JCTVC-D502) [delivered later than originally planned – 8 March]
- Finalized core experiment descriptions (JCTVC-D601 through JCTVC-D614)

Additional important current JCT-VC documents were noted as follows:

- HEVC software guidelines (JCTVC-C404)
- HEVC Reference Software Manual (JCTVC-D404)

- Common HM test conditions and software reference configurations (JCTVC-D600)

The various ad hoc groups and tool experiments had made progress and various reports from those activities had been submitted.

One key topic to be resolved was the need to establish an appropriate copyright status for the test model and reference software being developed by the JCT-VC, as noted in the JCT-VC Terms of Reference. The intent is for the software to be developed as part of the work to develop the HEVC standard and also for it to be published as reference software by ITU-T and ISO/IEC.

The status of work on the software copyright issue had remained essentially unchanged since the third JCT-VC meeting (Guangzhou, Oct. 2010). At the fourth JCT-VC meeting (Daegu, Jan. 2011), the USNB of the WG 11 parent body expressed its support for the spirit of the previously-expressed conclusions and recommendations, and it was planned that a decision on the subject should be made in coordination with the parent bodies during the current JCT-VC meeting (Geneva, March 2011). At that time, there was no disagreement regarding the suggestion that the JCT-VC may move forward at the March meeting with using one of the two suggested wordings and removing other copyright wordings from the software.

The JCT-VC work in general was reported to be moving forward at a rapid pace with a high degree of activity, and it was noted that a large number of contributions had been submitted for review at the Geneva meeting.

In the discussion of the overall progress of work on the project, the following aspects were discussed.

It was asked whether there were any cases where, after adoption of something, we have then discovered that significant information was missing from the proposal documentation, post-adoption design seemed to not match well with pre-adoption proposal information for other reasons, unforeseen side-effects had been introduced in the software integration process, significant proportions of the basis for some adoption had turned out to be due to extraneous effects, etc.?

Comment on being able to enable/disable features – this is usually done with compile-time macros (for decodability reasons). About 30 items were integrated for version 2.0 of the HM software – so there are lots of macros in the software, and it is generally difficult to maintain correct interaction between all these configurability options. The main focus is on the combination that represents our WD.

Comment on side-effects: Temporal MV predictor – two proposals JCTVC-D164 and JCTVC-D273 were adopted at the last meeting, and it turned out that these could not be simultaneously enabled, which was resolved by integrating one design that was considered effectively a superset of the other. It was noted that there are various contributions at this meeting affecting the same part of the design.

Some difficulty was expressed regarding difficulty integrating some adoptions into the text. In particular, JCTVC-D366 and JCTVC-D370 only seemed to have fairly limited detail provided in the proposal (e.g., missing VLC tables). We need to ensure that we have a complete description of what we are adopting when we adopt something.

Regarding intra chroma prediction modes – there were three very similar proposals at the last meeting which were considered the same during the discussion but actually differed in some small aspects: JCTVC-D255, JCTVC-D278, and JCTVC-D166. Those small aspects were apparently not considered during the discussion at the last meeting. The three proponents then worked out a unified approach, which is what was integrated. Contributions JCTVC-E395 and JCTVC-E407 discuss these aspects.

Similarly JCTVC-D234 (clean decoder refresh) and part of JCTVC-D080 (NAL unit type indicator) had been adopted, which may have been more different than anticipated. This is reportedly discussed in JCTVC-E400.

Reference picture list construction based on temporal level (JCTVC-D081) was not included in the software and text, although it had been adopted at the last meeting.

Disabling NxN for "smallest CU size" versus for 8x8 CU size specifically came up as a question – logically it made sense to interpret the intent as "smallest CU size".

In addition to text and software integration, it is desirable to be able to check whether the anticipated compression/complexity goals of an adoption worked out as expected.

Serialization of software integration is necessary to some degree to accomplish this (checking "before" and "after" behavior for a feature).

A generally greater level of discipline and scrutiny is needed as the project moves forward.

JCTVC-E002 JCT-VC AHG report: HEVC Draft and Test Model editing [K. McCann, T. Wiegand (co-chairs), B. Bross, W.-J. Han, J.-R. Ohm, J. Ridge, S. Sekiguchi, G. J. Sullivan (vice chairs)] [uploaded on 16th]

Reviewed in Track P.

This document reports on the work of the JCT-VC ad hoc group on HEVC Draft and Test Model editing between the 4th JCT-VC meeting in Daegu (20-28 January 2011) and the 5th JCT-VC meeting in Geneva (16-23 March 2011).

The second HEVC test model (HM2) was developed from the first HEVC test model (HM1), following the decisions taken at the 4th meeting of JCT-VC in Daegu from 20-28 January 2011.

In earlier meetings, JCT-VC had defined a "Test Model under Consideration" (TMuC). The majority of the tools within the HM had previously been included in the TMuC in some form, but the HM has substantially fewer coding tools than the TMuC.

Two editorial teams were formed to work on the two documents that were to be produced:

- JCTVC-D502 Encoder-side description of HEVC Test Model (HM) [Ken McCann (primary), Benjamin Bross, Shun-ichi Sekiguchi]
- JCTVC-D503 HEVC text specification Working Draft 2 [Thomas Wiegand (primary), Woo-Jin Han, Jens-Rainer Ohm, Gary J. Sullivan]

Editing JCTVC-D503 was assigned a higher priority than editing JCTVC-D502.

Initial drafts of both the JCTVC-D502 and JCTVC-D503 documents were published a week prior to the 5th JCT-VC meeting. A second draft of each was published on Monday 14th March.

In the case of JCTVC-D502, the document is still a rough skeleton that still requires significant improvement. A structure was adopted where the main body of the document is split into two parts.

- Section 5 as the test model description, giving a general tutorial overview of the codec architecture
- Section 6 as the encoder description, giving details of the encoder

In the case of JCTVC-D503, the document is a more complete draft, that:

- Incorporated Partial Merging according to JCTVC-D441
  - removed direct mode
  - moved merge to prediction_unit and added candidates
  - added partial merge restrictions
  - inter NxN partitioning only for smallest coding_unit
- Updated transform_tree and transform_coeff syntax
- Added transform_coeff to coding_unit syntax (Fix)
- Incorporated intra NxN partitioning only for smallest coding_unit according to JCTVC-D432

    - Incorporated modified temporal motion vector predition according to JCTVC-D164
    - Incorporated simplified motion vector prediction according to JCTVC-D231
    - removed median
    - removed pruning process
    - changed the selection manner of left/top predictor
- 8-tap luma interpolation filter according to JCTVC-D344
- 4-tap chroma interpolation filter according to JCTVC-D347
- Improved deblocking filter text according to JCTVC-D395
- IBDI syntax is removed
- Updated syntax and semantics
    - Two tool-enabling flags (adaptive_loop_filter_enabled_flag and cu_qp_delta_enabled_flag) are added in SPS according to software. However, low_delay_coding_enabled_flag is not added – it could be handled by more general reference management scheme. merging_enabled_flag is not added – partial merging (JCTVC-D441) was adopted thus merging cannot be turned off any more. amvp_mode[] is not added since amvp cannot be turned off any more due to absence of median predictor (JCTVC-D231). Note that software has all switches.
    - cu_qp_delta (coding unit layer), syntax and semantics are added. (JCTVC-D258)
    - co_located_from_l0 (slice header), syntax and semantics are added.
- Clean decoding refresh (CDR) (JCTVC-D234).
- Temporal motion vector memory compression (JCTVC-D072)
- Constrained intra prediction (JCTVC-D086)
- Mode-dependent intra smoothing (JCTVC-D282)
- Mode-dependent 3- scan for intra (JCTVC-D393)
- Merging chroma intra prediction process into luma intra prediction process
- Combined reference list (JCTVC-D421)
- Chroma intra prediction mode reordering (JCTVC-D255/D278/D166)
- Adaptive loop filter text is added
- Entropy slice is added (JCTVC-D070)
- High precision bi-directional averaging (JCTVC-D321)
- Reduction of number of intra prediction modes for 64x64 blocks (JCTVC-D100)
- Misc.
    - TPE bits are reduced from 4 to 2
    - Clipping is applied to (temporally) scaled mv – need to revisit

However, some open issues for JCTVC-D503 remain:

- The question over whether support for monochrome, 4:2:2 and 4:4:4 (with and without separate color planes) be included from the start? Currently, it has been left in the text as it doesn't seem to affect much text.
- Handling of the term "frame". One suggestion would be to change all occurrence of "frame" to "picture" (all occurrences of "field" will be removed)
- Large size table (zigzag and de-scaling matrices) is not inserted yet.
- Slice-header syntaxes and their semantics are not included yet. Also possible modifications that may be necessary because of larger treeblocks (64x64) compared to macroblocks (16x16) are not yet considered.
- Text representing entropy coding named as "LCEC" is missing. The name LCEC may need to be adjusted. Currently, there is a place holder with CAVLC.
- Text representing CABAC entropy coding needs to be extended.
- Clipping is applied to temporally scaled motion vector in 8.4.2.1.7. Do we need this? (c.f. AVC seems not)
- SPS- and slice-level syntax items are significantly different from software in terms of both meaning and position. Needs to be unified.

The recommendations of the HEVC Draft and Test model Editing AHG were to:

- Approve the edited JCTVC-D502 and JCTVC-D503 documents as JCT-VC outputs
- Continue to edit the HEVC WD and Test Model documents to ensure that all agreed elements of HEVC are fully described
- Compare the HEVC documents with the HEVC software and resolve any discrepancies that may exist, in collaboration with the Software AHG
- Continue to improve the editorial consistency of HEVC WD and Test Model documents
- Ensure that, when considering the addition of new tools to HEVC, properly drafted text for addition to the HM Test Model and/or the HEVC Working Draft is made available in a timely manner

In the group discussion, the following remarks were recorded:

- It was suggested to use the software "issue tracker" for software mismatch with text (esp. for aspects where the text is correct but the software is not).
- It was suggested to remove the prior "tree block" terminology from the documents.
- Releasing more interim versions of text between meetings was suggested. This had been difficult in the last meeting cycle due to the exceptionally short interim period.

JCTVC-E003 JCT-VC AHG Report: Software development and HM software technical evaluation [F Bossen, K Sühring, D Flynn] [uploaded on 30th]

Reviewed in Track P.

This document was verbally discussed prior to document upload.

Adoptions without a substantial effect on common conditions were not in the first integration cycle.

The "2.1" integration cycle had not yet been completed by the opening of the meeting.

JCTVC-D081 reference list contruction with temporal ID had been adopted but no software had yet been provided. It seemed likely that other aspects of the design in the same general area of the high-level syntax needs other work to reach a point where integration of this would be straightforward. It was therefore suggested to release version 2.1 without this.

It was noted that contribution JCTVC-E279 has software with support of temporal ID that may be useful to use as a basis for some of the high-level syntax integration work.

It was noted that some of the prior software integration work had not proceeded in the cleanest possible way.

It was remarked that the software integration guidelines JCTVC-C404 seem to be getting generally ignored by contributors to the software integration effort.

It was also remarked that some of the submitted software had been written to try to make it run fast rather than to be readable and maintainable.

Excessive duplication of sections of code was another observed phenomenon.

The software is now substantially faster in terms of encoding time.

JCTVC-E004 JCT-VC AHG report: Slice support development and characterization [R. Sjoberg (Ericsson), Y. Chen (Qualcomm), M. Horowitz (eBrisk), K. Kazui (Fujitsu), A. Segall (Sharp)] [uploaded on 16th]

Reviewed in Track P.

This report summarizes the slice support development and characterization ad-hoc activities between the 4th and the 5th JCT-VC meeting and the input documents to this meeting related to this ad-hoc group.

The following timeline of activites was noted:

February 18	AHG kick-off message sent
March 1	First version of slices announced on reflector (revision 596)
March 2	Bug-fix, second version of slices released (rev 600)
March 3	HM-2.0-dev-slices code merged into HM-2.0-dev
March 4	Bug-fix, third version released ("rev 609")

The only change in "rev 609" was to set AD_HOC_SLICES_TEST_OUTOFORDER_DECOMPRESS to 0.

Basic slices and entropy slices has been implemented on top of HM 2.0. A branch, HM-2.0-dev-slices, was used for adding slices on top of HM 2.0.

The main effort had been implementation of basic slices and entropy slices. Loss due to slice usage has become larger with HM2 compared to HM1 – the largest such loss (around 1%) was for random access (both for LC and HE). No explanation/reason was yet identified for this.

The coding efficiency impact for 1500 byte slices was reported, which is somewhat higher for RA than was the case in HM 1.

There are some known issues with the current slice implementation. These are:

- The slice code always puts ALF syntax for the entire picture in the first slice
- The slice header is not accounted for when the code is configured for byte size limited slices
- AD_HOC_SLICES_TEST_OUTOFORDER_DECOMPRESS does not work with bitstream buffering

- Slice header syntax elements differ between source code and Working Draft (basically, there should be more in the header than there is)

The relevant input contributions were reviewed.

In the discussion, it was remarked that decoder crashes were observed with LCU size less than 64x64, and this needs to be fixed. (There is already a ticket for this and a fix may have been provided.)

JCTVC-E005 JCT-VC AHG report: Spatial transforms [Pankaj Topiwala, Madhukar Budagavi, Rajan Joshi, Robert Cohen] [first upload on 12th]

Reviewed in Track B.

The following coding tools and analysis methods were used for study in this AhG.

- Spatial integer block transforms of size 4, 8, 16, 32, whose coding efficiency is comparable to HM transforms, but whose implementation complexity is lower.
- Methods to evaluate computational complexity of proposed transforms, and its impact on software or hardware implementations.

Example of past proposals that demonstrated such tools, analysis methods or conclusions include the following: JCTVC-D036, JCTVC-D224, JCTVC-D256, JCTVC-D339, JCTVC-D365, JCTVC-D037, JCTVC-D071, JCTVC-D257.

New proposals are welcome along these or similar lines, and are especially sought in the domain of hardware implementation complexity analysis. Regarding specific transform proposals, it is intended to conduct experiments similar to core experiments, with cross-checks, etc; see below.

This AhG was quite active in this reporting cycle. Work progressed on the two CEs within this AhG: CE7 on Alternative Transforms, and CE10 on Core Transforms. Within CE10, four proposed transform designs were submitted and evaluated using a variety of performance and complexity metrics (tabulated below), which are reported in JCTVC-E030. For CE7, its activities are reported in JCTVC-E027. In addition to submissions directly related to CEs, there were also documents in the general AhG topic area, related to topics such as dynamic range analysis, and quality of approximation to the true DCTs. This AhG naturally interacts with several other AhGs, notably on Complexity Assessment and Quantization.

JCTVC-E006 JCT-VC AHG report: In-loop and post-processing filtering [T. Yamakage (Toshiba), K. Chono (NEC), Y. J. Chiu (Intel), I. S. Chong (Qualcomm), M. Narroschke (Panasonic)] [first uploaded on 15th]

Reviewed in Track P.

This report summarizes the In-loop and post-processing filtering Ad hoc activities between the 4th JCT-VC meeting in Daegu, Korea (20 to 28 January 2011) and the 5th JCT-VC meeting in Geneva, CH (16 to 23 March 2011). There are six technical proposals related to this AHG. Most of the mandates are covered by CE8 contributions.

JCTVC-E007 JCT-VC AHG report: Coding block structures [K. Panusopone, W.-J. Han, T. K. Tan, T. Wiegand] [uploaded on 15th]

Reviewed in Track B.

This report summarizes the Coding block structures Ad hoc activities between the 4th JCT-VC meeting in Daegu, Korea (20 to 28 January 2011) and the 5th JCT-VC meeting in Geneva, Switzerland (16 to 23 March 2011).

Several changes were made to coding block structure at the Daegu meeting including removal of NxN PU partition type except for the smallest CU size and replacing 2NxN and Nx2N PU partition type with "partial merge" mode.

There were some activities relating to Coding block structure AhG occurred between the Daegu meeting and the Geneva meeting. CE2 studies several flexible motion partitioning methods which will impact PU partitioning. Several companies conducted independent investigations of RQT. One such study is a joint effort by Motorola Mobility, NEC, I2R, and Texas Instruments to evaluate RQT in the HM at various maximum depths and with an implicit TU signaling approach. Their findings were reported to the group on the JCT-VC reflector and its coding performance results were tabulated in the AHG report.

JCTVC-E008 JCT-VC AHG report: Reference pictures memory compression [Keiichi Chono, Takeshi Chujoh, ChongSoon Lim, Ali Tabatabai, Minhua Zhou] [first upload on 15th]

Reviewed in track A.

The run-time decoder-side MC memory access calculation module was integrated into HM2.0. Decoder-side MC memory access bandwidths of HM2.0 Anchor streams were measured and uploaded to the SVN site. In the high efficiency setting, decoder MC memory access measures of HM2.0 are reportedly reduced by 21.8% and 24.1% for RA and LD cases compared to those of TMuC0.9; in the low complexity setting, decoder-MC memory access measures of HM2.0 are reportedly increased by 25.5% and 24.1% for RA and LD cases compared to those of TMuC0.9.

Fixed rounding using a Bit Depth Increase (BDI) distortion metric (from JCTVC-D152) was integrated into HM 2.1. It was reported that even with the BDI distortion metric, Class E results with fixed rounding are inferior to those of BDI off.

All results (including compression) are still inferior than BDI on. Particularly, class E suffers (around 7% between BDI on and BDI off, memory compression loses around 3.5%).

JCTVC-E009 JCT-VC AHG report: Entropy coding [M. Budagavi, G. Martin-Cocher, A. Segall (AHG Chairs)] [first upload on 15th]

Reviewed in Track B.

It was reported that there are several contributions to the Geneva meeting that are related to the mandates of this Ad Hoc Group. They were broadly categorized as follows:

- CE5 (low complexity entropy coding improvements) related contributions
- CE11 (coefficient scanning and coding) related contributions
- LCEC related contributions
- Context processing and coefficient scanning related contributions
- PCM related contribution
- Others (JCTVC-E042 Unified End-Of-Slice Detection for LCEC and CABAC, and JCTVC-E428 Low Complexity Embedding of Information in Transform Coefficients)

A summary of the contributions was provided in the report.

JCTVC-E010 JCT-VC AHG report: Quantization [M. Budagavi, K. Sato, G. Martin-Cocher (AHG Chairs)] [uploaded on 15th]

Reviewed in Track B.

It was reported that there are several contributions to the Geneva meeting that are related to the mandates of the Ad Hoc Group. They were broadly categorized as follows:

- Sub-LCU level delta QP
  - Need for delta QP support at sub-LCU level
  - Syntax changes needed to support sub-LCU level delta QP,
  - Prediction methods for calculation of delta QP using neighboring CU information,
  - Simulation results of sub-LCU level delta QP implementation.
- Quantization matrices
  - Need for quantization matrix compression in HEVC
  - Syntax changes needed to support quantization matrices,
  - Quantization matrix compression methods,
  - Simulation
- Others
  - Adaptive De-Quantization Offset

JCTVC-E011 JCT-VC AHG report: Video test material selection [Teruhiko Suzuki] [uploaded on 16th]

Reviewed in Track A.

It was pointed out that the current test sets include many panning scenes and doesn't cover a very wide variety of scenes. It is good to test a greater variety of test materials. As a starting point, re-testing of the existing VCEG/MPEG test sequences was proposed. It was noted that it often takes a certain amount time to obtain permission for new sequences to be used in standardization work. The main reason not to use the prior existing test sequences in CfP was reportedly related to the relatively old camera technology used to generate those sequences. But a wide coverage of natural sequences is more helpful for the development of video codec.

The effort to collect a greater variety of test materials is on-going; however it may take more time to get permission to use the materials from the content rightsholders. One of the concerns from the content rightsholders is the scope of the use of test materials in JCTVC. Some content rightsholders don't allow recipients to re-distribute the materials to JCT-VC or other organizations.

The AHG recommended to clarify the conditions to use test materials in JCTVC.

Comments on this were as follows:

- Material that can only be accessed via the provider would be acceptable under the condition that such an offer is sufficiently durable
- Usage conditions would need to be clarified; in general the usage for development and promulgation of standards should not expire.

The AHG noted that problems of the current class E sequences were reported. All of the "Vidyo" sequences are slightly trembling vertically and this is especially visible in chroma components. These effects are are not present in other common sequences. Those sequences had been pre-compressed by the acquiring camera system, and this maybe one of the reasons why the unusual characteristics were evident. It was recommended to collect more appropriate uncompressed class E test materials, if tele-conference sequences are necessary.

It was reported that the following contributions were relevant to the AHG:

- JCTVC-E139 [W. Ding (Beijing univ. of technology)] Test material for screen content coding
- JCTVC-E176 [W.Zhang, O. Au, X. Wen, J. Dai (HKUST)] Test sequences for screen content coding
- JCTVC-E305 [G. Cook, W. Gao, D. Wang, J. Zhou, H. Yu (Huawei)] Video Test Material Submission for "Screen Content" Coding Experiments: Scrolling Text, Overlays, Editing, and Window Switching

JCTVC-E012 JCT-VC AHG report: Complexity assessment [Daniele Alfonso, Justin Ridge, Xing Wen] [uploaded on 9th]

Reviewed in Track A.

This report summarized the activities of the Ad Hoc Group on Complexity Assessment between the 4th JCT-VC meeting held in Daegu in January 2011 and the current meeting in Geneva.

There was low activity specifically directed to this AHG on the reflector, although its relationship with other AHGs is noted.

Two particularly relevant contributions into this meeting were noted as follows.

- JCTVC-E054, “Preliminary complexity assessment on ARM”.
- JCTVC-E086, “Summary of Complexity Assessment for CEs and Three-Level Assessment method”

JCTVC-E013 JCT-VC AHG report: Parsing robustness [J. Xu (Microsoft), M. Coban (Qualcomm), Y.-W. Huang (MediaTek), J. Jung (Orange Labs), P. Onno (Canon Research Centre France)] [uploaded on 16th]

Reviewed in Track A.

This AHG report described the mandates of the AHG, listed 12 relevant input documents, and recommended to review the input documents and to discuss solutions for parsing robustness.

JCTVC-E014 JCT-VC AHG report: Screen Content Coding (SCC) [Oscar Au, Jizheng Xu, Haoping Yu] [uploaded on 14th]

Reviewed in Track P.

This contribution summarizes the Screen Content Coding (SCC) Ad Hoc Group activities between the 4rd JCT-VC meeting in Daegu, Korea (20 to 28 January 2011) and the current 5th JCT-VC meeting in Geneva, Switzerland (16 to 23 March 2011).

There had been some input documents on Screen Content Coding (SCC) in the 2nd and 3rd JCTVC meetings. Some SCC test materials were made available and some WG 11 National Body comments related to SCC were received in the 4th JCTVC meeting. During that meeting, there was a decision to look further into the issue.

The Call for Video Test Material of SCC (JCTVC-D501 and MPEG w11867) was produced in Daegu.

The Call was disseminated, and an ftp site was set up for test sequences. Three parties submitted material.

Currently, the sequences are available from a special account at the Hannover ftp server (not the usual hevc login). Some viewing was conducted at the meeting (coordinated in Track A). It was noted that some clarifation of source video test sequence copyright issues may be needed.

Four relevant contributions were noted (3 test sequence contributions JCTVC-E176, JCTVC-E139, JCTVC-E305, and 1 coding tool proposal JCTVC-E145).

JCTVC-E015 JCT-VC AHG report: Motion compensation interpolation [K. Ugur, E. Alshina, P. Chen, T. Chujoh (AhG Chairs)] [uploaded on 16th]

Reviewed in Track A.

This report reviewed the mandates of this AHG and noted that the AHG was closely related to a CE.

The report suggested that this AHG should be discontinued (not re-established), as it seemed rather duplicative with the CE and did not have specific standalone activity during the period between the Daegu and Geneva meetings. It was suggested that, in general, excessively overlapping definitions of AHG and CE activities should be avoided in the future.

JCTVC-E016 JCT-VC AHG report: high-level syntax [Y.-K. Wang (Huawei), J. Boyce (Vidyo), Y. Chen (Qualcomm), K. Kazui (Fujitsu), T. Schierl (Fraunhofer HHI), R. Sjöberg (Ericsson), T. K. Tan (NTT DOCOMO)] [uploaded on 16th]

Reviewed in Track B.

This report summarizes the activities of the high-level syntax Ad Hoc Group between the 4th JCT-VC meeting held in Daegu in January 2011 and the current meeting in Geneva.

The main topic of the discussion on the e-mail reflector related to whether to change nal_ref_idc in NAL unit header from two bits to one bit. There was one opinion expressed that two bits should be kept as they are, at least for now, unless the bit is clearly needed. Another opinion expressed was that due to the inclusion of temporal_id, the only use of the two bits for indication of transport priority in RTP payload format would disappear and therefore the bit could be purely wasted. The AHG suggested that we can keep this issue open at the moment unless there are new input contributions on this subject.

Relevant contributions were listed in the report.

JCTVC-E017 JCT-VC AHG report: Decoder-side motion vector derivation (DMVD) [Yi-Jen Chiu, Elena Alshina, Haoping Yu] [first uploaded on 11th]

Reviewed in context of CE1.

The report reviewed the mandates of the AHG. In addition to CE1 documents, it was noted that input contributions JCTVC-E055 and JCTVC-E216 were relevant. It was reported that otherwise, not much activity occurred in this AHG beyond the work of the CE.

JCTVC-E018 JCT-VC AHG report: Scalable coding investigation [J. Boyce, J. Kang, W. Wan, Y.-K. Wang] [uploaded on 15th]

Reviewed in Track P.

This report summarizes the activities of the Scalable coding investigation Ad Hoc Group between the 4th JCT-VC meeting held in Daegu in January 2011 and the current meeting in Geneva.

The main topic of the discussion on the e-mail reflector related to scalable coding since the January meeting was related to the requirements for scalable coding in HEVC. The link to the public MPEG output document for MPEG-H requirements that was issued from the January MPEG meeting was posted.

http://mpeg.chiariglione.org/working_documents/mpeg-h/vision-apps-reqs.zip

The following contributions related to scalable coding were noted to have been submitted to the current JCT-VC meeting:

- JCTVC-E279, "Extensible High Layer Syntax for Scalability"
- JCTVC-E422, "NAL unit header concept with support for bitstream scalability"
- JCTVC-E431, "Spatial Scalability for HEVC"

In the discussion, it was suggested that for telecom apps, scalability is especially important. Multiview support was also suggested.

Hypothetical timelines were discussed:

- In the first version
- Overlapping "phases" of work (with hooks)
- Sequential phases of work (perhaps with hooks)

There was a discussion of the possibilities of "full fledged" versus "simplified" approaches to the topic.

One topic that was discussed was the definition of "Hooks". This does not mean just high-level syntax and network access, but rather the design of the single-layer codec to be useful as a reasonable base layer. To achieve this, it was suggested that an "overlapping" development could be more helpful than a "sequential" approach.

It was suggested to discuss and clarify this further, including consultation with the parent bodies (and to potentially create a unified requirements doc).

3 Project development, status, and guidance

JCTVC-E390 The art of writing standards: Some "shalls" and "shoulds" for better quality interop specs [G. J. Sullivan (Microsoft)]

This contribution provided information and advice regarding the drafting of interoperability specifications.

In the interest of saving meeting time, it was not presented in detail.

Participants were requested to study this contribution.

JCTVC-E447 HEVC Reference Software Manual [F Bossen (DOCOMO USA Labs), D Flynn (BBC), K Sühring (HHI)] [late registration]

This contribution provided a text manual for use of the HEVC reference software.

IT was produced by the Software development and HM software technical evaluation AHG, and was approved by the JCT-VC.

3.1 Screen content coding

See section discussing candidtate source video test materials.

3.2 Software copyright disclaimer text

After further consultation between the parent bodies ITU-T SG 16 and ISO/IEC JTC 1/SC 29/WG 11 at their co-located meetings with the 5th meeting of the JCT-VC, and according to the plans established at the 3rd and 4th JCT-VC meetings, SG16 and WG11 approved a license and disclaimer header language for use by the JCT-VC for the collaboratively-developed video coding software known as the HEVC reference software. The HEVC reference software copyright license header language is the BSD license with preceding sentence declaring that contributor or third party rights are not granted, as recorded in N10791 of the 89th meeting of ISO/IEC JTC 1/SC 29/WG 11. Both ITU and ISO/IEC will be identified in the <OWNER> and <ORGANIZATION> tags in the header. This software is used in the process of designing the new HEVC standard and for evaluating proposals for technology to be included in this design. Additionally, after development of the coding technology, the software will be published by ITU-T and ISO/IEC as an example implementation of the HEVC standard and for use as the basis of products to promote adoption of the technology. It was noted that this important disclaimer language has been under consideration at every JCT-VC meeting, since the first meeting in April 2010 (as recorded in the JCT-VC documents JCTVC-A200, JCTVC-B001, JCTVC-C001, JCTVC-D001, JCTVC-E001 and others), and no objections to its adoption had been expressed in multiple recent meetings of the JCT-VC or its parent bodies.

Any new software contributions should use the new header, and the headers on the current software should be changed prior to any "official" future release.

Now that an agreed JCT-VC copyright statement has been established (assuming parent body approvals this week), different copyright statements shall not be committed to the committee software repository (in the absence of subsequent review and approval of such actions). As noted in JCTVC-E001, it must be further understood that any initially-adopted such copyright header statement language could further change in response to new information and guidance on the subject in the future.

4 CE1: Decoder-side motion vector derivation

4.1 Summary

JCTVC-E021 CE1: Summary report of core experiment on decoder-side motion vector derivation (DMVD) [Yi-Jen Chiu (Intel), Haoping Yu (Huawei), Yu-Wen Huang (MediaTek), Shun-ichi Sekiguchi (Mitsubishi Electric), Wen-Hsiao Peng (NCTU)]

In this core experiment, DMVD techniques have been tested for the following functionalities:

- Candidate-based decoder-side motion vector derivation (C-DMVD) for B pictures (no proposal)
- C-DMVD for GPB pictures (no proposal)
- DMVD-based Bi-prediction (JCTVC-E154)
- C-DMVD skip mode only (JCTVC-E084, JCTVC-E294)

Note: Previous gain of DMVD was reduced when the transition from HM1 into HM2 was made, as the time for implementing C-DMVD with candidate-based method was too short (would have been test 1), and only skip mode was implemented (test 4).

4.2 Contributions

4.2.1 Bi-prediction

JCTVC-E154 CE1: Report of DMVD-based Bi-prediction C.-C. Chen, C.-L. Lee, W.-H. Peng, H.-M. Hang (NCTU/ITRI)

This contribution reports the experimental results on the DMVD-based Bi-prediction technique described in CE1. The technique forms a bi-prediction for a 2Nx2N PU based on two sets of motion parameters, one is specified in uni-prediction syntax and the other is signaled by the motion merging mechanism. Two predictors are created and combined linearly using OBMC. Depending on how the merged motion parameters are derived, a separate OBMC window function is applied. The compression performance and the complexity impacts of this technique are evaluated in two tests. Test #1 allows each 2Nx2N PU to choose from a set of six different window functions. Test #2 provides one additional set of window functions at the cost of extra signaling overhead. When compared with the HM-2.0 anchor in common test conditions, the technique is observed in Test #1 to have 0.4-3.2% BD-rate reductions, with an average of 1.6%. The encoding time is increased by 53% while the decoding time is increased by 4%. In Test #2, it achieves 0.6-3.7% BD-rate reductions, showing an average of 1.9%. The encoding time is doubled, whereas the decoding time is increased by 6%.

In principle, this is a new proposal. Not really related to DMVD - does not use MV derivation by SAD calculation at the decoder side (in contrast to JCTVC-B072 and JCTVC-D175), but rather a merging with OBMC, combining predictors and adapting the OBMC window function depending on MV constellation. Also modified block matching criterion for OBMC (encoding time increased by >50% for test 1, almost 100% for test 2. Gain is higher for LD.

Up to 3 hypotheses are used, but unclear how much gain due to that.

One expert comments that the method could be up to 3x memory bandwidth in worst case at the decoder side.

Further study was encouraged.

JCTVC-E213 CE1: Cross-verification report of NCTU's proposal (JCTVC-E154) by JVC KENWOOD [Motoharu Ueda (JVC), Satoru Sakazume (??)]

JCTVC-E232 CE1: Cross-verification report of NCTU's proposal (JCTVC-E154) by TUB [Michael Tok, Andreas Krutz (Tech. Univ. Berlin)]

4.2.2 DMVD skip mode

JCTVC-E084 CE1: Report of self-derivation motion estimation techniques at video decoder side on HM2.0 [Yi-Jen Chiu, Lidong Xu, Wenhao Zhang, Hong Jiang (Intel)]

This contribution provides test results for the CE1 topic of Self Derivation of Motion Estimation (SDME) techniques on HM 2.0 reference software. The skip-mode only rounded-candidate based SDME are tested for bi-prediction mode on HM2.0 reference software. To quantize the impact of the memory access bandwidth in checking multiple candidate motion vectors, the tests of SDME techniques only consider the candidate motion vectors within a predefined range to confine the required pixels used for the process of sum-of-absolute-difference (SAD) and of motion compensation filtering. Two test points of Skip-mode only rounded-candidate based SDME with 8-point MV refinement has reported that an overall 1.3% BD bit rate reduction (up to 2.4%) for the test of random access (high efficiency) category under the common test conditions with an overall 3% increase in encoding time and an overall 11% increase in decoding time increase. Two test points of Skip-mode rounded-candidate based SDME without MV refinement has reported an overall 0.7% BD bit rate reduction (up to 1.4%) for the test of random access (high efficiency) category with an overall 1% increase in encoding time and an overall 4% increase in decoding time.

Additional notes:

Uses up to 9 candidate motion vectors with SAD computation in skip mode. BR red. in RA/HE 0.7%-0.9% depending on search range limitation 8/32. Decoder RT increase 4%. With additional refinement of best candidate (8 positions), 1.3%/1.7% are achieved, but decoder RT increase is 11%/16%.

JCTVC-E093 CE1 Subtest1: Cross-verification on Candidate-based DMVD without MV refinement [Shun-ichi Sekiguchi, Yusuke Itani (Mitsubishi Electric)] [late upload]

(It was remarked that the title seems a bit confusing, as this is not actually related to candidate-based DMVD.)

JCTVC-E082 CE1: Cross check results for contribution JCTVC-E084 [Sven Klomp, Jörn Ostermann (Univ. Hannover)]

JCTVC-E294 CE1: Huawei report on DMVD in HM2.0 [S. Lin, M. Yang, H. Yu (Huawei)]

Spatial and Temporal Direct Mode (STDM), a continuation of the work, has been implemented into HM2.0 software and tested following the common test requirements. A memory constraint module is added into the STDM algorithm to resolve the serious concerns about memory access bandwidth of the DMVD technology which are shown in the last meeting. This document describes these techniques in details, which includes descriptions of coding algorithms and their implementation, coding performance, and complexity evaluation and analysis. According to the test results, an average bit-saving of 0.93% has been achieved with very little additional decoding complexity, the decoding time is about 6% more than that of the anchor. Also a serial of tests in different conditions are simulated to evaluate the performance between the AMVP, MERGE and STDM algorithm.

0.9% for RA HE, 0.7% for RA LC, 5%/6% decoder time increase. In skip mode, up to 9 candidates with restricted displacement area (4x size of prediction unit) searched with SAD criterion.

Would make sense to introduce an upper limit of the search window size as in JCTVC-E084 (currently it could hypothetically go up to 128x128)

It is claimed that the memory access bandwidth is not critical when an internal cache is used.

There was some doubt raised about that.

JCTVC-E440 CE1: Cross-check result of Huawei's STDM (JCTVC-E294) [Yi-jen Chiu, Lidong Xu, Wenhao Zhang, Hong Jiang (Intel)] [late registration / missing prior]

4.3 Discussion and Conclusions

Plan: Continue the DMVD study in an AHG (rather than CE).

5 CE2: Flexible motion partitioning

5.1 Summary

JCTVC-E022 CE2: Summary Report of core experiment on Flexible Motion Partitioning X Zheng, P. Bordes, P. Chen, I.-K Kim

This document summarizes the activity of CE2 related to Flexible Motion Partitioning. The description of the experiment can be found in JCTVC-D602r1. In this CE, three tools for motion partitioning have been studied: Asymmetric Motion Partitioning with Overlapped Block Motion Compensation (OBMC), Non-rectangular Motion Partitioning (NRMP) with OBMC and unified solution (AMP+NRMP+OBMC). An additional tool related to CE2 has also been evaluated: Asymmetric Motion Partitioning + OBMC + Non-Square TU. 8 companies have been involved as proponent or cross-checker.

JCTVC-E376 is also related.

5.2 Contributions

JCTVC-E316 CE2: Test results of asymmetric motion partition (AMP) with overlapped block motion compensation (OBMC) [I.-K. Kim (Samsung), P. Chen, L. Guo (Qualcomm)] [late upload]

In this document, test result of asymmetric motion partition (AMP) with overlapped block motion partition (OBMC) is provided. The average gain for high efficiency is 1.1% with 14% encoding and 3% decoding time increase.

Gain is 0.8% and 1.4% BR reduction for HE RA and LD, respectively, decoding time increased about 5%/1%, encoding time increase 14%/13%.

Minimum partition size for AMP is 16x16, additional shifts are 4 in both directions.

Supports PU merge.

JCTVC-E259 CE2: Cross-check report of test 2a and 2b [M. Winken (HHI)] [late upload / missing prior]

JCTVC-E373 CE2: Test results of non-rectangular motion partitioning (NRMP) with overlapped block motion compensation (OBMC) [X. Zheng, H. Yu (Huawei & HiSilicon), P. Bordes, L. Guo, P Chen] [late upload / missing prior]

This contribution is related to Core Experiment 2: flexible motion partitioning. In this document, test result of non-rectangular motion partitioning (NRMP) with overlapped block motion partition (OBMC) is provided. The average gain for high efficiency is from 0.9% to 1.6%.

JCTVC-E252 CE2: Cross-check report of Non Rectangular Motion Partitioning (NMRP) + Overlapped Block Motion Compensation (OBMC), proposal JCTVC-E373 [Laurent Guillo, Ronan Boitard (INRIA)]

JCTVC-E374 CE2: Unified solution of flexible motion partitioning [P. Bordes, P. Chen, I.-K Kim, L. Guo, H. Yu, X. Zheng (??)]

This contribution is related to Core Experiment 2: flexible motion partitioning. In this contribution, Asymmetric Motion Partitioning (AMP) + Non-Rectangular Motion Partitioning (NRMP) + Overlapped Block Motion Compensation (OBMC) is proposed.

Gain is 1.4% and 2.1% BR reduction for HE RA and LD, respectively, decoding time increased about 10%, encoding time increase 75%.

Unclear how much gain comes due to AMP, how much due to OBMC.

(Note: JCTVC-E376 has results on OBMC alone of 0.6% for RA, 0.9% for LD, but it does OBMC everywhere).

Also JCTVC-E374 suggests to adopt JCTVC-E316.

It is argued that both methods have a synergistic effect.

Most encoder runtime increase probably due to AMP. Most decoder runtime increase probably due to OBMC.

Some concern is raised about additional memory bandwidth (tool of memory bandwidth AHG should be used for that).

5.3 *Discussion and Conclusions*

Plan: Further study in CE to provide additional information:

- Gain due to AMP and due to OBMC.
- Memory bandwidth measurement at decoder.
- Further decrease of encoder runtime and/or improvement of performance recommended.

6 CE3: Interpolation filtering for MC (luma/chroma)

6.1 *Summary*

JCTVC-E023 CE3: Summary report of core experiment on interpolation for MC (Luma) T.Chujoh, E.Alshina [late upload]

In this core experiment, interpolation filters for motion compensation of luminance pixels have been discussed. There are following two purposes;

- Improvement of coding efficiency by interpolation filter
- Reduction of complexity and reference frame memory access bandwidth generally

Proponent NTT SONY TOSHIBA KDDI eBrisk Video Motorola Mobility

Contribution number JCTVC-E078 JCTVC-E128 JCTVC-E134 JCTVC-E188 JCTVC-E284 JCTVC-E358

HE RA Y BD-rate (%) -0.03 0.01 0.04 0.10 0.15 -0.20 0.08

LD -0.10 0.05 0.30 0.16 -0.09 -0.10 -0.08

LC RA -0.42 -0.57 0.30 0.01 0.04 -1.10 0.29

LD -1.13 -0.57 1.32 -0.12 -0.06 -1.40 -0.26

All -0.42 -0.27 0.49 0.04 0.01 -0.70 0.01

Proponent NTT SONY TOSHIBA KDDI eBrisk Video Motorola Mobility

Contribution number JCTVC-E078 JCTVC-E128 JCTVC-E134 JCTVC-E188 JCTVC-E284 JCTVC-E358

Proponent Encoding Time (%) 140% 96% 103% 105% 101% 125% 97%

Decoding Time (%) 98% 97% 99% 102% 100% 98%

Cross-checker

Encoding Time (%) 72% 104% 103% 99%

Decoding Time (%) 106% 99% 99% 102%

Encoding Time (%) 96% 101% 102% 98%

Decoding Time (%) 100% 97% 101% 103%

Single Operations

Worst case / pixel 115% 69% 100% 100% 100% 115% 88%

Average of operations / pixel 114% 72% 100% 100% 100% 114% 93%

Bandwidth Worst case / pixel 100% 67% 100% 100% 100% 100% 100%

Average of bytes / pixel 100% 79% 100% 100% 100% 100% 93%

Bi Operations

Worst case / pixel 115% 100% 92% 88% 100% 115% 88%

Average of operations / pixel 114% 103% 94% 91% 100% 114% 93%

Bandwidth Worst case / pixel 100% 100% 100% 100% 100% 100% 100%

Average of bytes / pixel 100% 100% 88% 88% 100% 100% 93%

Total Operations

Worst case / pixel 115% 100% 92% 88% 100% 115% 88%

Average of operations / pixel 114% 93% 96% 94% 100% 114% 93%

Bandwidth Worst case / pixel 100% 100% 100% 100% 100% 100% 100%

Average of bytes / pixel 100% 93% 92% 92% 100% 100% 93%

6.2 Contributions

JCTVC-E284 An Adaptive Interpolation Filtering Technique [Faouzi Kossentini, Nader Mahdi (eBrisk)]

In this contribution, an Adaptive Interpolation Filtering (AIF) technique is proposed for interpolation filtering of the luminance samples of video sequences. In the proposed technique, for each video picture, the encoder first generates two new 8-tap filters for each reference picture list. Then, the encoder selects, for each sub-sample position, either one/two HM 2.0 predefined 8-tap filters or the corresponding newly-generated 8-tap filters. Finally, the encoder transmits up to four 8-tap filters per video picture. Compared to HM2.0, the proposed technique yields average BD-rate reductions of 1.8% for LD LC, 0.4% for LD, 0.7% for RA LC and 0.3% for RA, while still maintaining the same decoding times. The average encoding time, however, increases by approximately 25%.

AIF Filter Selection:

- For each reference picture list, select between HM 2.0 one/two 8-tap filter(s) or corresponding new AIF filters for each picture/slice & sub-sample position
- New AIF filters can be determined by a specific application and/or generated on-line (i.e., optimized for the picture/slice)

Sub-sample position grouping (as in HM 2.0)

- Employ at most two 8-tap AIF filters for each one of four groups of sub-sample positions
- Side information (i.e., the decision & coefficient bits) is reduced without significant coding efficiency loss

Estimation of filter coefficients is claimed "one-pass" – actually the data are touched twice (with simplified ME in first pass)

Encoding of filter coefficients done differentially

Approach of adapting filter from the past frame (expecting similar statistics) does not work as good (smaller gain)

The gain for HE is almost zero – most probably as the gain of minimizing prediction error is already realized by ALF / interaction with ALF needs to be clarified

In fact, gain is zero for HE RA, however encoder run time increased by 20%; compared to that, ALF only increases by 7-8% (and even less with the new single-pass version)

Concern raised that adaptive coefficients may require multpliers in hardware (unlike current fixed filters)

Most gain is said to be realized at medium rates

Gain is higher for specific sequences (Steam, Nebuta)

JCTVC-E248 CE3: Cross-check Results for the Proposal of eBrisk (JCTVC-E284) [Semih Esenlik, Thomas Wedi (Panasonic)] [late upload / missing prior]

JCTVC-E078 CE3: Region-based adaptive interpolation filter [Shohei Matsuo, Yukihiro Bandoh, Takeshi Ito, Seishi Takamura, Hirohisa Jozawa (NTT)]

This document reports the performance of a region-based adaptive interpolation filter that adjusts filter coefficients based on the characteristic of the input video signal. In the proposed method, a frame is segmented into multiple regions, and filter coefficients for each region are derived. The basic idea is that filter coefficients are designed for each region in a frame when the frame consists of multiple regions with different characteristics. The proposal was implemented in HM2.0 software to evaluate its performance. Compared to the anchor of HM2.0, the average BD-rate gain for HE-RA, HE-LD, LC-RA and LC-LD were 0.03%, 0.10%, 0.42% and 1.13%, respectively. The maximum gain was about 5.6% for the sequence "vidyo3" in LC-LD case.

Based on JCTVC-B051, JCTVC-D150

Options are DCTIF, frame-based AIF and 5 different region-based interpolation filters. Criteria are motion speed …

Only one MC was used (no re-estimation)

Again, the gain is marginal for the HE cases.

Question: Has anybody tried to investigate what happens if ALF is switched off in HE or switched on in LC?

The gain by AIF (in LC) is much less than the gain by ALF.

The proponent says that he would expect ALF and AIF to be independent in sequences with changing frequency profile (which is not the case in current test sequences).

How are threshold values selected? Based on histogram of motion vectors. Currently they are not transmitted (i.e. decoder needs to compute the histogram) – this seems not to be a good solution, signaling would be preferable.

JCTVC-E195 CE3:Cross-check for NTT's proposal on Region-Based Adaptive Interpolation Filter (JCTVC-E078) [Tomonobu Yoshino, Sei Naito (NEC)]

JCTVC-E128 CE3: Results on Bi/Single MC interpolation filter [Kenji Kondo, Teruhiko Suzuki (Sony)]

This contribution reports results on enhanced MC filter, Bi/Single (BIS) switching interpolation filter [JCTVC-C164, JCTVC-D090], in Core Experiment3 (CE3). In the test, the coding performance and complexity was measured under common test conditions in CE3, which is defined in JCTVC-D603. In JCTVC-D090, the filter coefficients had 8 bit accuracy. In this contribution, it is changed from 8 to 6 bit in order to compare with HM 2.0. This BIS filter has different 2 sets of coefficients that are for Bi-prediction and Single-prediction. In JCTVC-D090, the filter length was 8 tap both bi-prediction and single-prediction. In this contribution, filter length of single-prediction is changed from 8 to 6 tap to reduce complexity. This BIS filter was implemented in HM 2.0 and experiment was carried out. The test results was 0.0% for RA HE, -0.6% for RA LC, 0.0% for LD HE, and -0.6% for LD LC. The encoding time was 96%, 95%, 97%, and 95% for RA HE, RA LC, LD HE, and LD LC. The decoding time was 99%, 98%, 97% and 97% for RA_HE, RA LC, LD HE, and LD LC.

Filter length for single prediction is reduced from 8 to 6 tap for half pel, and 5 tap for quarter pel

Comment by one expert: Gain may be due to the fact that 2 different filter choices are offered, such that the method may be seen as a kind of simple adaptive interpolation filter.

Again, the gain is practically zero for HE cases.

Concern about motion estimation complexity? Not necessary in this method to perform ME twice.

JCTVC-E244 CE3: Cross-check of Sony's proposal JCTVC-E128 [K. Ugur (Nokia)]

JCTVC-E347 CE3:Cross-verification of SONY's Luma Interpolation Contribution (JCTVC-E128 and case 0 of JCTV-E129) [L. Guo, I.-S. Chong, M. Karczewicz (Qualcomm)]

JCTVC-E358 CE3: Report on Motorola Mobility's interpolation filter for HEVC [J. Lou, K. Minoo, D. Baylon, K. Panusopone, L. Wang (Motorola Mobility)] [late upload]

This document reports the results of Motorola Mobility's interpolation filter for HEVC. The simulations were conducted using HM2.0 software with Motorola Mobility's modifications. Compared with the current interpolation filter in HM2.0, the proposed method applies a 7-tap filter for quarter-pel positions while keeping the same process for half-pel positions. The proposed method saves 0.1% on LDHE setting and saves 0.3% on LDLC setting. The proposed method loses 0.1% on RAHE setting and loses 0.3% on RALC setting. Cross-check will be provided by Samsung and HHI. The attached spreadsheet contains detailed data of the results.

Typically better for higher-resolution classes.

Loss observed for BQ Square.

Results diverging (gains/losses) for the different test cases, on average zero with slight decrease in complexity (using 7 tap instead of 8 tap filter for quarter-pel position).

JCTVC-E249 CE3: Cross-check of Motorola Mobility's proposal JCTVC-E249 [Haricharan Lakshman (Fraunhofer HHI)]

JCTVC-E388 CE3: Cross-verification for Motorola Mobility's test by Samsung [E. Alshina, J. Chen, W.-J. Han (Samsung)]

JCTVC-E134 CE3: Non-uniform tap length filtering for bidirectional prediction [T.Chujoh, K.Kanou, T.Yamakage (Toshiba)]

In this contribution, experimental results of non-uniform tap length filters for bidirectional prediction are reported. This is one of proposals of core experiment 3 on interpolation for MC (Luma). The purposes of this core experiment are to further investigate interpolation filtering for motion compensation (Luma) technology. The worst cases of complexity of interpolation process are two dimensional quarter pixel positions of bidirectional prediction. The shorter tap length filters are introduced in those cases. As two different filter coefficients sets of non-uniform tap length filters for bidirectional prediction are tested, loss coding efficiency of variation 1 is an average of 0.49% and that of variation 2 is an average of 0.04%. The complexity analyses of 8/6-tap non-uniform tap length filters show worst case of computational complexity and average of computational complexity and memory bandwidth are reduced from them of 8-tap DCT-IF.

The presenter was not available during the discussion of the contribution due to the earthquake in Japan. The following interpretation was achieved by the help of E. Alshina and the cross-check party.

Variation 1 should not be considered. Variation 2 has better optimized filter coefficients. 6-tap is used for the "inner" quarterpel positions (1D quarterpel interpolations are still 8-tap) in bidirectional prediction. 3 new filters are proposed for half-pel, quarter-pel 8-tap and quarter-pel 6-tap. For unidirectional prediction, the DCT-IF of HM2 is used.

JCTVC-E200 CE3: Cross verification of non-uniform tap length filtering for bidirectional prediction (JCTVC-E134) [Kenji Kondo, Teruhiko Suzuki (Sony)]

JCTVC-E351 CE3: Cross-Verification of Toshiba's Contribution (JCTVC-E134) by Qualcomm [G. Van der Auwera, I. S. Chong, M. Karczewicz (Qualcomm)]

JCTVC-E355 CE3: Cross-check report from Motorola Mobility for Toshiba's interpolation filter (JCTVC-E134) [J. Lou, K. Panusopone, L. Wang (Motorola Mobility)] [late upload]

JCTVC-E135 CE3: Verification of Qualcomm's MC interpolation filter [T.Chujoh, K.Kanou, T.Yamakage (Toshiba)] [withdrawn]

This contribution was withdrawn.

JCTVC-E188 CE3 : Switching interpolation filter scheme [Tomonobu Yoshino, Sei Naito (KDDI)]

In the previous meeting, Switching Interpolation Filter (SIF) approach was proposed as shown in JCTVC-D285. The proposed SIF approach provided additional improvement for LD/LC coding conditions without an increase in encoding and decoding time. In this contribution, SIF approach is implemented in HM2.0, and the coding performance is evaluated under all common conditions. The BD-rate Y improves -0.1% for LD cases, but the coding performance degrades 0.1% for RA cases.

Question: This is one-pass encoding. Could it improve when two-pass encoding is done? A: Possibly, but not tested.

JCTVC-E205 CE3: Cross-check for KDDI's proposal on Switching interpolation filter scheme (JCTVC-E188) [Shohei Matsuo, Yukihiro Bandoh, Takeshi Ito, Seishi Takamura, Hirohisa Jozawa (??)] [late upload 2011/03/17]

JCTVC-E328 CE3: Cross-check of JCTVC-D285 results from KDDI [Faouzi Kossentini, Hsan Guermazi (eBrisk)]

6.3 Discussion and Conclusions

a) "Simplified designs":

- Reduction of number of filter taps for certain positions (in particular quarterpel was investigated, as this is most challenging due to asymmetry of filters). This would be advantageous in terms of memory bandwidth as well as computational complexity.
- Proposals so far: unidirectional only (JCTVC-E128) bidirectional only (JCTVC-E134), both (JCTVC-E358).
- Some concerns were expressed about "frequently switching" between different filters – may require extra chip area for hard-wired implementation

- If interpolations are pre-computed (before ME), using different filters for uni and bi prediction would double number of computations and memory (at encoder)
- Unified design (only one filter choice for each direction) would be desirable.
- It is mentioned that interpolation filters can have an impact on subjective quality, this was not investigated so far.
- The interpolation filter is a core part of HEVC and should not be changed by every meeting unless significant advantage is shown. The review of the proposals indicates that more improvements may be possible.
- Continue CE
- High sequence dependency? We should be careful that fixed sets of filters are not tuned for specific set of sequences

b) Adaptive/switched IF

- General observation: Gain mainly for LC cases, most probably due to some interdependency with ALF – this needs some further investigation (e.g. testing with ALF on in LC and ALF off in HE)
- Difficult to compare the different approaches, as the degree of encoder optimization is different (such as single/double pass in ME). Results should be given that allow to judge "complexity scalability", e.g. every method with a single-pass and double pass mode, or one encoder configuration that is close to 100% and one other (t.b.d.)
- Adaptive filters with reasonable degree of freedom in parameters could minimize the danger of tuning the standard for a set of test sequences.
- Continue CE

(Chujoh and Alshina will continue chairing the CE.)

One expert suggests that methodologies where additional random sequences are tested could minimize the danger of tuning elements to the set.

7 CE4: Slice boundary processing and slice granularity

7.1 Summary

JCTVC-E024 CE4: Summary report of core experiment on slice boundary processing and fine granularity [Y.-W. Huang (MediaTek), I.-K. Kim (Samsung)] [late upload]

This contribution is a summary of Core Experiment 4 (CE4) on slice boundary processing and fine granularity. In CE4, there are three subsets including Subset1: Slice granularity, Subset2: Slice boundary processing, and Subset3: Slice common information sharing, as described in JCTVC-D604. Three, two, and one proposal were evaluated in the three subsets respectively, and experiments were conducted according to the common test configurations in JCTVC-D600. Detailed results will be provided by each proponent individually. In CE4, slice-related issues have been studied in the following subsets:

- Subset1: Slice granularity (three proposals). Uses leaf-aligned slices, i.e. it is not necessary to reduce LCU size as in the current HM2 implementation. Smallest CU could be as small as 8x8.
- Numbers in square parenthesis are percentage deviation from the 1500 bytes target. Lower number means that less overhead for packet headers occurs.
- Note: JCTVC-E401 is also related.

-	Software	Condition	HE-AI	HE-RA	HE-LD	LC-AI	LC-RA	LC-LD
1	HM-2.0-dev-slices (rev 609)	LCU=64x64, LCU-aligned	4.9 [12.3]	4.3 [8.4]	2.5 [5.6]	Failed	Failed	Failed
2	HM-2.0-dev-slices (rev 609)	LCU=32x32, LCU-aligned	6.6 [3.8]	7.2 [3.0]	5.7 [2.7]	Failed	Failed	Failed
3	HM-2.0-dev-slices (rev 609)	LCU=16x16, LCU-aligned	10.6 [1.2]	18.0 [1.5]	18.4 [1.6]	Failed	Failed	Failed
4	MediaTek (JCTVC-E043)	LCU=64x64, leaf-CU-aligned, 2-step addressing, EOS flag	5.3 [2.0]	4.6 [2.5]	2.7 [3.0]	5.8 [0.5]	4.4 [0.9]	2.5 [1.2]
5	MediaTek (JCTVC-E043)	LCU=64x64, leaf-CU-aligned, 2-step addressing, no EOS flag	5.3 [2.0]	4.5 [2.5]	2.6 [3.0]	5.8 [0.5]	4.4 [0.9]	2.5 [1.2]
6	Huawei (JCTVC-E298)	LCU=64x64, leaf-CU-aligned, 2-step addressing, EOS flag	5.5	4.7	2.8	5.8	4.4	2.6
7	Huawei (JCTVC-E298)	LCU=64x64, leaf-CU-aligned, 2-step addressing, no EOS flag	N/A	N/A	N/A	N/A	N/A	N/A
8	Ericsson (JCTVC-E260)	LCU=64x64, leaf-CU-aligned, 1-step addressing, EOS flag	5.1	4.4	2.6	5.6	4.3	2.5
9	Ericsson (JCTVC-E260)	LCU=64x64, leaf-CU-aligned, 1-step addressing, no EOS flag	5.1	4.5	2.6	5.6	4.3	2.5

Discussion:

- Is the assumption "one slice per packet" reasonable? In practice, both other approaches (chopping a slice for several packets and several packets per slice) are used.
- Leaf aligned slices may complicate encoding and decoding
- Actions: Unify the three methods (BO group – R. Sjoberg); after reviewing JCTVC-E401, this BoG reported its conclusions as found in JCTVC-E483.
- Notes relating to JCTVC-E401 are recorded below.
- The CE had recommended support of fine granularity slices (harmonizing JCTVC-E298, JCTVC-E260, JCTVC-E043) without restricting slice boundaries to be at LCU boundaries. The BoG produced a proposed syntax for this, which supported establishing a slice boundary at any SCU boundary – signaling an LCU address, a flag specifying whether a sub-LCU address will be sent within the LCU for the slice, and an SCU address within the LCU. It was suggested by a participant that it may be desirable to be able to disable the refinement granularity signaling at the sequence level
- A participant suggested limiting the slice granularity to 16x16 or larger. Decision: Agreed.

- The initial BoG proposal did not support 32x32 granularity with 64x64 LCUs. It was agreed to support this. For signaling, we will send the deepening of granularity (relative to LCU size) at the PPS level, using 2 bits. In the slice header, we send first_slice_flag and, if zero, send the necessary number of bits as a u(v) to identify the start position at the specified granularity. Decision: Agreed.
- For purposes of this discussion it was assumed that a satisfactory way would be established to handle the end of slice flag.
- It was remarked that the value 0x000002 as cabac_zero_word would satisfy the desire to be able to distinguish between cabac_zero_word and RBSP zero strings.

- Subset2: Slice boundary processing (two proposals):

A) (JCTVC-E044) De-blocking filter is operated across slice boundaries after all slices are decoded (which is currently not possible under the assumption of parallel decoding of slices, even though a flag exists in HEVC for slice-independent de-blocking, the same as in AVC). The proposal is to add another processing step for boundary filtering after the adjacent slices have been decoded.

- Results:

-	Condition	HE-AI	HE-RA	HE-LD	LC-AI	LC-RA	LC-LD
1	1500 bytes per slice, SBF off	5.6	4.7	2.7	5.8	4.5	2.7
2	1500 bytes per slice, SBF on	5.3	4.6	2.6	5.5	4.3	2.5
3	2 slices per picture, SBF off	0.6	1.3	1.6	0.6	1.2	1.4
4	2 slices per picture, BF on	0.5	1.3	1.6	0.6	1.1	1.3

- This means that it is necessary to save coefficients, motion vectors etc. at the slice boundaries, to perform the de-blocking in a second pass. This can introduce a processing and storage penalty for single-core implementations.

- In principle, the visual artifacts at slice boundaries could also be removed by post processing (ignoring the small advantage in prediction as given in the results above); as it is targeting the case of parallel processing, the results with 2 slices per picture are more relevant.

- A similar approach is reportedly included in AVC-SVC for enhancement layer. Would it be possible to re-use this?

- Text (syntax and semantics) was requested, if possible based on the SVC approach, The subject was then revisited when that became available

- Deblock filter is fully parallel, although two-step

During a revisiting discussion, it was mentioned that the current design of the deblocking filter (with the parallel design as adopted from the deblocking CE) would support this functionality unless the smallest size would be reduced to 4x4.

B) (JCTVC-E283) Modified intra prediction at slice boundaries

(Results only for case of 1500 byte slices)

- Combined: Method 1for negative direction, method 2 for positive direction

Case	Condition	HE-AI	HE-RA	HE-LD	LC-AI	LC-RA	LC-LD
5	Proposed intra prediction off	4.9	4.4	2.6	5.5	4.3	2.5

6	Proposed intra prediction on	4.3	4.2	2.5	4.7	4.0	2.4

- JCTVC-E203 and JCTVC-D386 are similar (for case of constrained intra prediction). Contributors were suggested to break out and identify commonalities for a reasonable unified padding procedure in case of missing boundary samples (to be used both at slice boundardies and for constrained intra prediction).

Adopted – see decision under BoG JCTVC-E488.

- Subset3: Slice common information sharing (one proposal)

This allows parallel decoding and w.r.t. ALF parameters and does not have a significant impact on coding efficiency.

-	Condition	HE-AI	HE-RA	HE-LD	LC-AI	LC-RA	LC-LD
1	1500 bytes per slice, sharing off	4.9	4.4	2.6	5.5	4.3	2.5
2	1500 bytes per slice, sharing on	4.8	4.6	2.9	5.3	4.2	2.6

Originated from previous proposal JCTVC-D128 where the information was put in additional RBSP (not in PPS). JCTVC-E281 tries to solve the same problem (again by introducing additional parameters in RBSP). JCTVC-E222 and JCTVC-E073 also suggest additional information in RBSP

In total, the amount of information for ALF is typically 1K-4K per picture (depending on whether on/off map is used and on picture size). Of these, the filter coefficients (<1K per filter) are conveyed at picture level in the current proposal, whereas the map parameters are conveyed in the slices.

No doubt that it is necessary to convey ALF parameters outside (at higher level) than slice layer.

Statement of one expert: PPS is correct place for information that stays constant over one picture. If something can change within picture, the PPS is not the right location.

Multiple ALF parameter sets per picture – could be useful to have this capability (should be studied in CE8). In that case, conveying it in the picture parameter set would require a mechanism to associate the slice with the respective filter (currently up to 16 filters are supported).

Granularity of ALF should be decoupled from the granularity of slices.

Even when multiple ALF parameters are used in a picture, across-picture referencing (e.g. differential coding of filter parameters) should be allowed.

Error resilience concept of AVC: Safe transmission of PPS, or self-contained.

Decision: Adopt JCTVC-E045 (Move filter parameters to PPS, map in slice layer). Depending on further discussions (track B) about RBSP concepts, it would not be a problem to put the filter parameters elsewhere. Use conditionally-present presence flags at the picture level, and at the slice level to replace the data of the picture level. (When the data is not present at the picture level but the ALF is enabled, presence at the slice level should be implicitly required without need of the presence flag.)

7.2 Contributions

7.2.1 Subset 1

JCTVC-E043 CE4 Subset1: Leaf-CU-Aligned Slices [C.-W. Hsu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)]

This contribution reported the results of CE4 Subset1: leaf-CU-aligned slices. The purpose is to evaluate LCU-aligned slices and leaf-CU-aligned slices. The target number of bytes per slice was set to 1500, and the JCTVC-D600 anchor without slice partitioning was used for comparison. For LCU-aligned slices, different LCU sizes from 64x64 to 16x16 were tested. The bit rate increase of 64x64-LCUs is reportedly 1.5-7.4%, while the bit rate inaccuracy is 5.4-11.7%. The bit rate increase of 32x32-LCUs is reportedly 2.0-10.7%, while the bit rate inaccuracy is 2.7-3.8%. The bit rate increase of 16x16-LCUs is 5.3-40.5%, while the bit rate inaccuracy is 1.2-1.6%. For leaf-CU-aligned slices, the 2-level end-of-slice signaling in JCTVC-D127 and the unified end-of-slice detection in JCTVC-E042 were tested. The unified end-of-slice detection reportedly further saves 0.1% bit rate in comparison with the 2-level end-of-slice signaling. When the JCTVC-D600 anchor is compared, the bit rate increase of leaf-CU-aligned slices with the unified end-of-slice detection is reportedly 1.7-7.7%, while the bit rate inaccuracy is 2.0-3.0%.

JCTVC-E394 CE4: Cross-verification of MediaTek proposal on slice granularity (JCTVC-E043) [P. Chen (Qualcomm)]

JCTVC-E260 CE4 Subset1: Ericsson fine granularity slices [R. Sjöberg, P. Wennersten (Ericsson)]

In order to increase the granularity of possible slice boundary positions this contribution proposes to remove the restriction that slices can only start on largest coding units. Instead it is proposed that slices are allowed to start on any coding unit. The slice start positions are signaled by a fixed length code (FLC) with a one-bit shortcut for indicating the first block in a picture. Compared to HM-2.0-dev-slices, the average BDR increase for the proposal is reported to be 0.08% for a 1500 byte slice test case.

JCTVC-E301 CE4 Subset1: Cross-check report for Ericsson's Fine granularity slices [Q. Shen, Q. Xie, H. Yu (Huawei)]

JCTVC-E298 CE4 Subset1: Report on fine granularity slice partition [Q. Shen, Q. Xie, H. Yu (Huawei)]

This contribution analyzes the necessary of supporting CU based slice partition, and reports the performance of the proposal which signals the slice start and end address in slice header.

JCTVC-E087 CE4-subset1: Cross-check result of Huawei's fine granularity slice partition [M. Shima (Canon)]

7.2.2 Subset 2

JCTVC-E044 CE4 Subset2: Slice Boundary Filter [C.-W. Hsu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)]

This contribution reported the results of CE4 Subset2: slice boundary filter (SBF). For LCU-aligned 1500-byte slices, the bit rate saving of the SBF-on case is reportedly 0.1-0.3% over the SBF-off case when slice-independent deblocking filter (DF) and adaptive loop filter (ALF) are enabled. For two slices per picture, the bit rate saving of the SBF-on case is reportedly 0-0.1% over the SBF-off case when slice-independent DF and ALF are enabled. It is reported that the subjective quality differences between the SBF-on and the SBF-off cases can be easily observed.

JCTVC-E272 CE4: Cross-verification on slice-boundary filtering - Subset2 case1 and case2 [I.-K. Kim (Samsung)]

JCTVC-E283 CE4 Subset2: Report of Intra Coding Improvements for Slice Boundary Blocks [Y. Lin (HiSilicon), C. Lai (HiSilicon), J. Zheng (HiSilicon), L. Liu (HiSilicon)]

This contribution presents the experimental results of Intra Coding Improvements for Slice Boundary Blocks in Core Experiment 4 (CE4), which was firstly proposed in the contribution of JCTVC-D302 at the preceding JCT-VC meeting.

In this document, two improvements on reference pixel processing for slice boundary blocks are proposed. Firstly, "unavailable" reference pixels for boundary blocks are padded with the value of the closest pixel to the upper-left corner from an available neighbor block, instead of being padded with a fixed DC value. Secondly, for those positive directions in UDI, "unavailable" reference pixels are generated by projecting the reference pixels of an available neighbor block. Then the generated reference pixels are further used for UDI intra prediction.

The experimental results show the proposed two improvements achieve an average BD-rate reduction of 0.6% and 0.7% with approximately the same encoding and decoding time for Intra HE and LC configurations in case of 1500bytes slice. It also shows the improved performance with 0.1%-0.3% bit-rate reduction for random access and low delay configurations.

JCTVC-E089 CE4-subset2: Cross-check result of Huawei's intra coding improvements for slice boundary blocks [M. Shima (Canon)]

7.2.3 Subset 3

JCTVC-E045 CE4 Subset3: Slice Common Information Sharing [C.-Y. Tsai, C.-W. Hsu, Y.-W. Huang, S. Lei (MediaTek)]

This contribution reported the results of CE4 Subset3: slice common information sharing. In the current HM, the ALF parameters are adapted at picture level. However, the entire ALF information is always sent in the first slice header even when a picture contains multiple slices, which is harmful for parallel slice decoding. In JCTVC-D128, for the sake of decoding multiple slices in parallel, it was proposed to add an option of moving ALF coefficients and slice common information to a picture-layer raw byte sequence payload (RBSP), e.g. the picture parameter set (PPS), and leaving ALF CU on/off flags in separate slice headers. Compared with the current syntax in HM, the slice common information sharing technique reportedly show 0.1% bit rate increase and 0.1% bit rate decrease for HE and LC configurations, respectively, with the JCTVC-D600 test configurations and 1500-byte slices.

JCTVC-E063 Cross-verification of MediaTek's slice common information sharing by Fujitsu [K.Kazui (Fujitsu)]

7.3 Discussion and Conclusions

See also the above notes in the section discussing the CE summary report.

JCTVC-E488 BoG report on padding of unavailable reference samples for intra prediction [Rickard Sjöberg (Ericsson), Changcai Lai (HiSilicon), Keiichi Chono (NEC), Viktor Wahadaniah (Panasonic)] [BoG uploaded 2011/03/19]

Proposals JCTVC-E203 (Panasonic), JCTVC-E283 (HiSilicon), JCTVC-D386 (Ericsson) and JCTVC-D086 (NEC, Panasonic) are all related to the handling of unavailable reference samples for intra prediction in HEVC. The JCT-VC requested a break-out group to try to produce a single proposal from discussion of the ideas in these four input documents.

Two BoG meetings were held and attended by proponents of the four related input documents. A joint proposal was agreed upon and documented in the BoG report.

It was remarked that the provided text needs some improvement.

Decision: Adopt as suggested by BoG

8 CE5: Low complexity entropy coding improvement

8.1 Summary

JCTVC-E025 CE5: Summary report of low complexity entropy coding improvements [X. Wang, I.K. Kim, P. Wu] [late upload]

This document summarizes the activities in the Core Experiment CE5 on low complexity entropy coding (LCEC) improvements. A group of nine companies has registered for participation in CE5.

Proposal	**Title**	**Cross-check**
JCTVC-E319 (Sony)	Improvements on transform coefficients coding in LCEC	JCTVC-E245 (Cisco) JCTVC-E387 (Qualcomm)
JCTVC-E383 (Qualcomm)	Coefficient coding with LCEC for large block	JCTVC-E322 (Sony)
JCTVC-E404 (Qualcomm/Microsoft)	LCEC coded block flag coding under residual quadtree	JCTVC-E458 (Samsung)
JCTVC-E072 (ZTE)	Adaptive Coding of InterPredMode Syntax Elements	JCTVC-E393 (Qualcomm)
JCTVC-E160 (LGE)	Modified Joint Coding on Prediction Mode Signaling	JCTVC-E180 (ZTE)
JCTVC-E143 (Microsoft/ Qualcomm)	Counter based adaptation for LCEC	JCTVC-E159 (LGE) JCTVC-E178 (ZTE)

		JCTVC-E264 (MediaTek)

In the discussion, it was asked whether the contributions in this category are independent (and can therefore be considered separately). The coordinator indicated that this was probably not the case.

8.2 Contributions

8.2.1 Improvements on transform coefficients coding in LCEC (3.1.a JCTVC-E319, JCTVC-D261)

JCTVC-E319 CE5: Improvements on transform coefficients coding in LCEC [Jun Xu, Munsi Haque, Ali Tabatabai (Sony)]

In JCTVC-E319, for intra block, use dedicated mapping tables for Luma of 4x4, 8x8 and 16x16/32x32 in run mode coding. In addition to the single sorting table of HM2.0, 3 more sorting tables are used. It is reported that the BD-rate savings are 0.3% for Intra, 0.1% for random access and 0.1% for low delay.

It also extends the coefficient coding to 16x16 and 32x32 by: 1) Introduce tables to support large ranges of last nonzero transform coefficient position in 16x16 and 32x32 coefficient coding. 2) Extend run-mode table to support 16x16 and 32x32 coding, and the table is shared for Intra, Inter and Chroma blocks. It is reported that when extending the coefficient coding to 32x32 blocks the BD-rate savings are 2.4% for Intra, 1.5% for random access and 0.5% for low delay.

It was noted that substantial degradation of chroma fidelity was reported for the 16x16 and 32x32 cases. It was suggested that a side-effect of the non-zonal coding for luma is the more frequent use of small transforms for chroma, which harms fidelity (e.g., Nebuta, esp. 10 bit sequences).

The zonal coding seems to affect the ability to reach conclusions

The zonal coding is triangular shaped region using first n coefficients in the scan order.

It was remarked that transform size decisions are based primarily on luma.

This is not really an entropy coding proposal issue – more of a transform / coding structure proposal.

Subjective impact? – this is not really just an entropy coder.

In the CABAC case, we don't prune the coefficients (based in part on decisions at the previous meeting).

It was remarked that the ability to use lower-complexity decision making rather than RDO and subjective effects were used to justify keeping all coeffs in the CABAC case at the previous meeting. RDO or some test of what is being discarded becomes essentially mandatory for determining whether a zonal coding is a desirable selection.

It was suggested to review the pruning-related content of the precding meeting report.

Decision: Tentative – Drop the pruning.

Evaluated this versus JCTVC-E383 for the coding of the large blocks as BoG – notes elsewhere in this report.

The other aspect of this proposal adds a substantial amount of tables and provides only a very small gain, so did not seem to need further consideration.

JCTVC-E245 CE5: Cross-check of Sony's contribution on improved coefficient coding for LCEC [A. Fuldseth (Cisco)]

JCTVC-E387 CE5: Crosscheck of Sony's contribution (JCTVC-E319) on LCEC transform coefficient coding [X. Wang, L. Guo, M. Karczewicz (Qualcomm)]

8.2.2 Coefficient coding with LCEC for large block (3.1.b JCTVC-E383, JCTVC-D374)

JCTVC-E383 CE5: coefficient coding with LCEC for large block [M. Karczewicz, X. Wang, W.-J.Chien (Qualcomm)]

In JCTVC-E383, coefficient coding is extended to 16x16 and 32x32 block sizes, with special considerations in avoiding large size VLC table. The table size reduction mechanisms include: 1) In coding the last nonzero transform coefficient position, code number cn for {lev, last_pos} pair is calculated based on formula rather than look-up tables; 2) In level mode coding, for intra block, the same formula used for calculating code number cn for {lev, run}for 4x4 and 8x8 blocks is re-used for 16x16 and 32x32 block; for inter block, the code number calculation is also based on formula, which also trims the initial run-level table size at least by half.

It is reported that when extending the coefficient coding to 16x16 blocks, BD-rate savings are 2.5% for Intra, 1.1% for random access and 0.8% for low delay. When also extending the coding scheme to 32x32 blocks, BD-rate savings are 2.9% for Intra, 1.4% for random access and 1.0% for low delay.

According to JCTVC-E319 proponents, the JCTVC-E383 approach is more complicated and diverges more from the spirity of the current design. According to the JCTVC-E383 proponents, the JCTVC-E319 approach requires substantially greater table sizes. A BoG was asked to discuss this further (coordinated by A. Fuldseth). This was requested to include review of draft text to the extent feasible.

The BoG results were reviewed Friday at 4:30 pm.

JCTVC-E478 BoG report on extending LCEC to larger block sizes [A. Fuldseth (Cisco), M. Karczewicz (Qualcomm), M. Haque (Sony)] [BoG report uploaded ??]

The purpose of this BoG discussion was to reach a common understanding of the difference between contributions JCTVC-E319 (Sony) and JCTVC-E383 (Qualcomm) with respect to extending LCEC to block sizes larger than 8x8.

Companies participating included Qualcomm, Sony, Nokia, Telnet, Panasonic, and Cisco.

Summary of results:

Both JCTVC-E319 and JCTVC-E383 propose to extend the number of transform coefficients encoded by LCEC from 8x8 to 16x16 and 32x32. The main differences between the two contributions are the following:

JCTVC-E319 (Sony): Extension to 32x32 increases table sizes by at least 30 KB and 20 KB in the encoder and decoder respectively. Coding gains of 2.4%, 1.5%, and 0.5% for intra, random access, and low delay, respectively are reported.

JCTVC-E383 (Qualcomm): This contribution reduces the total table size of LCEC by removing/ reducing some of the major tables used for coding of 8x8 blocks, and extending the coefficient coding to 16x16 and 32x32 blocks without adding any new major tables.

Coding gains of 2.9%, 1.4% and 1.0% for intra, random access, and low delay, respectively are reported.

Recommendations

Based on the results above, the BoG recommended adopting JCTVC-E383 in the HM.

Decision: Agreed.

Regarding CAVLC draft text – see notes elsewhere.

8.2.3 Coded block flag coding

JCTVC-E404 CE5: LCEC coded block flag coding under residual quadtree [P. Chen, X. Wang, W. Chien, M. Karczewicz (Qualcomm), B. Li, J. Xu (Microsoft)]

This is a joint proposal based on JCTVC-D375 and JCTVC-D142. According to the proposal, coded block flags and split flags are coded jointly to further improve coding efficiency. The original joint coding of Y, U and V coded block flag at CU root level is extended in two ways: 1) It further includes transform split flag if available; 2) The joint coding is not only performed at CU root level, but also extended to higher transform depth level so that the benefit of such joint coding can be maximized. It is reported that with the proposed coding scheme, there is slight BD-rate saving under default LC configurations. When using a maximum TU depth of 3, the BD rate savings are 0.3% for Intra, 0.5% for random access and 0.7% for low delay.

(This discussion was chaired by F. Bossen.)

It was agreed that the text should be reviewed to the extent feasible.

This would potentially simplify software somewhat but not fully harmonize LCEC/CABAC.

Adding a few tables (16 entries).

No gain for intra in default configs because of no split. Default configs RA: 0.1% gain, LD: 0.2%.

Claimed benefits: coding efficiency, harmonization.

Related document: JCTVC-E365 on study of RQT depths.

Small gain but other benefits (harmonization).

Decision: Adopted.

8.2.4 Prediction mode coding and codeword adaptation

JCTVC-E072 CE5: Adaptive Coding of InterPredMode Syntax Elements [Wen Zhang, Ming Li, Ping Wu (ZTE)]

In this proposal, four syntax elements named split_flag_coding_type_depthX (where X = 0, 1, 2) and pred_mode_coding_type are introduced into P/B-slice header to indicate different coding types used in a current slice, where coding type is defined as type of coding order of the related elements, such as SkipFlag, MergeFlag, InterFlag, IntraFlag, split flag, etc. These flags are adaptively and jointly coded. The encoder determines the values of pred_mode_coding_type and split_flag_coding_type_depthX for the current slice according to the statistical results of the occurrence of the inter-frame prediction modes in each CU split layer obtained from the previous coded slices. It is reported that average BD-rate savings are 0.1% for random access and 0.3% for low delay, respectively.

For further study.

JCTVC-E160 CE5: Modified Joint Coding on Prediction Mode Signaling [J. Lim, B. Jeon (LGE)]

In HM2.0, LCEC joint coding of prediction mode includes both prediction mode and prediction partition. According to this contribution, such joint coding is limited to prediction mode, with partition signaled separately. Additionally, initial mapping tables between symbol and codeword index are tuned according to the portion of each prediction mode. It is reported that the proposed method achieves BR-rate saving of 0.1% for random access and 0.1% for low delay case.

Further study of more efficient coding and state initialization is encouraged.

8.2.5 Counter based adaptation for LCEC

JCTVC-E143 CE5: Counter based adaptation for LCEC [L. Guo (Qualcomm), B. Li (USTC), X. Wang (Qualcomm), M. Karczewicz (Qualcomm), J. Xu (Microsoft)]

This is a joint proposal based on JCTVC-D140 and JCTVC-D370. According to the proposal, counters are used in VLC mapping adaptation to avoid unnecessary frequent swapping of codeword mapping associated with the current VLC adaptation in HM2.0. In the proposal, such counter based adaptation is applied to coded block flag coding, inter prediction mode coding and the joint coding of inter prediction direction and reference frame index. It is reported that the average BD-rate savings are 0.2% for Intra, 0.5% for random access and 0.8% for low delay.

(This discussion was chaired by F. Bossen.)

Text should be reviewed to the extent feasible.

Presentation not available at time of presentation, but uploaded later.

Q: why not use counter for all syntax elements? A: would increase complexity too much.

Related contributions: JCTVC-E080, JCTVC-E258.

Remark: counter-based may be equivalent to swapping, depending on counter max value.

Remark: already some non-uniformity in LCEC (some syntax elements not adapted)

Remark: LCEC text still incomplete

Decision: Adopted.

JCTVC-E159 CE5: Cross-check report of Microsoft and Qualcomm's Counter based adaptation for LCEC [J. Lim, B. Jeon (LGE)] [initial version rejected (placeholder) – second version late upload]

JCTVC-E178 CE5: cross check report of qualcomm and microsoft's JCTVC-E143 [Wen Zhang, Lei Wang (ZTE~~??~~)] [late upload]

JCTVC-E180 CE5: cross check report of LGE's JCTVC-E160 [Wen Zhang, Lei Wang (ZTE~~??~~)] [late upload]

JCTVC-E264 CE5: Cross Verification of JCTVC-E143 Proposed by Microsoft and Qualcomm [C.-Y. Chen, Y.-W. Huang (MediaTek)]

JCTVC-E322 CE5: Cross-verification of Qualcomm's coefficient coding for LCEC by Sony [Jun Xu, Munsi Haque, Ali Tabatabai (SONY)]

JCTVC-E393 CE5: Cross-verification of ZTE proposal on Inter prediction mode coding for LCEC (JCTVC-E072) [W.-J. Chien, X. Wang, M. Karczewicz (Qualcomm)]

JCTVC-E434 CE5: Cross Verification of JCTVC-E383 proposed by Qualcomm [J.-L. Lin, Y.-W. Huang (MediaTek)] [late upload]

JCTVC-E458 CE5: Cross-verification of LCEC coded block flag coding under residual quadtree (JCTVC-E404) [Jianle Chen, Vadim Seregin (Samsung)][late registration]

8.3 Discussion and Conclusions

See notes in sections above.

9 CE6: Intra prediction improvement

9.1 Summary

JCTVC-E026 CE6: Intra Prediction Improvements Summary Report [Ali Tabatabai, Keiichi Chono, Muhammed Coban, Marta Mrak, Akiyuki Tanizawa]

This contribution provides a summary of Core Experiment 6, Intra Prediction Improvements. From a total of 9 proposed CEs, 8 had been cross-checked with a full match by at least one organization. For cross checking, the recommended test conditions of intra-only were used for both high efficiency and low complexity as defined in the document JCTVC-D606.

Intra prediction improvement core experiments are divided into 7 categories

- CE6.a: Block Based Intra Prediction
- CE6.b: Short Distance Intra Prediction
- CE6.c: Edge Based Intra Prediction
- CE6.d: Parallel Intra Coding
- CE6.e: Planar Intra Prediction
- CE6.f: Intra Smoothing
- CE6.g: Number of Intra Prediction Directions

Core Experiments	Technology	Proponent(s)	Cross-checker(s)
CE6.a.1	Bidirectional Intra Prediction	Toshiba JCTVC-D108	Withdrawn
CE6.a.2	Bi-Intra Prediction Using Slope Information	Sejong University/SKT JCTVC-D287 JCTVC-E170	Huawei JCTVC-E290 Sharp JCTVC-E161
CE6.a.3	Bidirectional Intra Prediction for Positive Directions in UDI	HiSilicon /Huawei JCTVC-D300 JCTVC-E286	Microsoft JCTVC-E149
CE6.a.4	Chroma Intra prediction by Reconstructed Luma Samples	Samsung/LG Electronics JCTVC-D350 JCTVC-E266	KDDI R&D Lab. JCTVC-E254 [withdrawn] Microsoft JCTVC-E468 [some diffs]
CE6.b.1	Short Distance Intra Prediction Method	Microsoft/HiSilicon/Huawei JCTVC-D299	Qualcomm JCTVC-E406 Samsung JCTVC-E271 Mitsubishi JCTVC-E067
CE.6.b.2	Combined Intra Prediction	BBC JCTVC-D191 JCTVC-E130	Toshiba JCTVC-E207 Ghent Univ. JCTVC-E263
CE6.c	Differential coding of Intra Modes (DCIM)	Sharp ,Sony, Panasonic, Toshiba JCTVC-C169, JCTVC-C176 JCTVC-D279, JCTVC-E318	Qualcomm JCTVC-E397 Sejong University JCTVC-E371 NHK JCTVC-E077
CE6.d	Parallel Intra Coding	Sharp Labs. of America JCTVC-B112, JCTVC-D074 JCTVC-E315	Toshiba JCTVC-E208
CE6.e	Planar Intra Prediction	Nokia, LG, NTT Docomo, Santa Clara University JCTVC-D326, JCTVC-	NEC JCTVC-E185,

		D083, JCTVC-D235, JCTVC-D026	JCTVC-E186 Toshiba JCTVC-E209 Qualcomm (verbal OK) Orange Labs Sony (Combined Tool) Sharp JCTVC-E162 Samsung JCTVC-E124 Huawei JCTVC-E112
CE6.f.1	LUT-based Intra Prediction Filtering	Mitsubishi JCTVC-D109	NEC JCTVC-E184 Qualcomm JCTVC-E369
CE6.f.2	Mode Dependent Multi Filter Intra Smoothing	Qualcomm JCTVC-D282	Withdrawn
CE6.g	Number of Intra Prediction Directions	Mitsubishi JCTVC-C310? JCTVC-E068	Peking Univ. JCTVC-E439 (Not Uploaded 03/13/11)

9.2 Contributions

9.2.1 CE6.a

JCTVC-E149 CE6.a: Cross-check report for JCTVC-E286 [J. Xu (Microsoft)] [late upload]

JCTVC-E161 CE6.a: Cross-check of Bi-Intra Prediction using Slope Information from Sejong University and SKT (JCTVC-D287) by SHARP [T. Yamamoto (SHARP)]

JCTVC-E170 CE6.a : Bi-Intra Prediction using Slope information [Chan-Won Seo (Sejong Univ.), Jong-Ki Han (Sejong Univ.), Jeongyeon Lim (SKT)]

JCTVC-E254 CE6 Subset A: Cross check report of Samsung's proposal (JCTVC-E266) from KDDI [Kei Kawamura, Tomonobu Yoshino, Sei Naito (KDDI Corp.)] [missing]

Withdrawn

JCTVC-E266 CE6.a: Chroma intra prediction by reconstructed luma samples [J. Chen, V. Seregin, W.-J. Han (Samsung), J. Kim, J. Moon (LGE)]

This document reports results of "Chroma intra prediction by reconstructed luma samples" method proposed in document JCTVC-D350 within the context of CE6. In the proposed method, chroma samples are predicted from luma samples of the same block by linear model relationship. Compared to the HM2.0, the average BD-rate gain was reported as 0.8%, 7.8% and 5.9% for intra configuration, and 0.4%, 8.6% and 5.6% for random access configuration, respectively for Y, Cb and Cr components.

For block size N*N, there are 3N multiplies and 6N adds and one 64-element table-lookup (16 b result) to calculate "alpha" and "beta" parameters applied to the luma samples. Luma samples are decimated horizontally and averaged vertically to convert the resolution to match that of the chroma. Each chroma sample is then generated by a multiply, add, shift, and clip.

The proponent indicated that subjective quality is also improved by the technique.

Previously chroma predicted as 1) same as luma, 2) vert, 3) horiz, 4) DC, 5) 45-degree diagonal.

The objective coding gain from the 5th case was asserted to be very minimal.

The proposal removes the diagonal case and inserts the new mode as the nominally 2nd most probable.

This introduces a new sequential dependency between luma and chroma.

It was asked whether the feature could be disabled for larger block sizes (e.g., disable for 32x32 luma) to reduce the decoding block processing burden.

Currently, regardless of block size, there are 34 "directions" supported (although there are differences in regard to at which level the signaling occurs).

The subject was revisited to consider the performance for large blocks and to study draft text before considering whether to adopt. A cross-check is reported in JCTVC-E468. Another is reported in JCTVC-E503.

The scheme was also tested in a previous CE that reported to Daegu.

It was reported that the scheme still provided nearly all of the same gain when it was not applied to larger blocks.

It was remarked that there should be a disabling flag in the high-level syntax if this is adopted – e.g., for purposes of potential later profiling or to avoid inefficiencies for encoders that choose not to use it.

The question was asked whether this interferes with other tools such as SDIP. However, as implemented, SDIP only applies to luma.

The runtimes were not significantly affected.

Decision: Adopted (with disabling flag as described above).

Further study is encouraged to determine whether application to 16x16 chroma is a significant implementation burden – if so, we would consider disabling it for large (i.e., 16x16 chroma) blocks.

Study toward determining the effectiveness of this for 4:4:4 coding (e.g., in the AVC context) is also encouraged.

It was remarked that this brings up a significant issue – the lack of 4:4:4 and 4:2:2 support.

JCTVC-E503 Cross-check report of JCTVC-E266 [M. Budagavi (TI)] [late registration 2011/03/22]

JCTVC-E468 CE6.a.4: Cross-check report for JCTVC-E266 [J. Xu (Microsoft)] [late registration 2011/03/17 / uploaded 2011/03/19]

New Microsoft cross-check of JCTVC-E266. Cross-checker did not initially study it in full detail, but reported that he later studied it during the meeting and found it to match the proposal.

JCTVC-E286 CE6 Subset A: Report of Improved Intra prediction for positive directions in UDI [Y. Lin, C. Lai, J. Zheng, L. Liu (HiSilicon)]

This contribution presents experimental results of Bidirectional UDI Intra Prediction (BUDI) for Core Experiment 6 (CE6) on intra prediction improvement. BUDI was first proposed to replace mode 6 (i.e. ver+8) in JCTVC-D300. In this document, BUDI has been extended to other positive directions, including ver+8, ver+5 and hor+6. Three BUDI schemes have been tested based on HM2.0 for both Intra HE and LC configurations. The test results show the original BUDI scheme with replacement of mode ver+8 achieves 0.4% HE and 0.5% LC bit-rate reduction with approximately the same encoding and decoding time. The extended BUDI scheme achieves an average BD-rate reduction of 0.6% and 0.7% with minimum complexity increase (2-4%). It is also reported that the division-free implementation for the extended BUDI scheme achieves 0.5% and 0.6% bit-rate reduction.

Simpler computation for mode 6.

Overall, it is suggested by the proponent to just consider mode 6.

It was asked whether this is applied to chroma. Yes, it was.

Table look-up 64 bytes. Perhaps in a speed-optimized implementation, this would become a full-block table size.

A way to avoid the table was also studied (not described in the document), which involves using approximation using an add and shift instead of a division or table look-up.

Since the most promising variation is not documented, this should be documented and become a CE to test this approximation method for potential adoption at the next meeting.

JCTVC-E290 CE6.a: Cross-check Report for CE6.a.2 Sejong's Bi-Intra Prediction [J. Zheng, Y. Lin (HiSilicon), H. Yu (Huawei)]

9.2.2 CE6.b

JCTVC-E067 CE6.b: Cross-verification report on Short Distance Intra Prediction [Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric)] [late upload / missing prior]

JCTVC-E130 CE6.b.2: Report on Combined Intra Prediction with Parallel Intra Coding by BBC and Sharp [Marta Mrak, Andrea Gabriellini (BBC), Jie Zhao, Andrew Segall (Sharp)]

This report presents results for Combined Intra Prediction (CIP) and its integration with Parallel Intra Prediction (PIP) in HM2.0. The presented approach is primarily in the context of the CE6 Intra Prediction Improvement (JCTVC-D606) category (b) on Short Distance Intra Prediction, and also incorporates concepts from CE6 category (d) on Parallel Intra Coding.

The results reporedly show that applying CIP in AI configurations provides a gain of 0.2% for HE and 0.4% for LC Y BD-rate (0.3% and 0.5% YUV BD-rate) on average, without substantial increases in runtimes, compared to HM2.0. The gain is reportedly larger for higher resolutions, e.g. the average gain for Class A is reported as 0.4% (HE) and 0.8% (LC) Y BD-rate.

In the CIP design, two intra predictions are performed and averaged together. One is a conventional intra prediction and the other is a local average of neighboring reconstructed samples within the same prediction block.

Note: The actual prediction process takes place at the TU level, not at the PU level.

PIP (see JCTVC-E315) has also been integrated into HM2.0 and CIP has been used as an additional prediction tool for blocks coded with PIP. This integrated approach has been tested for 2x parallelism. The results for PIP, without CIP, from JCTVC-E315 show small losses in coding efficiency. The results from this contribution reportedly demonstrate that by providing additional prediction options, CIP reportedly almost completely compensate for losses introduced by PIP (average 0.2% loss in BD-rate with PIP with CIP). The net result of the combination is reportedly a small loss in compression performance relative to the anchors.

When additional rate-distortion optimization searches are performed at the encoder (higher complexity of the encoder), some improvement was shown.

No action taken.

JCTVC-E207 CE6.b.2: Cross check report of BBC's proposal (JCTVC-E130) from Toshiba [A. Tanizawa, T. Shiodera (Toshiba)]

JCTVC-E239 Verification results of CE6.b1: short distance intra prediction (SDIP) (JCTVC-E278) [M. Budagavi, V. Sze (TI)]

JCTVC-E263 CE6.b.2: Cross-check report of Combined Intra Prediction with Parallel Intra Coding (JCTVC-E130) from Ghent University-IBBT [Glenn Van Wallendael, Sebastiaan Van Leuven, Jan De Cock, Rik Van de Walle (??)]

JCTVC-E271 CE6.b1: Cross-verification of Short Distance Intra Prediction Method (JCTVC-E278) by Samsung [J. Chen, W.-J. Han (Samsung)]

JCTVC-E406 CE6: Cross verification of Microsoft, Huawei, Hisilicon's Short Distance Intra Prediction Method (Part 2) JCTVC-E278 [Muhammed Coban (Qualcomm)]

JCTVC-E278 CE6.b1 Report on Short Distance Intra Prediction Method [X. Cao (Tsinghua), X. Peng (USTC), C. Lai (HiSilicon), Y. Wang (Tsinghua), Y. Lin (HiSilicon), J. Xu (Microsoft), L. Liu (HiSilicon), J. Zheng (HiSilicon), Y. He (Tsinghua), H. Yu (Huawei), F. Wu (Microsoft)]

This document reports experimental results of the short distance intra prediction (SDIP) scheme for core Experiment 6 on intra prediction improvement. SDIP was presented in JCTVC-C101 and JCTVC-C270. By dividing the NxN block into lines or non-square blocks, SDIP can reduce the energy of the prediction residuals by reducing the distance of predicted pixel and its reference pixels. When integrated into the HM2.0 software, it was reportedly shows 2.5% and 4.0% bit rate saving on average, under all intra high efficiency and low complexity conditions, respectively, with about 24% (intra) and 47% (intra LC) encoding time increase and no obviously decoding time increase. Up to 6.4% bit rate saving is achieved on sequences with rich textures.

Non-square partitions: 32x32 CU can be split into 8x32/32x8, 16x16 CU into 4x16/16x4 and further into 1x16/16x1, 8x8 CU into 2x8/8x2, 4x4 PU into 1x4/4x1.

Remark: It is desirable to minimize the number of partitions (subject to performance trade-offs).

Note: a new transform is introduced (2x2 DCT)

Note: one prediction mode is modified (bidirectional prediction used for one of the modes).

Results presented with and without 1x4/4x1 partitions, with and without bidirectional predictions.

Everything: 2.5/4.0% savings for intra-only

No 1x4/4x1: 2.4/3.7% savings

No 1x4/4x1, no bidirectional: 2.0/3.2% savings

It is claimed that when 1x4/4x1 is not used, there is no increase in decoder complexity (memory bandwidth, etc.).

Many cross-verifications from non-proponents: Qualcomm, Samsung (JCTVC-E271), Mitsubishi, TI.

Mitsubishi verified only no 1x4/4x1, no bi-directional.

TI concern: change in the block structure. Flow very different. Did not do in-depth study of implementation issues. Remark: May be related to alternate transforms.

Samsung: main change is in flow. Complexity increase in decoder may not be very large.

Qualcomm: Many changes in the software, not clear where the gains come from.

Q: changes to the deblocking process? A: No changes to deblocking process. Proponent claims that no change is required, that some visual evaluation was done and no blocking issues were observed.

It was asserted that 4x1 and 1x4 doesn't seem to make sense, and was suggested not to further consider it.

Q: Gains are smaller than the ones reported at the last meeting? A: Fewer prediction modes are tested in encoder – leading to reduction in encoding time and coding gain. Concern: some of the drop may come from interaction with other tools (e.g., adaptive scans adopted in Daegu, MDCS).

Remark: Similar techniques were studied in the context of AVC: ABT.

BUDI: Bidirectional prediction with weighted averaging.

Q: Does one require an encoder to use heavy RDO to reap any benefits from this technique? A: Extensive testing has not been in that regard to determine the answer to that question.

The group indicated that it was inclined to adopt this scheme (a version without 1x4/4x1, and without BUDI) since it provides attractive coding efficiency gains. The subject was revisited later after review of alternate transforms. Complexity issues should be further studied, for example in ad-hoc activity (e.g., complexity assessment). Text was currently not available at the time of this discussion. Proponents were asked to draft text for review. Further notes on the topic are recorded elsewhere in this report.

9.2.3 CE6.c

JCTVC-E318 Differential Coding of Intra Modes [Ehsan Maani, Ali Tabatabai, Tomoyuki Yamamoto, Akiyuki Tanizawa, Virginie Drugeon (Sony, Sharp, Toshiba, Panasonic)]

Differential Coding of Intra Modes (DCIM) is an Intra prediction tool especially intended for sequences with a lot of dominant edge information. In this document, a summary of the current implementation of DCIM and its evolution since its original proposal was presented. On average, using this technique, 1.4% and 1.6% gain compared to HM 2.0 anchors were reported for AI High Efficiency (HE) and AI Low Complexity (LC) settings, respectively.

For DCIM operation, the encoder can choose among 17 current modes, or 1 DCIM "edge" mode, 10 DCIM "sub" modes, or a DCIM bipredictive mode.

Edge derivation is performed in the decoder for each DCIM mode, which is an additional step in the decoding process. It was remarked that this increases the pipelining steps in the decoding process.

It was remarked that the decoder line buffering requirements increase for the intra prediction.

It was also remarked that encoders may not have access to the reconstructed left neighbor, causing sequential dependency difficulties in the encoder.

A participant asked about the need for the bipredictive case in the design. The impact of this particular element of the design was estimated at 0.3% and 0.1%. The bipredictive case involves a weighted average of two intra predictors.

This combination was not described in the core experiment description – it is a new combination.

It was asked whether the new scheme is a general design that can be operated with any granularity of angular quantization (as in our current UIP scheme) or is limited to a specific number of designed directions.

It was remarked that 4-tap filtering is applied in the scheme rather than the 2-tap filtering used in the current design – thus increasing the complexity of computing each predictor. This is not described in JCTVC-E318 or any submitted design documentation.

The group considered it important (for other proposals as well as this one) to have full designs documented to enable proper study. Working draft text is also needed for adoption of proposals (at least ordinarily).

For further study.

JCTVC-E077 CE6.c: Cross-check report on Differential Coding of Intra Modes (DCIM) [Yasuko Sugito, Atsuro Ichigaya (NHK)]

The cross-checker did not study the implementation (just ran the experiment without studying the functionality).

JCTVC-E371 CE6.c: Cross-check of Differential Coding of Intra Modes (DCIM, JCTVC-E318) by Sejong University [Chan-Won Seo (Sejong Univ.), Jong-Ki Han (Sejong Univ.), Jeongyeon Lim (SKT)]

JCTVC-E397 CE6.c: Cross-Verification of Differential Coding of Intra Modes (JCTVC-E318) [G. Van der Auwera, M. Coban, M. Karczewicz (Qualcomm)]

9.2.4 CE6.d

JCTVC-E315 CE6.d Parallel Prediction Unit for Parallel Intra Coding [Jie Zhao, Andrew Segall (SHARP)]

Previously, the concept of a parallel prediction unit (PPU) was proposed in JCTVC-D074. The parallel prediction unit defines a group of pixels that are intra-coded, and where the intra coding may be done in a parallel fashion. Parallelization is achieved by partitioning the intra-coded blocks into two sets. Blocks in the first set are predicted in parallel using available pixels outside the PPU; blocks in the second set are also predicted in parallel using available pixels outside the PPU as well as pixels from the first set of blocks. This document provides updated results on the parallel prediction technology in the context of HM2.0. Two configurations are considered. For the case of 2x parallelism, a coding efficiency impact (degradation) of 0.0%, 0.1% and 0.3% for, respectively, random access, low delay and all intra common test conditions is reported. For the case of 8x parallelism, a coding efficiency impact of 0.1%, 0.2% and 0.3% for, respectively, random access, low delay and all intra common test conditions is reported.

The focus of the contribution is primarily for the 4x4 case for high-resolution video.

When tested, the scheme was applied only to high-resolution video.

The averaging done for the reported results therefore included some cases where the "proposed method" was no different than the "anchor". Among the cases where there was actually a tested difference, the amount of the difference for the 2x parallelism case would be approximately 0.2%, 0.1%, and 0.5%, for RA, LD, and AI, respectively.

It was remarked that a decoder would need to support both ways of operating if adopted as proposed (i.e., using a decoding process that is different for different picture sizes).

For the upper left block, neighbors to the right and below are proposed to be used, with weighted averaging, to form the prediction.

A participant suggested to consider using 8x8 prediction with a 4x4 residual transform as an alternative.

Another suggestion was to predict the first row of blocks (the top two blocks) first and the second row of blocks as a second stage. Each row could be predicted as a single 8x4 region using two parallel 4x4 predictors (possibly using different prediction directions for the two 4x4 blocks in the 8x4 region), or – alternatively – as an ordinary 8x4 predictor.

It was suggested that we should first decide whether the problem that this is solving is serious, and that if we decide that it is serious, we should seek a simple and consistent design structure.

It was remarked that for the decoder, the sequential nature of the 4x4 prediction process is not necessarily a big problem, and that other ways of addressing that for very high resolution video will also be considered – such as tiling.

Further study in comparision with the three above suggested alternatives was suggested to be performed as a CE.

JCTVC-E208 CE6.d: Cross check report of Sharp's proposal (JCTVC-E315) from Toshiba [A. Tanizawa, T. Shiodera (Toshiba)]

9.2.5 CE6.e

JCTVC-E110 Report of CE6 e.1.d: Adding plane mode to UDI [Guichun Li, Lingzhi Liu, Nam Ling, Jianhua Zheng, Philipp Zhang (??)]

JCTVC-E112 Cross check Report for LG's CE6.e proposals [Guichun Li, Lingzhi Liu, Nam Ling, Jianhua Zheng, Philipp Zhang (??)]

JCTVC-E124 CE 6e : Cross Check for DoCoMo's Proposal JCTVC-E321 on Planar mode experiments and results [Ankur Saxena, Felix Fernandes (Samsung)]

JCTVC-E162 CE6.e: Cross-check of Planar Intra Prediction (1.f+2.a+3.b and 1.f+2.b+3.b) by SHARP [T. Yamamoto (SHARP)]

JCTVC-E165 CE6.e: Cross verification of SCU's proposal (JCTVC-E110) on Planar Intra Prediction (1.d) [Yongjoon Jeon (LG Electronics)]

JCTVC-E166 CE6.e: Report on Planar Intra Prediction by LG [Yongjoon Jeon, Seungwook Park, Byeongmoon Jeon]

JCTVC-E209 CE6.e: Cross check report of combination with (1.a+2.b+3.a) for Planar intra prediction from Toshiba [A. Tanizawa, T. Shiodera (Toshiba)]

JCTVC-E317 CE6.e: Nokia report on planar intra prediction [Jani Lainema, Kemal Ugur, Oguz Bici (Nokia)]

JCTVC-E321 CE6.e/f: Planar mode experiments and results [Sandeep Kanumuri (DOCOMO USA Labs), Frank Bossen (DOCOMO USA Labs)]

JCTVC-E450 CE6 e: Cross check of experiment 1f+2b+3b (LG - JCTVC-Exxx) [Joel Jung, Elie Mora (Orange Labs)][late registration]

JCTVC-E185 CE6: Cross-verification report of planar intra prediction (JCTVC-D235) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)]

JCTVC-E186 CE6: Cross-verification report of planar intra prediction (JCTVC-D326) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)]

General discussion of 6.3 planar prediction

Suggestion: For 6.e "planar pred", focus on Docomo's JCTVC-E321 (1.c variant) & Nokia's JCTVC-E174 (1.g has a little more beyond the CE) – seems to not conflict with other aspects and to provide additive gain.

It was remarked that fast mode decision is present for luma, not implemented for chroma, which is why the encode time increases.

The decoder has some added complexity to support this planar mode.

Benefit of planar mode is asserted to not only provide objective gain. Some examples were provided in JCTVC-E321. Also, JCTVC-E186 has some examples.

It was suggestion to consider the subjective results for those alternatives.

Decision: Adopt addition of planar as proposed in JCTVC-E321 (1.c+3.b+2.a variant).

9.2.6 CE6.f Intra smoothing

JCTVC-E069 CE6.f: LUT-based adaptive filtering on intra prediction samples [Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric), Kazuhisa Iguchi, Yoshiaki Shishikui (NHK)]

This document is a proposal of the proposed smoothing scheme in the CE, based on proposal JCTVC-D109.

In this contribution, a test result on LUT-based adaptive filtering on intra prediction samples defined in Core Experiment 6.f was reported. It was reported that the BD-rate gains of the tested scheme were 0.2% and 0.4% with regards to HM-2.0 AI default configurations of high efficiency and low complexity settings, respectively, with 1% faster encoding time and 1-2% faster decoding time.

It was remarked that the proposal has two aspects:

- It removes a double-filtering case in the current design, which reduces the complexity of that case (and does not provide coding gain – actually resulting in a loss of coding efficiency).
- It also adds a (2-3 tap) filtering of one row and one column of the DC predictor signal (not of the reference samples, but of the prediction signal) in some cases, which adds complexity (and improves the prediction quality and improves the prediction continuity in the boundary region) in these cases. The gain is reportedly larger for higher-resolution content.

It was asked whether the effect of these two changes could be studied separately, and the proponent indicated that they may be able to provide this information.

It was asked whether there is a subjective effect of removing the filtering (which is unknown).

It was asked what is done in regard to "unavailable" neighbor cases. The treatment of "availability" should be made consistent across all modes. It was remarked that the software may be somewhat different than AVC in some such cases – allowing use of a direction in cases where a neighbor is more "unavailable" than in AVC.

A revised contribution was provided to discuss the two distinct aspects described above.

The contribution also provided test results on using both the proposed scheme and a planar intra prediction with DST proposed in JCTVC-D235 is also reported. In this case, it was reported that the BD-rate gain of the tested scheme was 0.2% for both high efficiency and low complexity settings.

Decision: Adopted (both aspects).

JCTVC-E369 CE6.f: Cross-Verification of Mitsubishi/NHK's LUT-Based Intra Prediction Filtering Contribution (JCTVC-E069) by Qualcomm [G. Van der Auwera, M. Coban, M. Karczewicz (Qualcomm)]

JCTVC-E184 CE6: Cross-verification report of LUT-based intraprediction filtering (JCTVC-E069) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)]

9.2.7 CE6.g

JCTVC-E068 CE6.g: Verification report on number of intra prediction directions [Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric)]

This contribution is a verification report of Core Experiment 6.g on number of intra prediction directions. As described in JCTVC-C606, five test cases are verified using all intra conditions, and the increases in BD-rate compared to the anchor are reported.

It was noted that 64x64 intra prediction is really operated as four 32x32 intra predictions, so whatever you signal at the 64x64 level is just a way to save bits by collecting together four 32x32 decisions into a single syntax element.

After discussion – although what we have currently may not be what we would like to end up with in a "clean" design, we should do further study and consider changing this later – e.g., to remove the signal whenever the intra prediction region is larger than the largest available transform block or to allow signalling of any prediction mode that is available at the largest transform block size.

JCTVC-E439 CE6.g: Cross-verification report for Mitsubishi Electric's proposal (JCTVC-E068) by Peking Univ. [Liang Zhao, Li Zhang, Siwei Ma, Debin Zhao (??)] [late registration]

9.3 Discussion and Conclusions

A proponent suggested adopting JCTVC-E174 Planar prediction – there seems to be some objective gain (and likely subjective) – with signaling of planar mode at PU level – although this was not part of the original CE plan.

Regarding short distance intra prediction (SDIP) – see above.

DCIM – differential coding of intra modes (DCIM) – discussed above

Chroma prediction based on recontructed luma of JCTVC-E266 (6.a.4) – cross-check JCTVC-E254 not submitted – a new cross-check by Microsoft was submitted in JCTVC-E468.

Adaptive intra smoothing (AIS) 6.f – discussed above.

Combined intra prediction – discussed above.

Parallel intra JCTVC-E315 – discussed above.

A revised version of the CE summary was recommended to be uploaded.

Planar mode – discussed above.

10 CE7: Alternative transforms

10.1 Summary

JCTVC-E027 CE7: Summary report of core experiment on alternative transforms [R. Cohen, C. Yeo, R. Joshi, F. Fernandes] [late upload]

The purpose of Core Experiment 7 was to characterize the performance, in terms of both compression efficiency and complexity, of several transforms other than the 2-D integer DCT transform currently in HM. Some of these proposed transforms are secondary transforms applied after the HM transform, and some are used in place of the HM transform, under certain conditions. Some combinations of the proposed transforms are tested as well. This document and the accompanying spreadsheet provide a summary of activities and results for this core experiment.

The summarization in this section depends on that described in the summary report, and may not reflect full consensus.

CE7-related proposals and cross-checks

Tool #	Proponent (Tool Type)	CE7 Doc.	Cross-verification				Other related docs.	Remarks
1	Qualcomm Toshiba I^2R Huawei (Mode Dep. DCT/DST; Intra)	E098	E075 Panasonic	E123 Samsung	E126 BBC			2 variants
2	Samsung (Mode Dep. DCT/DST; Intra)	E125	E099 I^2R	E127 BBC	E461 Panasonic	E460 DOCOMO USA Labs		4 variants
3	Peking Univ.							Withdrawn
4	Samsung (ROT; Intra)	E380	E076 Panasonic	E420 Qualcomm				4 variants
5	Panasonic (Secondary mode dep. transform; Intra)	E074	E179 Toshiba	E379 Samsung				
6	NHK (R-D adaptive selection of DCT or DST; Intra and Inter)	E107	E413 MERL					
7	HKUST							Withdrawn

The types of proposed transforms and methods generally fall into one or more of the following categories:

- Mode-dependent DCT/DST, where the horizontal and vertical transform depends upon the Intra prediction mode.
- Mode-dependent secondary 4x4 KLT, used horizontally and/or vertically depending upon mode.
- Secondary rotational transform, rate-distortion optimized selection.
- Adaptive selection of 2-D DCT or DST, rate distortion optimized selection.

Brief descriptions for each of the proposals are shown in the table below. For more details, please refer to the document number associated with each tool.

Tool #	Proponent	JCT-VC Doc.	Tool Description
1	Qualcomm Toshiba I²R Huawei	E098	(Intra) Horizontal and vertical transforms are HM DCT and/or odd type-III (type-VII) DST, depending upon Intra prediction mode. Two variants: 1: Coefficient scanning from HM 2.0; 2: "Weak" scans for low-complexity conditions.
2	Samsung	E125	(Intra) Horizontal and vertical transforms are HM DCT and/or type-VII (odd type-III) DST, depending upon Intra prediction mode. Four experiments apply this technique to: 1: 4x4 & 8x8, DCT portion modified from HM; 2: 4x4, DCT portion modified from HM; 3: 4x4 & 8x8; 4: 4x4.
3			Withdrawn
4	Samsung	E380	(Intra) Rate-distortion optimized selection of a secondary rotational transform, applied after the HM transform. Four variants: 1: ROT as secondary transform after HM transform; 2: Same as experiment 1, but ROT implemented via lifting; 3: ROT as secondary transform after Tool 2 (experiment 3) above; 4: Same, except ROT used as secondary transform only if Most Probable Mode for Intra prediction was used for current PU.
5	Panasonic	E074	(Intra) For 4x4 blocks, Horizontal and vertical transforms are HM DCT and/or odd type-III (type-VII) DST, depending upon Intra prediction mode. For 8x8 and larger, the HM transform is performed first, followed by a secondary 4x4 KLT, which is applied horizontally and/or vertically (depending upon the Intra prediction mode) to the low-frequency coefficients.
6	NHK	E107	(Intra and Inter) Rate-distortion optimized selection of HM DCT or type-II DST. The butterfly operations of the horizontal DCT and DST transforms are merged so that the DCT and DST coefficients are output simultaneously.
7			Withdrawn

Tabulated information regarding complexity and compression performance was reported in the summary report.

The DST schemes that are proposed use a matrix multiply approach. It was remarked that it may be odd to standardize a scheme that requires a matrix multiply DST and a butterfly-factored style DCT-like transform.

It was remarked that the precision of the core HM-DCT may somewhat affect the reported results.

It was agreed to have a BoG discussion (coordinated by R. Cohen) at approx 11am Friday, then revisit the subject.

10.2 Contributions

JCTVC-E074 CE7: Mode Dependent 2-step Transform for Intra Coding [Youji Shibahara, Takahiro Nishi (Panasonic)]

For 8x8 and larger, HM-DCT is applied and then a mode-dependent transform is applied (either pseudo-DST "KLT" or no operation in each dimension – 4 possibilities selected by the mode without syntax, similar to ROT but without syntax) to 4x4 low-freq coeffs.

For 4x4, chooses between two transforms – a pseudo-DST or a DCT-like transform that is not quite the same as the HM transform (more precise approx of DCT than HM).

1.1% for AI HE.

JCTVC-E075 CE7: Cross Check Report for Qualcomm, Toshiba, I2R and Huawei's proposal (JCTVC-E098) by Panasonic [Youji Shibahara, Takahiro Nishi (Panasonic)]

JCTVC-E076 CE7: Cross Check Report for Samsung's proposal (JCTVC-D357, JCTVC-D360 and JCTVC-C096) by Panasonic [Youji Shibahara, Takahiro Nishi (Panasonic)]

JCTVC-E098 CE7: Mode dependent intra residual coding [R. Joshi, P. Chen, M. Karczewicz (Qualcomm), A. Tanizawa, J. Yamaguchi (Toshiba), C. Yeo, Y. H. Tan (I2R), H. Yang, H. Yu (Huawei)]

0.9% for AI HE. Reportedly similar to JCTVC-E125, which had 1% for AI HE.

If the block size is 4x4 or 8x8, the mode is used to determine whether a "HM-DCT" or DST in each dimension – with HM-style scanning (3 types, depending on the prediction mode).

In the LC case there is a scanning trick also included in the proposal. Results were provided with and without this scanning trick.

Differences: Different mapping of which transform is selected in a few modes, and tiny difference in some transform coefficient values.

Suggestion: Focus on JCTVC-E125, JCTVC-E098 and JCTVC-E074.

JCTVC-E125 CE7: Mode-dependent DCT/DST without 4*4 full matrix multiplication for intra prediction [Ankur Saxena, Felix Fernandes (Samsung)]

JCTVC-E099 CE7: Cross-check of Samsung's proposal on alternative transforms (JCTVC-E125) [C. Yeo, Y. H. Tan (I2R)]

JCTVC-E107 CE7.6: Simplified adaptive transform selection [Atsuro Ichigaya, Yasuko Sugito, Shinichi Sakaida (??)]

JCTVC-E123 CE7 : Cross Check Report for Mode Dependent Intra Residual Coding (JCTVC-E098) by Samsung [Ankur Saxena, Felix Fernandes, Elena Alshina, Vadim Seregin (Samsung)]

JCTVC-E126 CE7 Tool 1: Cross Check Report for Mode Dependent Intra Residual Coding (JCTVC-E098) by BBC [Andrea Gabriellini, Marta Mrak (BBC)]

JCTVC-E127 CE7 Tool 2: Cross Check Report for Samsung's Mode-dependent DCT/DST (JCTVC-E125) by BBC [Andrea Gabriellini, Marta Mrak (BBC)]

JCTVC-E179 CE7: Cross check report of Panasonic's proposal (Tool5 : JCTVC-E074) from Toshiba [A. Tanizawa, J. Yamaguchi (Toshiba)]

JCTVC-E379 CE7: Cross-verification for Panasonic's test (JCTVC-E074) by Samsung [E. Alshina, A. Saxena, W.-J. Han (Samsung)]

JCTVC-E380 CE7: Experimental results of ROT by Samsung [E. Alshina, A. Alshin, F. Fernandes, A. Saxena, V. Seregin, Z. Ma, W.-J. Han (Samsung)]

A combination approach was described – found in JCTVC-E380 v5 (uploaded on 17th, not in previous versions) described in "test 5":

- If the intra pred mode is the "most probable" mode
  - Core transform as in HM is applied
  - RD-optimized selection among four secondary transforms (ROT) also applied (with syntax to determine which)
- Otherwise,
  - If the block size is 4x4 or 8x8, the mode is used to determine whether a "HM-DCT" or DST in each dimension (JCTVC-E125, which is similar to JCTVC-E098) – with HM-style scanning (3 types, depending on the prediction mode)
  - Otherwise, HM-DCT is applied and then a mode-dependent transform is applied (either pseudo-DST "KLT" or no operation in each dimension – 4 possibilities selected by the mode without syntax, similar to ROT but without syntax) to 4x4 low-freq coeffs (from JCTVC-E074)

It was remarked that an encoder may not be aware of whether the intra pred mode that has been selected is the "most probable" mode or not at the time of its decision to use a particular prediction mode.

JCTVC-E413 CE7: Cross-verification of NHK's (JCTVC-E107) Simplified Adaptive Transform Selection [R. Cohen, A. Vetro, H. Sun (MERL)]

JCTVC-E420 CE7: Crosscheck of Samsung's ROT results (JCTVC-E380) [R. Joshi (Qualcomm)]

JCTVC-E460 Cross-check of mode-dependent DCT/DST (restricted to 4x4 TUs) for intra coding (JCTVC-E125) [S. Kanumuri, F. Bossen (DOCOMO USA Labs)] [late registration]

JCTVC-E461 CE7: Cross-check report for Samsung's proposal on adaptive DST/DCT transform (JCTVC-E125) by Panasonic [Youji Shibahara, Takahiro Nishi (Panasonic)] [late registration]

10.2.1 MDDT simplification

10.2.2 ROT improvements

10.3 Discussion and Conclusions

It was suggested to hold a Transform BoG at 13:40 Thurs (coordinated by P. Topiwala). A BoG discussion was held on Friday, coordinated by R. Cohen, as recorded below.

JCTVC-E480 BoG Report on Transforms [R. Cohen (MERL)] [available 03-19??]

This report summarizes a BoG on transforms meeting held from approximately 11:00 to 13:00 on Friday, March 18 2011. The purpose of this BoG was to get a better understanding of implementation and complexity-related aspects of the alternative transforms from JCTVC-E074, JCTVC-E098, and JCTVC-E125, so that informed decisions on whether to adopt these transforms could be made. Developments that occurred after the meeting are also reported here, because they may simplify the decision process.

At the end of the Core Experiment 7 discussions on Thursday, it was decided to form a BoG on Transforms to clarify any complexity, implementation, and performance questions related to the alternative transforms of JCTVC-E074, JCTVC-E098, and JCTVC-E125. A meeting for the BoG on Transforms was held from approximately 11:00 to 13:00 on Friday, 18 March 2011. Approximately 25-30 people attended. This report contains a summary of the meeting.

JCTVC-E125 and JCTVC-E098 reportedly both implement a very similar mode-dependent DCT/DST on 4x4 and 8x8 blocks, so it was agreed to refer to this transform as JCTVC-E125. For 16x16 and larger, the 2-D HM core transform is used. The DCT portion of the DCT/DST is the same as that used in HM.

JCTVC-E074: For 4x4 blocks, this proposal uses a matrix-multiplication implementation of JCTVC-E125. For 8x8 blocks and larger, it applies a 4x4 transform on the lower-frequency coefficients output from the HM core transform. This 4x4 transform is mode-dependent, where the mode determines whether a DST is applied horizontally and/or vertically.

All these transforms operate only on Intra slices.

Coding performance and complexity were discussed in the report, along with other comments about these proposals.

After the BoG met, there were discussions among the proponents and BoG Chair regarding the questions and comments from the meeting participants. The proponents then proposed the 4x4 mode-dependent DCT/DST from JCTVC-E125 for adoption at this time, and recommended further study of the 8x8 and secondary transform tools. Specifically, the modified proposal from the proponents was:

- JCTVC-E125 and JCTVC-E098 can be referred to as JCTVC-E125, due to their similarity.
- The 4x4 mode-dependent DCT/DST of JCTVC-E125 was proposed for adoption by these proponents.
- JCTVC-E074 and the 8x8 transforms of JCTVC-E125 should both be further studied in a CE.

In the discussion, it was suggested for scaling of any new transforms to be set to match the JCTVC-E243 scaling.

The reported coding performance improvement from this scheme, as reported from JCTVC-E125 (Table 5 of v4), was 0.8%, 1.3%, 0.3%, and 0.5% for AI HE, AI LC, RA HE, and RA LC, respectively, with approximately no encoder or decoder runtime effect.

General discussion of SDIP and MDDT

Little benefit was shown (thus far) for applying the DST scheme to larger block sizes.

Transform precision improvement alone (without adding more transforms) provides roughly 0.3% improvement for the AI HE case. The proponent of JCTVC-E125 remarked that a test of this issue had been done privately by the proponent of JCTVC-E074, and it was concluded that the gains from the transform precision and transform adaptation are approximately additive.

It was noted that the coefficient scan is different in different prediction modes, and this also applies with the added transform combinations, and it was asked whether the scan order could be fixed for each 2D tranform combination.

It was noted that we are adding an additional prediction mode (the planar prediction mode) at this meeting, and it was remarked that if the MDDT concept is adopted, it seems likely that the DST variant should be associated with that prediction mode, and it was suggested that additional benefit might be observed due to the interaction between the planar and MDDT effects.

It was remarked that SDIP and MDDT seem related.

It was remarked that mode-dependent scan order may not be necessary with SDIP.

It was agreed that the SDIP and MDDT intra coding tools, including associated transforms and scans, should be integrated into a common software package for testing interaction between the tools.

Options that were discussed for adoption decisions relating to SDIP and MDDT:

- No adoption of SDIP and MDDT, software dev / testing in CE
- Adoption of SDIP and MDDT, testing in CE with HM 3.0
- Adoption of MDDT, further testing of combination in CE
- Adoption of SDIP, further testing of combination in CE

Remarks: SDIP provides higher coding efficiency gains, but also increases encoder run times

It was remarked that for SDIP, encoder run time increases vary significantly across sequences (from about 5% speed up to about 60% slow down). Explanation from proponent: an early skip method has been implemented to bypass SDIP search in some cases.

Remark: SDIP is more difficult to implement.

Remark: SDIP currently not compatible with RQT.

Remark: All intra tools should be extended to support rectangular blocks for testing.

In further discussion, it was remarked that it actually seems possible that MDDT and SDIP do not strongly interact and that each of these has had stable gains for multiple meeting cycles, and it was agreed to consider each on its own merits for action at this meeting.

Decision: Agree to adopt JCTVC-E125 ("MDDT", 4x4 only).

Decision: Agree to adopt JCTVC-E278 ("SDIP", no 1x4/4x1, no BUDI).

During a later discussion of different subjects, a revisit was requested to discuss the SDIP adoption.

Follow up discussion was held in a plenary – in response to a comment on the residual coding structure of SDIP, reflecting desire for "harmonization".

A desire for addition software review of proposals (in general) was expressed.

In the follow-up discussion on SDIP in plenary, it was remarked that:

- After adoption, study of software unveiled that the proposal seems to imply more changes than anticipated. Would also be desirable to be better harmonized with existing coefficient encoding, block structures.
- In general, we still have the problem that often proposals are not yet up to the quality of standard text description (partially caused by the fact that the WD is a moving target yet)
- It was agreed to adopt this feature into the HM (but not 3.0 yet) in a separate branch, not to include it in the WD, and not to include it in the common conditions; and in parallel to conduct a CE on further improvement/harmonization of SDIP.
- A general question was asked whether CE software should be open to everybody? Or be provided with the contribution document upload? This subject was left for further discussion except as noted elswhere in this report.

Decision: After further plenary discussion, the group agreed upon an alternative procedure for handling complicated feature adoptions, as described further in this report below. This alternative procedure was agreed to be applied in this case.

11 CE8: Non-deblocking loop filtering

11.1 Summary

JCTVC-E028 CE8: Non-deblocking Loop Filtering - Summary Report [T. Yamakage (Toshiba), I. S. Chong (Qualcomm), M. Narroschke (Panasonic)] [late upload]

This contribution is a summary of core experiment 8 (CE8) on non-deblocking loop filtering. There are five Subtests in CE8, Number of inputs (Subtest 1), Filter adaptation (Subtest 2), Enhancement schemes of loop filtering process (Subtest 3), Adaptation for Low Complexity design (Subtest 4) and Complexity reduction and/or quality improvement (Subtest 5) for adaptive loop filtering included HM 2.

The subtests of this CE were characterized as follows for discussion purposes:

- Subtest 1 changes the threshold parameters of deblocking, or uses both non-deblocked and deblocked inputs for loop filter
- Subtest 2 is about block-based adaptation vs. pixel-based of HM, and directional characterization
- Subtest 3 uses adaptive offset additionally, or enhanced filter types
- Subtest 4 uses fixed sets of coefficients for low complexity configuration

- Subtest 5 investigates modification of filter shapes.

11.2 Contributions

11.2.1 Subtest 1

JCTVC-E140 CE8.1: DF-combined adaptive loop filter [T.Ikai, T.Yamazaki (SHARP)]

This contribution is a CE8 subtest 1 (Single- and multi-input schemes in Non-deblocking loop filtering) proposal. In this contribution, the DF (Deblocking Filter) combined adaptive loop filter was evaluated. It is asserted the proposed technique provides coding efficiency improvement and the functionality to process the two inputs in parallel case. The coding gains of 1.1%, 0.7%, and 0.7% in HE IO, HE RA, HE LD were reported. In parallel case, the coding gains of 1.3%, 0.7%, 0.5% in HE IO, HE RA, HE LD were reported. The decoding time ratio between 104% and 105% and the encoding time ratio between 99% and 103% were reported in HE case. The WD2 base drafted text has been prepared.

Uses the sample before deblocking as additional input.

Visual check? Some cases (at low bit rates) have more blocking artifacts.

With the additional input, it is necessary to use one more frame memory at the encoder (decoder can process both in parallel, which is an advantage compared to multiple-input filters discussed during last meeting).

Even though it is claimed that highest gain is at high rates, this is not evident from the Excel sheet in v2 – new version will be uploaded.

Question: Was the 2-input ALF tested in context with the one-pass encoding ALF from HM 2.1? Not tested.

No action.

JCTVC-E173 CE8.1: Verification results of Sharp's Proposal JCTVC-E140 [T. Yamakage, T. Watanabe (Toshiba)]

This contribution reports verification results of JCTVC-E140 (CE8.1: DF-combined adaptive loop filter) for CE8 Subtest1. Coding efficiency results are reportedly exactly matched with the proponent's results for both parallel and non-parallel cases. No mismatch between encoder and decoder is observed. Relative encoding and decoding time are similar to those of proponent's.

JCTVC-E193 CE8.1: Deblocking parameter adjustment for 1-input ALF [T. Yamakage, S. Asaka, T. Watanabe, T. Chujoh (Toshiba), C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek), M. Karczewicz, I. S. Chong (Qualcomm)]

This contribution proposes appropriate parameters for deblocking filter to improve coding efficiency for CE8 Subtest 1: Number of inputs. In this contribution, both beta and tc in the current HM 2 design are offset slightly so that the impact on subjective picture quality is reportedly negligible. When using beta offset of -2 and tc offset of -4, coding efficiency improvements are 0.7% for I Only case and 0.5% for Random Access and Low delay cases for High Efficiency configuration described in JCTVC-D600 and JCTVC-D608. Encoding and decoding time are approximately the same as those for the anchor. In an Annex, there are additional results of coding efficiency improvement for combination of beta and tc offsets using the first 2 seconds of each test sequence. Results were reportedly verified by Ericsson.

JCTVC-E334 CE8.1: Cross-verification of proposal on deblocking parameter adjustment for 1-input ALF (JCTVC-E193) by Ericsson [Andrey Norkin (Ericsson)]

This contribution is a part of the core experiment on non-deblocking loop filtering (CE8) and it cross-verifies proposal JCTVC-E193 (Toshiba/MediaTek/Qualcomm) on deblocking parameter adjustment for 1-input ALF. The adjustments to the deblocking parameters for configurations using ALF are sent in the slice header. The proposed technique reportedly results in average BD-rate reduction of 0.6% for three high efficiency configurations. The results are confirmed by the cross-verifier. The subjective video quality on a majority of the studied sequences is reportedly similar to that of the anchor except two cases when the proposal is subjectively worse than the anchor.

The subjective quality is similar to the anchor on the majority of the sequences except two cases, Vidyo3 and Vidyo4 low-delay, QP37, which are worse than the anchor.

- To check whether objective improvements are consistent over different sequences & test points (e.g. do Vidyo3/4 drop?)
- Have subjective viewing to confirm or disconfirm the observation with some more experts
- Encoder only? Check if current implementation / syntax does have the option to signal de-blocking parameters (it should …)

No extensive visual test was made (only Vidyo3 and Vidyo4 were shown to some more experts who indicated that it was worse) – further study should be performed, also to understand where the BD rate gain comes from.

11.2.2 Subtest 2

JCTVC-E323 CE8 Subtest 2: Block based adaptive loop filter [I. S. Chong, M. Karczewicz (Qualcomm)]

This contribution reported the results of CE8 Subtest 2: Block based adaptive loop filter (ALF). A novel pixel classfication method is proposed in this contribution. First, block based classification (i.e., 4x4 block based) is proposed instead of the pixel based classification as in the current ALF in HM2.0. Moreover, directional information is related to a Laplacian activity metric based classification method in HM2.0. No syntax changes are made (although the decoding process changes) and the pixel classfication method in HM2.0 (i.e., Laplacian based activity metric) is replaced with the method propsed in this contribution. In comparison with the JCTVC-D600 anchor, the proposed method reportedly achieved 0.2%, 0.5%, and 0.4% bit rate reductions for HE-AI, HE-RA, and HE-LD, respectively, with roughly unchanged encoding time (i.e., 2% increase) and 6-8% decoding time reduction. And results of some variants are also provided, i.e., block based ALF without directional harmonization and merging this proposal with MediaTek's CE8 subset2 proposal. This contribution was reportedly cross checked by JCTVC-E109 and JCTVC-E131.

The proponent suggested to refer to JCTVC-E047 which gives more noticeable gain.

The gain of the current contribution does not come due to block-based method, but rather the directional adaptation.

The question was asked whether there was any v~~V~~isual deterioration observed? A: No~~t observed~~.

Reasons for complexity reduction of decoder: Less frequent switching due to block-based method, smaller windows to measure pixel activity (could also be used in current ALF).

Number of different filters investigated at the encoder is higher than 16 (which improves the pixel classification), but it is later reduced by merging classes to not more than 16. There was some discussion of whether the directional classification is really necessary (encoder issue).

Realistically, block-based adaptation as such may give 4-6% of decoder runtime reduction (in total, the ALF takes 25-30% of total decoder runtime).

Without other measures like directional adaptation, the block based adaptation would cost 0.1% in BR increase.

JCTVC-E111 CE8 Subtest 2: Cross-check of Qualcomm's proposal (JCTVC-E323) on block-based filter adaptation and directional features [P. Lai, F. C. A. Fernandes (Samsung)]

JCTVC-E137 CE8.2: Cross-check result of Qualcomm's Block based adaptive loop filter (JCTVC-E323) by Sharp [T.Ikai, T.Yamazaki (SHARP)]

JCTVC-E141 CE8.2: Region-based adaptive loop filter using two-dimensional feature [T.Ikai, T.Yamazaki (SHARP)]

In this contribution, a region-based adaptive loop filter using two-dimensional feature was evaluated as one of the CE8 subtest 2 proposals. The technique uses two-dimensional feature, activity and direction information based on block level adaptation rather than pixel level adaptation, where up to eighteen sets of filter coefficients are sent In the case of 4x4 block, the coding gains of 0.2%, 0.5% and 0.6% in HE IO, HE RA, HE LD were reported. Decoding time ratios between 96% and 99% and the encoding time ratio between 83% and 94% were reported in HE case. In the case of 2x2 block, the coding gains of 0.4%, 0.8% and 1.0% in HE IO, HE RA, HE LD, the decoding time ratio between 103% to 106% and the encoding time ratio between 94% and 97% were reported. On Windows platform, the decoding time ratio wasere reportedly 88% to 90% in 4x4 and 93% to 96% in 2x2. Some WD2 base drafted text had been prepared.

Splitting was performed based on pixel activity and direction.

Splitting can only be performed after deblocking.

Regarding the decrease of encoding time – where does it come from? A: Optimizing of merging by pre-defining a subset of merging candidates. Decrease in decoding time is reportedly less than in JCTVC-E323 (which is better optimized though similar).

JCTVC-E325 CE8 Subset 2: Cross-Verification of Sharp's Adaptive loop filter by Qualcomm [I. S. Chong, M. Karczewicz (Qualcomm)]

Confirms results. Raises the question of whether the method is combinable with one-pass encoding of HM 2.1.

JCTVC-E046 CE8 Subtest 2: Adaptation between Pixel-based and Region-based Filter Selection [C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)]

This contribution reported results of CE8 Subtest 2: adaptation between pixel-based and region-based filter selection, which was one of the coding tools jointly proposed by MediaTek, Qualcomm, and Toshiba in JCTVC-D119. In HM2.0, pixel-based filter selection is used for adaptive loop filtering (ALF). All pixels of a picture are classified into 16 groups, and after group merging one filter is applied for each group. In this proposal, a region-based filter selection method is added. When a picture chooses the region-based filter selection, the picture is divided into 16 roughly-equal-size regions where each region is aligned with largest coding unit (LCU) boundaries. Similar to the pixel-based method, regions can be merged, and after region merging one filter is applied for each region. A flag is added in the slice header to switch between the pixel-based ALF and the region-based ALF. When compared with the JCTVC-D600 anchor, the proposed method reportedly achieved 0%, 0.2%, and 0.4% bit rate reductions for HE-AI, HE-RA, and HE-LD, respectively, with 1-2% encoding time increase and 1-4% decoding time decrease.

JCTVC-E247 CE8 Subtest2: Cross-check Results for Proposal JCTVC-E046 [Semih Esenlik, Matthias Narroschke (Panasonic)]

JCTVC-E505 Description and result of the combination of JCTVC-E323 and JCTVC-E046 [I. S. Chong, M. Karczewicz (Qualcomm), C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W Huang, S. Lei (MediaTek), T. Yamakage, T. Chujoh, T. Watanabe (Toshiba)] [late registration 2011/03/22]

Not necessary to review

JCTVC-E475 Cross Verification of Combination of JCTVC-E046 and JCTVC-E323 [J. Xu (Microsoft)] [late registration 2011/03/17, uploaded 2011/03/18]

General discussion on subset 2

V3 of JCTVC-E323 reports a combination of JCTVC-E323 and JCTVC-E046 where the directional-adaptive block-based method of JCTVC-E323 replaces the option of pixel-based mode of JCTVC-E046. The reported bit rate reductions are 0.1%, 0.5% and 0.8% for AI, RA and LD, whereas the decoder runtime reduction is 6%, 9% and 7%. Cross check: JCTVC-E475.

In addition, the participants in subset 2 of CE8 believe that elements of the encoder optimization and signaling from JCTVC-E141 could also beneficially be used in this combination.

How does the region-based scheme interact with multiple slices in a picture? This should not be a problem as switching between region-based and block-based is done at picture level.

After successful cross-check:

Decision:

- Adopt the block-based solution of subtest 2, i.e. combination of JCTVC-E323 with JCTVC-E046
- Continue further optimization of the block-based approach by the methods of JCTVC-E141 as said above under JCTVC-E046

11.2.3 Subtest 3

JCTVC-E047 CE8 Subtest 3: Adaptation between ALF and AO [C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W Huang, S. Lei (MediaTek), M. Karczewicz, I. S. Chong (Qualcomm), T. Yamakage, T. Chujoh, T. Watanabe (Toshiba)]

This contribution reported the results of CE8 Subtest 3: adaptation between adaptive loop filter (ALF) and adaptive offset (AO), which is a joint proposal from MediaTek, Qualcomm, and Toshiba. In order to avoid using multiple pixel classification methods in the decoder, the pixel classification is simplified and unified for both ALF and AO. Moreover, adaptation between ALF and AO at picture level is implemented to reduce average decoding time. In comparison with the JCTVC-D600 anchor, the proposed method reportedly achieved 0.2%, 0.7%, and 1.0% bit rate reductions for HE-AI, HE-RA, and HE-LD, respectively, with roughly unchanged encoding time and 10-11% decoding time reduction.

Pixel classification: Window size is 3x3, comparing the center pixel against each neighbor, class allocation depends on number of neighbors that are by amplitude lower or larger than current sample.

Pixel classification is different from the method used in the block-based method of JCTVC-D323. Straight combination would not be possible or lose the advantage that common building blocks are used for ALF and AO.

For software implementation, switching between ALF and less complex AO gives decoder runtime benefit, however hardware implementations most probably needs additional dedicated circuitry for the buildung blocks that are different.

Has visual comparison been made? As switching between two different filters may happen on a frame-by frame basis, this could lead to visual impariments? No, but in Guangzhou a similar switchable method (JCTVC-C143 and previously JCTVC-B077) was visually tested and no problems were reported.

The worst case should be considered, i.e. a decoder may be enforced to use ALF all the time. In that case, only the simplification of the pixel classification relative to the HM would stay as an advantage.

JCTVC-E109 CE8 Subtest 3: Cross-check of MQT's proposal (JCTVC-E047) on adaptation between ALF and AO [P. Lai, F. C. A. Fernandes (Samsung)]

JCTVC-E108 CE8 Subtest 3: Loop filter with directional similarity mapping [P. Lai, F. C. A. Fernandes (Samsung)]

This contribution presents the summary of Samsung's proposal to core experiment 8 (CE8) on Non-deblocking loop filtering, based on JCTVC-D221. Due to the mapping process involved in the directional filters, results that were originally proposed to CE8 Subtest 2 and Subtest 5 have been moved to Subtest 3 and reported altogether in this document. For pixel- or block-based filter adaptation, directional gradients are computed to classify pixels or blocks. Fixed number of 4 filters are utilized, each being a combination of a non-linear directional filter and a linear spatial filter. Experimental results under different settings, compared against HM 2.0 as anchor, are presented in this contribution along with cross-checker's results.

Saves 0.2% in AI and RA; increases 0.3% in LD; Decoding time increase between 30% and 50%, not fully consistent with cross-check. Encoding time increase even higher.

4x4 block-based adaptation, based on directional gradient, 4 filters 7x7 each, 25 coefficients. Classification is simpler, but filter operation is more complex than current HM ALF.

JCTVC-E288 is using the directional adaptation only in combination with HM ALF.

JCTVC-E138 CE8.3: Cross-check result of Samsung's Loop filter with directional similarity mapping (JCTVC-E108) by Sharp [T.Ikai, T.Yamazaki (SHARP)]

JCTVC-E175 CE8.3: Verification results of Samsung's Proposal JCTVC-E108 [T. Yamakage, T. Watanabe (Toshiba)]

JCTVC-E265 CE8 Subtest 3: Cross Verification of JCTVC-E108 Proposed by Samsung [C.-Y. Chen, Y.-W. Huang (MediaTek)]

JCTVC-E234 Verification results of CE8: Samsung's contribution on ALF (JCTVC-E108) [M. Budagavi (TI)]

JCTVC-E327 CE8 Subset 5: Cross-Verification of Samsung's Adaptive loop filter by Qualcomm [I. S. Chong, M. Karczewicz (Qualcomm)]

No action on subtest 3 (AO adopted in a different context of CE13)

11.2.4 Subtest 4

JCTVC-E320 Parametric Adaptive Loop Filter [Ehsan Maani, Wei Liu]

This document provides a brief description and results of Parametric Adaptive Loop Filter which was introduced as a low complexity alternative to conventional ALF techniques [JCTVC-D270]. In this approach, a set of fixed filters is used instead of the traditional online-trained Wiener filters. The encoder chooses the best (in RD sense) filter for a Coding Unit (CU) and transmits the index of the filter in the bitstream to the decoder. The selection of the best filter at the encoder requires only a single-pass processing for each Large CU (LCU), therefore, reducing the encoder delay significantly compared to traditional ALF approaches which require multi-pass processing. On average, using this technique, 1.9%, 4.1%, and 3.4% gain compared to HM 2.0 anchors could be achieved for Low Complexity (LC) Intra, low delay, and random access, respectively.

(The contribution's presentation slide deck had not been uploaded when discussed.)

The proposal uses a set ~~Uses set~~ of 32 fixed filters (size 9x9 with 23 non-zero coefficients). LCU-level optimization, no multi-pass optimization is necessary.

Classifications include local activity, gradients, direction. Different filter shapes based on direction. All filter shapes are derived from a base-shape.

Filter coefficients were trained by a set of test sequences which included some of the test set.

For LC case, the decoding runtime increases by approx. 50% for intra, approx. 20% for RA and LD cases. Encoder runtime increases by 30/4/6%.

More improvements can be expected. For example, smaller filters could be envisaged.

No visual comparison made so far.

Further study (CE) recommended

JCTVC-E065 CE8 subtest4: Cross-verification on Low Complexity ALF design [Shun-ichi Sekiguchi, Kazuo Sugimoto (Mitsubishi Electric)] [late upload]

This contribution reports cross-verification results on CE8 subtest4 that evaluates a low-complexity ALF design proposed in JCTVC-D270. The cross-verification work was performed using software that implements JCTVC-D270 technique into HM2.0 code base provided by the JCTVC-D270 proponent. Reported performance results were obtained by building and running the provided software on 64bit Linux platform. It had reportedly been confirmed that objective R-D performance produced in this work perfectly matches with CE report from the proponent. Similar tendencies on encoding and decoding time were also reported.

Additional results provided fro HE case, where the increase in BR is 1.7/1.7/0.3%; decoder runtime 74/74/76%; encoder runtime 74/93/93 for AI/RA/LD.

In chroma, improvements over HM are reported (where 7x7 filters are used in contrast to 5x5 of HM).

JCTVC-E331 CE8 Subset 4: Cross-Verification of SONY's Adaptive loop filter by Qualcomm [I. S. Chong, M. Karczewicz (Qualcomm)]

11.2.5 Subtest 5

JCTVC-E060 CE8 Subtest 5: Luma ALF with reduced vertical filter size [M. Budagavi, V. Sze, M. Zhou (TI)]

This contribution analyzes implementation complexity of Luma Adaptive loop filter (ALF) at decoder. Implementation complexity is determined by not just computations but also memory bandwidth/memory size (area). This contribution presents Luma ALF filter sets that reduce vertical size of filter thereby reducing the line buffer/memory bandwidth requirements. This contribution is a continuation of work first presented in JCTVC-D039 and studies Luma ALF filters with maximum vertical size of 5. Among the filter sets studied in this contribution, filter set Nx5-Set1 is asserted to provide the best trade-off in terms of complexity reduction and coding performance. Nx5-Set1 filter is reported to reduce memory bandwidth or memory size requirements by 33% and worst case computations by 15%. Nx5-Set1 filter is reported to provide average Y-BD-Rate loss of: 0.1% HE_Intra, 0.2% HE_RA, 0.3% HE_LD.

Reduction in decoder runtime by roughly 5% with set 1, roughly 3% with set 3.

Set 3 increases the number of worst-case multiplication by roughly 15%. Among the two, set 1 would be reasonable.

In an implementation where deblocking and ALF are run in parallel, saving in memory would only be around 20% realistically.

It is reported that contributors of JCTVC-E060 and JCTVC-E342 are working on a unification (filters with height 5, diamond/cross-shape switchable and reduced number of independent coefficients)

JCTVC-E225 is also similar

JCTVC-E340 CE8: Cross-check of JCTVC-D039 results from TI [Faouzi Kossentini, Hsan Guermazi (eBrisk)]

JCTVC-E342 Adaptive Loop Filtering Using Two Filter Shapes [Faouzi Kossentini, Hsan Guermazi, Nader Mahdi, Mohammed Ali BenAyed (??)]

This contribution presents the advantages of utilizing two different filter shapes in the Adaptive Loop Filtering part (that is applied to the luminance samples) of the HM-2.0 encoder/decoder. More specifically, it was reported that the switching between a 5×7 modified-diamond shape and a 13×7 cross shape yields good complexity-performance trade-offs.

Loss in intra-only is 0.3%; 0.2% and 0.1% in LD and RA.

Decoder runtime is reported to be decreased by around 10%

The number of independent coefficient values is 10 for each filter. Selection about cross-shape or diamond is done at picture level. This means that with same number of filters less side information is necessary than in the current HM2 ALF. Precision of coefficients is the same

To be confirmed: Is encoding done as in HM2?

Encoding is similar as in HM (multi-pass), however the decision is different as it is first decided which filter shape to be used.

One expert mentioned that due to the choice of filter coefficient dependencies, the diamond-shaped filter can be tuned to various directional characteristics whereas the cross-shaped filter is horizontal/vertical symmetric.

JCTVC-E233 Verification results of CE8: eBrisk Video's contribution on ALF (JCTVC-E342) [M. Budagavi (TI)]

Conclusion on Subtest 5:

- Reduction of complexity at the core part of the ALF, both in terms of memory access and number of computations is likely to be needed
- Approach of combination (reduced filter height, reduced number of coefficients) could be a good solution – it is announced that a unified solution is currently tested and results will be available during the meeting
- See related discussion under JCTVC-E492.

JCTVC-E492 Results on a Combined Adaptive Loop Filtering Algorithm Using Two Filter Shapes [F. Kossentini, H. Guermazi, N. Mahdi, M. A. BenAyed (Ebrisk), M. Budagavi, V. Sze, M. Zhou (TI)] [late registration 2011/03/20]

This contribution reports on the results on an EBRISK-TI combined adaptive loop filtering algorithm that is applied to the luminance samples of video sequences. The proposed algorithm allows for the selection of one of two filter shapes, a 7×5 modified-diamond shape and a 19×5 cross shape, for each picture/slice. Compared to HM 2.0, the proposed algorithm reduces the memory (5 instead of 7 lines) and computational (maximum of 12 instead of 20 coefficients) requirements, while yielding an average loss of only 0.26%.

Losses were 0.32, 0.21 and 0.26 for LD, RA and AI. Decoding time reduced by 9/5/12%, Dec time compared to case where the largest shape would be selected ("worst case") reduced by roughly 14%.

Both filters are 5 lines high.

It is argued that the combined proposal has slightly worse performance than the two original ones. One explanation for this is that the number of lines is reduced to 5 (compared to 7 in Ebrisk's), whereas the number of coefficients is reduced to 12 (compared to 17 in TI's).

Was visual quality checked? Partially.

Several experts expressed concerns that the combination may not have been fully optimized as it was made very fast.

Decision:

- Adopt to HM (not 3.0 yet) in separate branch, not to WD, not to common conditions; in parallel CE on further improvement

The software coordinator expresses support for having the same filter routines for luma and chroma.

It was suggested to establish a CE on filters for chroma with the same shape as for luma.

JCTVC-E487 CE8 Subtest 5: Cross-check of eBrisk's proposal (JCTVC-E342) with vertical length-5 filters and 9 coefficients P. Lai, F. C. A. Fernandes (Samsung) [late registration 2011/03/19 / uploaded 2011/03/21]

Confirms the performance and runtimes. Did not inspect subjective quality.

JCTVC-E499 Cross check of JCTVC-E492, Results on combination of JCTVC-E342 + JCTVC-E060 [A. Abbas, J. Boyce] [late registration 2011/03/21]

11.3 Discussion and Conclusions

See discussions under sub-categories above.

12 CE9: MV coding and skip/merge operation

12.1 Summary

JCTVC-E029 CE9: Summary report of core experiment 9 on MV Coding and Skip/Merge operations [Joel Jung, Benjamin Bross, Peisong Chen, Woo-Jin Han] [late upload]

This document summarizes the activities in the Core Experiment CE9 on motion vector coding and Skip/Merge operations. It also includes adaptive motion vector resolution experiments. A total of 15 companies or universities have registered to the CE. A few emails were exchanged mainly to coordinate the cross-check activity and exchange the modified versions of the HM2.0 software. Also it can be noticed that some experiments were withdrawn by the proponents due to lack of time running the experiment, or insufficient results. In some cases of very close experiments, only the best performing method has been maintained in the CE. Finally, 29 experiments are proposed for the MV coding part. Initially, the CE also contained, and 2 experiments related tofor the adaptive MV resolution, but they have been withdrawn.

Most interesting results come from Experiments T and M31

There is a high relationship with MV compression.

The group first reviewed 4 highlighted documents, and then continued in a BOG.

12.2 Contributions

JCTVC-E048 CE9: Results of Experiments M-Series [J.-L. Lin, Y.-W. Chen, Y.-P. Tsai, Y.-W. Huang, S. Lei (MediaTek)]

This contribution reported the results of CE9 experiments M-series. The results were summarized as follows. In experiment M01, replacing the temporal candidate by T_{BR} reportedly achieved 0.8%, 1.0%, 0.9%, and 1.3% bit rate reductions for HE-RA, LC-RA, HE-LD, and LC-LD, respectively. In experiment M07, the modified derivation of spatial candidates reportedly achieved 0.6%, 0.8%, 0.2%, and 0.3% bit rate reductions. In experiment M12, the modified derivation of temporal candidates reportedly achieved 0%, 0%, 0.3% and 0.6% bit rate reductions. In experiment M27, the combination of M01, M07, and M12 reportedly achieved 1.3%, 1.7%, 1.2% and 2.0% bit rate reductions. In experiment M31, the combination of M01, M07, JCTVC-D125 (2.4′), and JCTVC-D274 (3) reportedly achieved 1.3%, 1.8%, 1.5%, and 2.6% bit rate reductions.

M31 – 1.3, 1.8, 1.5, 2.6 for HE-RA, LC-RA, HE-LD and LC-LD

Spatial candidates were derived with a pre-defined priority.

It was asked why the performance w.r.t. LC-LD is so divergent between M031 and T?

Temporal motion vector predictor? Is still in the first place of the list.

One expert raised a concern that scaling of MV may be critical for HW implementation when used in 4x4 blocks (same is used in the T test).

The discussion was continued in a breakout group – see under JCTVC-E481

JCTVC-E158 CE9 : Cross-verification of experiment M11, M12, M19, M20, M21, M29, M30 and M31 (JCTVC-E048) [J. Park, S. Park, B. Jeon (??)]

JCTVC-E229 CE9: Cross-check report of experiment M22-M26 by Panasonic [Toshiyasu Sugio, Takahiro Nishi (Panasonic)]

JCTVC-E273 CE9: Cross-verification on M01, M02, M03, M07 and M10 of JCTVC-E048 [I.-K. Kim, T. Lee (Samsung)]

JCTVC-E102 CE9: Skip/Merge Simplification with Reduced Candidate Set (Test L) [Y. H. Tan, C. Yeo, Z. Li (I2R)]

One of the major goals of CE9 is to evaluate possible modifications to the motion information derivation process during inter coding. In this test, the Coding unit (CU) level Skip mode is first modified such that the motion vector derivation process of the Merge modes is used. On top of this Skip-Merge mode, the effect of reducing the number of possible Skip-Merge candidates is studied.

(The presentation slide deck had not been uploaded when discussed.)

2 candidates (left/top) are used for skip.

No change for RA/HE, gains of around 0.4-0.5% for RA/LC and LD/HE, loss around 0.7% for LD/LC. No obvious explanation for this divergence of results. One cross-checker reports that the loss is no longer observed if a different interpolation filter (6tap instead 8tap) is used.

2Nx2N merge still exists.

One expert mentions that one goal of CE9 was to unify predictors of AMVP, skip, merge. This is nopt achieved here.

Has relation to the changes suggested in Test B (except for number of candidates)

Merge/skip also used in Test T along with other methods.

JCTVC-E419 CE9: Cross-verification Results of Experiment L for I2R Proposal (JCTVC-E102) by SKKU [Jungyoup Yang, Kwanghyun Won, Byeungwoo Jeon (??)]

JCTVC-E116 CE9: Simplified upper/left MVP calculation based on JCTVC-D055 [Minhua Zhou (TI)]

This document reports CE9 testing results of the simplified upper/left MVP calculation proposed in JCTVC-D055. The testing results using HM2.0 software reveal that there is no coding loss by using the proposed simplification. The simplified method reduces the AMVP complexity by lowering number of memory access and arithmetic operations.

(The presentation slide deck had not been uploaded when discussed.)

Simplification was asserted, without affecting compression – only a change in spatial candidates. It was suggested that this would make sense to adopt, provided that AMVP would stay as it is currently (further discussed in a breakout group).

See decision under JCTVC-E481.

JCTVC-E155 CE9: Verification of TI's proposal (JCTVC-E116) [A.Fujibayashi, T.K Tan (NTT DOCOMO), F. Bossen (DOCOMO USA Labs)]

Did not appear to need review

JCTVC-E204 CE9: Results of Tests B, C, D and T [Benjamin Bross (HHI)]

This document reports test results of core experiment 9 evaluating motion vector derivation and skip tools. All four tested variants are using merge skip instead of AMVP skip. Test T achieves average BD rates from –2% for low delay high efficiency (LD HE) to –1.1% for low delay low complexity (LD LC) compared to the HM2.0 anchor with AMVP skip. For all tests, the encoder runtimes are ranging from 97% to 103% of the anchor encoder runtimes.

Test T: MVs with different refidx are used, but scaled accordingly.

Gain: 1.1% for LD LC, 2% for LD RA, 1.4% and 1.9% for HE RA and HE LD, respectively.

Simplification was claimed: MV deriving process for skip mode is avoided, as the same as for merge is used; unify derivation processes for uni and bi prediction.

Question: What would be implications when only P-slices would be used (which is not defined in test conditions)? A: In fact, uni-directional prediction is often used in current tests. (e.g. preferably in key frames of hier. B).

One comment: The unified method may imply (slight) memory bandwidth increase at encoder unless only list 0 is used.

JCTVC-E103 CE9: Cross-check of Test D from HHI [Y. H. Tan, C. Yeo (I2R)]

JCTVC-E228 CE9: Cross-check report of experiment C by Panasonic [Toshiyasu Sugio, Takahiro Nishi (Panasonic)]

JCTVC-E246 CE9: Cross-check of experiment B (HHI JCTVC-E204), M27 and M28 (MediaTek JCTVC-E048) [Joel Jung, Jean-Marc Thiesse (Orange - FT)]

JCTVC-E456 CE9: Cross Verification of Experiment T Proposed by HHI in JCTVC-E204 [Y.-W. Chen, Y.-W. Huang (MediaTek)] [uploaded 2011/03/17]

JCTVC-E218 CE9: Cross verification of experiments G and H by Canon [Patrice Onno (Canon)]

JCTVC-E230 CE9: Experiment A, I, J and S Modified derivation process of reference index for skip mode and temporal motion vector predictor [Toshiyasu Sugio, Takahiro Nishi (Panasonic)]

Experiment A, I, J and S aims to verify the modifications that were proposed in JCTVC-D274. It includes enhanced reference index decision for skip mode, enhanced temporal motion vector predictor. And instead of adding two derived temporal motion predictors in, one temporal motion vector is selected according to referred direction and added into mvpList. This contribution reports the evaluation results about them.

No need to review, as it is subsumed in M31.

JCTVC-E058 CE9: Cross-check Result of Test I&J&S [Kazushi Sato(Sony)]

JCTVC-E250 CE9: Cross-check of Test A (Panasonic JCTVC-E230) [Benjamin Bross (HHI)]

JCTVC-E285 CE9: Cross-check of Test O (Qualcomm JCTVC-E350) [Benjamin Bross (HHI)]

JCTVC-E350 CE9 Subtests N and O: Improvement on AMVP [J. Park, S. Park, B. Jeon (LG Electronics), Y. Zheng, W. Chien, M. Karczewicz (Qualcomm)]

This contribution presents a modified Advanced Motion Vector Prediction (AMVP). In AMVP, MVs of the spatial neighboring PUs are regarded as spatial neighboring MVPs if and only if they are with the same reference index and the same reference list as the MV of the current PU. In this proposal, MVs with a different reference index or a different reference list are also considered with related scaling method. This method is also applied to the merge skip method proposed by HHI in CE9 test D (JCTVC-E029). The simulation results report that the proposed method on top of default HM 2.0 achieves average 0.5% and 0.7% bit rate reduction for RAHE and RALC, and average 0.1% for both low delay configurations. Encoding and decoding time are avg. 105% and 102% respectively. On the other hand, the proposed method on top of the merge skip method achieves 0.3% (RAHE), 0.8% (RALC), 0.6% (LDHE), -0.7% (LDHE) bit rate reductions. The average encoding and decoding time ratio are 114% and 101% respectively.

No need to review, as it is subsumed in M31.

JCTVC-E285 CE9: Cross-check of Test O (Qualcomm JCTVC-E350) [Benjamin Bross (HHI)]

JCTVC-E267 CE9: Cross Verification of Experiment N Proposed by LG and Qualcomm in JCTVC-E350 [Y.-W. Chen, J.-L. Lin, Y.-W. Huang (MediaTek)]

12.3 Discussion and Conclusions

JCTVC-E481 BoG report of CE9: MV Coding and Skip/Merge operations [Benjamin Bross, Joel Jung] [BoG uploaded 2011/03/21]

This contribution summarizes the activities of the BoG on motion vector coding and skip/merge operations in CE9. The suggested action is as follows:

- Modified spatial MVP derivation process
- Reduced search in left/top spatial MVP candidate detection
- Modified TMVP derivation process
- Modified TMVP candidate position
- Modified TMVP refidx derivation for merge
- Merge Skip

Following points of current adoptions are suggested to be further studied in the CE with the goal of potential complexity decrease:

- Unification of the temporal candidates (H or Co-located): suggestion to check one position only
- Study of spatial MVP scaling for small (8x8, 4x4) blocks
- Skip mode with no fixed reference index

The reported gain of the entire package is summarized as RAHE -1.4 LDHE -1.9 RALC -2.1 LDLC -1.6 AVE -1.8.

It was reported that the software of the suggested combination exists and will be provided in a cleaned up version (which includes the fix for motion data compression).

Decision: Adopt the package as suggested in JCTVC-E481.

13 CE10: Core transforms

13.1 Summary

JCTVC-E030 CE10: CE Report [Pankaj Topiwala, Madhukar Budagavi, Rajan Joshi, Arild Fuldseth, Ilkoo Kim]

Four core transform proposals were generated: Cisco/TI (JCTVC-E243), FastVDO/Samsung 1 (JCTVC-E353), FastVDO/Samsung 2 (JCTVC-E277), Qualcomm (JCTVC-E370). These proposed designs offer a variety of transform computational approaches, from full matrix multiplication to totally multiplication-free designs. All reportedly achieve approximately the same RD performance as the HM transforms, but offer complexity reductions in various areas. These proposals were tested in a variety of ways to measure both coding efficiency and complexity.

CE10 Proposals and Cross-Checks

Proponent	Cross-Check Normal Qp	Cross-Check Low/High Qp	Match Success
Cisco/TI (JCTVC-E243)	Qualcomm (JCTVC-E366)	Samsung/FastVDO (JCTVC-E274)	Yes | Yes
FastVDO/Samsung 1 (JCTVC-E353)	Motorola (JCTVC-E356)	Zenverge | Sharp (JCTVC-E416)	Yes | ~Yes
FastVDO/Samsung 2 (JCTVC-E277)	Cisco/TI (JCTVC-E235)	Qualcomm (JCTVC-E367)	Yes | Yes
Qualcomm (JCTVC-E370)	Samsung/FastVDO (JCTVC-E275)	Cisco/TI (JCTVC-E236)	Yes | Yes

	Cisco/TI	**FastVDO / Samsung Proposal 1**	**Samsung / FastVDO Proposal 2**	**Qualcomm**
Proposed transform sizes	4x4-32x32	16x16-32x32	4x4-32x32	4x4-32x32
Normal QP range	BD-Rate (%)	BD-Rate (%)	BD-Rate (%)	BD-Rate (%)
Intra	-0.3	0.0	0.0	-0.1
Random access	-0.1	0.0	0.0	-0.1
Low delay	-0.2	0.0	-0.1	-0.1
Intra LC	-0.5	0.0	-0.3	-0.3
Random access LC	-0.3	0.0	-0.1	-0.2
Low delay LC	-0.1	0.0	-0.1	0.0
Ave				
Low QP range	BD-Rate (%)	BD-Rate (%)	BD-Rate (%)	BD-Rate (%)
Intra	-1.1	0.0	-0.3	-1.1
Random access	-0.8	0.0	-0.5	-0.5
Low delay	-0.9	0.0	-0.7	-0.6
Intra LC	-2.5	0.0	-0.5	-1.8
Random access LC	-1.6	0.0	-1.1	-1.1
Low delay LC	-1.9	0.0	-1.6	-1.3
High QP range	BD-Rate (%)	BD-Rate (%)	BD-Rate (%)	BD-Rate (%)
Intra	-0.1	0.0	0.1	0.0
Random access	-0.2	0.0	-0.1	-0.1
Low delay	-0.2	0.0	0.1	0.1
Intra LC	-0.1	0.0	0.1	0.0
Random access LC	-0.1	0.0	0.0	0.0
Low delay LC	-0.2	0.1	0.0	-0.1

Some summary complexity metrics for the various proposals were summarized in the report as follows:

	B.1.1	B.1.2		B.2.1			B.2.3	B.2.4	B.2.5
	RD Perf normal, low, high			Arith compl. (mult-, add-centric) 32pt			DynRng 16b	Speed (s)	# Cascaded
Proposal	BdNorm	BDLow	BDHi	Mults	Adds	Shifts	(Yes/No)	Opt. SW	blocks 32pt
HM2.0				7424	13440	4224	No		
Cisco/TI (E243)	-0.25	-1.47	0.03	65536|21888	65536|23808	2048	Yes		
FV/Sam. (E353)	0	0	-0.02	4224|0	12928|22976	4480|17152	Yes		
Sam./FV (E277)	-0.1	-0.78	0	6656	14976	2944	Yes		
Qcomm (E370)	-0.13	-1.07	0	5888	11904	0?	No		

Differences are observed in these proposals in regard to dynamic range, bit depth, precision, and cascading (and possibly other effects).

Some analysis results for the CE were not yet completed.

Some optimized results were reported to be available in JCTVC-E243 in regard to the number of cycles for SIMD implementation, and the proponent indicated that software could be made available.

At low QP, the gain seems dominated by the 4x4 behavior.

It seemed apparent that the 4x4 and 8x8 (which are current the AVC design) can be improved.

Simulation speed is asserted to be approximately unaffected (with cross-verification) by JCTVC-E243.

Draft text for JCTVC-E243 is reportedly available (shorter than the current WD text).

All of these proposals had 16 b intermediate storage.

JCTVC-E243 reported that increasing precision further did not result in substantial gain (less than 0.2% at smallest QP).

Decision: The JCT-VC agreed to conduct a "Software-only adoption" of JCTVC-E243 – the Working Draft transform section will just say that the transform is TBD, and there should not be an assumption that JCTVC-E243 has a higher status for future consideration than other proposals.

Continue/define a CE to finish the analysis – basis for all CEs is to be the JCTVC-E243 that is in the software.

13.2 Contributions

JCTVC-E235 Verification results of CE10: Samsung/FastVDO's contribution on core transform - normal QP range (JCTVC-E277) [M. Budagavi (TI)]

JCTVC-E236 Verification results of CE10: Qualcomm's contribution on core transform - low and high QP range (JCTVC-E370) [M. Budagavi (TI)]

JCTVC-E243 Transform design for HEVC with 16 bit intermediate data representation [A. Fuldseth, G. Bjøntegaard (Cisco), M. Sadafale, M. Budagavi (TI)]

JCTVC-E274 CE10: Cross-verification on Cisco/TI’s transform (JCTVC-E243) [I.-K. Kim, T. Lee (Samsung)]

JCTVC-E275 CE10: Cross-verification on Qualcomm’s transform (JCTVC-E370) [I.-K. Kim, T. Lee(Samsung)]

JCTVC-E277 CE10: Fast integer transform based on modified Loeffler's factorization [I.-K. Kim, T. Lee, J. Chen, V. Seregin, Y. Hong, W.-J. Han (Samsung), P. Topiwala (FastVDO)]

JCTVC-E353 CE10: Fast Core Transforms, Proposal 1 [Pankaj Topiwala (FastVDO), Wei Dai, Ilkoo Kim (Samsung??)]

JCTVC-E356 CE10: Cross-check report from Motorola Mobility for FastVDO/Samsung's fast integer transform (JCTVC-E353) [J. Lou, K. Panusopone, L. Wang (Motorola Mobility)]

JCTVC-E416 Cross check of FastVDO/Samsung's fast integer transform [Kiran Misra, Louie Kerofsky, Andrew Segall (Sharp)] [late upload 2011/03/18]

JCTVC-E366 CE10: Crosscheck of Cisco/TI's contribution (JCTVC-E243) on core transforms - normal QP range [R. Joshi (Qualcomm)]

JCTVC-E367 CE10: Crosscheck of Samsung's fast integer transforms based on Loeffler factorization (JCTVC-E277) - high and low QP range [R. Joshi (Qualcomm)]

JCTVC-E370 CE10: Scaled orthogonal integer transforms supporting recursive factorization structure [R. Joshi, Y. Reznik, J. Sole, M. Karczewicz (Qualcomm)]

JCTVC-E444 CE10: Cross-check of Qualcomm's proposal on scaled orthogonal integer transforms (JCTVC-E370) [C. Yeo (I2R)] [late registration]

JCTVC-E472 Cross Check of CE10: Qualcomm's Proposal on Scaled Transform -- 16bit Low and High QP Range (JCTVC-E370) [Jie Zhao, Andrew Segall] [late registration 2011/03/17 / uploaded 2011/03/18]

13.3 Discussion and Conclusions

14 CE11: Coefficient scanning and coding

14.1 Summary

JCTVC-E031 CE11: Summary report of core experiment on coefficient scanning and coding [V. Sze (TI), K. Panusopone (Motorola Mobility), J. Chen (Samsung), T. Nguyen (Fraunhofer HHI), M. Coban (Qualcomm)] [late upload]

This contribution is a summary of core experiment 11, Coefficient scanning and coding. Eleven companies have been registered in CE11 and tools from five proposals have been evaluated on the condition defined in document by the Software Ad Hoc Group. A sixth proposal was withdrawn. Several of the proposed tools had several variations, totaling a set of ten results. In addition to measuring the coding efficiency, the bins statistics for distribution across syntax elements, method of coding bins and number of contexts are reported. Methods of scan pattern selection and signaling are also to be reported by proponents.

Various methods have been proposed for coding the transform coefficients of the residual to reduce complexity and/or improve coding efficiency. This core experiment evaluates the coding efficiency and complexity impact of

- Alternative binarization and context modeling/selection for syntax elements related to transform coefficients. (i.e. significiant_coeff_flag, last_signifiicant_coeff_flag, and abs_coeff_level_minus1)
- transform coefficient scanning order methods for improving coding efficiency

Characteristics of the proposals were tabulated as follows.

Proposal Document #	Cross-Verification Document #	Author(s)	Title
JCTVC-D336 (JCTVC-E253)	JCTVC-E121	J. Zan, D. He (RIM)	CE11: Cross-verification of HHI's (JCTVC-D336) Reduced-Complexity Entropy Coding of Transform Coefficient Levels
	JCTVC-E326	V. Sze (TI)	CE11: Cross-verification of HHI's (JCTVC-D336) Coding of transform coefficient levels with Golomb-Rice codes
JCTVC-D185 (JCTVC-E227)	JCTVC-E403	J. Sole (Qualcomm)	CE11: Cross-check of Panasonic's context size reduction for the significance map (JCTVC-E227) by Qualcomm
JCTVC-D262 (JCTVC-E338)	JCTVC-E164	Hisao Sasai, Takahiro Nishi (Panasonic),	CE11: Cross-check report for Qualcomm's proposal JCTVC-D262 on Parallel Context Processing for the significance map
	JCTVC-E300	Cheung Auyeung (Sony)	CE11: Cross check of Qualcomm JCTVC-D262 on parallel context processing for the significance map in high coding efficiency
JCTVC-D311	JCTVC-E150*	J. Xu (Microsoft)	CE11.B: Cross-check report for Huawei's adaptive coefficient scanning

(JCTVC-E296)	JCTVC-E255	T. Nguyen (HHI)	CE11: Cross-check JCTVC-D311 - Adaptive coefficients scanning for inter-frame coding
JCTVC-D374 (JCTVC-E392)	JCTVC-E100	C. Yeo (I2R)	CE11: Cross-check of Qualcomm's proposal on adaptive scans
	JCTVC-E132	Y.Yasugi, T. Yamamoto(SHARP)	CE11: Cross-check report of Qualcomm's Adaptive Coefficient Scanning for LCEC (JCTVC-D374) by SHARP
	JCTVC-E357	J. Lou, K. Panusopone, L. Wang (Motorola Mobility)	CE11: Cross-check report from Motorola Mobility for Qualcomm's adaptive coefficient scanning for LCEC (JCTVC-E392)

The following summary of modifications for CE11 proposals was provided as part of the CE summary presentation:

- D336/E253 (HE)
  - Modify binarization of coefficient levels
  - Change number of context-coded binary symbols
- D185/E227 (HE)
  - Change number of contexts for significant_coeff_flag and last_significant_coeff_flag
- D262/E338 (HE)
  - Modify method of signaling last significant coefficient information: Transmit location (X,Y) of last significant coefficient (instead of last_significant_coeff_flag) before all significant_coeff_flag
  - Modify context selection of first 10 significant_coeff_flag
- D311/E296 (HE)
  - For Inter CU, select one of three transform coefficient scanning method (zig-zag, vertical, horizontal) based on pixel texture for each block
  - New zig-zag scan proposed
- D374/E392 (LC)
  - For Intra CU in LCEC, change transform coefficient scanning for each coefficient position based on statistics (counter adaptation)

Five schemes were proposed to consider. Among these, JCTVC-E227 and JCTVC-E338 propose changes to the same parts of the design. The others seem like they can be considered independently.

JCTVC-E344 is a closely related new contribution.

Coding performance and complexity measurements were produced in the CE.

JCTVC-E253, JCTVC-E227, and JCTVC-E338 had essentially no coding efficiency impact reported (less than 0.1%).

JCTVC-E338 reported a 5% AI/ 2% RA/ 0% LD reduction in total CABAC bin counts.

JCTVC-E253 reported greater usage of bypass versus regular coded bins.

JCTVC-E227 reported reductions in the number of contexts.

JCTVC-E338 increases the number of contexts.

Runtimes were essentially unaffected by the proposals, except for JCTVC-E296 which has a proposal 2 that increases encoding time by approximately 6%.

14.2 Contributions

JCTVC-E121 CE11: Cross-verification of HHI's (JCTVC-D336) Reduced-Complexity Entropy Coding of Transform Coefficient Levels [J. Zan, D. He (RIM)]

JCTVC-E227 CE11: Context size reduction for the significance map [Hisao Sasai, Takahiro Nishi (Panasonic)]

This contribution is a test report for JCTVC-D185 as tested in CE11. The proposed technique is aimed to reduce the number of contexts for the significance map. The proposed modifications have been implemented in HMv2 and their coding efficiencies were evaluated. The reduction of the used context size is reported as −22.4% (107 to 83) for the "significant_coeff_flag" and −73.1% (104 to 28) for the "last_flag". The BD BR for the high efficiency intra, random access, and low-delay configurations is reported as 0.03%, 0.00% and -0.14% by reducing "significant_coeff_flag" and "last_flag", −0.04%, −0.08% and −0.22% by reducing only "significant_coeff_flag", 0.08%, 0.08% and 0.02% by reducing only "last_flag", respectively.

The two changes proposed are essentially independent of each other.

For reducing the number of contexts for the "significant_coeff_flag", some (very small – e.g., 0.13%) improvement of coding efficiency was actually reported.

For reducing the number of contexts for the "significant_coeff_flag", some (very small – e.g., 0.08%) degradation was reported.

Decision: This "N1" aspect was adopted.

General clean-up of the related software modules was also encouraged.

For significant coefficient flag, a conditional context derivation scheme had been used for 16x16 and 32x32, and this was extended to the 8x8 case.

JCTVC-E338 is related.

New contributionss JCTVC-E335 and JCTVC-E344 (which is characterized as building on JCTVC-E338) seem related also.

JCTVC-E335 seems less closely related, so it can be discussed separately. JCTVC-E344 is discussed in this section due to its close relationship with the work in this CE.

JCTVC-E403 CE11: Cross-check of Panasonic’s context size reduction for the significance map (JCTVC-E227) by Qualcomm [J. Sole (Qualcomm)]

Cross-checker studied the software and reported matching results.

JCTVC-E489 Modification to JCTVC-E227 in CE11 for reduced dependency with MDCS [V. Sze (TI), H. Sasai (Panasonic)] [late registration 2011/03/20]

This contribution proposes modifying JCTVC-E227 (from Panasonic) evaluated in CE11 such that the conditional context dependency in significant_coeff_flag (i.e. dependency on neighbors) is removed in 8x8 blocks. In HM-2.0, conditional context dependency in significant_coeff_flag only exists in 16x16 and 32x32; mode dependent coefficient scanning (MDCS), which allows for vertical and horizontal scan in addition to zig-zag, is allowed only in 4x4 and 8x8. At the Dageu meeting, several contributions (JCTVC-D260, JCTVC-D363, JCTVC-D195) were made to eliminate dependencies on the most recently processed significant_coeff_flag positions to help with parallel processing. Proposal JCTVC-D260 was adopted since it eliminated diagonal dependencies, which is necessary for the zig-zag scan in 16x16 and 32x32 blocks. In JCTVC-E227, conditional context dependency in significant_coeff_flag exists in 8x8 which will lead to dependencies when used with the vertical and horizontal scans in MDCS. To avoid introducing dependencies, this contribution proposes removing conditional context dependency in significant_coeff_flag from 8x8 in JCTVC-E227. Coding efficiency of -0.02% AI, -0.01% RA, -0.09% LD was measured in high efficiency, while a context reduction of 11 is still achieved (compared to 24 in the original JCTVC-E227 proposal). TI made the modifications and results; proposal has been cross-checked by Panasonic (JCTVC-E491). This contribution proposes adoption of the modified JCTVC-E227 (N1: significant_coeff_flag change) into HM.

Discusses removing the conditional context dependency for the 8x8 level, for parallelism dependency reasons.

Cross-check in JCTVC-E491.

Decision: Adopted (modification of JCTVC-E227-related adoption).

JCTVC-E491 Cross-check report for TI's proposal on Modification to JCTVC-E227 (JCTVC-E489) [Hisao Sasai (Panasonic)] [late registration 2011/03/20 / uploaded 2011/03/20]

JCTVC-E338 CE11: Parallel Context Processing for the significance map in high coding efficiency [J. Sole, R. Joshi, M. Karczewicz (Qualcomm)]

In JCTVC-D262, a technique for the parallelization of context processing was proposed. The method separates syntax elements of the significance map to facilitate parallel processing. Significance coefficient flags and last significant coefficient flags are separated by encoding the position of the last significant coefficient before the position of the other significant coefficients within a block. The position of the last coefficient is encoded explicitly by signaling its X and Y coordinates with a unary code.

This contribution is part of CE11 and reportedly shows the results of the technique in HM2.0. The (luma) BD-rate impact for the high efficiency intra, random access, and low-delay configurations is reported as −0.03%, 0.01%, and −0.10%, respectively. For chroma, the BD-rate impact is reported as −0.02% for intra, −0.85% for random access and −1.90% for low delay. Thus, some (very small) coding efficiency benefit was reported.

The total number of bins is also reduced, both on average and in the worst case.

However, there is an increase in the number of contexts used.

The spirit of the proposal was described as similar to that of some TI proposals of the Guangzhou meeting.

Some new contexts were added for the significant coefficient flag (107 contexts increased to 170, according to JCTVC-E164. Some concern was expressed regarding this aspect.

JCTVC-E164 CE11: Cross-check report for Qualcomm's proposal JCTVC-D262 on Parallel Context Processing for the significance map [Hisao Sasai, Takahiro Nishi (Panasonic)]

The software was studied as well as tested and no difficulties were observed.

JCTVC-E344 Context reduction of the last transform position in JCTVC-D262 for CE11.1 [Cheung Auyeung, Wei Liu (Sony)]

(This was a new proposal contribution – not actually part of the related CE.)

JCTVC-D262 was studied in CE11.1 for the coding of the position of the last transform coefficient. This contribution reduces the number of contexts for coding the last transform coefficients proposed in JCTVC-D262 from 120 to 82 for YUV 4:2:0 video and with essentially the same BD performance. The result of this contribution was cross-checked by Panasonic.

This reportedly builds on JCTVC-E338. Relative to JCTVC-E338, there is some (very very small) improvement in (luma) BD average performance.

Decision: Tentatively (text and technical description to be reviewed), adoption of the following approach was planned (based on JCTVC-E403)

- "N1" part of JCTVC-E227, in combination with
- JCTVC-E344 refinement of
- JCTVC-E338

A BoG (coordinated by Joel Sole) was asked to produce text and more precise description of the above for review, as further discussed below.

JCTVC-E494 BoG report on the draft text for the combination of proposals JCTVC-E227, JCTVC-E338 and JCTVC-E344 [J. Sole (Qualcomm), C. Auyeung (Sony), H. Sasai (Panasonic)] [BoG uploaded 2011/03/20]

This document was the BoG report of the above-described activity, which was reportedly verified in JCTVC-E504 which is listed below.

Decision: Adopted.

In a later discussion, it was reported that an interaction had been found with the MDCS (mode-dep coef scanning), and a new document JCTVC-E489 had been submitted to discuss this – see notes elsewhere regarding refinement adopted from JCTVC-E489.

JCTVC-E504 Cross-check report of proposal JCTVC-E494 [C. Yeo (I2R)] [late registration 2011/03/22]

JCTVC-E172 Cross-check report for Sony's proposal on Context Reduction [Hisao Sasai, Takahiro Nishi (Panasonic)]

The software was studied as well as tested and no difficulties were observed.

JCTVC-E253 CE11: Coding of transform coefficient levels with Golomb-Rice codes [T. Nguyen (Fraunhofer HHI)]

This document reports the results on JCTVC-D336 – "Reduced-complexity entropy coding of transform coefficient levels using a combination of VLC and CABAC/PIPE". The main approach of the proposed method is to increase the number of bypass bins by coding the absolute transform coefficient levels minus 3 up to a specific maximum value with truncated Golomb-Rice codes. In theory, the upper limit of regular bins for the coding of transform coefficient levels can reportedly be reduced by a factor of 4.

An additional simulation on low QP was run to analyze the impact for high bit rates.

The proposal is to reduce the maximum number of bins per pixel of coefficient data was about 26 bin.

Two variations were described in the proposal. One was a bit different than in the original CE plan, including some VLC change.

The coding efficiency impact for this latest variation was approximately neutral (<0.1%) or, at low QP for AI, somewhat beneficial.

The VLC output goes through the bypass mode of CABAC.

The maximum bin count per pixel for context-modeled CABAC encoded coefficient bins was reportedly reduced to approximately 6 bins.

Text was provided.

Decision: Adopted.

JCTVC-E296 CE11: Adaptive coefficients scanning for inter-frame coding [J. Song (Huawei), M. Yang (Huawei), H. Yang (Huawei), H. Yu (Huawei)]

In this document adaptive coefficients scanning with three scanning patterns was investigated and tested. In JCTVC-D311, a scanning pattern for every Transform Unit (TU) is chosen based on the texture direction of a reference block and no flag is sent to the decoder side. In this proposal a modified adaptive coefficient scanning is contributed. One flag is explicitly signaled to the decoder side to indicate whether the scanning pattern is zigzag or the pattern based on the texture direction. If the scanning pattern is not zigzag, the texture direction is detected after the parsing procedure to determine the actual residual block. Experimental results reportedly show that the modified scanning provides 0.3% and 0.8% BD-rate gain for random access, and low-delay test conditions, respectively, in high efficiency (HE) configurations.

This is not the same as what was planned to be tested in the CE – it is a new proposal. In the new proposal, the decoder can parse the data without accessing the texture.

The complexity of the encoder and decoder are increased by the (new) proposal (relative to the current HM reference).

As proposed, it is necessary to perform texture detection and perform a transposition before performing the inverse transform in the decoder. It was remarked that, in addition to increasing complexity, this introduces a serialization dependency (not allowing the inverse transform to be performed before those other steps).

The chroma scanning pattern is matched to the luma scanning pattern.

A participant asked why this idea had only been tested in the HE case rather than also in the LC case.

We try to avoid differences between the HE and LC designs.

Some investigation seems needed that would go beyond a CE, since application to the LC case is not defined.

For further study (e.g., in entropy coding AHG).

JCTVC-E255 CE11: Cross-check of JCTVC-E296 (JCTVC-D311) Adaptive coefficients scanning for inter-frame coding [T. Nguyen (Fraunhofer HHI)]

The cross-checker said that the current software implementation of the proposal does not seem adequate.

JCTVC-E150 CE11.B: Cross-check report for JCTVC-E296 [J. Xu (Microsoft)] [late upload / missing prior]

The cross-checker did not study the software very closely and could not comment on its quality.

JCTVC-E300 CE11: Cross check of Qualcomm JCTVC-D262 on parallel context processing for the significance map in high coding efficiency [Cheung Auyeung (Sony)]

JCTVC-E326 CE11: Cross-verification of HHI's (JCTVC-D336) Coding of transform coefficient levels with Golomb-Rice codes [V. Sze (TI)]

JCTVC-E392 CE11: Adaptive Coefficient Scanning for LCEC [X.Wang, L. Guo, M. Coban, M. Karczewicz (Qualcomm)]

This document reports the results of Qualcomm’s CE11 adaptive coefficient scanning method for LCEC. Counter based adaptation is used for coefficient scanning in intra block coding. The average bit rate savings are reported as 1.0%, 0.4% and 0.0% for AI LC, RA LC and LD LC cases, respectively. On average there is a reported 2% running time increase at the encoder and the decoder.

The proposal involves some complexity increase.

It was asked why this proposal is only used for LCEC. The proponent indicated that they had assumed that CABAC had sufficient built-in adaptivity, but had not really studied the opportunity for unification or applicability of the proposal.

It was remarked that the designs for CABAC and LCEC seem to be drifting apart randomly.

Note: It was agreed that CAVLC seems like a better (more neutral) name than LCEC.

It was asked how far apart CAVLC and CABAC are currently in terms of coding efficiency – and roughly 8% on average was suggested as an estimate. It was suggested that an information document be provided with details.

The status of text drafting on the subject was discussed. The proponent indicated a willingness to help produce appropriate text for CAVLC in general. It was agreed that technical work on CAVLC design will not be done at the next meeting if the situation has not dramatically improved. Cisco volunteered, as one of the original proponents of the CAVLC design, to provide the basis text for CAVLC work – tentatively within two weeks after the meeting.

A participant indicated that speed optimization of implementations would be adversely affected by this proposal.

The proposal affects all block sizes. In the existing HM design prior to this meeting, only 64 coefficients maximum are sent in the CAVLC case. The proponent indicated that only the first 64 coefficients should be adapted to avoid excessive extra complexity for handling the high frequency coefficients.

JCTVC-E100 CE11: Cross-check of Qualcomm's proposal on adaptive scans [C. Yeo (I2R)]

The software was studied as well as tested. No difficulties were reported.

JCTVC-E132 CE11: Cross-check report of Qualcomm's Adaptive Coefficient Scanning for LCEC (JCTVC-D374) by SHARP [Y.Yasugi, T. Yamamoto (SHARP)]

The software was studied as well as tested. No difficulties were reported.

JCTVC-E357 CE11: Cross-check report from Motorola Mobility for Qualcomm's adaptive coefficient scanning for LCEC (JCTVC-E392) [J. Lou, K. Panusopone, L. Wang (Motorola Mobility)] [late upload]

The software not actually studied. However, no difficulties were reported.

14.3 Discussion and Conclusions

15 CE12: Deblocking filter

15.1 Summary

JCTVC-E032 CE12: Summary report of core experiment on deblocking filtering [Andrey Norkin, Byeungwoo Jeon, Matthias Narroschke] [late upload]

This contribution is a summary report on Core Experiment 12 (deblocking filtering). There are two subsets in CE12. Subset 1 comprises proposals aimed at improving subjective and objective performance of deblocking filtering. Subset 2 comprises approaches that address parallelization aspects of deblocking filtering. Subset 1 contains four proposals and Subset 2 contains two. All the proposals are based on HM2.0 and experiments are performed according to the common test conditions provided in JCTVC-D600. All results are verified by cross-checkers.

Cross-checkers often commented that it is difficult to visually distinguish between HM anchor and other methods.

In terms of encoder and decoder runtime in the parallelization case, it can at most give information that the parallelization does not affect the runtime in sequential processing.

15.2 Contributions

15.2.1 Subset 1: Deblocking filters improving objective or/and subjective performance

JCTVC-E079 CE12 Subtest 1: Improved Deblocking Filter [J. An, Q. Huang, X. Guo, Y.-W. Huang, S. Lei (MediaTek)]

This contribution proposes a deblocking filter which is based on the deblocking filter in HM2.0 and the previous contribution of JCTVC-D163. Some modifications are made in luma filter and chroma filter including filter decision, filter selection and weak filter operation. It is reported that the average BD-rate reductions between 1.2% and 1.7% for six configurations (HE-AI, LC-AI, HE-RA, LC-RA, HE-LD and LC-LD) can be observed for luma and chroma component, respectively. Moreover, the encoding and decoding time of proposed deblocking filter is essentially the same to that of the anchor.

Modifications for luma: Boundary strength, filter conditions (based on TU rather than PU boundary), thresholds/clipping (add one more threshold), weak operation.

Modifications for chroma: Decision and unit size.

Uses same filter for LC and HE.

One cross-checker commented that the filter settings are closer to AVC deblocking than the current HM.

How was the lookup table designed? Using a sub-set of the test sequences at various QPs (tuned to test set?)

One cross-checker (also proponent of JCTVC-E417) reports that the HM lookup table seems to be better suitable for inter, whereas the AVC lookup table is better for intra.

4x4 deblocking is introduced for chroma – one expert notes that an advantage of HEVC is that smallest blocksize for DF is 8x8, 4x4 could be an implementation burden.

Results are also shown in a presentation deck about a combination of this method with the method of JCTVC-E276 (luma deblocking from JCTVC-E276 and chroma from JCTVC-E079) – will be uploaded in a revised version.

It is reported that more of such combinations are planned and shall be included in the visual test. Question is raised in how far this is useful and would lead to any evidence for a decision.

This filter is certainly more complex (in terms of decision) than the current HM filter. It was remarked that reduction of deblocking complexity (compared to AVC) is an advantage of HEVC.

JCTVC-E071 CE12 Subset1: Cross-verification of MediaTek's proposal JCTVC-E079 [Ikeda Masaru, Suzuki Teruhiko (Sony)]

JCTVC-E256 CE12 subset 1: Cross verification of MediaTek’s deblocking by Ericsson [Kenneth Andersson, Andrey Norkin, Rickard Sjöberg (Ericsson AB)]

JCTVC-E144 CE12 Subset 1: Deblocking for large size blocks [Z. Shi (USTC), X. Sun (Microsoft), J. Xu (Microsoft)]

This document presents a deblocking scheme for large size blocks to reduce blocking artifacts. For large smooth regions with small variation, an extra smoothing deblocking mode is introduced to suppress the visually severe blocking artifacts. It is observed that the proposed method can reduce blocking artifacts in smooth regions, which are usually more visible to human eyes.

Additional conditions are set depending on neighboring TU sizes. Slightly more complex than current HM deblocking filter. No effect on BD rate/SNR

JCTVC-E311 CE12 Subset1: Cross-verification of Microsoft's proposal JCTVC-E144 [J. An, X. Guo (MediaTek)] [late upload / missing prior]

JCTVC-E276 CE12.1: Ericsson deblocking filter [Andrey Norkin, Kenneth Andersson, Rickard Sjöberg (Ericsson)]

This contribution proposes a deblocking filter developed from the current HEVC deblocking filter. The proposed filter provides an average BD-rate reduction of 1% on the six common test configurations. The decoding time is reported to be 99.9% of HM2.0. It is reported that the subjective performance of the proposal is better than HM 2.0.

Modifications of current deblock filter:

- Different delta values for p1 and q1
- Check for natural edges (requires additional comparison of dp and dq at both sides)
- Decision whether to filter one or two pixels
- Chroma: Perform filtering when there are coefficients in one of the adjacent blocks (current filter is claimed to be too weak for chroma in low delay)

Otherwise, HEVC deblocking filters are more unchanged (no modification of thresholds).

-0.7/-0.9 for AI HE/LC, -0.9 for RA in both, -1.5/-1.2 for LD HE/LC.

In case of natural edges that are not filtered and filter length are reduced in some cases from 6 to 4, it is claimed that the complexity is reduced. Otherwise, the detection of natural edges increases number of operations, which may occur in worst case. Furthermore, a division by 6 is included (once per edge).

Comment of one cross-checker: Homogeneity test independent on both sides is similarly used by JCTVC-E079 and JCTVC-E417. Improvement is assumed to be rather from separate inequality test rather than using separate delta.

JCTVC-E171 CE12: Verification results of Ericsson's Proposal JCTVC-E276 [T. Yamakage, S. Asaka (Toshiba)]

JCTVC-E270 CE12.1: Cross-verification of the deblocking filter from Ericsson (JCTVD-E276) by Samsung [V. Seregin, J. Chen (Samsung)]

JCTVC-E310 CE12 Subset1: Cross-verification of Ericsson's proposal JCTVC-E276 [Q. Huang, J. An, X. Guo (MediaTek)] [late upload / missing prior]

JCTVC-E418 CE12 Subset1: Cross-verification Results of Ericsson Deblocking Filter (JCTVC-E276) by SKT/SKKU [Jungyoup Yang, Kwanghyun Won, Byeungwoo Jeon, Jeongyeon Lim (??)]

JCTVC-E417 CE12 Subset1: SKT/SKKU Deblocking Filter [Jungyoup Yang, Kwanghyun Won, Byeungwoo Jeon, Jeongyeon Lim (??)] [late upload]

This contribution proposes a deblocking filter modified from the one in the HM2.0 with special attention to intra coded blocks. It is reported that the proposed filter has BDBR gain of 1.2% (HE_IO) and 1.1% (LC_IO) with approximately the same encoding and decoding time compared to HM2.0. The subjective quality of the proposed method is also reported to be similar to that of the HM2.0 anchor.

Inter coded blocks are handled the same way as in the HM. Modifications for intra coded blocks are:

- 5 boundary strength values (instead of 2 in HM)
- Filtering decision (additional condition for second positions)
- Modified weak filter: Only 4 pixels instead of 6

Results: AI -1.2/-1.1, RA -0.9/-0.5, LD -1.3/-0.6 for HE/LC

Filtering of chroma was modified in version 2 of the contribution. In v1, chroma is sometimes wrongly filtered, as HM software decides based an BS values. Further tc settings for intra blocks modified. In total, v2 gave slightly better gain (and particularly no losses for chroma).

Comment: Again, this is closer in many respects to the AVC filter rather than the HM.

JCTVC-E500 Cross-check report of SKT/SKKU Deblocking Filter (JCTVC-E417) [J. Kim, M. Kim(KAIST), S. Cho(ETRI)] [late registration 2011/03/21]

JCTVC-E151 CE12: Cross-check report for JCTVC-E417 [J. Xu (Microsoft)] [late upload / missing prior]

JCTVC-E467 CE12 Subset1: Cross-check of SKT/SKKU's proposal on Deblocking Filter (JCTVC-E417) [Y. H. Tan, C. Yeo (I2R)] [late registration 2011/03/17 / uploaded 2011/03/18]

15.2.2 Subset 2: Parallel deblocking filters

JCTVC-E181 CE12 Subset2: Parallel deblocking filter [Ikeda Masaru, Tanaka Junichi, Suzuki Teruhiko (Sony)]

In this contribution, parallel deblocking filter for HEVC is proposed. The proposal includes the followings:

- Parallelization of filtering
- Line-based filtering decision
- Parallelization of filtering and filtering decision

Parallelization of filtering can provide both frame-based processing for SW and LCU-based processing for HW. Y BD-rate for the parallelization of fitering (item2) is 0.0/0.0/0.0/0.0/0.0/0.0% for AI/AI_LC/RA/RA_LC/LD/LD_LC in average. Subjective quality is the almost same as HM-2.0. Run-time increases slightly and they are small enough, and additional memory isn't required, but slight latency is required in LCU-based processing.

Line-based filtering decision can decide strong filter/weak filter/no filtering for each line in 8x8 block boundary. Y BD-rate for line-based filtering decision with parallelization of filtering (item3) is -0.1/-0.1/-0.2/-0.2/-0.4/-0.3% for AI/AI_LC/RA/RA_LC/LD/LD_LC in average. Subjective quality is reportedly improved in some cases such as BQMall. Runtimes increase slightly and they are small enough, additional memory isn't required and the modification is quite simple.

Parallelization of filtering and filtering decision can provide further flexibility than parallelization of filtering. Y BD-rate for the parallelization of filtering and filtering decision (item1) is 0.1/0.1/0.1/0.1/0.1/0.1% for AI/AI_LC/RA/RA_LC/LD/LD_LC in average.

Consists of two components: Filtering parallelism (item 2) and decision parallelism (item1). Both are tested independently, and then in combination (item 3).

Include item 3 in subjective viewing of CE12 Subtest 1.

It is claimed that the only disadvantage in non-parallel processing comes due to additional latency, no additional memory requirement.

The current implementation is frame based.

JCTVC-E257 CE12: Cross-check results of the parallel deblocking filter of Sony (JCTVC-E181) [Matthias Narroschke, Semih Esenlik (Panasonic)]

JCTVC-E314 CE12 Subset 2: Cross-Verification of Sony's Parallel Deblocking Contribution (JCTVC-E181) by Qualcomm [G. Van der Auwera, I. S. Chong, M. Karczewicz (Qualcomm)]

JCTVC-E224 CE12: Results for parallel deblocking filter decisions [Matthias Narroschke, Thomas Wedi (Panasonic)]

This contribution is a part of the CE12, Subset 2: It presents the results for the Parallel deblocking filter decisions which was presented first in JCTVC-D214. For the deblocking of a current coding unit, it is proposed to perform all required decisions based on the unfiltered signal of the current coding unit. This has dependencies which are present in the current HM2.0 deblocking filter design. The dependencies increase the parallel processing capabilities of the deblocking filter. As a consequence, the sequential operations in the critical path required for the decision and filtering operations of the deblocking filter are reduced by 30%. Experiments following the common conditions reportedly show that the BD-bit rate stays unchanged for the luminance signal and almost unchanged for the two chrominance signals. An increased subjective quality is reportedly noticeable at the same bit rate.

Current HM makes decision and filtering steps of horizontal and vertical independent of each other.

With the proposal, dependent sequential operations in deblocking one CU are reduced from 44 to 32.

Parallel process is for decisions, but subsequent filtering is the same as HM.

How much memory is needed to store the decisions? Up to 14 bits for 64x64 CU.

It is said that ~~already~~ a merged software already exists which however was not run yet. The proponent was asked to report back when a description of the combination exists and after a "sanity check" was run with the software.

JCTVC-E070 CE12 Subset2: Cross-verification of Panasonic's proposal JCTVC-E224 [Ikeda Masaru, Suzuki Teruhiko (Sony)]

JCTVC-E312 CE12 Subset 2: Cross-Verification of Panasonic's Parallel Deblocking Contribution (JCTVC-E224) by Qualcomm [G. Van der Auwera, I. S. Chong, M. Karczewicz (Qualcomm)]

JCTVC-E496 Results for a straight forward combination of parallel deblocking techniques JCTVC-E224 and item 2 of JCTVC-E181 [M. Narroschke (Panasonic), M. Ikeda (Sony)] [late registration 2011/03/21]

This contribution presents BD-bit rate results for a combination of the two parallel deblocking filter proposals JCTVC-E224 from Panasonic and JCTVC-E181, item 2, from Sony.

Decision: Adopt combination of JCTVC-E181 item 2 (parallel filtering) and JCTVC-E224 parallel decision procedure, as in JCTVC-E496.

15.3 Discussion and Conclusions

JCTVC-E501 BoG report on subjective viewing test for deblocking filter proposals [Andrey Norkin, Kenneth Andersson, Keiichi Chono, In Suk Chong, Matthias Narroschke, Byengwoo Jeon, David Flynn] [BoG report / uploaded 2011/03/22]

This contribution is a report of the break-out group on informal subjective viewing for the deblocking filtering that was held during the Geneva meeting on 19 March 2011. The subjective viewing was conducted according to the mandate of core experiment 12 on deblocking filtering JCTVC-D612. The goal of informal subjective viewing test was to determine how the deblocking filter proposals affect the subjective quality.

Only a small subset of sequences was selected where it was expected that largest differences would be visible

Some problems were experienced with the player software (random frame drops, background).

In general, differences are rather small with overlapping confidence intervals.

Seems that the adopted parallel processing approaches cannot be distinguished from the anchor.

One expert mentioned that this was acombination of critical viewing test and randomized test, whereas for the small differences that can be expected here, a critical viewing test by experts may be more useful.

Which of the proposals is keeping complexity the same or reducing complexity? None.

Experts who have not participated in this CE expressed some concern about complexity increase.

One expert expressed concern about JCTVC-E144 about the compatibility with parallel deblocking methods regarding the length of the filter that was used.

Conclusion: Continue CE, work on combinations of methods as much as possible to strip down the set of candidate technologies, discuss and establish test procedures for critical viewing, include "simple" modifications (treshold parameters as e.g. done in CE8 SS1) of existing deblocking filter.

16 CE13: Sample adaptive offset

16.1 Summary

JCTVC-E033 CE13: Summary report of core experiment on sample adaptive offset [Y.-W. Huang (MediaTek)] [late upload]

This contribution is a summary of Core Experiment 13 (CE13) on sample adaptive offset. In CE13, six different cases were tested. Each test was conducted by the proponent and a crosschecker. Common test configurations in JCTVC-D600 were used in all experiments. It is reported that sample adaptive offset achieves 0.5%, 1.3%, 2.2%, 0.7%, 1.8%, and 3.0% bit rate reductions for HE AI, HE RA, HE LD, LC AI, LC-RA, and LC-LD respectively with roughly unchanged encoding time and 1-3% decoding time increase. The decoding process of the sample adaptive offset is LCU-independent, which means the number of line buffers required on the decoder side is zero.

16.2 Contributions

JCTVC-E049 CE13: Sample Adaptive Offset with LCU-Independent Decoding [C.-M. Fu, C.-Y. Chen, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)]

This contribution reported the results of CE13 for evaluating MediaTek's proposal on sample adaptive offset (SAO) including band offset (BO) and edge offset (EO). BO and EO classify pixels by intensity interval and 1-D pixel patterns respectively. One offset is derived for each category of pixels. A picture can be divided into multiple regions aligned with largest coding unit (LCU) boundaries, and each region is allowed to switch between BO and EO. The SAO decoding process of an LCU does not require any data from other LCUs; i.e. the SAO decoding process is LCU-independent and does not need any line buffer. Compared with the JCTVC-D600 anchor, SAO reportedly shows 0.5%, 1.3%, 2.2%, 0.7%, 1.8%, and 3.0% bit rate reductions for HE-AI, HE-RA, HE-LD, LC-AI, LC-RA, and LC-LD, respectively, with unnoticeable encoding time increase and 1-3% decoding time increase.

In contrast to previous contribution, an additional line buffer is not necessary. The relevant change is that the method is not appied at LCU boundaries.

Does this lead to visual artifacts? According to the cross-checker (Samsung) this is not the case.

What is the interaction with weighted prediction? This was not tested.

It is said by the cross-checker that by tendency the method has an edge-sharpening effect which would not be the case with weighted prediction.

JCTVC-E332 CE13: Cross-Verification of MediaTek's adaptive offset [I. S. Chong, M. Karczewicz (Qualcomm)]

JCTVC-E385 CE13: Cross checking of case 3 and case 4 of JCTVC-D122 on picture quadtree adaptive offset proposed by MediaTek. [Ali Tabatabai, Cheung Auyeung, Ehsan Maani (Sony)] [initial version rejected (placeholder) – version 2 late upload]

JCTVC-E389 CE13: Cross-verification for MediaTek's test (JCTVC-E049) by Samsung [E. Alshina, I.-K. Kim, W.-J. Han (Samsung)]

The report will be updated by the information that the method was inspected visually.

Gain with AO on, ALF off:

HE RA: 1.3, LC RA 1.8 HE LD 0.9 LC LD 2.5

This indicates that gains with ALF are additive. Therefore the method should be adopted for both LC and HE cases.

16.3 Discussion and Conclusions

Decision: Adopt for both LC and HE.

17 CE14: Intra mode coding

17.1 Summary

JCTVC-E034 CE14: Summary report of core experiment on intra mode coding [S. Lei (MediaTek)] [late upload]

This contribution is a summary of core experiment 14 (CE14) on intra mode coding. There are two Subtests described in CE14 description document, JCTVC-D614. Subtest 1 is the Most Probable Mode Signaling for luma and Subtest 2 is Intra Mode Derivation with Multiple Predictor Sets (MPS) technology.

There are three test reports from three proponents for Subtest 1, respectively. Each report was confirmed by at least two cross-checkers. Two of the three reports are exactly matched and bitstream exchanges can be done. These two reports reported 0.5% BD-rate gain for both the high-efficiency and low-complexity intra only configurations. These two reports also reported essential the same encoding time and decoding time as those of anchor JCTVC-D600. The third report reported less BD-rate gain. The Subtest 2 was withdrawn by its proponent because of lack of gain.

17.2 Contributions

JCTVC-E088 CE14 Subtest 1: Intra Most Probable Mode Coding for Luma [M. Guo, X. Guo, S. Lei (MediaTek)]

JCTVC-E105 CE14 Subtest 1: Cross-check report from Institute for Infocomm Research [H. L. Tan, Y. H. Tan, C. Yeo (I2R)]

JCTVC-E131 CE14.1: Results for DOCOMO's proposal and cross verification of MediaTek's implementation for the most probable mode signalling for luma. [TK Tan (NTT DOCOMO)]

JCTVC-E136 CE14: Test Results for Intra Mode Coding by Multiple Mode Candidates [Wenpeng Ding (??)]

JCTVC-E210 CE14 subtest 1: Cross check report of BUT's proposal (JCTVC-E136) from Toshiba [A. Tanizawa, T. Shiodera (Toshiba)]

JCTVC-E268 CE14.1: Cross-verification of the most probable mode signalling for luma (JCTVC-E131) [J. Chen (Samsung)]

JCTVC-E313 CE14 Subset 1: Cross-verification of NTTDOCOMO's Proposal JCTVC-E131 [M. Guo, X. Guo (MediaTek)]

17.3 Discussion and Conclusions

Text was provided in JCTVC-E131 for subtest 1, and was reviewed. The Mediatek and Docomo implementations (JCTVC-E088 and JCTVC-E131) were considered more mature than JCTVC-E136.

The group appreciated that text had been provided.

Decision: Adopted subtest 1 as in JCTVC-E088 / JCTVC-E131.

Subtest 2 was withdrawn.

18 Non-CE Technical Contributions

18.1 Clarification and Bug Fix Issues

JCTVC-E395 HM2 Chroma Intra Coding Description [Ali Tabatabai (SONY), Shawmin Lei (Media Tek), Oscar Au (HKUST)] [initial version rejected, version 2 includes patent statement]

This document describes the chroma intra prediction mode coding in the HM2.0 encoder based on the adopted technologies JCTVC-D255, JCTVC-D166 and JCTVC-D278.

See notes in section discussing JCTVC-E407.

JCTVC-E407 HM2.0 Chroma Intra Coding Description for WD2 [Xun Guo (MediaTek), Ali Tabatabai (Sony), Oscar Au (HKUST)] [initial version rejected]

This document describes the chroma intra prediction mode coding in HM2.0 for WD2 based on the adopted technologies in JCTVC-D255, JCTVC-D166 and JCTVC-D278.

JCTVC-D255/JCTVC-D278 vs. JCTVC-D166 were different in swapping two table entries 1111 <-> 1110. In further investigations, it was reported that the solution of JCTVC-D166 has slightly better compression perfomance, most likely due to the better adaptation of CABAC contexts.

Decision: Use the suggested solution of JCTVC-E407 in WD3 (was in fact already integrated in HM2.0 software, even though it slightly deviates from the original decision of the 4th meeting which referred to JCTVC-D255 while assuming that JCTVC-D278 and JCTVC-D166 are exactly the same).

JCTVC-E433 Proposed text of JCTVC-D260 for WD2 [Cheung Auyeung, Wei Liu (Sony)]

The HM2.0 adopted a parallel processing friendly and lower complexity alternative to the context selection of the significance map in TMuC 0.9 from JCTVC-D260. This contribution provides JCTVC-D262 text for WD2.

The technology was integrated in HM2.0 software, but not in HM and WD text. No change was proposed relative to the original contribution, so it was concluded to use this for drafting of the WD3 text.

JCTVC-E485 Report on fix of CBF for RDOQ [T. Nguyen, M. Siekmann (HHI)] [late registration 2011/03/19]

It was observed that the chrominance PSNR is dropped by up to 1 dB in the HE configuration when RQT is disabled in the very first version of the TMuC software ("Ticket 85"). The workaround was to set the CBF probability to 0.5, which results in the same behavior for the case when RQT is disabled (1 dB gain for chroma). This document reports results for assigning correct probabilities to the CBF flag for RDOQ in the HE configuration.

It is mentioned by W. J. Han that this bug has existed for a long time and that this proposal is a reasonable fix.

The BD rates for chroma are significantly increased, whereas luma is decreased (for all three cases: AI, RA, LD). Apparently, rate is shifted from chroma to luma, whereas PSNR is largely unchanged.

Decision: Adopt this bugfix as switchable option (enabled by default).

18.2 HM Settings and Common Test Conditions

JCTVC-E361 Supporting one list only coding for HM [J. Lou, K. Minoo, D. Baylon, K. Panusopone, L. Wang (Motorola Mobility)] [late upload]

Complexity (and memory access bandwidth in particular) is an important consideration. Single-list (uni-predictive) coding is reportedly preferred for these applications. However, the current HM test conditions exclude single-list coding, and it was asserted that there is some risk that this type of coding mode may not receive adequate study as the HEVC standard design is finalized. This document requests modifications to HM common test condition to include the single-list coding case.

Compared to current LC-LD configuration, it was estimated that the encoding time would be decreased by 47%, and decoding time by 15% by the use of single-list encoding.

In this context, the reference to single-list encoding refers to encoding without use of biprediction (i.e., P slices in the AVC sense).

It was suggested that it would not be advisable to replace LD overall by a "P-only" configuration, as this would not achieve the highest compression performance. Likewise, it was suggested that it would not be advisable to redefine only the LC variation of the LD cases.

The group agreed that definition of such a low-delay configuration with "P-only" configuration (GPB off) would be interesting for selected CEs (such as interpolation filters), and that such a configuration should be defined for such a usage (mandatory only within selected CEs), both for HE and LC.

Note that this does not change the syntax or decoding process of the design, but rather is only the definition of additional test configurations to be used for some experiments.

18.3 Source Video Test Material

JCTVC-E139 Test Material for Screen Content coding [Wenpeng Ding (??)] [late upload]

Did not need presentation (covered by AHG & BoG report).

JCTVC-E176 Test sequences for screen content coding [Xingyu Zhang, Oscar C. Au, Xing Wen, Jingjing Dai (HKUST)]

Did not need presentation (covered by AHG & BoG report).

JCTVC-E305 Video Test Material Submission for Screen Content Coding [G. Cook, W. Gao, D. Wang, J. Zhou, H. Yu (Huawei)]

This contribution consists of a submission of nine test sequences in response to W11867, "Request for Video Test Material for 'Screen Content' Coding Experiments". Copyright statements as well as descriptions of the sequences and the creation process of the sequences were included. The sequences consist of camera-view content with text overlays and scrolling text, and camera-view content with document editing, scrolling and window switching. By construction, the sequences are free of compression. It was also noted that, compared to the HM2.0 anchor sequences, the compression of these sequences leads to quite varied results, including both significant increases and decreases of the BD-rate.

Comment: It would be interesting to try other colors for the banner.

Viewing of the compressed sequences was done during the meeting (and announced on the reflector).

JCTVC-E493 BoG report on Screen Content Coding (SCC) [Oscar Au, Jizheng Xu, Haoping Yu] [BoG uploaded 2011/03/20]

This contribution provides a summary of two sessions of SCC test material subjective viewing held at 4pm and 6pm on 18 March 2011, and the Break Out group meeting on Screen Content Coding (SCC) held at 6:30pm on 18 March 2011.

- Test sequences were shown.
- Copyright issues may need to be clarified (not for the statements as delivered, but for content contained within the scenes).
- Particularly, edited use of existing test sequences must be clarified with copyright owners.

Recommended for study in an AHG:

- Make an assessment which of the sequences are critical for HEVC, and which are the appropriate rates/QP settings for screen content coding evaluation
- Only the Huawei sequences currently come with coding results

18.4 Application-Specific Topics

JCTVC-E061 Requirements of very low delay applications [K.Kazui, J.Koyama, S. Shimada, A. Nakagawa (Fujitsu)]

This contribution states that the high-level syntax and semantics for very low delay coding based on the intra MB line refresh scheme, proposed in JCTVC-B031, JCTVC-C021 and JCTVC-D054, are needed to satisfy the requirement of the real-time video transmission applications with the minimal loss of coding efficiency. Real-time video transmission applications, such as on-the-spot broadcasting and TV conference over a wireless channel, requires correct reconstruction of the decoding picture when the decoding process restarts from a recovery point due to the bitstream error caused by an erroneous transmission channel.

Some confusion was expressed in regard to recognizing that this contribution is in fact a specific technology proposal rather than just an advocacy for application requirements.

It was asked why the demonstrated drift error shows up as green color deviations, whereas the luminance seems to be OK? A: For the refresh, the buffer is initialized as zero. (Perhaps initialization the neutral color would be better.)

It was noted that this functionality could likewise be done by using slice coding tools, and asked why not to use slice coding. It was indicated that the implementation in HM 0.9 did not contain the current slice implementation yet.

It was suggested that when horizontal slices would be used, the bit-rate variations would be too large (and commented that this is rather a problem of rate control, as not enough bits may be left for the inter parts)

The proposal could also relate to the tile concept, and associated buffer models.

Ultra-low delay is a reasonable requirement, but this specific tool – which would then need to be implemented by any decoder – would not necessarily be something we would embrace without more careful investigation about alternatives.

JCTVC-E145 Intra and inter coding tools for screen contents [C. Lan (Xidian Univ.), X. Peng (USTC), J. Xu (Microsoft), F. Wu (Microsoft)]

Two intra coding tools, RSQ and BCIM, were presented for coding screen contents using AVC framework in JCTVC-B084 and TMuC0.7 in JCTVC-C276. In this document, a lossless LZ tool based on LZMA is presented to further improve screen image coding. The previous two tools were extended to support inter-frame coding and corresponding tools were developed accordingly to improve the coding efficiency of screen content video sequences. The coding performance of these tools in the HM2.0 context were tested for intra coding and low delay cases.

(The presentation slide deck had not been uploaded when presented.)

Intra coding tools included Residual scalar quantization, base colors and index map, Lempel-Ziv EC.

Inter coding tools included Motion-Compensation-Aided Base Color and Index Map, Motion-Compensated Residue Base Color and Index Map, and Motion-Compensated Residue Scalar Quantization.

Coding results were shown.

It was asked why extreme PSNR values (around 60 dB) were reported? It was argued that with the nature of the data, this is the range of required visual quality.

One expert commented that measuring running the HM with another distortion measure (such as maximum deviation) might give better performance

It was asked what is the frame rate? Would, e.g., 10 frames per second be sufficient?

It was asked whether color correction was done? One expert mentioned that this kind of content would be equivalent to gamma corrected.

It was remarked that (among the results shown) LZ performs almost best at least for intra.

It was asked what are the relevant bit rates and quality ranges?

It appeared that there are many questions that the AHG needs to resolve after selection of the test material, particularly exploring reasonable quality/rate ranges for applications that make extensive use of screen content.

JCTVC-E431 Spatial Scalability for HEVC [Koohyar Minoo, David Baylon, Ajay Luthra (Motorola Mobility)]

(Reviewed Tuesday in a joint meeting session with VCEG and MPEG Requirements.)

Scalability in video coding allows for efficient delivery of video at different qualities or resolutions. This contribution presented an approach that provides for scalability with HEVC. In particular, the focus is on spatial scalability. For factor-of-two scalability in both the horizontal and vertical directions, results of the proposed approach for Class B through Class E sequences using HM 2.0 reportedly show an average luma BD bit rate savings over simulcast of 30% for the Intra Low Complexity case.

(The presentation slide deck had not been uploaded prior to the presentation.)

The contribution proposes "Decomposition based scalable coding" which is a non-overcomplete representation.

The method was not described in detail. Results were presented for intra-only, reported to be relatively close to single layer.

Further study was encouraged.

18.5 Loop Filtering

JCTVC-E251 Decisions for deblocking [Matthias Narroschke, Thomas Wedi (Panasonic)]

In the HM2.0, one single decision for enabling the deblocking is performed for each edge segment of eight columns/lines using two calculated decision values. In contrast to the HM2.0, H.264/MPEG-4 AVC uses eight individual decisions based on eight individually calculated decision values for each edge segment. The change of the decisions to ones similar as in H.264/MPEG-4 AVC can reduce the BD-bit rate by 0.2% in average over all test cases. However, the calculation of additional decision values is associated with additional computational expense. In order to achieve this BD-bit rate reduction at a lower additional computational expense, it is proposed to modify the decisions according to a compromise between the current HM2.0 and AVC. The proposed compromise performs eight individual decisions but needs to calculate only four decision values for each edge segment. The same average BD-bit rate reduction of 0.2% is achieved compared to HM2.0 (I-HE: 0.1%, I-LC: 0.1%, RA-HE: 0.2%, RA-LC: 0.2%, LD-HE: 0.3%, LD-LC: 0.3%) with approximately no encoder/decoder run time increases. For the low delay high efficiency configuration, an average BD-bit rate reduction of 0.7% was reportedly achieved for the Class E sequences. Increased subjective quality is reportedly noticeable at the same bit rate.

It was agreed to include JCTVC-E251 in the subjective viewing of CE12 Subtest 1 – see remarks in the section discussing JCTVC-E501.

JCTVC-E476 Cross-Verification of Panasonic's Contribution (JCTVC-E251) by Qualcomm [G. Van der Auwera] [late registration 2011/03/17]

Confirmed the results, but did not check the codebase.

JCTVC-E190 Adaptive loop filtering using directional activity [Kei Kawamura, Tomonobu Yoshino, Sei Naito (??)]

HM2.0 employs QC-ALF as an adaptive loop filtering approach. QC-ALF classifies each pixel based on activity of the decoded pixel value, and Wiener filter coefficients are calculated for every category. However, QC-ALF doesn't consider activity direction when evaluating the activity. Thus, it is reportedly difficult to design an appropriate loop filter for the texture with various edge directions. This contribution proposes a loop filtering approach that considers the activity direction to evaluate the activity from the result of a Laplacian operation. Experimental results reportedly show that BD-rate differences against HM2.0 are -0.3% and -0.4% for LD/HE and RA/HE, respectively.

It was asked whether the number of encoding passes was reduced from 16 to 9?

Apparently it is rather a reduction to 9 filter categories, depending on horizontal/vertical activities.

HM 2.1 one-pass encoding still has 16 filters.

It was discussed whether this proposal had any benefit over the method of JCTVC-E323 that has been adopted? The answer did not seem obvious.

JCTVC-E194 Unified Chroma Filter Shape with Luma for ALF [T. Yamakage, T. Watanabe, T. Chujoh (Toshiba), C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek), M. Karczewicz, I.S. Chong (Qualcomm)]

This contribution presents coding results of replacing adaptive loop filters for chroma with the same shape as used for luma. There was reportedly no coding efficiency loss for luma, but 0.2-0.7% losses for chroma, with savings in decoding time of 1-4%. Coding results were confirmed by TI. Encoding and decoding time have discrepancies which can be attributed to differences of the test operating environments. The contributor proposed to replace the current rectangular shape with the same shape as luma in order to reduce the complexity.

Even though 5x5 diamond was used, the syntax would allow up to three sizes.

It is also emphasized by one participant that the freedom of choosing a larger size would be desirable

It is reported that a 7x7 diamond would approximately reproduce the coding efficiency of the 5x5 rectangular scheme.

JCTVC-E237 Verification results of Toshiba, MediaTek, Qualcomm's contribution on chroma ALF (JCTVC-E194) [M. Budagavi (TI)]

JCTVC-E287 Chroma ALF with reduced vertical filter size [M. Budagavi, V. Sze, M. Zhou (TI)]

This contribution analyzes implementation complexity of Chroma Adaptive loop filter (ALF) at the decoder. Implementation complexity is measured in terms of computations and memory bandwidth/memory size (area). This contribution discusses Chroma ALF filters that reduce vertical size of filter thereby reducing the line buffer/memory bandwidth requirements. Three Chroma ALF filters are proposed: 9x3, 7x3, and 5x3 rectangles. The proposed filters have a maximum vertical size of 3 and are reported to reduce memory bandwidth/memory size requirements by 50% when compared to HM 2.0 chroma ALF filter. The worst case multiplications for HM 2.0 chroma (5x5), 5x3, 7x3, and 9x3 filters were reported to be: 13, 8, 11, 14 respectively. Among the three filters proposed in this contribution, the 9x3 filter is asserted to provide the best trade-off in terms of complexity and coding performance. Filter 9x3 is reported to provide U-BD-Rate of: 0.1% HE_Intra, 0.3% HE_RA, -0.1% HE_LD, V-BD-Rate of: 0.1% HE_Intra, 0.4% HE_RA, -0.1% HE_LD, Y-BD-Rate of: 0.0% HE_Intra, 0.0% HE_RA, -0.1% HE_LD.

Compared to the diamond shape method (JCTVC-E194) this method may be advantageous in terms of memory size, whereas the diamond shape may be advantageous in terms of number of operations

It was said that during the Daegu meeting it was said to be beneficial to have the same filter shape for chroma and luma for the reference software. It seemed unclear whether this also true for hardware implementations. See notes under JCTVC-E492.

Further study was recommended about the benefit of the chroma filter shapes in terms of implementation complexity vs. compression performance, as well as the benefit of having unified filter shapes is necessary. To be studied in CE/AHG work.

JCTVC-E177 Verification results of TI's Proposal on Chroma ALF (JCTVC-E287) [T. Yamakage, T. Watanabe (Toshiba)]

JCTVC-E453 CE8 Subtest 5: Cross Verification of JCTVC-E287 Proposed by TI [T.-D. Chuang, C.-Y. Chen, Y.-W. Huang (MediaTek)] [late registration]

JCTVC-E206 In-loop filter based on non-local means filter [Masaaki Mtsumura, Yukihiro Bandoh, Seishi Takamura, Hirohisa Jozawa (NTT)]

This contribution reports the performance of a technique that utilizes an adaptive denosing filter as the in-loop filter of the HM. In the proposed method, a denoising filter called non-local mean (NLM) filter is added in a deblocking filter process of the encoder/decoder in addition to the original deblocking filter of HM2.0. The proposal was implemented in HM2.0-r598 software (for High Efficiency) to evaluate its performance. Compared to the anchor of HM2.0-r598, the average BD-rate gains were "intra (Y:-1.6%, U:-1.4% and V:-1.8%)", "lowdelay (Y:-2.9%, U:-2.5% and V:-3.3%)" and "random access (Y:-1.9%, U:-2.8% and V:-2.8%)", respectively. The maximum gain was about "lowdelay (Y:-4.1%, U:-8.8% and V:-8.9%)" for the sequence "BasketballDrill".

Encoding/decoding time 145/152% for AI, 118/124% for RA, 112/131% for LD.

It was asked what would happen if this is taken out of the loop (either as pre-filter or post-filter)?

It is mentioned that further reduction of complexity is expected – unclear whether this would sacrifice the performance.

Further study was recommended – complexity reduction would make it attractive.

JCTVC-E225 Line Memory Reduction for ALF Decoding [Semih Esenlik, Matthias Narroschke, Thomas Wedi (Panasonic)]

This contribution proposes a method to reduce the line memory that is required by ALF (Adaptive Loop Filter) in the decoder side. In the current HM 2.0, de-blocking filtering and ALF pose additional difficulties in the block based decoding procedure. Namely, since the two filtering operations require samples from neighboring blocks, additional horizontal and vertical line memory need to be employed which increases the manufacturing costs of the video chips. This contribution focuses on the reduction of the line memory for LCU-based (Largest Coding Unit) decoding. The main focus is the reduction in "horizontal" line memory whose size is directly proportional to the width of the decoded picture. With the help of the proposed technique the horizontal line memory that needs to be employed is reduced by 33% for luma and 20% for chroma with 0.01% increase in the coding efficiency. In addition to the main contribution two optional extensions are discussed that work together with the main proposal.

Several experts emphasized that line-buffer reduction is valuable, but there may be different methods to achieve this, and more study appears to be needed.

Is it compatible with the one-pass encoding implementation? The proponent believes so.

Some concern raised whether it would be visually acceptable when within a CU some blocks are filtered and some not ("option 2")

The interaction with other recent adoptions seemed unclear (parallel de-blocking, adaptive offset in particular).

Further investigation (CE) was recommended.

JCTVC-E465 Verification results of CE8: Panasonic's contribution on ALF "Line memory reduction for ALF decoding" (JCTVC-E225) [Faouzi Kossentini, Nader Mahdi (eBrisk??)] [late registration 2011/03/17]–

JCTVC-E288 Loop filtering with directional features [P. Lai, F. C. A. Fernandes (Samsung)]

This contribution presents a block-based filter adaptation scheme with directional features (FAD). Blocks of 4x4 sizes are classified using four directional gradients. All 16 pixels within each 4x4 block are classified into the same class. For each class, the filter design follows the same procedure as the ALF in HM 2.0. The proposed filtering method will have up to 4 filters as compared to up to 16 as ALF in HM 2.0.

Classification of blocks is similar to JCTVC-E108. Reduction of computation is reported by computing Laplacians only on a subset of pixels.

The contribution emphasizes similarity with the adopted block-based method.

Reports BD rate increases by 0.4%, 0.4% and 0.1% for AI, RA, and LD.

Encoding / decoding times reported may not be reliable and diverge in the cross-check.

It was agreed to include this in a CE on loop filtering (for further reduction of complexity).

JCTVC-E466 Cross-Verification of Samsung's Contribution (JCTVC-E288) by Qualcomm [Y. Zheng (Qualcomm??)] [late registration 2011/03/17]

JCTVC-E197 Comments on Common Test Conditions for ALF [Ming Li, Ping Wu, Lei Wang, Wen Zhang (ZTE)]

In this document, two alternative configurations are proposed to reduce the ALF complexity. The first one is to disable ALF for the frames that are not used as references for random access (RA) configurations. Since hierarchical QP assignment is used in low complexity (LD) cases, the other one is to apply ALF to I-frames and the P/B frames using the smallest QP (that currently equals to QPI + 1). Based on the experimental results, it is suggested to adopt these two configurations to the high efficiency (HE) cases in the common test conditions, i.e. RAHE and low delay (LD) HE (LDHE).

It is suggested to apply ALF only on I pictures or key pictures in HE.

Results indicate that the average loss in RA is 0.3% and in LD is 1.2%, while encoder/decoder times are reduced to roughly 95/70%.

The scheme had not been tested visually – it seemed that potentially there could be artifacts.

This approach could be seen as encoder optimization, whereas in the standardization (particularly of the HE cases) we should target for the best possible gain.

18.6 Block Structures and Partitioning

18.6.1 RQT related subjects

JCTVC-E365 Evaluation of RQT in HM and related TU representation [K. Panusopone (Motorola Mobility), K. Chono (NEC), Y.H. Tan (I2R), M. Zhou (TI)] [late upload]

This contribution reports the outcome of an evaluation of RQT in HM and related TU representations. Several different configurations of RQT were tested to evaluate the trade-off between coding performance and complexity.

Summary results, of Y BD-rate versus the anchor, are tabulated below.

	Implicit TU	**Depth=1**	**Depth=2**	**Depth=3**	**Depth=4**
AI HE	0.4	0.4	0.1	0.0	0.0
AI LC	0.0	0.0	-0.1	-0.4	-0.3
RA HE	1.0	1.7	0.3	0.0	-0.1
RA LC	0.8	1.9	-0.1	-0.2	-0.2
LD HE	1.1	2.3	0.3	0.0	-0.1
LD LC	1.1	3.0	-0.1	-0.2	0.0

"1 level" means no splitting.

For intra, the RQT root is the PU. For inter, the root is the CU. If the root is bigger than 32x32, the root is 32x32.

For common test conditions

- For CABAC, RQT depth = 3.
- For CAVLC, RQT depth = 1 for intra, 2 for inter.

Changing the CABAC depth to 2 instead of 3 results in approx 0.2-0.3% degradation.

Changing the CAVLC depth to always 2 instead of sometimes 1, result 0.1% gain.

Note that JCTVC-E404 improves the CAVLC behavior by 0.5% for depth 3.

It was remarked that there may be some opportunity for improved RD optimization relating to accounting for coded block flags. The commenter was encouraged to submit more information about this suggestion.

It was remarked that, visually, smaller blocks may generally be better than larger blocks. Another participant remarked, alternatively, that larger blocks help with film grain. In any case, the larger blocks would still be selectable by the encoder regardless of the maximum tree depth.

Decision: To harmonize the two cases, set the RQT max depth to 3 always for the common configurations.

The contributor suggested an "Implicit TU" derivation (described in JCTVC-E364) such that when there is no TU tree (i.e., "max depth = 1"), the transform blocks should not cross PU boundaries (the TU tree root should be at the PU rather than the CU level in this case) – with chroma following the luma structure.

Decision: Agreed (text necessary).

JCTVC-E083 Evaluations and Suggestions about TU Representation [S. Liu, Z. Zhou, S. Lei (MediaTek)]

This contribution first evaluates the TU representation for current HEVC. Results reportedly show that about 80% of the achievable coding gain can be obtained by setting the maximum depths of RQT to 2 compared with 3 as in the current anchor condition (HE) and single size transform. Secondly, this contribution proposes a method for reducing overall encoder complexity by reducing the number of transforms for the MERGE_2Nx2N mode during the RDO process. For the HE case, this method reportedly results in 6-7% overall encoding time reduction with an average 0.3% BD-rate increase compared with anchor. The contribution proposes two alternative schemes for TU representation. In HE conditions, Method one reports about 10% encoding time reduction in average, with average 0.4% BD-rate increase. In HE conditions, Method two reports an average 8% encoding time reduction, with average 0.2% BD-rate increase.

A similar study was reported in JCTVC-E365.

The second part of the contribution is about encoder complexity reduction – to apply a fast search technique that has been used for partial merge decisions to also be used for full 2Nx2N CU merge decision-making with a reported 7% speed-up with 0.2% and 0.4% degradation in compression.

Perhaps the degradation could be avoided with further study.

This aspect was suggested for further study.

Part 3 of the contribution reported results for an inferred split with depth = 2.

Seen something like this before at last two meetings – and it gives up some coding performance.

JCTVC-E182 Cross-check of MediaTek's proposal on TU Representation (JCTVC-E083) [Ketan Tang, Oscar C. Au, Xing Wen, Jingjing Dai, Chao Pang, Feng Zou (HKUST)] [Never uploaded]

The following information was verbally reported: The software was studied as well as run. No difficulties were reported.

However, the cross-verification contribution document JCTVC-E182 was never actually uploaded.

JCTVC-E104 RQT depth selection [Y. H. Tan, C. Yeo, H. L. Tan, Z. Li (I2R)]

In this proposal, a different configuration of the transform quad-tree depth is evaluated. In the default configuration of HM 2.0, the maximum depth of the transform quad-tree is different for different efficiency and complexity settings. This contribution reports experimental results on setting the maximum level of the transform quad-tree level to two for all experiment settings. It also presents some modifications to the intra encoding mode decision process that reportedly results in a complexity reduction while maintaining coding performance.

When modifying the encoding search rule and changing the RQT depth = 2, approximately ~10% faster encoding time and 0.4% improvement in AI LC was reported, with degradations of 0.2% for HE RA and 0.2% for HE LD, and 0.2% improvement in LC LD. Note that the reference was using RQT depth = 3 in these tests. The proponent was asked to test the modified search, with RQT depth = 3.

Testing of this was performed and the proponent uploaded a revision of the contribution with the additional results. With the RQT depth set to 3, the encoder was not running faster but was producing improved coding efficiency for AI HE and AI LC by approximately 0.2%.

The proposal was non-normative as presented, but would change the HM encoder description. The contributor volunteered the effort for that.

The software change was asserted to be just a few macro setting changes.

In the discussion, it was suggested that a somewhat different configuration setting of the scheme might provide further benefit.

Further study (e.g., in the AHG on encoding complexity reduction) was recommended regarding the configuration settings and potential interaction with the latest RQT design.

JCTVC-E291 Cross-check Report for I2R's Proposal JCTVC-E104 by MediaTek [Zhi Zhou, Shan Liu (MediaTek)] [late upload / missing prior]

After some initial confusion, it was reported that the results matched (except for minor variations in encoding times likely resulting from platform differences).

JCTVC-E364 Proposal on RQT root location [K. Panusopone, X. Fang, L. Wang (Motorola Mobility)] [late upload]

This contribution describes a modification to the RQT structure for TU partitioning in the current HM. The proposed structure ties the RQT root to the CU size and PU partitioning type. Some optimization techniques to the modified RQT structure are also described.

See notes above in section discussing JCTVC-E365.

Some encoder improvement for a previous JCTVC-D250 scheme was also reported, using more accurate cost estimates.

The implicit TU case still has loss relative to common conditions.

JCTVC-E183 Cross-verification report of efficient transform unit representation (JCTVC-D250 / JCTVC-E364) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)]

The software was studied algorithmically, and contained few changes, and was compiled and tested without difficulties, with matching results.

JCTVC-E425 Fast encoder control for RQT [Mischa Siekmann, Heiko Schwarz, Benjamin Bross, Detlev Marpe, Thomas Wiegand (HHI)] [late upload]

This document reports test results of a fast encoder control for the residual quadtree (RQT), in which testing a further splitting of transform blocks is omitted if no coefficient of the current transform block exceeds a given threshold. Encoder speedups of more than 10% were reported with an average loss of 0.4% BD rate.

The scheme starts with the largest transform size. If all coefficients are below a threshold, smaller transform block sizes are not tested.

The threshold changes with the QP value.

A participant asked how the encoding time speed-up depends on the QP values. It seems to be fairly consistent across QP values.

It was asked how many lines of code were needed to make this change. The answer was not known.

It was considered to make this something we would put in the software and disable by default.

It had been implemented only for inter cases – for no particular reason.

Results were not provided for LC cases.

For further study.

JCTVC-E377 Limiting Chroma Transform Depth in Residue Quad Tree (RQT) [L. Guo, X. Wang, P. Chen, M. Karczewicz (Qualcomm)]

In Daegu meeting, it was reported (JCTVC-D060) that some loss of chroma coding performance can be observed with Residue Quad Tree (RQT). In this contribution, it is suggested that maximum chroma transform depth be limited relative to luma component, so that chroma component does not have to share the same transform depth as luma. Simulation results reportedly show that by doing so an average BD-rate saving of roughly 1% can be obtained for U and V respectively with no loss on luma, using all three HE test configurations.

The proponent noted that chroma may tend to be smoother than luma.

It was remarked that the interpretation of BD BR measures for chroma is problematic.

It was noted that this includes a 32x32 transform for chroma, which we have not had in the design.

A participant suggested that the subjective effect may be negative. Another indicated that the subjective effect may be beneficial. It was further remarked that the subjective effect may be different for different block sizes at which the limitation is imposed.

Further study was encouraged.

18.6.2 Other contributions on block structures and partitioning

JCTVC-E081 Syntax and Structure for Coding and Utilizing Partition Types [S. Liu, X. Zhang, S. Lei (MediaTek)]

This contribution reports a couple of methods and syntax modifications for coding and using partition types. First, a modification to the current inter partition type code word table is proposed, which aligns the syntax of coding partition types for SCU (smallest coding unit) to other CUs in all depths. An average of 0.1% BD-rate savings are reportedly observed for Low Complexity configurations (coding gain/loss is negligible for HE in overall) with no encoding or decoding time increase. Second, a hierarchical partition type structure is proposed, which reportedly reduces encoding time by around 13% in average, with an average 0.4% BD-rate increase. No increase for decoding time was reported. Two parts of the proposal were discussed:

Part 1: Proposing a change of order for the partition type coding for intra partitions.

Stability seems preferable at this point.

Part 2: Disables the rectangular partion types at large block sizes. Also seems specialized to 64x64 max size, and makes the shapes available depend on the block size.

Further study of the general subject was encouraged.

JCTVC-E282 Cross check of JCTVC-E081 [A. Abbas, J. Boyce (Vidyo)] [late upload]

Proponent software was compiled and run, with matching results. The software may not have been studied algorithmically.

JCTVC-E085 Method and Syntax for Partial CU Merge [S. Liu, X. Zhang, S. Lei (MediaTek)]

This contribution proposes a partial CU merge approach related to when the 2nd PU of an Nx2N or 2NxN CU is larger than the SCU size. Experimental results report average encoding time reduction of 13% compared with HM2.0 High Efficiency anchors; 18% compared with HM2.0 Low Complexity anchors, with average BD-rate increases of less than 0.1% for HE and 0.2-0.3% for LC. Decoding time reportedly remains (approximately) the same.

The proposal adds additional forced merge cases and reduces merge candidates.

It was remarked that this may exacerbate sequential spatial dependencies, increasing parallelism difficulty.

It was suggested that testing this as an encoder-only optimization might be desirable.

A participant asked about potential subjective artifacts – this had not been reviewed.

It was suggested to test simply disabling all rectangular splits, at least as a point of comparison for further study.

It was noted that the forced merge change and the reduction of merge candidates are two distinct changes.

Further study (e.g. in a motion data coding CE) was encouraged.

JCTVC-E445 Cross-check of MediaTek's proposal on partial Merge (JCTVC-E085) [Y. H. Tan, C. Yeo (I2R)] [late registration]

The software was studied as well as compiled and run, and matching results were reported.

JCTVC-E090 Adaptive CU Depth Range [X. Li, J. An, X. Guo, S. Lei (MediaTek)]

In current HEVC (HM 2.0), CU depth has a fixed range established at the sequence level. In this contribution, it is proposed to adaptively select CU depth range to avoid potential encoding redundancies while reducing encoding complexity. Based on CU depth information of previously coded slices and CUs, CU depth range is adapted at slice or CU level. CU splitting flag and bi-prediction flag of CU depth outside the depth range are removed from corresponding entropy coding tables. Encoding time is reportedly reduced (since CU depths beyond the depth range and bi-prediction at maximal CU depth are not tested during encoding). It is reported that the encoding process is speeded up by 9%, 8%, 21%, 27%, 26% and 32% on average for AI HE, AI LC, RA HE, RA LC, LD HE and LD LC configurations, respectively, with reported BD BR increases of 0.0-0.3% (the average of six cases being 0.15%).

A participant remarked that some of the constraints may potentially cause visual artifacts.

It was remarked that some proposals that advocate changes of coding structure or syntax seem to be targeted for certain ways of optimizing encoder decision-making, and then avoiding signaling for the cases that the optimized encoder would not consider – which may end up somewhat reducing the ability of encoder designers to choose their own optimization schemes.

Another suggestion was to consider moving the SPS-level syntax to the PPS.

In the proposal, it was remarked that the available depth and parsing process for CUs changes from CU to CU, based on behavior of neighboring CUs.

The general feedback was that we should strive to separate encoder optimizations from syntax optimization. The syntax should enable as much encoder design flexibility as possible.

It was recommended to establish an encoder optimization AHG.

JCTVC-E153 Cross-check report for JCTVC-E090 [J. Xu (Microsoft)] [late upload]

The software was studied as well as compiled and run, with matching results.

18.7 Motion Compensation and Interpolation Filters

JCTVC-E041 Weighted Prediction [Philippe Bordes (Technicolor)]

This document presents results of Weighted Prediction (WP) implementation into HM2.0. The WP technique can compensate for illumination variation in video sequences. It is part of the AVC standard and this feature is useful in video encoder and in video splicing applications in particular. Experimental results were made on fade sequences and a comparison is made with other Illumination Compensation (IC) tools.

The results reportedly indicated that WP has a large gain (10-38% depending on the configuration) for the test sequences with linear fading, and the contribution states that WP outperforms other IC tools. However, it was reported WP has no impact on coding efficiency for the regular test sequences.

It was proposed that, depending on the type of slice (P_SLICE or B_SLICE), one could choose among three weighting algorithms:

- Default: the default HEVC uni-prediction or bi-prediction.
- Explicit: the weighting factors are transmitted explicitly in the slice header.
- Implicit: the weighting factors for bi-prediction are derived from the distance of the current POC with the POC of the reference pictures, relatively to the distance between references POC (B_SLICE only).

It is said that the WP tool proposed is exactly the same as in AVC. However, some differences were noted as clarified below.

It was asked what are the results on the current test set? Following the results reported in Guangzhou (JCTVC-C041) the gain is reportedly approximately zero. Some comparison against JCTVC-C041 was made, but just using old results.

It was asked whether there was a tool to derive the weights at the encoder? Currently, the known weights from artificially produced sequences are used. It was asked whether an estimation tool could be provided? In JCTVC-C041 (which was not the AVC WP), automatic estimation was made. Without estimation, WP is useless and cannot compete with other tools that have similar objective capabilities.

It was suggested that in real-time applications, estimation of the weight may be a problem.

The proposal here is to apply WP globally. In contrast AVC allows (by combining with other tools e.g. refidx) to turn it on and off at MB level.

There was a consensus that this is something useful.

It was suggested to establish an AHG (chair P. Bordes) to study WP, and develop encoder tools for the potential inclusion of the AVC method of WP (parameters at PPS/slice level) in the HM, and to study methods for block-based local adaptation of weighted prediction.

JCTVC-E129 Memory bandwidth reduction MC filter [Kenji Kondo, Teruhiko Suzuki (Sony)]

In this contribution, an interpolation filter (IF) for memory bandwidth reduction (MBR) is proposed. This MBR-IF targets memory bandwidth and computation reduction in motion compensation (MC) process. Memory bandwidth can reportedly be reduced to 59% of worst case by use MBR-IF. MBR-IF was implemented into HM2.0. Simulation results are reported with +0.1% for RA HE, +0.1% for RA LC, +0.0% for LD HE, and -0.2% for LD LC for reduction level 1. In complexity analysis, it was reported that the memory bandwidth can be reduced to 67%, 52% and 40% for reduction level 0, 1, and 2.

Comment: If the block goes across a page in DDR, the situation is even worse.

Usage of 8-tap and 7-tap filters, depending on position (towards block boundary), was proposed.

The reported change in BD values was marginal.

Symmetry of half-pel position filters is given up – does this not increase number of multiplications? The reports of decreased number of worst case is not fully understandable (said to be the same as in CE3, but it may depend on understanding what "worst case" means).

The average number of operations (for test set) increases.

Regarding visual quality – does the usage of mixture of symmetric and asymmetric filters have any impact? It is said that inspection on a PC monitor did not show any difference.

9 (?) different filters are used in total – is this not disadvantageous when frequent switching is done?

One cross-checker reports that number of different filters is difficult to identify in the software.

As different filters are used at PU boundaries, it would be very difficult to pre-compute interpolations at the encoder (current implementation uses other HM filters for ME).

Current CE3 complexity measures have only the decoder in mind – encoder measures should be included as well.

Though interesting in terms of memory bandwidth reduction, this proposal has a number of issues that would require careful consideration (as said above) – further study.

JCTVC-E167 Verification of Sony's memory bandwidth reduction MC filter level 1 (JCTVC-E129) [T.Chujoh, K.Kanou, T.Yamakage (Toshiba)] [withdrawn]

Withdrawn.

JCTVC-E189 Cross-verification report on memory bandwidth reduction MC filter (JCTVC-E129) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)] [initial version rejected (placeholder) – second version late upload]

JCTVC-E378 CE3: Cross-verification for Sony's test (JCTVC-E128) by Samsung [E. Alshina, J. Chen, W.-J. Han (Samsung)]

JCTVC-E241 Low complexity bi-predictive interpolation with 6-tap DCT-IF filter [K. Ugur, J. Lainema (Nokia)]

This contribution proposes to use a 6-tap DCT-IF filter for interpolation of bi-prediction samples instead of the current 8-tap DCT-IF filter for the low complexity configuration. It is reported that by using a filter with fewer taps, the worst-case complexity of the current interpolation filter in HM is reduced. The coding efficiency impact of the proposal is 0.5% on average for the low-complexity cases. However, it is argued that most of the coding efficiency loss is due to single low-resolution BQSquare sequence and for high-resolution Class-A, -B, -E sequences, the proposal reportedly improves the coding efficiency of low complexity cases by 0.8% on average, while reducing the complexity.

The suggestion is to use a 6-tap DCT-IF for bi prediction and use 8-tap for uni prediction to reduce the worst-case memory bandwidth and complexity.

It was asked how the motion estimation was done? This was reportedly the same as in Sony's JCTVC-E128.

Other proposals (Sony, Motorola) suggested to use an lower-cutoff filter for uni prediction and the higher-cutoff filter for bi prediction (for better performance). In contrast to that, the reduction of worst case complexity is the highest goal here.

Further study in CE3 was suggested.

JCTVC-E242 On clipping in bi-directional averaging [K. Ugur, J. Lainema (Nokia)]

This contribution presents a simplification in clipping operations involved in bi-directional averaging. Using the proposal, the intermediate prediction values for each one of the directions are not clipped but rather a single clipping is performed after bi-directional averaging is performed. The change in coding efficiency using the proposal is reported to be negligible.

Some recorded comments on the proposal were as follows:

- Could there be problems at the encoder side?
- Can pre-computed values of ME be re-used – are they clipped? The ME currently operates at 8 bits.
- This means that with any higher precision in the loop, MC has to be re-done anyway.
- It is also irrelevant then whether same or different clipping is used for uni and bi pred.

Decision: Adopt.

JCTVC-E471 Cross-verification of Nokia proposal JVCTV-E242 on clipping in bi-directional averaging [Minhua Zhou (TI)] [late registration 2011/03/17]

JCTVC-E304 Overlapped Block Motion Compensation for Regular Block Partitions [L. Guo, P. Chen, R. Joshi, M. Karczewicz (Qualcomm)]

In this contribution, overlapped block motion compensation (OBMC) has been applied to regular partitions (2NxN and Nx2N block partitions) in HM 2.0. Specifically, if a CU is partitioned into2NxN or Nx2N, OBMC is applied to the horizontal boundary of the two 2NxN blocks, and to the vertical boundary of the two Nx2N blocks. The method achieved a BD-rate reduction of 0.5% on average for the random access case, and 0.8% on average for the low delay case. No increase in encoding time was observed and 1%-3% increase in decoding time was observed.

The width of overlap is 2 pixels at each side, with weights 1/8, 1/4, 3/4, 7/8.

Some comments recorded during the discussion were as follows:

- OBMC is considered in the mode decision (not motion estimation). It was asked how it could work without this?
- Could better performance be achieved when in included in the ME? Would be interesting to understand whether this tool gives complexity scalability vs. performance
- In case of bi prediction, 4 hypotheses are used. Does this have implication on memory bandwidth?

Further investigation in CE2 (OBMC with/without AMP).

JCTVC-E441 Cross-verification of Overlapped Block Motion Compensation for Regular Block Partition (JCTVC-E304) [X. Zheng (Huawei)] [late registration / uploaded 2011/03/17]

JCTVC-E376 Asymmetric Motion Partition with OBMC and Non-Square TU [Y. Yuan (Tsinghua), X. Zheng (HiSilicon), X. Peng (USTC), L. Liu (HiSilicon), Y.

Wang (Tsinghua), X. Cao (Tsinghua), J. Xu (Microsoft), C. Lai (HiSilicon), Y. He (Tsinghua), H. Yu (Huawei)]

This contribution is related to core experiment 2: flexible motion partitioning. In this contribution, non-square Transform Unit is proposed to be used at asymmetric motion partitions. Overlapped block motion compensation (OBMC) is applied at motion partition boundary.

A non-square TU (NST) size is derived from the asymmetric motion partition size.

Results for AMP+OBMC: 0.8/1.4/0.7/1.0 for HERA/HELD/LCRA/LCLD.

Results for AMP+OBMC+NST: 1.0/2.0/1.0/2.2.

The presentation deck includes more results about the combination of AMP+NST.

This introduces more dependencies between the transform tree and prediction tree.

The non-square TU could also be used with Nx2N and 2NxN partitions (see JCTVC-E278).

This seemed interesting – further study in the CE2 context was recommended.

JCTVC-E349 CE2: Cross-verification of Asymmetric Motion Partitioning with OBMC and Non-Square TU from Tsinghua, Huawei &HiSilicon, Microsoft and USTC (JCTVC-E376) [L. Gu, Peisong Chen, M. Karczewicz (Qualcomm)] [initial version rejected]-

JCTVC-E464 CE2: Cross-verification of Asymmetric Motion Partition with OBMC and Non-Square TU (JCTVC-E376) [L. Guo, P. Chen, M. Karczewicz (Qualcomm)] [late registration 2011/03/17]

JCTVC-E359 Motorola Mobility's adaptive interpolation filter [J. Lou, K. Minoo, D. Baylon, K. Panusopone, L. Wang (Motorola Mobility)] [late upload]

JCTVC-E359 proposes an adaptive method for generation of sub-pixel samples for temporal prediction of each Prediction Unit (PU). In this contribution, the choice of filters is implicitly signaled based on the PU size. More specifically, this contribution proposes that for temporal prediction, a PU with a given size uses a certain class of interpolation filters to generate samples at each sub-pixel position. Although with this scheme it is asserted to be possible to have as many classes of interpolation filters as the number of allowed PU sizes, this contribution reports results based on two classes of interpolation filters. The proposed method reportedly saves 0.1% in bit rate on the LD HE setting and saves 0.5% on the LDLC setting. The proposed method achieves on average the same performance as the anchor on RAHE setting and loses 0.1% on RALC setting. A cross-check was provided later by Sharp. The attached spreadsheet contains detailed data of the results.

(The presentation slide deck had not been uploaded when reviewed.)

Switches between 7-tap and 8-tap filters implicitly, depending on PU size.

JCTVC-E358 had reported gain of 0.3% for LDLC. Most of the additional gain is in BQ Square.

It was asked what is the assumption then that justifies the derivation of the filter from the PU size?

It is mentioned that the current filters are potentially not optimum for unidirectional prediction (see also JCTVC-E361).

Other methods of adaptive interpolation (with explicit signaling) seemed to look more promising

More evidence would be required that there are other cases of implicit derivation of the filter (beyond uni vs. bi prediction) which give reasonable gain.

JCTVC-E449 Cross Check of Motorola Mobility's Interpolation Filter [Jie Zhao, Andrew Segall (Sharp)] [late registration / available 2011/03/16]

JCTVC-E426 Experimental results of 4 taps/5 bits Chroma DCTIF in HM2.0 [Elena Alshina, Jianle Chen, Alexander Alshin, Nikolay Shlyakhov (Samsung)] [late upload]

This contribution provided simulation results for 4 taps Chroma interpolation filter with 5 bits precision for coefficients representation. It used in HM2.0 instead default 4 taps Chroma filter with 6 bits coefficients. The proposed variant shows 0.1% average performance improvement for Chroma components (no performance change for Luma). Because of the low bit-depth for filter coefficients, the proposed variant requires less number of operations and reduces the dynamic range of calculations.

Reducing bit-depth of interpolation is additional factor in complexity reduction – it was questioned whether this is an important issue.

The current implementation is 32 bit accuracy – it was asked whether 16 bits would be sufficient when considering that the data could be 10 bit and including the case of bi prediction.

Note: It is also reported that the result of interpolation filtering in the HM is different depending on whether the filtering is horizontal first or vertical first. This bug should be investigated and resolved.

18.8 Motion Vector Coding

18.8.1 Decoder-side estimation

JCTVC-E055 Evaluation of decoder-side motion estimation within HM 2.0 [Sven Klomp, Jörn Ostermann]

Decoder-side motion estimation (DSME) is used to reduce the bit rate needed to transmit motion information. Simulation results based on the JM reference software were previously presented (JCTVC-B026). This contribution presented coding performance measurements within the HM 2.0 reference software. Bit rate reduction of 2.3% and 1.8% were reported in RA-HE mode for Class A and Class B, respectively.

The performance of DSME in conjunction with the DMVD approach proposed in JCTVC-E294 was evaluated in this contribution. The bit rate was reportedly reduced by 2.6% and 2.3% using the combined approach compared to the HM-2.0 anchors.

DSME for frame interpolation applied only for B pictures.

The best results are for sequences with linear motion.

Results for other classes were not available.

Encoder runtime was doubled, and it was commented that the decoder complexity was far from practical.

JCTVC-E216 Bi-prediction by single motion vector using decoder-side inter-reference ME [Motoharu Ueda (JVC)]

This proposal focuses on the complexity analysis of the technique "Refinement motion compensation using DMVD (RMC)" proposed in the past JCT-VC meetings under CE1/TE1 activity. The conventional bi-predictive motion compensation is executed by single motion information using decoder-side inter-reference motion estimation indirectly in this technique.

In this contribution, the decoder complexity of this technique is evaluated in the various aspects such as the worst case of memory access, and block matching operation.

A simplified algorithm is proposed to reduce the decoder complexity. The first one is to change the search range of DMVD. The second one is to change the sub-pixel filtering on decoder-side motion estimation. The last one is to restrict the PU size that can be used for DMVD.

The simulation results reportedly show that the proposed technique provides 1.5% BD-rate gain on the original algorithm and 1.2% BD-rate gain on the simplified algorithm against HM2.0 under random access conditions.

Also the simulation results reportedly show that the proposed technique increases encoder runtime by 42% and decoder runtime by 21% on the original algorithm and 23% and 14% on the simplified algorithm, tested against HM2.0 under random access condition.

Further discussion in AHG activity was recommended.

18.8.2 MV Coding

JCTVC-E062 Improvement on simplified motion vector prediction [K.Kazui, S.Shimada, J.Koyama, A.Nakagawa (Fujitsu)]

This contribution proposes a simplified motion vector prediction (SMVP) previously adopted in HM2.0.

The proposed scheme extends the original SMVP scheme so that the possibility to obtain the maximum number of motion vector predictor candidates for a target motion vector reportedly improves, with some increase of computational complexity. Specifically, a motion vector with a different reference index from that of the target motion vector is also used as a candidate only if there is no motion vector with the same reference index of the target motion vector in spatially-neighboring prediction unit partitions. The proposed scheme does not require syntax change relative to the original SMVP scheme. Only the deviation process of motion vector predictor candidates list is changed.

The average coding gains of the proposed scheme over the SMVP scheme in HM2.0 for the common test sequences are 0.5% and 0.8% for the random access high efficiency configuration and random access low complexity configuration, respectively. The coding gains for Keiba sequence, which have a large number of occluded background areas, are 4.2% and 4.5% for random access high efficiency configuration and random access low complexity configuration, respectively.

This seemed very similar to methods investigated within CE9. The main difference may be the priority assignment, where an MV with refidx closer to the target MV is prioritized.

Higher coding gain is found for sequences with larger amount of occlusions (e.g. Keiba which is not in the test set any more).

Further study was suggested.

JCTVC-E064 Improvement to AMVP/Merge process [Yusuke Itani, Shun-ichi Sekiguchi, Kohtaro Asai, Tokumichi Murakami (Mitsubishi Electric)]

In this contribution, two changes to AMVP/Merge process in HM-2 are proposed. The first one is a modification to the derivation process of a predictor candidate list for AMVP by introducing motion vector scaling. The second one is to disable the use of temporally co-located motion information in both AMVP and merge mode when a PU size is smaller than or equal to 8x8. The performance evaluation of the proposed changes based on HM-2 reportedly shows 0.1% and 0.3% coding gain for HE RA and LC RA, and 0.1% and 0.3% coding gain for HE LD and LC LD with no loss of coding efficiency in all inter test conditions, while keeping the same level of complexity relative to HM-2.

A small simplification of MV scaling was reported without a significant change in compression efficiency.

Further study in the new configuration (CE9) was suggested.

JCTVC-E122 Cross-verification of Mitsubishi proposal on Improvement to AMVP/Merge process [Minhua Zhou (TI)]

JCTVC-E095 Unified motion vector removal process for AMVP [Shigeru Fukushima, Masayoshi Nishitani, Toru Kumakura, Motoharu Ueda (JVC)]

In the HM2.0, the "different motion vector removal process" was removed for simplification. However, removing the different motion vector removal process always brings coding loss because the different motion vector removal process can remove useless MVP candidates.

This proposal aims to unify the "different motion vector removal process" and the "identical motion vector removal process" to obtain the coding gain that results from these two processes while using a simplified algorithm.

It can remove a 'different' motion vector and an 'identical' motion vector the the same process.

The proposed algorithm requires some changes from HM2.0. At first, the identical motion vector removal process is removed. Second, the different motion vector removal process is restored. Finally, the different motion vector removal process is modified to consider the index cost of MVP for removing more MVP candidates when the cost of the MVD is the same.

The simulation results reportedly show that the proposed technique provides overall 0.2% BD-rate gain.

There is an issue of complexity in the parsing process: a dependency of MVD and MVP.

It could be necessary to use a fixed number of MVP.

Regarding complexity, there appears to be no issue with software implementations, but it may be difficult for hardware.

Further study was suggested.

JCTVC-E157 Cross verification of Unified motion vector removal process for AMVP (JCTVC-E095) [A.Fujibayashi (NTT DOCOMO), F. Bossen (DOCOMO USA Labs)]

It was reported that the software is well implemented and reproduces the reported results, issues to be resolved are confirmed (as listed above).

JCTVC-E101 Simplified AMVP candidate derivation for Inter and Merge modes [C. Yeo, Y. H. Tan, Z. Li (I2R)]

In this contribution, a simplification of the selection of motion vector predictor candidates when performing Inter coding is presented. For large prediction units, existing methods for deriving motion vector predictor candidates may require checking a large number of neighboring partitions within a loop. The worst-case number of checks depends on the size of the prediction unit. In CE9, two methods are tested for limiting the worst-case number of partitions to be checked to a constant when deriving motion vector predictor candidates. This contribution tested different configurations from what was tested within CE9. Experimental results reportedly indicate that compared to the configurations tested in CE9, the proposed configurations achieve similar or slightly better compression performance while maintaining the search complexity.

This appeared to be similar to method F of CE9 (also in terms of complexity).

Contribution noted.

JCTVC-E402 Cross-check of I2R's Simplified AMVP candidate derivation (JCTVC-E101) by Qualcomm [J. Sole, M. Coban (Qualcomm)]

JCTVC-E115 Evaluation results on merge mode in HM2.0 [Minhua Zhou (TI)]

This contribution reports evaluation results of the HM2.0 merge mode. It was reported that the temporal MVP in the merge MVP list and the partial CU merge mode actually lead to coding loss. The loss caused by the temporal MVP and partial merge mode is reportedly 0.0% (HE-RA), 0.2% (LC-RA), 0.1% (HE-LD), 0.4% (LC-LD) for temporal MVP, and 0.5% (HE-RA), 0.7% (LC-RA), 0.2% (HE-LD), 0.4% (LC-LD), respectively. It was recommended to remove the temporal MVP from the merge mode MVP list (item a) for error resiliency enhancement and merge MVP list pruning complexity reduction, and add a high-level partial CU merge disabled flag (item b) to allow encoder to disable the partial CU merge mode based on design choices.

The results were cross-checked by JCTVC-E147 (item a) and JCTVC-E146 (item b).

Item a) may apply to HM2.0, but most probably not to the new configuration. There may also be strong interaction with the MV compression. It appeared that it would be premature to take such suggested action at this time.

The intention of item b is to disable sub-LCU-level merging without being forced to give up Nx2N and 2NxN mode

It seemed that a reasonable comparison would be against an encoder which does not use merge at all.

Evidence about encoder complexity reduction should also be shown.

Further study was suggested.

JCTVC-E119 A study on unification of JCTVC-D273 and JCTVC-D164 in HM2.0 software [Minhua Zhou (TI)]

The document presents an alternative way of combining JCTVC-D273 and JCTVC-D164, both of which were adopted into HM2.0. The alternative method unifies the two contributions as follows: 1) move the temporal co-located MVP to the first place of the MVP list (JCTVC-D164), and 2) if the motion vector to be referred as co-located partition information is not available in one direction (e.g. L0 or L1), the motion vector of the other direction (e.g. L1 or L0, if it is available) is used to derive temporal motion vector predictor (JCTVC-D273). Compared to the current method enabled in the HM2.0 software which is JCTVC-D164 based, the alternative method reportedly has lower complexity and is slightly more efficient (e.g. 0.1% in HE-LD). It is therefore recommended to conduct further study on the unification of JCTVC-D273 and JCTVC-D164 in the HEVC reference software under the consideration of motion vector compression proposals.

Not necessary to be presented, for information (according to contributor).

JCTVC-E146 On merge candidate construction [B. Li (USTC), J. Xu (Microsoft), F. Wu (Microsoft), H. Li (USTC)]

In the current design of HEVC, HM-2.0, merge mode is widely used. From the 4th JCT-VC meeting, the concept of partial merge was introduced to HEVC, which means when one CU is larger than the smallest CU, and it has two partitions, the first part will be inferred as merge mode. But what will happen if the first part does not have any merge candidate is unclear. This contribution presents a method to avoid the possibility that one PU is inferred as merge mode but without any available merge candidate. In that case, a zero vector is inserted as a candidate. It was reported that the proposed method does not have impact on complexity or RD performance.

Another suggestion is to change the context model of the merge flag slightly.

The proposal is adding a "zero merge candidate" (and always coding the merge flag).

The current syntax does not clearly specify what to do when no merge candidate is available. In addition, there is a "bug" in the current decoder software which never shows up, as the encoder never brings the decoder into this situation. This method would resolve that.

Decision: Adopt "zero merge candidate" (including the necessary context change for merge flag coding) and "zero motion vector when merge MVP candidate list is empty" (the latter aspect being the same as JCTVC-E118)

JCTVC-E343 Extended Motion Vector Prediction for Bi predictive Mode [Y. Zheng, W.-J. Chien, M. Karczewicz (Qualcomm)]

This contribution presents an extended motion vector prediction method for bi-predictive mode. In the current HEVC Test Model (HM2.0), Advanced Motion Vector Prediction (AMVP) method is adopted to predict the motion vector. In bi-predictive mode of HM2.0, the motion vector predictor candidate sets of each reference picture lists (list 0 and list 1) are independently built. In this contribution, the decoded motion vector of list 0 is scaled according to the POC distance. The scaled motion vector of list 0 can be used as a motion vector predictor of list 1 based on the local motion smoothness constraint. This contribution reports 0.7% and 0.6% bit rate reduction under random access high efficiency and random access low complexity coding configurations, respectively. It also reports no encoding and decoding complexity increase in terms of run time.

For LD cases, BR gain is 0.1%.

The additional candidate increases complexity. This introduces a dependency between list0 and list1 (also in terms of parsing).

Further study in the new configuration was recommended (CE).

JCTVC-E462 Cross Verification of JCTVC-E343 Proposed by Qualcomm [J. Park, Y. Choi, S. Park, B. Jeon (??)] [late registration 2011/03/17]

JCTVC-E396 Unified Motion Vector Predictor Selection for Merge and AMVP [Y. Zheng, W.-J. Chien, M. Karczewicz (Qualcomm)]

This contribution proposes a unified motion vector predictor selection method for Merge mode and AMVP. This method aligns the motion vector predictor selection procedure by searching four fixed neighboring blocks. The method defines the neighboring blocks based on the partition shape and partition index. The simulation result shows the performance drop of 0.28% (RA_HE, RA_LC, LD_HE, and LD_LC average) in BD rate saving with 10% encoding complexity reduction. Combined with JCTVC-E343, the simulation result shows the performance gain of 0.1% (RA_HE, RA_LC, LD_HE, and LD_LC average) in BD rate saving with 10% encoding complexity reduction.

It is not as obvious that similar encoder simplifications could be achieved by similar optimization with other configurations.

Further study was recommended.

JCTVC-E454 Cross Verification of JCTVC-E396 Proposed by Qualcomm [J.-L. Lin, Y.-W. Huang (MediaTek)] [late registration / upload 2011/03/19]

JCTVC-E398 On Temporal Motion Prediction used for Merge and AMVP Y. Zheng, W.-J. Chien, M. Karczewicz (Qualcomm)]

In the current HEVC Test Model (HM2.0), Advanced Motion Vector Prediction (AMVP) method and merge mode are adopted for motion information compression. The index of the motion candidate with the minimum rate-distortion cost is signaled to the decoder. The codeword of the index is determined based on the number of the available motion candidates. In order to parse the slice, full knowledge of all motion predictor candidates is necessary. It is proposed to remove the co-located motion predictor, so an independent parsing process can be enabled. This contribution reports a combination of two modifications on the spatial motion predictors to replace the co-located motion predictor with average 0.5% coding performance loss.

The contribution was noted.

JCTVC-E455 Cross Verification of JCTVC-E398 Proposed by Qualcomm [J.-L. Lin, Y.-W. Huang (MediaTek)] [late registration / uploaded 2011/03/19]

18.8.3 Motion Data Compression

JCTVC-E059 Modifications of temporal mv compression and temporal mv predictor [S. Park, J. Park, B. Jeon (LGE)]

This contribution proposes modifications of temporal motion vector memory compression scheme and a position change of the temporal motion vector predictor. Regarding temporal MV memory compression scheme, three modifications are proposed: 1) correcting for inconsistency of MV and reference index, 2) changing representative MV position, 3) replacing zero MV of an intra block by an MV of a neighbour inter block, and 4) changing the center position of the temporal MV predictor. For a combination of all modifications, average BD-rate savings of 0.7% for RAHE, 0.7% for RALC, 0.8% for LDHE and 0.8% for LDLC are reported.

Tool 1 was similar to JCTVC-E221, JCTVC-E147, JCTVC-E211, JCTVC-E307.

Tool 2 was similar to JCTVC-E221, JCTVC-E147, JCTVC-E211, JCTVC-E092, JCTVC-E307.

Impacts: Tool 1: 0.1%, Tool 2: around 0.4%, Tools 2 & 3: around 0.5%, Tool 1 & 2 & 3: around 0.6%.

(Tool 1 can rather be seen as bug fix and should be adopted)

Decision: Adopt Tool 1.

Note: The current WD says that everything that is relevant for temporal MV prediction, i.e. motion vector field, refidx and mode is decimated to a resolution of 16x16, taking the values that apply to the top left pixel position. The current software does not exactly implement this, which must be fixed. This bug fix should already be used in the tests for CE9 breakout group from now on (Microsoft will provide the code).

It was suggested to investigate the other parts in CE work; Tool 3 seems to give relatively marginal gain.

Due to the interdependency with the expected changes in AMVP/merge/skip as result from the previous CE9 it can hardly be predicted how any of the tools suggested for MV compression will behave in HM3. The usual process of conducting a CE is therefore to be applied.

JCTVC-E114 Cross verification of LG proposal JCTVC-E059 on modifications of temporal mv compression and temporal mv predictor [Minhua Zhou (TI)]

JCTVC-E269 Cross Verification of JCTVC-E059 Proposed by LG [Y.-W. Chen, J.-L. Lin, Y.-W. Huang (MediaTek)]

JCTVC-E092 Motion Vector Decimation for Temporal Prediction [X. Guo, J. Lin, Y.-W. Huang, S. Lei (MediaTek)]

This contribution proposes a motion vector (MV) decimation method for storing the MV data at lower resolution. Specifically, the MVs from the bottom right 4x4 block in a MV compression unit are used as the MVs of the whole unit instead of the top left one as in HM2.0. Moreover, the reference indices of the bottom right block are also used for the whole unit to avoid the possiblity of mismatch between MVs and reference indices. It is reported that average BD-rate reductions of 0.3%, 0.3%, 0.5% and 0.4% are observed by using the proposed method for RA-HE, RA-LC, LD-HE and LD-LC configurations, respectively, with almost no change of encoding and decoding time.

Further study in a CE was recommended.

JCTVC-E442 Cross-verification of MediaTek proposal on motion vector decimation (JCTVC-E092) and context dependent intra mode coding (JCTVC-E201) [P. Chen, M. Karczewicz (Qualcomm)] [late registration]

JCTVC-E498 Cross-check result of MediaTek's MV decimation for temporal prediction (JCTVC-E092) [Lidong Xu, Yi-jen Chiu, Wenhao Zhang, Hong Jiang (??)] [late registration 2011/03/21]

JCTVC-E096 Partition size based selection for motion vector compression [Shigeru Fukushima, Masayoshi Nishitani, Motoharu Ueda, Kazumi Arakage, Hideki Takehara (JVC)]

Reduced resolution storage of motion vector data adopted in the HM2.0 can reduce memory size by cutting the quantity of motion vector data stored. On the other hand, the reduction of the motion vector data causes some coding loss because of reliability degradation of the temporal predictor.

This proposal aims to enhance the reliability of the temporal predictor in case of use with motion vector compression.

The candidates proposed to be stored are the center four 4x4 blocks in the 16x16 block. The prediction partition size is compared in z-scanning order. The motion vector of the block having the partition size that is the largest is selected.

The simulation results reportedly show that the proposed technique provides 0.1% BD-rate gain for high efficiency setting and 0.2% BD-rate gain for low complexity setting without an increase of the complexity.

It was discussed whether to further study this in a CE. This tool seems to give relatively low gain. ~~It is however not known how much can be realized in the HM3 context. The procedure of a potential CE needs to be worked out carefully.~~

JCTVC-E308 Cross-check of motion vector compression by JVC KENWOOD (JCTVC-E096) [Tomoyuki Yamamoto, Andrew Segall (SHARP)]

JCTVC-E097 Temporal predictor restriction harmonized with motion vector compression [Hideki Takehara, Shigeru Fukushima (JVC)]

The maximum number of access times to motion vector data of reference pictures depends on the minimum partition size allowed to use temporal predictor. Furthermore allowance of using the temporal predictor for any block size causes an increase of both encoder and decoder runtime.

This proposal aims to reduce the maximum number of access times to the temporal predictor in the parsing process of the decoder by harmonizing the partition size of using the temporal predictor with the partition size of the motion vector storage.

The number of access times to the temporal predictor in this proposal is reportedly reduced to 1/16 compared with the HM2.0 anchor.

The simulation results reportedly show that the proposed technique causes overall 0.1% BD-rate loss. Overall encoder runtime is 101%, decoder runtime is 98-99% compared with the HM2.0 anchor, respectively.

The reported motivation was the reduction of the checking process at the decoder side.

JCTVC-E064 has a similar concept.

One expert mentioned that this could lead to a solution where the temporal candidate for smaller block sizes is done by table lookup.

Further study in a CE was suggested.

JCTVC-E191 Cross-verification report on temporal predictor restriction method harmonized with motion vector compression (JCTVC-E097) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)] [initial version rejected (placeholder) – version 2 late upload]

(Initially the wrong title was registered – the contribution refers to JCTVC-E097, not JCTVC-E096.)

JCTVC-E117 Evaluation results on motion vector storage compression [Minhua Zhou (TI)]

This document reports evaluation results of the motion vector storage compression adopted in the HM2.0. The test results reportedly reveal that for 16x motion vector compression used in the HM2.0, the average coding loss is 0.6% (HE RA), 0.7% (LC RA), 0.9% (HE LD) and 0.9% (LC LD), respectively. If 4x motion vector compression is used, the coding loss is reduced to 0.1% (HE RA), 0.2% (LC RA), 0.1% (HE LD) and 0.1% (LC LD), respectively. It was recommended to maintain 16x motion vector compression in the HEVC test model but to study other possibilities to reduce the quality loss.

(The presentation slide deck had not been uploaded at the time of its presentation.)

The contribution indicates that the loss due to current MV compression (16x) is rather large. The target should be to reduce the gap compared to original MV field by using a better MV compression method.

JCTVC-E142 Dynamic range restriction of temporal motion vector [S.-C. Lim, H. Y. Kim, J. Kim, J. Lee, J. S. Choi (ETRI)]

This contribution presents a dynamic range restriction of temporal motion vectors. In HM 2.0, temporal motion vectors are used as a temporal predictor to improve coding efficiency both in advanced motion vector prediction (AMVP) and in prediction unit (PU) merge. In order to use the temporal motion vectors, they have to be stored in the memory before encoding and decoding of the current picture. In the last meeting, a temporal motion vector memory saving method (JCTVC-D072) was adopted in HM 2.0. This method reduces the spatial resolution of motion vector data to be stored in the memory. To further reduce the memory size and the memory access bandwidth, the dynamic range restriction of temporal motion vector is proposed in this contribution. The proposed method controls the bit width for storing each temporal motion vector component. The experimental results show that the proposed method additionally reduces the required memory size by about half on top of HM 2.0 with about 0.2% coding loss for random access and low delay test conditions on average.

The method clips large motion vectors. This could be disadvantageous in case of large motion. In fact, the results with steam locomotive are worse. The loss also is close to zero for the LD cases, where it is less probable that large vectors occur (with the current test sequences).

Dynamic ranges of MVs could also be related to levels.

Further study in a CE was suggested.

JCTVC-E336 Cross Check of ETRI's Proposal on Dynamic Range Restriction of Temporal Motion Vector JCTVC-E142 [Jie Zhao, Andrew Segall (SHARP)]

JCTVC-E147 On motion information compression [B. Li (USTC), J. Xu (Microsoft), F. Wu (Microsoft), H. Li (USTC)]

In the current design of HEVC, MV compression is used to reduce the memory required by the MV information in the reference frame. This contribution proposes to further reduce the memory requirement by compressing reference frame indexes and modes, while reporting that some coding gain can be achieved. This document also presents a modification to improve the coding efficiency without increasing complexity. In the proposed method, on average 0.5%, 0.6%, 0.7% and 0.7% bit-savings can reportbe achieved for RA_HE, RA_LC, LD_HE and LD_LC settings.

Also includes disabling the TMVP in merge (see under JCTVC-E115 – which was not adopted).

It was agreed to adopt the refidx and mode bug fix aspects (see notes under JCTVC-E059).

Other elements should be further studied in a CE.

JCTVC-E163 Cross-verification of Microsoft proposal JCTVC-E147 on motion information compression [Minhua Zhou (TI)]

JCTVC-E211 Modified motion vector memory compression [T. Shiodera, A. Tanizawa, T. Chujoh, T. Yamakage (Toshiba)]

This contribution proposes a modified motion vector memory compression (MMC) method which includes two parts. One is reference index memory compression which reduces the reference index memory requirement to one sixteenth in same manner as motion vector memory compression. The other part is a modified representative motion vector derivation which uses the MV of the bottom-right 4x4 block (position 12 or 15) as a representative MV instead of the upper-left 4x4 block in a compressed 16x16 block.

Experimental results reportedly show that the proposed method can achieve the average BD-rate gain of 0.5% for random access cases and 0.6% for low delay cases without additional encoder/decoder complexity.

The contributors were not present due to the earthquake in Japan – the contribution was reviewed based on just the document.

Item 1 is the "bug fix"

Item 2 was similarly proposed in other contributions.

Further study in a CE was recommended.

JCTVC-E337 Cross Check of Toshiba's Proposal on Modified MV Memory Compression (JCTVC-E211) [Jie Zhao, Andrew Segall (SHARP)]

JCTVC-E221 On memory compression for motion vector prediction [Edouard Francois, Christophe Gisquet, Guillaume Laroche, Patrice Onno, Nael Ouedraogo (Canon)]

This contribution presents some modifications of the motion vector memory compression algorithm proposed in JCTVC-D072 which was adopted during the last meeting. The motion vector memory compression reduces the size of the motion vector buffer to store temporal co-located vectors. The current implementation stores the motion vector data from previous frames at lower resolution by summarizing a block of 16 motion vectors by the top left motion vectors of this block. The first proposed modification consists of using a different motion vector for the summarization. The second proposed modification reduces the amount of bits needed to store the different motion data related to the co-located temporal predictor. The proposed modifications reportedly give 0.5% bit rate savings in average for the four configurations with 52x motion memory compression ratio compared to storing the entire motion vector field.

The approach uses adaptive clipping/scaling (quantization) of the MV, depending on the range.

It also uses the bottom-right value instead of top-left.

Further study in a CE was suggested.

JCTVC-E410 Cross Check of Canon's Proposal on Memory Compression for Motion Vector Prediction (JCTVC-E221) [Jie Zhao, Andrew Segal (Sharp)] [late upload 2011/03/17]

JCTVC-E231 Modified motion vector compression method [Toshiyasu Sugio, Takahiro Nishi (Panasonic)]

In this contribution, a modified motion vector compression method was proposed. It was proposed that a representative motion vector was searched among 4x4 blocks according to encoding order. And when referring as a co-located partition, the representative motion vector was scaled by using reference index of each 4x4 block and reference index correspond to it. Experimental results reportedly showed 0.6% BR saving for HE and LC on average in the RA scenarios, and 0.6% BR saving for HE and 0.7% BR saving for LC on average relative to the HM2.0.

Proposes a "refidx bug fix".

Also proposes an alternative method to select the representative MV within the 16x16 region.

Further study in a CE was suggested.

JCTVC-E352 Cross Check of Panasonic's Proposal on Modified Motion Vector Compression Method (JCTVC-E231) [Jie Zhao, Andrew Segall (SHARP)]

JCTVC-E292 Simplification and improvement of merge mode coding [S. Li (Tsinghua), X. Zheng (HiSilicon), Y. He (Tsinghua)]

This contribution propose a complexity reduction and a new candidate derivation method for merge coding. It is reported that by removing the temporal merge mode candidate can reduce coding complexity and improve the coding performance. By using these two methods, the total encoding time can reportedly be reduced by 2% to 4%, and BD-bit rate reduction can be 0.1% to 0.5% on average.

The gain seemed relatively small.

For disabling TMVP in merge, see the discussion under JCTVC-E115 – this was not adopted.

Is is unclear how this would apply with HM3.

JCTVC-E438 Cross-verification of simplification and improvement of merge mode coding (JCTVC-E292) [P Chen, Y. Zheng, Marta Karczewicz (Qualcomm)] [late registration]

JCTVC-E307 Improved motion vector decimation [I.-K. Kim, T. Lee (Samsung)]

This contribution proposes a modified motion vector selection to be stored in motion vector decimation process. The proposed method selects the right-bottom motion vector instead of the left-top motion vector as the motion vector to be stored in the motion vector buffer. The experimental result -0.5%, -0.5%, -0.6%, and -0.6% BD-rate impact for high efficiency random access (HE-RA), low complexity random access (LC-RA), high efficiency low delay (HE-LD), and low complexity low delay (LC-LD), respectively. The proposed algorithm reportedly does not impact the complexity at both encoder and decoder side.

Not necessary to review (already covered in other contributions).

Further study in a CE was recommended.

JCTVC-E459 Cross-verification report for Samsung's contribution on motion vector decimation (JCTVC-E307) [Hirofumi Aoki, Keiichi Chono, Yuzo Senda] [late registration / missing prior]

CE planning discussion

Methodology for CE9 continuation (where the motion data compression will become part) was discussed:

- We have a number of tools on the table which could potentially give gain
- Categories:
  A) Selection of the representative candidate (how to subsample, and how to derive the predictor from the subsampled set)
  B) How to represent the relevant data fields (MV, refidx, mode) with finite number of bits (clipping, scaling etc.)
  C) Subsampling ratio?

An approach in the CE that implements at least two phases (first identifying the most promising solution in the given category, and then combining that with the best of other category(ies)) would be advisable.

18.9 Inter Mode Coding

JCTVC-E052 Reduction in Combinations of Reference Picture Indices for Bi-Prediction [T.-D. Chuang, J.-L. Lin, Y.-W. Huang, S. Lei (MediaTek)]

In the forward B-slices, the reference picture list 0 (LIST_0) and the reference picture list 1 (LIST_1) are identical, and there had been prediction redundancy in the uni-prediction (i.e. single list prediction) and the bi-prediction cases. In order to reduce the prediction redundancy, the concept of a combined reference picture list (LIST_C) was adopted in HM2.0 to unify the reference picture list for the uni-prediction. However, there still exists prediction redundancy in the forward bi-prediction, which was suggested to be removed. Reduced combinations of reference picture indices are proposed.

The encoding time is reportedly reduced by 19% and 26% with 0.6% and 0.4% bit rate increases for HE-LD and LC-LD, respectively.

Without the syntax modification, the penalty in bit rate would be 0.1% or 0.2% worse.

Parsing of list_1 refidx would depend on list_0.

Would this work if list_0 and list_1 are not identical? In that case, the speedup would not apply.

Even though this is used in the common conditions, this must not necessarily be the case.

It appeared that JCTVC-D089 (by LG) was proposing the same method during last meeting.

Concern was expressed that the rate gain would disappear when the current identity of lists (as in the test conditions) is not given.

It was suggested that this could potentially cause a problem with weighted prediction.

Following this discussion, the syntax change should not be adopted.

Encoder runtime reduction looks interesting, but there is concern that the reference software should not include elements where it is first necessary to check whether the two lists are identical.

JCTVC-E443 Cross-verification of MediaTek's proposal on Reduction in Combinations of Reference Picture Indices for Bi-Prediction (JCTVC-E052) [W.-J. Chien, M. Karczewicz (Qualcomm)] [late registration]

JCTVC-E080 Adaptive Inter Mode Coding for LCEC [X. Zhang, S. Liu, S. Lei (MediaTek)]

This contribution reports methods and results for coding the CU mode in inter slice with low complexity entropy coding (LCEC). In the proposed methods, the codeword length of each inter prediction mode is adjusted based on accumulated statistics and probabilities of a content dependent interval in a slice. The accumulated statistics and probabilities are measured by a set of counters. An average of 0.2% BD-rate savings are reported for low complexity configurations with random access setting, and an average of 0.3% BD-rate savings are reported for low complexity configurations with low delay setting. No encoding or decoding time increase was reported.

This relates to counter-based methods discussed in CE5. The method of JCTVC-E143 would be more or less a superset.

JCTVC-E427 Cross-check of MediaTek's proposal (JCTVC-E080) on Adaptive Inter Mode Coding for LCEC [P. Lai, F. C. A. Fernandes (Samsung)]

JCTVC-E469 Cross checking of MediaTek proposal JCTVC-E080 on adaptive inter mode coding for LCEC [Cheung Auyeung, Ali Tabatabai (Sony)] [late registration 2011/03/17]

JCTVC-E258 Improvement of inter mode coding and split flags coding for LCEC [Virginie Drugeon, Thomas Wedi, Matthias Narroschke (Panasonic)]

This contribution proposes modifications for inter mode and split flags coding in Low Complexity Entropy Coding (LCEC). In particular, the adaptation scheme of the tables used for inter mode coding in LCEC is modified as well as the number of tables. The statistics of the modes and the partitioning information of neighboring CUs are exploited. These modifications are tested in HM2.0 with reported 0.2% and 0.4% gain for the random access and the low delay configurations. A joint coding of the split flags for I frames with LCEC is proposed. This modification is reported to bring 0.2% gain for the intra configuration.

Proposing again counter-based adaptation (no need for further review).

Proposing additionally new tables: 3 tables per depth: 0.2% RA, 0.4% LD; 9 tables: 0.3% RA, 0.5% LD.

Proposing joint coding of split flags: 0.2% gain (could be related to JCTVC-E404 which was adopted).

Recommendation: Further study in CE.

JCTVC-E381 Improvement of inter prediction direction and reference frame index combined coding in LCEC [J. Chen, T. Lee, Y. Park (Samsung)]

In the current HM 2.0, inter prediction direction and reference frame index in combined coding for LCEC was improved by JCTVC-D141. But with extension of uni-prediction simplification in B slices by JCTVC-D421 which was adopted at the same time, the max index of reduced combined list is not modified. This proposal is the extension of max index setting for combined coding to the combined list. In this proposal, the max index of all the probabilities within the lookup table is set. To avoid keeping multiple initial lookup tables, one unified table is used with adaptive mapping the value and the meaning in lookup table depending on the number of references.

Most likely, this contribution provides a solution to implement JCTVC-D141 and JCTVC-D421 (adopted at the last meeting) as it was originally intended. In initial discussions, it was suggested that the software of JCTVC-E381 should be checked by the proponents of JCTVC-D141 and JCTVC-D421 and the proposal be adopted provided that no problem is found.

It was reported (Sunday morning) that no problem exists.

Decision: Adopt.

JCTVC-E495 Cross-check results for Samsung's proposal JCTVC-E381 from HiSilicon [J.Zhou (Hisilicon)] [late registration 2011/03/21 / uploaded 2011/03/22]

18.10 High-level syntax and slice structure

18.10.1 High-level syntax relationship to systems usage of bitstreams

JCTVC-E429 On Profile signaling [David Singer (Apple)]

This contribution discusses how profiles, and particularly files that are compatible with multiple profiles, could be signaled, and presents some of the alternative ways to indicate this.

In the AVC standard, the 'primary profile' is signaled with the numeric profile_idc indicator in the sequence parameter set. We also have 'level_idc', which functions somewhat similarly to profile_idc. The field is followed by a set of 'constraint_set' flags, some of which are used to indicate 'also compatible with' other profiles or other constraints.

There are a number of possibilities for that list:

a) a true list; a set of values terminated by one or more zero values, for example (this allows zero to be used as a padding value, which can help if the compatibility list might need additions after the initial writing).

b) a bit-field; we could allocate say 32 bits, and hope we never have more than 32 profiles;

c) an extending bit-field; we could one bit in each byte to indicate 'more bits follow' or 'end of list';

A "best use" indicator was suggested to also be valuable; for example, an AVC bitstream may be scalable (use SVC) or multi-view (use MVC) and still have an AVC-compatible base layer. Under these circumstances, the "best use" is as an SVC or MVC bitstream; reading it as an AVC bitstream means that there is data in the bitstream that is unused.

The "straw man" proposal was as follows:

- Defin profile_idc as a single-byte integer value, allocated in "clusters" of similar profiles such that files that are compatible with more than one profile are likely to use adjacent values.
- There is a field best_use_profile_idc. Bits are additionally allocated in groups of 7, with the 8th bit in each byte indicating the "end of list". The first bit is labeled bit(1), and bit(n) being 1 indicates that the file is also compatible with profile with some profile_idc value. Note that this can therefore accommodate arbitrary numbers of zero bytes, terminating with a byte with the value 1.

It was remarked that, in addition to signaling "profiles", such a syntax can also signal other sorts of constraints, such as "levels" and "constraint set" constraints.

It was remarked that the proposed byte string system may have a start code emulation issue.

It was remarked that the variable-length nature of the straw-man proposed list structure may be somewhat difficult to carry in some application environments.

It was remarked that the "best use" concept may not be necessary. Another participant remarked that this could be useful in "non-onion-shell" indicator scenarios.

It was agreed that the contribution reminds us of important issues that should be addressed in the work.

The hope was expressed that adopting a signalling scheme that is capable of expressing elaborate non-onion-shell arbitrary intersection relationships would not encourage the definition of profiles in such a manner.

Further study (e.g., in H-L syntax AHG) is needed to work out exactly what we would want in this regard.

JCTVC-E375 Design Consideration For Compability With AVC NAL Units [ChongSoon Lim, Viktor Wahadaniah (Panasonic)]

This contribution presents a suggestion to JCT-VC to consider the functionality of "backward compatibility" in the HEVC NAL unit header design with AVC NAL unit header using reserved NAL unit type values of AVC.

The contributor suggested, for example, to have a way for the HEVC NAL units to be structured as what would be interpreted as a reserved or application-specific NAL unit type by an AVC decoder, with the HEVC.

A participant remarked that it would be better for the system environment to handle the multiplexing rather than to specify this within the video bitstream specification.

It was also remarked that the AVC application-specific NAL unit types are already occupied in the important RTP application environment.

Additionally, RTP and possibly other (especially modern) system designs may have a mechanism to carry any necessary multiplex sub-stream type indicators.

It was remarked that such a functionality has not been expressed in the requirements for the HEVC project as communicated from the parent bodies.

18.10.2 Supplemental information

JCTVC-E280 Picture Orientation Information [S. Wenger, J. Boyce, D. Hong (Vidyo)]

This contribution proposes the inclusion of picture orientation information in the video bitstream at the sequence level, which indicates to the decoder to rotate the image after the decoding process, at angles of 0, 90, 180 or 270 degrees. The rotation information could be placed in the VUI or SPS, or in an SEI message. GPUs often provide hardware support for rotation, and are frequently used for post-decoding processing, such as color conversion and image scaling, so the decoder complexity increase for inclusion of this tool is asserted to be low. This feature was reported to be especially interesting for mobile phone videoconferencing applications, where overall system complexity can reportedly be reduced by shifting the rotation operation from pre-encoding to post-decoding as part of the rendering process. Additionally, coding efficiency can reportedly be improved for some sequences by rotating images prior to encoding. Rotation can reportedly cause coding losses for some sequences, but losses can reportedly be avoided by an "intelligent" encoder. Individual sequence gains were reported to be as high as 3.4%, with average gains for the test set reported to be 0.7% Intra LC and 0.5% RA LC with an "intelligent" encoder, and 0% Intra LC and 0.3% RA LC gain for a "naïve" encoder that always rotated by 90 degrees. When slices with a maximum size of 1500 bytes were used, average gains were 0.7% Intra LC and 0.7% RA LC with an "intelligent" encoder, and 0.3% Intra LC and 0.6% RA LC for a "naïve" encoder.

It was noted that this is not really a proposed "decoder processing" scheme, but rather some "display helper information".

It was remarked that some similar issues were discussed previously in JCTVC-C224.

It was remarked that performing an image rotation at the encoder side could also add delay.

It was remarked that the orientation information is a property of the video, which could mean that it is advantageous to convey the information in a tightly-coupled fashion with the video bitstream.

It was remarked that having this information at both the video and system layer could occur, and there would need to be some prioritization in the event of multiple indicators.

It was remarked that such a concept is not specific to HEVC, and could be considered for AVC as well.

It was remarked that doing it in SEI would allow the indicator to change dynamically, and that angles other than 90 degree increments should perhaps be considered, as the display process can choose to quantize that to 90 degree increments if it so chooses. Other more elaborate possibilities were also discussed.

For further study (e.g., H-L syntax AHG).

JCTVC-E346 Reuse of AVC SEI messages [Y.-K. Wang (Huawei)]

Reuse of AVC (as well as SVC and MVC) SEI messages in HEVC was discussed at the Daegu meeting as a response to the proposal in JCTVC-D082. The table provided in JCTVC-D082, which includes a list of all the AVC SEI messages and whether to reuse them in HEVC, was agreed as the starting point, with revisions documented in the meeting report in JCTVC-D500. This contribution provides an update to the table to reflect the agreed revisions, to maintain a clear state of the agreed starting point.

The contributor noted that his recollection differed from the meeting report in regard to the full_frame_freeze SEI message and the full_frame_freeze_release SEI message. The contribution asserted that these are probably not needed, as the output_flag in the NAL unit header could be used to achieve the same functionality.

It was remarked that the output_flag may belong somewhere other than the NAL unit header, such as the slice header, as the NAL unit header bits are particularly precious.

It was remarked that the freeze/release might still have a hypothetical usefulness even if the output_flag exists somewhere. However, since the need is potential need seems arguable and hypothetical, this will be left out at this time.

Decision: The current SEI intent (items marked Yes or Probably Yes in JCTVC-E346) should be reflected in the working draft.

18.10.3 Parameter sets and slice header sharing

JCTVC-E281 Slice parameter set [S. Wenger, J. Boyce (Vidyo)]

This contribution proposed a "slice parameter set" as a way to support the inclusion of in the bitstream Adaptive Loop Filter (ALF) coefficients, and possibly other aspects such as weighted prediction, reference picture list reordering, memory management control operation, and quantization weighting matrices. The concept is to have another parameter set level that can be shared by multiple slices but not necessarily by all slices in the picture. Moreover, the additional parameter sets could also be re-used for slices of different pictures.

The proposal was of a conceptual nature and did not include concrete syntax or semantics, nor did it provide simulation results.

Slice parameter sets were reportedly previously proposed by Miska Hannuksela of Nokia in JVT-C078 (http://wftp3.itu.int/av-arch/jvt-site/2002_05_Fairfax/JVT-C078.doc).

It was remarked that, when using the packet switched streaming (PSS) service specification of 3GPP, AVC parameter sets are transmitted out of band using the session description protocol (SDP).

It was noted that, for information that is not necessary for operation of the basic decoding process (without timing), AVC has SPS-level VUI and picture-level (and higher-level) SEI.

It was remarked that a prior proposal (JCTVC-D128, again discussed in JCTVC-E045) was related, although at this meeting it was planned to use the existing PPS and SPS levels for the time being rather than adding a new level of parameter sets. Another contribution to this meeting, JCTVC-E222, was also related.

The degree of need for such mechanisms should be considered in relation to the quantity of bit rate savings.

The contribution seemed interesting, and should be kept in mind in our work.

JCTVC-E309 Parameter set updates using conditional replacement [S. Wenger (Vidyo)]

This contribution proposed a mechanism to allow updates of existing parameter sets, without requiring the transmission of the complete parameter set data. The mechanism can be implemented without syntax changes relative to H.264/AVC's high level syntax, though a change in the semantics is required. The key motivation behind this change is the presumption that the use of ALF slice parameter sets, as proposed in companion document JCTVC-E281, may require frequent parameter set transmissions where the parameter sets differ only slightly in content. A "delta" transmission of individual parameters of the parameter set was suggested as a beneficial approach by the authors. Also proposed was a parameter set maintenance mechanism, one of whose incarnation is copy.

It was remarked that the "copy" and "delta" schemes would have error resilience effects. It was remarked that the "updating" scheme could be used to modify either the data from the same parameter set ID or from a different parameter set ID.

The contribution seemed interesting, and should be kept in mind in our work.

JCTVC-E222 Slices modifications for HEVC [Edouard Francois, Christophe Gisquet, Guillaume Laroche, Patrice Onno, Nael Ouedraogo (Canon)]

This contribution proposes a modification of the slice partitioning in HEVC. The entropy slices principle presented in JCTVC-D070 and adopted in HM2.0 is slightly modified. Slice headers that were located at the beginning of the entropy slices are moved to single slice parameter sets NAL unit located at the beginning of the frame. Indeed in HM2.0, the current Slice headers contain several coding parameters like POC, frame_num or slice_type related to the frame itself but are duplicated for all slices. The main goal of having several Slice headers was just to indicate the coding dependencies boundaries.

Furthermore, this contribution proposes to add information in the slice parameter set such as the coding dependencies signalization to indicate slice boundaries previously indicated with slice headers. Additional information related to the signaling of processing boundaries for loop filters is also in traduced in this slice parameter sets NAL unit.

The intent of this contribution is to provide solutions to ease the streaming of HEVC video and parallel decoding.

The "slice parameter set" proposed here is different than the one in JCTVC-E281. This one is sort of a picture header.

It was remarked that, from an error resilience perspective, the idea of moving the frame number out of the slice header into a single picture header could have serious adverse effects.

Also, moving some elements such as reference picture list reordering, from the slice level to the picture level would remove the ability to change these elements from slice to slice within the picture.

The contribution also proposes to signal aspects such as intra/inter coding type boundaries out of the slice header into the picture header.

Some combination of concepts from JCTVC-E281, JCTVC-E309, and JCTVC-E222 (and JCTVC-E412 and others described in this section) appear to show promise, and should be further studied (e.g., in a slice or HL syntax AHG).

JCTVC-E279 Extensible High Layer Syntax for Scalability [J. Boyce, D. Hong, S. Wenger (Vidyo)]

This contribution proposed the introduction of a new "dependency parameter set" and two new SEI messages, as well as changes to the NAL unit header, sequence parameter set, picture parameter set, and slice header, for support of scalability and future extensions. Specific proposed elements were as follows:

- Dependency parameter set: Introducing a dependency parameter set (DPS), above the sequence parameter set, to tie together related sequences, and describe their dependency relationships. This coud reportedly be used for scalability and multi-view, or future extensions (e.g. multiple description coding, etc.).
- NAL unit header: Adding a byte to NAL unit header for scalability information – spatial_id and quality_id, for certain NAL unit types. Add store_ref_base_pic_flag and use_ref_base_pic_flag to support MGS key pictures.

- Sequence parameter set: Adding information about temporal scalability layers. Adding the temporal_id_nesting_flag syntax element as proposed in JCTVC-D200. Adding sps_extension_flag for future extensions, including sequence level scalability parameters.
- Picture parameter set: Adding temporal_layer_switching_point_flag, similar to the one proposed in JCTVC-D200, but with some modifications. Adding pps_extension_flag for future extensions, including picture level scalability parameters.
- Temporal structure SEI message: A message which adds active # of temporal layers to the coding structure SEI message proposed in JCTVC-D200.
- Spatial and quality layer SEI message: A message containing the active # of spatial layers, and active # of quality layers in the highest active spatial layer.
- In slice header, putting pic_parameter_set_id first, so that it is easier to find PPS, without having to entropy decode additional fields. Adding slice_header_extension_flag for future extensions, including slice level scalability parameters.

Among these, it was particularly suggested to currently focus on two aspects

- Put temporal_id_nesting_flag into SPS, to always mark all higher layers as "unused for reference" when every picture in the CVS arrives
- Add temporal_layer_switching_point_flag to PPS, to mark all higher layers as "unused for reference" when a picture with this flag set to 1 arrives

A participant asked why the first of these is needed, since it is just a short-cut for a static value of the second one. It was commented that detecting the value of the bit on a picture-by-picture basis requires following the PPS index indirection link.

Another participant suggested that such a flag could be put into the NAL unit header. But NAL unit header bits are precious, and this is a picture-level property.

It was noted that a design principle has been the ability to parse the PPS without access to the SPS.

A revised version was uploaded to address this parsing issue.

Decision: Adopted (above two aspects, revised version).

18.10.4 Tiles

JCTVC-E408 Tiles [Arild Fuldseth (Cisco), Michael Horowitz (eBrisk), Minhua Zhou (TI)]

(The presentation slide deck was not uploaded at the time of its presentation.)

This contribution describes a coding technique called *tiles* that partitions a picture into rectangular segments. The technique has commonalities with the generalized slices concept of JCTVC-D378 with the tiles of JCTVC-D227 and sub-pictures of JCTVC-B062. Tiles (as described here) comprises vertical and horizontal boundaries that partition a picture into columns and rows, respectively. These column and row boundaries break prediction mechanisms (e.g., intra prediction and motion vector prediction) in the same way as slice boundaries unless indicated otherwise. Results from three experiments were presented comparing coding efficiency for tiles relative to a similarly-configured encoder using slices with LCUs processed in raster-scan order within a picture. Partial results for MTU size matching are reported, with these tiles being reported to provide 0.5%, 0.2%, and 0.5% coding gains for All Intra, Random Access, and Low Delay, respectively, relative to the anchor. Partial results for high-level parallel processing, reportedly show significant gains that are improved relative to those of "generalized slices". For memory constrained motion estimation using four tiles, an average of 12.5%, and 3.4% Y BD-rate advantage for the Random Access and Low Delay cases, respectively, was reported relative to a memory constrained anchor.

The discussion included the following comments:

- Some properties assumed to apply to all tiles or slices in the picture should perhaps be allowed to vary
- Some properties may best be separated for signaling purposes – e.g., whether the deblocking, intra prediction, MV prediction, mode prediction, parsing processing, qp control, etc., are performed across the boundaries.
- It was noted that in the proposal, crossing the boundary between tiles does not necessarily involve sending a slice header (as a way of improving coding efficiency for parallel tile encoding).
- Coding efficiency benefit was demonstrated relative to slice use, due to the tiles being more spatially coherent for prediction.
- QP prediction handling was discussed
- Test results for the second test were flawed due to forgetting to reset the entropy coder at the tile boundaries, and it was reported that a revision would be uploaded to fix this (perhaps a week or two after the meeting ends, with software included as well).
- Various ways of configuring, selecting, and using the tile structure (possibly varying from picture to picture) were discussed.
- It was suggested that JCTVC-E409 might be helpful in determining how to handle cabac_init_idc.

The group is favorably disposed to the proposal from the conceptual perspective.

Further study in an AHG (e.g., a slice-related AHG) was encouraged.

JCTVC-E414 Cross verification of Tiles (JCTVC-E408) [Kiran Misra, Andrew Segall (Sharp)] [late upload 2011/03/19]

This contribution reports a cross-check of the tiles experiment 1 corresponding to MTU size matching and outlined in document JCTVC-E408. The tile dimensions used were as specified for experiment 1 (Table 3) in JCTVC-E408. For reference HM-2.0-dev-slices software version 609 with common conditions and 1500 bytes slice limit was used. The software implementation was verified and the R-D results were reportedly identical to those provided by the proponent.

One of the three experiments of

The software was studied closely for all three experiments.

No difficulties were observed other than the reset bug reported above.

JCTVC-E421 Crosscheck of Cisco's Tiles Proposal (JCTVC-E408) [Muhammed Coban (Qualcomm)]

No difficulties were observed other than the reset bug reported above.

JCTVC-E412 Tiles for Parallel Decoding [Kiran Misra, Andrew Segall (Sharp)]

This contribution proposes an extension of the tiles concept that is proposed in JCTVC-E408. Tiles partition an image into rectangular segments. This is asserted as being beneficial for the encoder in several applications, including MTU size matching, parallel encoding, and memory constrained motion estimation. In this contribution, tiles are extended to support decoder parallelization as well. This is realized by signaling tile entry points in the bitstream, so that a decoder is able to enter the bitstream at the beginning of a tile. The signaling was asserted to be necessary as tiles do not necessarily always use a header, and thus cannot be located in the bitstream by a decoder (without completely parsing the bitstream). The approach supports sending tile entry points explicitly in the slice header or using markers in the bitstream. Experimental results were provided to show the asserted benefits of the approach.

Two approaches:

- Entry points sent in the slice header,
- Markers in the bitstream.

With the entry point method, a list of locations of tiles is sent in the slice header. If no tile boundaries are within the slice, the length of the list is set to 0.

It was suggested that entry point information could be sent as SEI, since it is not necessary for being able to perform decoding. The proponent indicated that they wanted to avoid the overhead of SEI signaling, and it would be necessary to identify which slice is being referred to for each location identifier (or equivalently to signal a position within the coded picture bistream rather than just within a slice's bitstream).

A usage of the marker approach was also described, using something like start codes within NAL units. A "lightweight" slice header handling allowing header sharing across slices (with some similarity to the "slice parameter set") was described, with QP and cabac_init_idc only sent for a "lightweight" slice header, was described.

To be further studied with JCTVC-E408 and with JCTVC-E281 / JCTVC-E309 / JCTVC-E222.

18.10.5 Wavefront parallel processing

JCTVC-E196 Wavefront Parallel Processing [Félix Henry, Stéphane Pateux (Orange)]

This contribution describes a method to perform parallel encoding and decoding of video using HEVC. As recommended in JCTVC-D243 (by TI), interleaved lines of LCUs are processed by the encoding/decoding threads. In order to limit the degradation of performance, a wavefront pattern of processing ensures that spatial and motion vectors dependency is preserved, as recommended in JCTVC-D073. An additional context buffer is used to synchronize CABAC along the second column of LCUs. It is asserted that this method provides a fixed encoding/decoding design with thread-independent bitstream content. The average BD-rate degradation was asserted to be 0.7% (intra 0.1%, random access 0.8%, low delay 1.3% with CABAC / HE coding conditions). It is also asserted that this method can be viewed as an extension of entropy Slices with LCU-limit.

Historical references VCEG-AK25 (MediaTek) and VCEG-AL21 (TI) were mentioned by the proponent.

An index table is sent in the slice header to indicated the numberand location of each decodable sub-codestream in the slice header).

Some coding efficiency degradation is observed (relative to basic sequential HM) due to extra header data and reduced degree of adaptive convergence for entropy coding by subsequent rows. Current delay is 2 LCU per row. The degradation in coding efficiency could be reduced by increasing that number.

Degradation is less than for schemes that reinitialize completely for each row of LCUs.

JCTVC-E415 Cross verification of Wavefront Parallel Processing (JCTVC-E196) [Kiran Misra, Andrew Segall (Sharp)] [late upload 2011/03/18]

Results matched. Software was studied extensively and it was further extended jointly as found in JCTVC-E470.

JCTVC-E409 New results for periodic inits for wavefront coding functionality [Kiran Misra, Andrew Segall (Sharp)]

This document reports results for re-initializing the CABAC engine at the start of each largest coding unit (LCU) row and transmitting the location of these re-initialization points to the decoder. The asserted benefit is wavefront processing at both the encoder and decoder, and the technique was previously proposed in JCTVC-D073. Here, results are presented with the current HM2.0 software.

Sequential decoder would not need the location of the start of LCU row positions; parallel decoder would.

In this contribution there is reinitialized to the default table at the start of each row; JCTVC-E196 reinitializes with a learned state from the partial row above.

Position indicator or marker sequence could be usedl

The SEI comment above applies regarding signaling of positions not needed by sequential decoder.

A cabac_init_idc flag is sent or not sent for each row.

The flag indicates whether the wavefront property is present or not.

Degradation was reported as 0.3%, 2.1%, 2.6 for AI, RA, LD CABAC, relative to ordinary one-slice-per-picture.

Encoder "friendliness" would need to be required.

JCTVC-E423 Cross verification of new results for periodic inits for wavefront coding functionality (JCTVC-E409) [Félix Henry (Orange)] [late upload 2011/03/18]

Cross-checked with match. Source code was studied closely and found to match the described scheme.

JCTVC-E470 Combined proposal for wavefront parallel processing JCTVC-E196 and JCTVC-E409 [Félix Henry (Orange Labs), Kiran Misra (Sharp), Stéphane Pateux (Orange Labs), Andrew Segall (Sharp)] [late registration 2011/03/17]

This contribution describes a merge of JCTVC-E196 (wavefront parallel processing) and JCTVC-E409 (new results for periodic inits for wavefront coding functionality). Each line of LCU is an independantly encodable/decodable part of the bitstream, and the corresponding substreams have individual headers, as described in JCTVC-E409. The first LCU of each line has its CABAC probabilities initialized with those obtained from the second LCU of the above line, as described in JCTVC-E196. It was asserted that this combination provides a fixed parallel encoding and decoding design with a level of parallelism, equal to the number of LCU lines. The performance degradation in High Efficiency was reported as 0.2% in All-Intra, 1.3% in Random Access, and 2.2% in Low Delay.

In this scheme, each LCU row is a separate substream (unlike JCTVC-E196, where wrapping across groups of rows occurs), but the contexts are initialized across rows as in JCTVC-E196.

This proposal provides a higher level of parallelism than JCTVC-E196, and improved coding efficiency relative to JCTVC-E409.

According to a contribution from Sharp two meetings ago, it was asserted that the wavefront and entropy slices schemes are mutually compatible.

A state buffer is written after decoding two LCUs of the first row. The state buffer is then read to start the decoding of the second row, and is then over-written two LCU's later, then read to start decoding of the third row, etc. So only one state storage is needed (approx 400 contexts * 7 b per context), used for intialization of all rows.

It was remarked that tiles can be another form of high-level parallelism enablement, and it was suggested to study all these together (with slices and entropy slices) to determine the best form of H-L syntax parallelism.

To be studied in the same AHG activity as above. A high-level parallelism scheme with reasonable coding efficiency degradation impact is desired.

JCTVC-E474 Cross Verification of JCTVC-E470 Proposed by Orange Labs and Sharp [C.-Y. Tsai, C.-W. Hsu, Y.-W. Huang (MediaTek)] [late registration 2011/03/17 / uploaded 2011/03/20]

When reviewed, the cross-check had not yet been completed, experiment runs were completed but the report was still being written. The software was not studied. Thus far, no problems had been identified in the cross-check activity.

18.10.6 NAL unit header

JCTVC-E345 NAL unit header and sub-bitstream extraction [Y.-K. Wang (Huawei)]

In HEVC WD2, the temporal_id field appears in the VCL NAL unit headers. There was a proposal in JCTVC-D080 to include temporal_id also in the NAL unit header of SEI NAL units for support of temporal subsets specific SEI messages. This document proposes the inclusion of temporal_id in the NAL unit header for all NAL unit types, and further proposes a sub-bitstream extraction process that is based on the information in NAL unit headers.

This lengthens the NAL unit header for the non-VCL NAL units.

It was noted that the NAL unit header is outside of the start code emulation prevention process, and we should keep in mind the need to avoid emulations.

It was remarked that extensibility of the NAL unit header syntax is important.

It was noted that the current variable-length nature of the NAL unit header may be considered a shortcoming in itself, such that making it fixed-length at 2 byts could be justified in terms of simplification.

For further study (e.g., as H-L syntax AHG) – plan to resolve at next meeting.

It was remarked that nal_unit_type = = 6 seems to be missing the fields similar to those included for types 1 and 5, and this should be fixed as a bug fix. Decision: Agreed.

Post-meeting note: It appears that the above reference to "nal_unit_type = = 6" was actually intended to refer to nal_unit_type = = 4.

It was also remarked that the reserved bits are currently specified to be equal to 0 rather than 1, which would be better for start code emulation prevention purposes. Decision: Agreed.

JCTVC-E422 NAL unit header concept with support for bitstream scalability [R. Sjöberg, T. Rusert, Z. Wu (Ericsson)]

Similar to the concept of NAL unit identifiers used in AVC and its SVC and MVC extensions (temporal_id etc.), the proposed concept is reported to facilitate identification of bitstream subsets according to high-level properties of NAL units. Unlike in the AVC NAL unit header design, the proposed concept uses a level of indirection to provide NAL unit header signalling, enabling signalling of NAL unit properties in so-called "NAL unit parameter sets" outside the NAL unit header. The NAL unit header itself would contain a reference to a NAL unit parameter set. The proposed concept is reported to provide an extensible mechanism for identification of bitstream subsets to support scalability features in the first HEVC version and in potential later amendments.

The contribution is on a purely conceptual level, and an implementation is not provided at this time. It is proposed to investigate the concept of NAL unit headers with indirection in the context of high-level syntax activities.

The proposal suggested that a convention should be established such that the parameter set index can be used for network/system-level prioritization.

It was remarked that the idea is intriguing, although requiring stream-carrying systems to have the associated indirection and state-storage capability may be a difficult request.

It was remarked that perhaps we should subsume the ordinary NAL unit type indicator into the parameter set as well – carrying the scheme to an extreme.

For further study (e.g., as H-L syntax AHG).

18.10.7 Decoded picture buffering

JCTVC-E399 Sliding Window for Temporal Scalability [Ying Chen, Marta Karczewicz (Qualcomm)]

This contribution asserts that the current sliding window reference picture marking mechanism is not desirable, especially when temporal scalability is supported with hierarchical coding structure. To support temporal scalability, reference picture list construction processes are constrained such that a picture with a higher temporal level will not be used as an inter prediction reference for the current picture. In this contribution, it is proposed that constraints be imposed for the sliding window marking process, such that a picture will not implicitly mark a reference picture with a lower temporal level in the DPB as "unused for reference".

The contribution proposes that, in the sliding window mode, pictures with a lower temporal level shall not be marked as "unused for reference".

It was suggested to consider the interaction with gaps in frame_num value. Long-term reference pictures are another way to avoid the FIFO marking process. The general principle was supported as a desirable characteristic of the design (also in the adaptive reference picture marking mode), but the exact scheme seems to need further study.

JCTVC-E400 Comments on Clean Decoding Refresh Pictures [Ying Chen, Muhammed Coban, Peisong Chen, Marta Karczewicz (Qualcomm)]

The clean decoding refresh (CDR) pictures as a type of random access points besides the IDR pictures were introduced to HEVC. This document includes discussions and proposals on four aspects related to the CDR pictures: the definition of a CDR picture, decoding of some pictures following the CDR picture, implicit reference picture marking after decoding of a CDR picture, and the detection of whether a CDR is being used for random access or just for "normal" playback.

Perhaps the definition could use improvement – the idea is to indicate that "if you start decoding from here, you can start (correct) display from here too, without decoding any of the pictures that you encounter after this position in bitstream order that cannot be correctly decoded" (where the first "here" refers to bitstream order and the second "here" refers to output order, and "cannot be correctly decoded" refers to containing references to pictures that precede the CDR picture in bitstream order).

Actually, that might not be exactly what all of us intend. The topic should be further studied.

The second aspect of the proposal is to introduce a flag in the slice header or in an SEI message to identify whether a picture that follows the CDR picture in bitstream order and precedes it in output order may be used for reference by other pictures that follow the CDR picture in output order (either directly or indirectly). This indicator would seem to only be useful if the definition is changed. Some participants seemed to think that an extra indicator.

The third aspect seemed to refer to the specification of how a decoder performs random access, which may be out of scope. We specify the conforming syntax and semantics of the bitstream and the decoding process for a (complete and conforming) bitstream, but we don't specify what a decoder must do for processing of incomplete bitstreams.

Regarding the fourth aspect, the word "immediately" should be removed from the CDR definition.

The potential need for an extra process in the decoder in response to the CDR NUT value should be further studied. At the moment the working draft does not specify any extra process to be performed by the decoder in response to the CDR property. Further study should be done to decide whether some decoder action should be specified in response to the CDR NUT value. At the moment, the indication of the CDR property is just advisory.

If necessary, the definition may be clarified in regard to the fact that currently no actual normative decoder action takes place in response to the detection of a picture being a CDR picture.

Some participants expressed the opinion that that if there is no normative decoder action specified for a syntax element (or value distinction), the information should be carried in some separate category of syntax for this kind of information, such as VUI or SEI.

JCTVC-E348 On reference picture list construction for uni-predicted partitions [Y.-K. Wang, Z. Wu (Huawei)]

This document proposed a different design for reference picture list construction for the creation of the combined reference picture list for uni-predicted partitions. In the proposed design, the list is not created from the final RefPicList0 and RefPicList1, as is the case in the current HEVC WD, but rather from all short-term and long-term reference pictures, by reusing existing steps of the reference picture list construction process.

AVC list construction is summarized as follows:

1) Initialization (for P, using picture numbers and long-term picture numbers; for B, using POC and long-term picture numbers)
2) Truncation of list length (when applicable)
3) Swapping in list 1 (when the two lists are identical)
4) Modification (when applicable)

HEVC WD list construction (with pictures of higher temporal layers not included) is summarized as:

A. P slices; same as AVC

B. B slices

    1) List 0 and list 1 are constructed otherwise the same as in AVC (all four steps)
    2) List Q created for uni-prediction from the pictures in list 0 and list 1 (after their finalization in step 4 above) in a specified mannereither by

        i. Using a default ordering, followed by truncation of the list Q length.
        ii. Using syntax (not based on the results of step B.2.i above).

In either case B.2.i or B.2.ii, only pictures in the final list 0 or list 1 can be in list Q.

MV predictors operate for list 0 and list 1.

The contribution proposes to be able to put some pictures into list Q that are not in either list 0 or list 1.

It also proposes different ways to create list Q that avoid having specialized different syntax for creation of list Q.

It was asked why we need syntax for B.2.ii that is different from the syntax for step 4. (If there is a desire to restrict the result of B.2.ii to the set of pictures in list 0 or list 1, that could simply be a constraint on the allowed use of the syntax used for step 4 rather than a completely different syntax.) Step B.2.ii could use the syntax of step 4 applied to an initial list constructed according to B.2.i.

This question and the interaction with MV prediction and weighted prediction should be studied (e.g., in H-L syntax AHG).

JCTVC-E053 Unified Syntax of Reference Picture List Reordering [C.-W. Hsu, J.-L. Lin, Y.-W. Huang, S. Lei (MediaTek)]

In this contribution, a syntax for reference picture list reordering was proposed.

The proponent did not request detailed review, and just requested further study relating to the various contributions.

JCTVC-E339 On num_reorder_frames and max_dec_frame_buffering [R. Sjöberg (Ericsson)]

This document discusses max_dec_frame_buffering and num_reorder_frames and proposes to move them from the optional VUI parameter part of the sequence parameter set and instead make them mandatory for every sequence parameter set.

One alternative opinion that was expressed was that if we force encoders to send information that is not essential to the decoding process, they may send incorrect information in these parameters.

Also, the opinion was expressed by a participant that mandating some such "optional" information can be done in application-specific environments if appropriate.

There were certainly also those who supported the proposal fully.

A participant suggested that some modified or additional parameters relating to the subject may also be useful.

Considering that the high-level syntax structuring may not yet be fully stabilized, this may be at a finer level of detail than is necessary to finalize at this time.

Further study was encouraged.

JCTVC-E401 Slice Design with Fine Granularity [Peisong Chen, Ying Chen, Xianglin Wang, Marta Karczewicz (Qualcomm)]

This was reported to be a follow-up proposal of JCTVC-D396. In the previous proposal, it was proposed that the boundary of two consecutive slices can be put inside a largest coding unit (LCU), and if it is allowed for the slice granularity to vary from picture to picture, it was proposed for the slice granularity for a group of pictures to be signaled in Picture Parameter Sets (PPSs).

Some statistics were presented regarding the quantity of data for each LCU for different types of pictures.

LCUs of pictures at high temporal levels often used very few bits, while those in intra pictures used much more.

The LCU size is not currently allowed to vary from picture to picture in a CVS.

The smallest CU size is also not currently allowed to vary from picture to picture in a CVS.

The proponent suggested allowing the slice granularity to vary from picture to picture in a CVS.

A BoG relating to CE (R. Sjoberg) was established to work on related issues in CE4.

The proponent indicated that a scheme was described in JCTVC-E043 that involved slice-level syntax for slice granularity specification rather than the PPS level as proposed in this contribution.

The proposal indicated a potential interest in alternatively changing the LCU size from picture to picture while using a slice granularity equal to the LCU size.

See notes elsewhere on action taken.

JCTVC-E042 Unified End-Of-Slice Detection for LCEC and CABAC [C.-W. Hsu, Y.-W. Huang, S. Lei (MediaTek)]

This contribution proposed to something previously proposed in JCTVC-D383 and also to send two stop bits in CABAC (like sending the RBSP stop bit twice). The CABAC decoder would look ahead to find the stop bits.

This is a proposal to save some bits relative to our current working draft. The proponent indicated that the savings, when used with 1500 byte slice structuring, would be about 0.1%.

The decoder would need to do some extra work after decoding each "slice granularity unit" to determine how to proceed.

Decision: Keep the current WD method for indication of the end of slice.

JCTVC-E405 Cross Verification of JCTVC-E042 Proposed by MediaTek [Q. Shen (Huawei)] [late upload]

Huawei had cross-checked the proposal of MediaTek in JCTVC-E042, and the RD performance provided by MediaTek reportedly matched the results we obtained. The implementation was reported to conform to the description. The encoding and decoding times were not provided in the cross-check test results.

JCTVC-E490 Simplifying decoder mismatch checking [David Flynn (BBC)] [late registration 2011/03/20]

It was reported that the current HM software provides no integrated means of identifying a mismatch between the encoder and decoder. A method was proposed for an encoder to embed an SEI message containing a fingerprint of each locally decoded picture; this may be used by a decoder to verify each decoded output frame. Such a system would reportedly allow the HM decoder to immediately flag the frame number of any decoding mismatch. Furthermore, it was reported that debugger breakpoints may be used to allow inspection of state as soon as a mismatch is discovered.

Currently, SEI messages that apply to the current access-unit must occur before the start of the primary coded picture. However, it was reported that the natural ordering for this message is after the primary coded picture.

It was noted that the output of some decoding experiments performed for testing purposes could be just the checksums with the decoded video being discarded.

Decision: Adopted. Prefix with an 8 b type code, one value of which indicates md5, another value indicates the CRC in H.271, and all other values reserved.

18.11 Quantization

An overview of related contribution concepts is as follows:

- Sub-LCU level delta QP
  - Need for delta QP support at sub-LCU level
  - Syntax changes needed to support sub-LCU level delta QP,
  - Prediction methods for calculation of delta QP using neighboring CU information,
  - Simulation results of sub-LCU level delta QP implementation.
- Quantization matrices
  - Need for quantization matrix compression in HEVC
  - Syntax changes needed to support quantization matrices,

- Quantization matrix compression methods,
- Simulation

- Others
  - Adaptive De-Quantization Offset

18.11.1 Sub-LCU level delta QP

JCTVC-E202 Support for Sub-LCU-Level QP in HEVC [Masato Shima (Canon), Sung-Chang Lim (ETRI), Yu-Wen Huang (MediaTek), Chong Soon Lim (Panasonic), Kazushi Sato (Sony), Madhukar Budagavi (TI)]

In the current design of HM, delta QP is sent only at LCU level e.g., once every 64x64 block. Hence the spatial granularity at which QP can change is reduced when compared to AVC which allows for signaling of delta QP at the 16x16 level. It was asserted that reduction in granularity of delta QP signaling in HEVC impacts the visual quality performance of perceptual rate control techniques that adapt the QP based on the source content and rate control performance. This (multi-company) contribution proposed that sub-LCU level QP control be supported in HEVC.

The contributors recommended that a core experiment be established to study the following aspects of delta QP transmission:

- Spatial granularity at which to signal deltaQP
- Delta QP prediction from neighboring CU QP values

A software development plan was proposed for the suggested CE.

JCTVC-E051, JCTVC-E220, and JCTVC-E436 have proposed syntax.

A basic question was at what granularity to indicate the granularity (SPS, picture, slice, LCU).

It was noted that in the current HM scheme, the QP prediction is the slice-level QP.

JCTVC-E051 Quantization: Sub-LCU Delta QP [T.-D. Chuang, C.-Y. Chen, Y.-L. Chang, Y.-W. Huang, S. Lei (MediaTek)]

This contribution described MediaTek’s proposal on combination of delta quantization parameter (dQP) syntax designs from JCTVC-D038 and JCTVC-D258. In HEVC Working Draft 1, a dQP was transmitted at the end of each 64x64 largest coding unit (LCU). In JCTVC-D038, TI proposed to send dQP with a finer granularity for better rate control. Subsequently, the requirement of sub-LCU dQP has been supported by six companies including Canon, ETRI, MediaTek, Panasonic, Sony, and TI. In JCTVC-D258, Sony proposed to send dQP right before the first nonzero quantized transform coefficient for better pipelined processing, which was adopted at the last JCT-VC meeting. In this contribution, a combined design of a finer dQP granularity and receiving dQP before quantized transform coefficients is proposed. The proposed design was integrated on top of HM-2.0-dev (rev609) software with matching results from its decoder and encoder.

JCTVC-E238 Verification results of MediaTek's contribution on sub-LCU delta QP (JCTVC-E051) [M. Budagavi (TI)] [initial version rejected (placeholder) – second version late upload]

The software was studied. No problem was identified in regard to matching what was reported.

JCTVC-E220 Preliminary Implementation on Sub-LCU-Level DeltaQP [Kazushi Sato, Jun Xu (Sony)] [late upload]

This contribution reports preliminary implementation of Sub-LCU-Level dQP with HM2.0 + JCTVC-D258 implementation. Source code is attached with this contribution.

The overhead for having the delta QP feature but never using it was reported for the CABAC case, based on prediction from previous coded area in scan order. An adaptive context was used, and the impact was negligible.

JCTVC-E486 Verification result of Sony's Preliminary Implementation on Sub-LCU-Level DeltaQP (JCTVC-E220) [M. Shima (Canon)] [late registration 2011/03/19]

JCTVC-E436 Sub-LCU QP representation [C. Pang, O. C. Au, J. Dai, F. Zou, X. Wen (HKUST)]

In this proposal, two methods are proposed to specify the spatial granularity of QP change. It was proposed to allow the granularity of delta QP information to change either at the slice header level or at the LCU level within a slice.

JCTVC-E198 Sub-LCU level delta QP signaling [M. Kobayashi, M. Shima (Canon)]

This contribution proposes sub-LCU level QP control functionality and alternative delta QP signaling methods. It is claimed in this contribution that the LCU level (64x64) QP control implemented in current HM is too coarse comparing to the small block level (16x16) QP control adapted by former video coding standards such as AVC. Accordingly, this contribution supports the concept of sub-LCU level QP control which was already presented in the former contributions, JCTVC-D038/JCTVC-D308. In addition, this contribution introduces several alternative delta QP calculation methods which can be used with the sub-LCU level QP control.

JCTVC-E215 Prediction-based QP derivation [Hirofumi Aoki, Keiichi Chono, Yuzo Senda (NEC)]

In this contribution, a prediction-based quantization parameter (QP) derivation method is proposed. In practical applications, adaptive quantization scheme is sometimes employed and efficient QP coding is asserted to be important as well as sub-LCU level QP signaling. The proposed method introduces QP prediction using neighbors into the QP coding in HEVC. For intra-coded CUs, intra prediction information, namely intra prediction direction, is also employed for predicting QPs. It is reportedly shown that average coding gains by the proposed prediction-based QP derivation are 0.5% for the intra high-efficiency configuration, 0.9% for the intra low-delay configuration and up to 0.4% for other configurations, when an adaptive quantization is employed and QP is signaled at CU level. It is also reported that no gain is achieved when QP is signaled at LCU level. Almost no additional complexity is reportedly introduced and no additional memory is asserted to be required by the proposed method. The proponent emphasized that the method proposed in this contribution does not leverage any temporal correlations and its coding efficiency is expected to be improved more by using temporal prediction. It was proposed that the QP coding issue be further studied in the context of Core Experiments.

JCTVC-E217 Improved dQP Calculation Method [C. Pang, O. C. Au, F. Zou, J. Dai, X. Wen (HKUST)]

In this proposal, the QP prediction method in AVC is changed in two different ways: previous prediction and left prediction. It is reported in some experimental results, based on using a subjective quality-based rate control algorithm that was not further described, the left prediction method outperforms the previous prediction method in terms of the number of non-zero dQP values.

JCTVC-E391 CU-Level QP Prediction [Muhammed Coban, Wei-Jung Chien, Marta Karczewicz (Qualcomm)]

Perceptual quantization and rate control algorithms might reportedly require QP change at the sub-LCU level. This proposal presents a spatial neighbor based quantization parameter (QP) prediction scheme for derivation of delta QP at CU level. In the current HEVC design, QP of the previous LCU in coding order is used as the predictor of QP instead of the neighboring CU's QPs. In this contribution, as an alternative to coding order based QP prediction method, spatial neighbor based prediction for delta QP calculation is presented.

Two methods: Predict from left neighbour (or above if none), or apply a specified pattern recursively within each set of four regions.

QP control syntax design for WD & HM 3

- Send minCUDQPsize at PPS level (0 = LCU size, 1 = half of that in both dimensions, 2 = half of that in both dimensions, etc.) using 4 bits.
- For the predictor of the QP value, use left neighbor (of upper-left corner of current CU) if available; else use previous in scan order.
- CU's that have no coded coefficients and CU's coded as PCM are inferred to have deltaQP of zero.

This is essentially the same or very similar to what is in proposals JCTVC-D038, JCTVC-E051, JCTVC-E217, JCTVC-E220, JCTVC-E391, and JCTVC-E436.

Decision: Adopted.

18.11.2 Quantization matrices

JCTVC-E056 Necessity of Quantization Matrices Compression in HEVC [Kazushi Sato, Hironari Sakurai(Sony)]

(The presentation slide deck was missing from the uploaded contribution when presented.)

At the previous JCT-VC meeting there was a proposal on compression of quantization matrices by TI. 16x16 and 32x32 transforms are employed in HEVC in addition to 4x4 and 8x8.

At that time question was raised how much bits have been typically spent sending quantization matrices in actual AVC streams. This contribution provides some such information on the data extracted from the AVC streams in actual products to show the assertion that quantization matrices compression is necessary in HEVC.

0.04% to 0.3% of the tested AVC bitstreams was reported to consist of quantization matrix data. Under certain assumptions, the proponent estimated that such data could become 10% or more of the bitstreams in the HEVC context.

In AVC, we have (4x4 and 8x8) * (intra and inter) for luma + 4x4 intra and inter for chroma

HEVC has more transform sizes and types than AVC.

Further study was encouraged (e.g., in a CE or AHG).

JCTVC-E073 Quantization matrix for HEVC [Junichi Tanaka, Yoshitaka Morigami, Teruhiko Suzuki (Sony)]

In this contribution, quantization matrix support for HEVC is proposed. The proposal includes the following methods:

1) Defining an additional parameter set type to transmit the parameters dynamically changes in bitstream and move such parameters, e.g. quantization matrix, from the existing parameter sets to the additional type of parameter set.
2) A quantization matrix consisting of QP offsets rather than scalings of the step size.
3) Three candidate encoding methods for predictive coding of the values.

The performance of proposed coding methods for quantization matrix was discussed in the contribution.

It was reported in the contribution that a subjective picture quality is improved by applying a quantization matrix to HEVC.

Software was provided with the contribution. The software is implemented in HM 2.0 and the source code is attached to this contribution. For further study of quantization issues, it is proposed to create a common software by creating a branch at HM software SVN server. The attached software could be a starting point of the common software . The common test conditions for quantization issue should be defined during Geneva meeting.

A v3 version of the contribution was to be uploaded to fix the problem that the software was omitted in the v2 upload.

Further study was encouraged (e.g., in a CE or AHG).

JCTVC-E435 QuYK [Gergely Korodi, Dake He (RIM)]

Two algorithms are proposed for compressing quantization matrix data. The first algorithm is applicable to general quantization matrices, and is universal in the sense that it is asserted to be asymptotically optimal if a stationary, ergodic source model generates the matrices. In addition to the universality, this algorithm is reportedly designed with consideration of storage and computational complexity on the decoder side. The second algorithm is designed for a special case of quantization matrices. It was designed assuming that the quantization matrix satisfies a given set of constraints.

It was reported that the first proposed method compresses the 32x32 matrix in JCTVC-D024 into 664 bits and that the more specialized algorithm results in 474 bits. In comparison, for the same matrix, it was reported that the best lossless method proposed in JCTVC-D024 produces 866 bits, and that the lossless method in the AVC produces 1578 bits.

The decoding process for the proposed compression method involves string substitution and arithmetic decoding. The number of contexts for the proposed arithmetic code was about 400. No training was used in designing the initial state. It was asserted that the number of contexts could be reduced in further work.

A method without arithmetic coding, using fixed-length coding of the symbols, was also described. It was asserted that the arithmetic coding reduces the necessary bit rate for this data by about 20-30%.

It was remarked that elements of the proposal could be combined with elements of other proposals such as the Sony proposal.

The proponent asserted that the decoding process for the scheme is very simple.

Further study was encouraged (e.g., in a CE or AHG).

General conclusions on quant matrices

It was generally agreed that HEVC should have some form of quantization matrix capability – most likely changeable at the picture level.

It was noted that integrating QM functionality into the HEVC software would take some work and none of the proposals thus far have actually done this. Moreover, this topic has a dependency on the transform design.

The further study should perhaps be in an AHG rather than a CE since it doesn't seem clear that an experiment is the way to evaluate the proposals – this seems more like a coordinated study than an experiment.

18.11.3 Adaptive dequantization offset

JCTVC-E091 Adaptive De-Quantization Offset [X. Li, X. Guo, S. Lei (MediaTek)]

In current HEVC (HM 2.0), de-quantization offset is always set to zero. In this contribution, it is proposed for the encoder to be able to specify a de-quantization offset based on the distribution of previously coded transformed coefficients. It is reported that 0.9%, 0.7%, 0.5%, and 0.5% luminance BD-rate reductions were obtained by the proposed method for RA HE, RA LC, LD HE, and LD LC configurations, respectively. In addition, higher coding gains (above 2% RD-rate reduction on average) were observed for chrominance components. The average encoding and decoding time for the proposed method were reported as 98% and 99% as those of the anchor.

It was asked whether an offset is sent for every frequency or just one offset is sent. Only one is sent.

The transmitted offset is scaled by the step size.

The offset is sent as an se(v).

The efficacy would depend on the encoder selection method.

It was remarked that the software is changing the Lagrange multiplier, and that this might affect the results.

This was proposed only for inter-predicted residual blocks; intra is unchanged.

It was remarked that it would be nice if RDOQ became unnecessary, and also that perhaps combining this with RDOQ could be desirable.

Balance between intra and inter may be changed (shifting the point along the RD curve for the inter pictures).

It was noted that Class E sequences had the most gain, which might indicate that the balance of intra and inter is affected.

Cross verified in JCTVC-E299.

It was suggested to study in relation to adaptive sample offset (see CE13).

Further study in a CE was encouraged.

JCTVC-E299 Cross-check result of MediaTek's AQO (JCTVC-E091) [Yi-Jen Chiu, Lidong Xu, Wenhao Zhang, Hong Jiang]

Software was studied as well as tested. Results matched.

18.12 PCM mode

JCTVC-E057 Pulse code modulation mode for HEVC [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)]

This contribution presents HM 2.0 based simulation results of Pulse Code Modulation (PCM) mode coding which conditionally transmits single-bit syntax in 2Nx2N intra PU header in order to indicate the use of PCM mode coding. This contribution also proposes an SPS syntax that specifies the intra CU sizes which convey I_PCM_flags; the new SPS syntax allows encoders to choose the sizes of PCM mode CUs by their preference, that is, it allows encoders to omit I_PCM flag transmission at non-PCM CUs and save some bits. Simulation results for common test sequences reportedly show average BD-rate losses of

0.00% (Y), 0.00% (U), 0.01% (V) for all intra high efficiency setting, 0.08% (Y), 0.10% (U), 0.09% (V) for all intra low complexity setting, -0.01% (Y), 0.07% (U), -0.05% (V) for random access high efficiency setting, 0.04% (Y), 0.03% (U), 0.00% (V) for random access low complexity setting, -0.04% (Y), 0.02% (U), 0.08% (V) for low delay high efficiency setting, and 0.02% (Y), 0.17% (U), 0.08% (V) for low delay low complexity setting, when PCM coding CU sizes are 64x64 and 32x32. Additional simulation results for a synthesized sequence reportedly demonstrate that the use of PCM mode coding avoids yielding the number of bits which is prohibitively greater than that of input video data and reduces decode time significantly. It is proposed that the PCM mode coding is adopted in HM ver. 3.

The bit depth of the PCM data could be signalled.

Proposes a single bit flag in the PU header for the Intra 2Nx2N case.

Proposes to choose a design as follows:

1. All 2Nx2N intra PU can use PCM
2. Signal minPCM size in SPS (suggested by proponent, which disables the feature if huge)
3. Signal maxPCM size in SPS
4. Termination and byte alignment like in AVC.

Should there be a restriction on max number of bits per coded area? TBD.

Some desire was expressed for having an upper limit of processing time on coded area.

The CABAC coding uses a fixed very low probability (as in AVC).

The coding efficiency impact is reportedly negligibly small (esp. in the mode 2 case, where the use can be entirely disabled).

Experiments showed that the bit rate of a coded area can sometimes "explode", and also that the decoding time can be reduced.

Emulation prevention bytes and IBDI LSBs have some impact.

Software was provided in the contribution, to generate the synthetic noisy video.

Decision: Adopted (with a worst-case bit limit, mode 2, Annex B of contribution), but not needed for first software release and to be disabled in the common conditions.

JCTVC-E066 Cross-verification report on PCM mode (JCTVC-E057) [Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric)]

JCTVC-E192 Proposal of enhanced PCM coding in HEVC [Keiichi Chono, Hirofumi Aoki (NEC), Viktor Wahadaniah, ChongSoon Lim (Panasonic)

Discusses two issues:

- PCM sample bit depth can be unnecessarily high (with BDI), proposes SPS syntax to indicate PCM bit depth
- Effect on in-loop filtering (e.g., deblocking and ALF).

In the current HEVC software, instead of the average QP across an edge, the QP on one side of the edge is used. The text doesn't actually specify which luma QP is used (needs fixing).

Proposes to send a flag in SPS that controls the loop filters: 1 = don't filter, 0 = filter with the current effective QP. Affecting both the DF and ALF.

Decision: Adopted – both aspects.

Further study for potential refinement and improved interaction with other aspects is encouraged.

JCTVC-E199 Cross verification of pulse code modulation mode for HEVC (JCTVC-E057) [Kenji Kondo, Teruhiko Suzuki (Sony)]

This contribution reports cross check results on PCM (Pulse Coded Modulation) mode for HEVC proposed by NEC in JCTVC-E057. In the test, the coding performance and complexity were measured under common test conditions, defined in JCTVC-D600. The proposed tools have reportedly been evaluated on the common conditions. Detailed results were summarized in an attached Excel sheet. The source code was provided by NEC to cross check.

JCTVC-E214 Cross-verification report on pulse code modulation mode for HEVC (JCTVC-E057) [Viktor Wahadaniah, ChongSoon Lim (Panasonic)]

The cross-checker verified that the software is correct and reported that the results matched.

18.13 Entropy Coding and transform coefficient coding

JCTVC-E156 Simplification of transform coefficient coding in LCEC [Y. Yasugi, T Yamamoto (SHARP)]

In this proposal, a method is presented to simplify the process of transform coefficient coding in LCEC (Low Complexity Entropy Coding). The run-mode loop of the coefficient coding process for a block is bypassed depending on the level of the last non-zero coefficient and type of the block. Experimental results reportedly show that parts of codes and tables for the run-mode can be removed with negligible impact on coding efficiency and complexity. The proposal has been cross-checked.

Would this simplification still apply with the modification adopted for JCTVC-E383? Not known

How often is the bypass actually used?

The real benefit is not clear, as it may imply additional check for the bypass of the runmode.

One expert mentions that this could simplify the last coefficient decision, but it would require more careful review how it works with the recent changes

Further study was suggested.

JCTVC-E169 Cross-Check of E-156: Simplification of transform coefficient coding in LCEC [Kazushi Sato (Sony)]

JCTVC-E226 Parallel Context Processing for Significance map using block-based context updates [Hisao Sasai, Takahiro Nishi (Panasonic)]

This proposal presents a technique for the parallelization of context processing to improve the throughput of the entropy coder for CABAC. In this contribution, it is proposed that block-based context updates are used for significance map. The context updates make difficult to increase through put due to their serial dependencies. The same probabilities are used for encoding and decoding within the coefficient block loop. The proposed solution were implemented in HMv2 and their coding efficiencies were evaluated. The parallelization improvements of the proposal comes at a reported cost of 0.2% performance loss.

Combined with JCTVC-D262/JCTVC-D338, the loss is less (around 0.1%)

Whereas hardware may benefit, software implementation might possibly have a slight disadvantage.

In hardware it would be beneficial for parallel processing, but memory size is increased due to the copying of the context table.

Would the performance drop increase when RDOQ is off?

Further study (not in CE) was suggested.

JCTVC-E430 Cross-verification of Panasonics (JCTVC-E226) Parallel Context Processing For Significance Map by Block-based context updates [V. Sze (TI)]

JCTVC-E240 Reducing size of the LCEC coefficient coding tables [Jani Lainema, Kemal Ugur (Nokia)]

This contribution proposes to reduce size of the VLC tables used in coding the last active DCT coefficient position in the LCEC entropy coder for block sizes 8x8 and above. In HM 2.0 the total size of these tables is 1024 bytes while the proposed approach reduces the size to 190 bytes. The reduced total table size is attributed to two things: reducing the number of tables from 8 to 5 and grouping some of the positions together to reduce the size of the individual tables. The reported effect to coding efficiency is 0.00% / -0.04% / 0.06% for LC Intra / LC random access / LC low delay configurations, respectively.

The contribution did not need detailed review, as another solution (JCTVC-E383) has been adopted for coding of large transform blocks.

JCTVC-E297 Cross-verification of Nokia's contribution Reducing size of the LCEC coefficient coding tables (JCTVC-E240) [L. Guo, X. Wang, M. Karczewicz (Qualcomm)]

JCTVC-E324 Joint Algorithm-Architecture Optimization of CABAC [V. Sze (MIT), A. Chandrakasan (MIT)]

This contribution proposes joint optimization of both the algorithm and architecture to ensure that high coding efficiency can be achieved in conjunction with high processing speed and low area cost. Specifically, it presents two optimizations that can be performed on CABAC, a form of entropy coding in AVC. First, subinterval reordering is proposed for the arithmetic decoder to increase the processing speed by 14 to 22% with no impact on coding efficiency. Second, modification of the mvd context selection is proposed to reduce memory requirements (i.e. area cost) by 50% with negligible coding efficiency impact (coding gains of 0.007% and 0.028% in HM-2.0). The results have been cross-checked by HHI.

On suggestion 1: One expert notes that IBM in the 1980’s formulated “software conventions” and “hardware conventions” for arithmetic coding. This contribution more follows the “HWC”. There are also compromises. E.g. flipping the bitstream (and using inverse logic) would just revert the order of subintervals.

Suggestion 2: Why not entirely switching it off? The suggested solution (reducing line buffer) does not help much. It could be better to get rid of all the contexts.

TI and Zenverge and a third hardware company support both suggestions, but there was no consensus on suggestion 1.

Decision: Adopt solution 2.

JCTVC-E424 Cross-check results for MIT's proposal JCTVC-E324 [T. Nguyen, M. Preiß (Fraunhofer HHI)]

JCTVC-E330 Reduced neighboring dependency in context selection of significant_coeff_flag for parallel processing [V. Sze, M. Budagavi (TI)]

This contribution proposes reducing the neighboring dependencies in the context selection of significant_coeff_flag for positions in the top-most row and left-most column of a transform (i.e. the top and left edge). While the simplified context selection method in JCTVC-D260 (adopted for HM-2.0), eliminates the neighboring dependency on the most recently decoded significant_coeff_flag within a diagonal, this contribution eliminates the dependency when wrapping from one diagonal to another during zig-zag scan. This modification was implemented in HM-2.0 and its coding efficiency was evaluated on HM-2.0 with a reported coding loss 0.1% for Intra, Low delay and Random Access in high efficiency. This contribution has been cross-checked by Sony (JCTVC-E382).

Removes dependency on top and left neighbor in first column/row, respectively. The advantage is that the context would not depend on immediate neighbor (advantageous in pipelining and parallel processing).

The problem could also be solved by replacing the zigzag scan by a pure diagonal scan. Further study (CE) was suggested.

JCTVC-E382 Cross check of TI proposal on context simplification of significance map [Ali Tabatabai, Cheung Auyeung (Sony)] [initial version rejected (placeholder) – second version late upload]

JCTVC-E354 Further study on entropy coding [V. Sze, M. Budagavi (TI)]

This contribution summarizes the key throughput challenges that exist for CABAC as well as other methods that have been proposed for entropy coding in HEVC. For CABAC, the serial dependencies due to multiple feedback loops cause a bottleneck in video codec implementations. Speculative computations are required when using parallelism and pipelining which are common techniques used to increase throughput. Alternative entropy coding methods for high efficiency entropy coding also contains feedback loops in the context modeling; thus their end-to-end throughput is unknown – accordingly, the throughput benefit compared to the CABAC (particularly at the decoder) needs to be studied. TE8 and TE12 reported that these approaches have coding losses compared to CABAC (between 0.2 to 0.5%). In addition to throughput, area cost (e.g. buffers and tables), and implementation complexity (e.g. multiple bitstreams) needs to also be studied.

The contributor indicated it was not necessary to use meeting time to present this.

JCTVC-E335 Unified scans for the significance map and coefficient level coding in high coding efficiency [J. Sole, R. Joshi, M. Karczewicz (Qualcomm)]

This contribution proposes the use of the same underlying scan for significance map coding and coefficient level coding in high efficiency configuration. Two methods are proposed. In the first one, for coefficient level coding, the coefficients are scanned in a reverse order from last significant coefficient to the first coefficient (DC). The BD-rate impact for this approach for the high efficiency intra, random access, and low-delay configurations is 0.01%, 0.10%, and -0.03%, respectively. The second method uses reverse scan order for both significance map and coefficient level coding after explicitly sending the position of the last coefficient as proposed in JCTVC-D262 and JCTVC-E338. The BD-rate impact for this case (for RDOQ off) is -0.27%, -0.18%, and -0.10% for the intra, random access, and low-delay configurations, respectively.

The second method (reverse scan) provides losses (up to 0.2%) in case of RDOQ on, but RDOQ has not been optimized for that scan. Second method has a relationship with the points recorded in the notes for JCTVC-E330 above (solution to dependency problem). The second method was not cross-verified.

The first method is supported by several experts; however no text is available currently. Furthermore, the advantage of the first method seems to be increased when the second part would be adopted.

Further study in CE (including investigation of RDOQ on for second method) was recommended.

JCTVC-E473 Verification of JCTVC-E335: Scans for coefficient level coding with CABAC [F. Bossen (DOCOMO USA Labs)] [late registration 2011/03/17]

Confirms the results on first method. Duplicate code for the case of 4x4 blocks is avoided due to the unified scan.

JCTVC-E362 On context selection for significant_coeff_flag coding [J. Lou, K. Panusopone, L. Wang (Motorola Mobility)] [late upload]

The scheme used in the current HM2.0 for CABAC significance map coding utilizes the nearest 5 neighbors for context modeling. This contribution document studies the use of 4, 3, and 2 neighbors for context modeling for significance map coding in CABAC. With the reduced number of neighbors, fewer coded neighbors are used for deriving the contexts. Especially for the 4 and 2 neighbor cases, only 1 scanning line of previous coded neighbors needs to be buffered as compared to 2 lines in the current design. The experimental results reportedly show that there is 0.2% to 0.3% bit rate increase for the 4 neighbor design, 0.0% to 0.2% bit rate increase for the 3 neighbor design and 0.3% to 0.4% bit rate increase for the 2 neighbor design. The cross-check results are provided by I2R.

The contribution was noted. This was extensively discussed at the preceding meeting, where context size 5 appeared to be good compromise. No action was taken.

JCTVC-E106 Cross-check of Motorola's proposal on reduced context selection for CABAC [H. L. Tan, C. Yeo (I2R)]

JCTVC-E363 Motorola Mobility's adaptive scan [K. Panusopone, Y. Yue, L. Wang (Motorola Mobility)] [late upload]

This contribution proposes a set of scan patterns that are asserted to match with the coefficient distribution after prediction. This, together with an associated mapping table, reportedly improves coding performance of HM.

5 different scans (2 new) for 4x4 and 8x8 each were proposed. Results were presented on intra LC, where a small gain was achieved in luma, and a small loss in chroma.

No action was taken. Introducing more scans seems undesirable without reporting significant gain.

JCTVC-E384 LCEC coefficient coding table reduction [M. Karczewicz, X. Wang, W.-J.Chien (Qualcomm)]

In this contribution, a scheme is proposed to reduce the size of VLC tables used in coding the {lev, run} pair in LCEC coefficient coding. By sharing a same mapping table for different values of lev and using formula to calculate the code number in certain conditions, the necessary table size can reportedly be reduced to less than half of the original size. Simulation reportedly showed that the scheme only has 0.00%, 0.07% and 0.05% impact on coding performance with all intra, low delay and random access configurations respectively.

The table size reduced from 968 to 434 bytes by deriving the values for the case of level=1.

It was noted that the proposal is compatible with the adoption of JCTVC-E383.

Decision: Adopt, but the provided software should be fixed to avoid generating compiler warnings ("-1" values should not appear in the software where the table is defined as unsigned int).

JCTVC-E448 Cross-check of Qualcomm's proposal on LCEC coefficient coding table reduction (JCTVC-E384) [Jani Lainema, Kemal Ugur (Nokia)] [late registration]

JCTVC-E428 Low Complexity Embedding of Information in Transform Coefficients [R. Cohen, S. Rane, A. Vetro, H.Sun (MERL)]

This contribution presents and examines a method for embedding transform decision information in quantized transform coefficients. To embed the information, the last non-zero coefficient may be adjusted during the coefficient scanning process. The decoder infers the decision based upon the value of this coefficient. To test this method, the adaptive DCT/DST software from JCTVC-D182 was modified to embed the transform selection flag instead of explicitly signaling it as side information. For Class C and D sequences coded using the Intra Low Complexity configuration, BD-Rate metrics for the implicit method ranged from −0.1% to 0.5%, and for the explicitly-signaled method, −1.1% to 0.7%.

The contribution was noted.

JCTVC-E446 Coefficient coding table improvement in LCEC [Seongwan Kim, Jaeho Lee, Sangyoun Lee (Yonsei University)][late registration]

In this contribution, additional run-level coding in LCEC, for intra and inter, is proposed. To reduce additional table size, run-level table is re-designed, optimized for 4x4 when maxrun is from 0 to 14 and for 8x8 when maxrun is from 15 to 27. Accordingly, when transform size is 4x4, re-designed run-level table is used without switching. In 8x8 size, run-level switching is performed only when maxrun is from 15 to 27. For 16x16 and 32x32, run-level switching is performed in all maxruns. The results show that an average coding gain of 0.6% is achieved for intra, and 0.4% for random access case.

Would the gain still be achievable with the newly adopted methods in CAVLC?

One expert raises concerns that the increase of VLC tables is not justified, though the gains look attractive. The tradeoff is not obvious – further study was suggested with a recommendation to try reduction of table sizes.

JCTVC-E479 Cross-verification of Yonsei university's proposal on coefficient coding table improvement in LCEC (JCTVC-E446) [Jianle Chen, Sunil Lee, Jeonghoon Park (Samsung)] [late registration 2011/03/17]

JCTVC-E477 Comparison of BD-rates and run-times of entropy coders in HM-2.0 [??]

Withdrawn

18.14 Intra prediction and mode coding

Track A – Intra mode coding

JCTVC-E113 Using MPS to encode extended UDI mode numbers for robustness [Guichun Li (Santa Clara Univ), Lingzhi Liu, Nam Ling, Jianhua Zheng, Yongbing Lin, Philipp Zhang (Hisilicon)]

Current intra prediction for HEVC uses unified directional intra (UDI) prediction. Using more non-directional prediction modes can reportedly improve not only the coding gain but also the subjective quality. In this contribution, multiple prediction sets (MPS) method is used to signal intra prediction modes when there is more than 1 non-directional mode. The method can reportedly lower the storage requirement of the system and improve the error resilience of intra prediction; the coding performance also can reportedly be improved.

Coding results were reported only for HE. In combination with planar mode, there was a loss of 0.1%, but the scheme is claimed to resolve a parsing dependency (improving error resilience?).

It was asked what kind of errors are assumed? As the dependency is within the same slice, information losses can be assumed to be unrecoverable anyway until the end of the slice.

This may be relevant for the throughput problem caused by dependent parsing. Further study in AHG on parsing was suggested.

JCTVC-E482 Cross-check report for JCTVC-E113 [J. Xu (Microsoft)] [late registration 2011/03/19]

JCTVC-E201 Context Dependent Intra Mode Coding [M. Guo, X. Guo, S. Lei (MediaTek)]

This contribution proposes a context dependent intra mode coding method for high efficiency configuration. In this method, the codeword for the intra mode of the current block is adaptively selected from 9 coding tables according to the intra modes of its neighboring blocks. It is reported that an average BD-rate reduction of 0.4% for high efficiency all-intra (HE-AI) can be observed, with almost no change of encoding and decoding time.

18 additional tables necessary:

- 4x4, 17 entries for each table (1 for MPM, 16 for remainder)
- 16x16~32x32, 34 entries for each table (1 for MPM, 33 for remainder)

By the tables, the modes are re-ordered. Total size of tables around 450 bytes.

Could not an alternative solution be to use existing FLCs and use different contexts? This could be a more simple solution.

Largest gain is for class E (0.6%), which would hardly be coded intra-only.

Would this introduce parsing dependencies?

Several experts expressed concern that the benefit would not be justified by the large increase in number of tables. Further study was recommended.

Conclusion: No CE13 on intra mode coding.

JCTVC-E442 Cross-verification of MediaTek proposal on motion vector decimation (JCTVC-E092) and context dependent intra mode coding (JCTVC-E201) [P. Chen, M. Karczewicz (Qualcomm)] [late registration]

JCTVC-E262 Intra Encoding acceleration by simplification of RDOQ [Glenn Van Wallendael, Sebastiaan Van Leuven, Jan De Cock, Rik Van de Walle (??)]

This contribution proposes an encoding acceleration by reducing Rate Distortion Optimized Quantization (RDOQ) evaluations in the intra encoding process. By disabling RDOQ when evaluating all modes and enabling it when the "best" mode is evaluated with full Residual Quadtree (RQT), one evaluation with RDOQ remains for every Prediction Unit (PU). For the intra configuration, this proposal reports 0.6% (Y), 1.1% (U), and 1.2% (V) BD-rate increase. Execution time is reduced to 93%. For Intra LC, 0.2%

(Y), -0.1% (U), and 0.0% (V) BD-rate increase is reported with 85% of the execution time. Results are cross checked by BBC in JCTVC-E484.

Intra prediction steps:

- SAD based mode decision on all modes
- RDO based mode decision on a set of best modes with simplified Residual Quadtree (RQT)
- Best mode is evaluated with full RQT

This looks interesting for the LC case. It seemed unclear how the performance would be with the new 3-level default setting (particularly with the simplification of step 2). Further study.

JCTVC-E484 Cross Check Report for Intra Encoding Acceleration by Simplification of RDOQ (JCTVC-E262) by BBC [Andrea Gabriellini, Marta Mrak (BBC)] [Late availability 03-19??]

JCTVC-E437 On intra prediction [Jane Zhao, Andrew Segall (Sharp)] [late upload]

This document seeks to improve the mode dependent intra smoothing (MDIS) technique that was adopted in the previous meeting. MDIS filters the source pixels used for intra prediction with different degrees of smoothing, with the degree determined by the intra prediction direction. While the technique provides gains for most sequences in the test set, this document observes losses in coding efficiency for smaller resolution sequences. The document reports that using edge directed smoothing in the construction of the neighborhood mitigates these issues. It is proposed to adopt the edge directed smoothing into the HM.

Losses were observed with current MDIS for flipped sequences (Foreman, Basketball Drill). The edge-adaptive method resolves the issue.

Gain for Class C: 0.3-0.4%

Basketball Drill is the only sequence with gain 1.6/2.1%

Some other sequences suffer (0.2% increase)

Additional operations at decoder (gradient operation, thresholding)

A fixed threshold was used (16), should this be adaptive?

Could this replace MDIS?

Study in CE6 was recommended.

~~Track B – Intra prediction~~

JCTVC-E174 Unified planar intra prediction [Jani Lainema, Kemal Ugur, Oguz Bici (Nokia)]

JCTVC-E168 Cross verification of Nokia's proposal (JCTVC-E174) on Unified Planar Intra Prediction [Yongjoon Jeon (LG)]

Track B (Tuesday)

JCTVC-E289 Simplified Planar Intra Prediction [Y. Lin, L. Liu, J. Zheng, C. Lai (HiSilicon)]

Track P (Tuesday)

This document presents two simplified planar Intra prediction methods with reduced calculation complexity. One is diagonal-based intra prediction and other is sub-block based intra prediction. It was reported that both of them can be easily implemented by only using addition and shift operations. Simulation results reportedly show the proposed methods reduce encoding time while keeping similar performance as the existing planar intra prediction.

It was asked whether the presented two-triangle technique might produce diagonal edge artifacts. A participant remarked that he had tested the same approach and had found that it does cause some artifacts.

A participant indicated that the 2x2 structuring and recursive nature of the other (2x2-based) proposed approach may cause some implementation difficulties.

It was remarked that the regularity of the current scheme (each prediction using the same equation) seems like an advantage over the proposed sub-block prediction technique.

Further study of ways to reduce complexity of the intra prediction processing elements is encouraged.

JCTVC-E372 Cross-Verification: Simplified Planar Intra Prediction (HiSilicon, JCTVC-E289) University [Chan-Won Seo (Sejong Univ.), Jong-Ki Han (Sejong Univ.), Jeongyeon Lim (SKT)]

JCTVC-E223 Single Interpolation for Multi-sample Prediction (SIMP) for Intra Coding [J. Lee, S.-C. Lim, H. Lee, D. S. Jun, H. Y. Kim (ETRI)]

Track B (Tuesday)

This contribution presents a method to reduce the computational complexity of intra prediction. In the angular prediction process in HM2.0, one interpolation is required for predicting each sample when the corresponding reference sample position is not located in an exact integer position. This contribution proposes to use single interpolation for predicting multiple samples, to reduce the computational complexity. It is asserted that, when applied to PU_32x32, the proposed method can reduce the number of interpolation operations to nearly half of HM2.0 case, with 0.1% and 0.0% coding loss in High-Efficiency (HE) and Low-Complexity (LC) configurations, respectively.

The technique is only applied in the 32x32 case, as proposed.

One motivation is that the correlation of the neighbouring sample values should be higher for large blocks than for the smaller ones. This may indicate that using simpler interpolation in these cases is sufficient.

It was remarked that the complexity per pixel is not a function of block size.

The proponent indicated that approximately 1% runtime savings was measured for the proposed scheme (which may be within the "noise" range of whether we can really measure it confidently or not).

It was asked whether this produces visual artifacts – such as jagged effects.

It was remarked that the weights stay constant over a row as currently specified, and that the overall complexity seems rather low for this method.

It was remarked that it seems generally "cleaner" to have a single approach that applies in general rather than to be using different schemes in different cases.

No action taken.

JCTVC-E360 Cross-Verification of ETRI's Contribution (JCTVC-E223) by Qualcomm [G. Van der Auwera, X. Wang, M. Karczewicz (Qualcomm)] [initial version rejected (placeholder) – second version late upload]

JCTVC-E201 Context Dependent Intra Mode Coding [M. Guo, X. Guo, S. Lei (MediaTek)]

JCTVC-E203 Constrained intra prediction scheme for variable-sized prediction units in HEVC [Viktor Wahadaniah, ChongSoon Lim, SueMonThet Naing (Panasonic)]

This contribution presents HM-2.0-based experimental results of the constrained intra prediction scheme initially proposed in JCTVC-D094. By adapting the constrained intra prediction scheme to HEVC characteristics, the proposed scheme is reported to give average BD-rate gains of 0.2% (Y), 0.3% (U), 0.3% (V) for random access, high efficiency setting, 0.3% (Y), 0.5% (U), 0.6% (V) for random access, low complexity setting, 0.1% (Y), 0.1% (U), 0.2% (V) for low delay, high efficiency setting, and 0.1% (Y), 0.2% (U), 0.1% (V) for low delay, low complexity setting, as compared to the AVC-style constrained intra prediction scheme adopted in HM 2.0 software. It was reported that the encoding and decoding times of the proposed scheme are the same as the AVC-style scheme. The contribution also recommended to investigate constrained intra prediction design for other intra prediction schemes besides directional intra prediction scheme.

This was reviewed in BoG discussions (see JCTVC-E488).

JCTVC-E212 Cross-verification report on constrained intra prediction scheme for flexible-sized prediction units (JCTVC-E203) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)]

18.15 Transforms

18.15.1 Core transform implementation

JCTVC-E341 Approximation Quality of Integer Transforms [Mathias Wien (RWTH Aachen)]

(informational)

For the core transform of HEVC, integer approximations of the DCT are considered. Some of the proposed transforms relate to the butterfly structure proposed by Chen in 1977. Some others rely on matrix definitions. For orthogonal transform approximations, a MSE-based measure has been proposed by de Queiroz to evaluate the approximation quality of the approximation under discussion. The measure is proposed as a potential aid in the transform selection process and the approximation quality of some integer transform approximations is discussed. The proponent suggested that non-negligible approximation errors relative to the DCT may be an indicator for impact on the visual reconstruction quality of the employed transform.

Various remarks were made regarding the characteristics of the DCT and its "approximation error" relative to the KLT in regard to coding gain and basis function shapes.

Collecting such information may be helpful (although we should be cautious to avoid over-interpretation of results from this measure).

JCTVC-E386 IDCT pruning [M. Budagavi (TI)]

(informational)

The high frequency region of large transforms is often zero due to quantization and energy compaction properties of transform. This contribution presents non-zero low frequency sub-block statistics of large transform blocks in anchor bitstreams of HM 2.0. The non-zero sub-block information can be used to carry out IDCT pruning where in the IDCT computations that have zero input and zero output can be eliminated. This contribution asserts that IDCT pruning is a useful technique that can be used to reduce SIMD computational complexity based on source statistics in decoder. It is also asserted to result in corresponding power savings in hardware transform engines. The complexity of pruned IDCT for HM 2.0 transform and transform implemented using partial butterfly (JCTVC-E243) are presented to demonstrate complexity reduction from IDCT pruning.

This contribution recommends that the pruning behavior of large transforms be considered in design of HEVC transforms.

Statistics from coding tests were reported regarding how often certain regions are zero in coded video sequences.

A participant suggested that such statistics could be checked for proposed inverse transforms.

The computational complexity of the lower-frequency basis functions may be more important than the computational complexity of the entire transform.

It was reported that some factorizations require more computations for pruned inverse transformation than others.

This seems useful to study in further work (although, as with the other issue above, we should be cautious to avoid over-interpretation of results from this measure).

JCTVC-E333 Transform Dynamic Range Analysis [Louis Kerofsky, Kiran Misra, Andrew Segall (SHARP)]

(informational)

This contribution describes how to determine bounds on the resource needs of the inverse transform operation used in HEVC. The analysis uses the HM-2.0 transform implementation for illustration but the methods are reportedly general. The analysis focuses on the bit-depth between transform stages necessary for inverse transform computation. The analysis uses a bound on the coefficient data prior to the transform to determine the intermediate bit-depth. Bounds assuming a linear transform are first derived. The transform used in HM-2.0 has nonlinearity due to conversion to integers at various stages. This error is analyzed and a bound on intermediate bit-depth increase was modified suitably. For each transform size 4x4, 8x8, 16x16, and 32x32 bit-depth increase bounds are established. These bounds can reportedly be used to determine memory bit-depth as well as general dynamic range analysis.

JCTVC-E411 Enforcing the 16-bit inverse transform dynamic range [Kiran Misra, Louie Kerofsky, Andrew Segall (Sharp)]

(informational)

This document reports new results for limiting the dynamic range within an inverse transform. The technique was previously proposed in JCTVC-D071. Here, results are updated for HM2.0 and reflect the change in IBDI configuration from four to two bits in the common conditions. Results reportedly show a BD-rate impact on coding efficiency of 0.0%. This comes with the asserted benefit of guaranteeing a 16-bit dynamic range limit at the input of the transform as well as within the transpose buffer. (In other words, at the input and output of the first 1-D inverse transform.)

Clipping at two positions was advocated: 1) after coefficent reconstruction prior to the operation of the first inverse transform stage, 2) between the horizontal and vertical inverse transform.

It was remarked that the way this issue was approached in the AVC case has not been free of problems.

It was remarked that some of the proposals have already been incorporating similar clipping operations.

The idea was generally supported in spirit, as something to keep in mind when the time comes to finalize our transform design.

JCTVC-E368 Crosscheck of Sharp's contribution (JCTVC-E411) on enforcing the 16-bit inverse transform dynamic range [R. Joshi (Qualcomm)]

The software was studied carefully and the results matched.

18.15.2 Alternative transforms

None.

18.16 IBDI and Memory Compression

JCTVC-E133 Adaptive scaling for reference pictures memory compression [T.Chujoh, T.Yamakage (Toshiba)]

(Presented by K. Chono)

In this contribution, a reference pictures memory compression from 10-bit to 8-bit on high efficiency anchor and a definition for standardization are proposed. This contribution shows a solution to improve coding efficiency by increasing internal process of video codec while minimizing reference frame memory access bandwidth. There are two points. Firstly, an adaptive scaling method with fixed length format is proposed and secondly, a definition by distortion for reference pictures memory compression is introduced. As experimental results, the loss bit rate of adaptive scaling is average of 0.82% while the loss bit rate of fixed rounding is average of 2.00% and the low bit rate of internal 8-bit is average of 2.59%.

Even though average memory access saving seems promising, worst case (local peak bandwidth saving) would be more relevant, as hardware would need to be designed for that case.

Current measurement software only measures variations at frame level – an AHG should investigate the local variations

Memory compression would be most beneficial for hardware implementation. Software would eventually implement the compression as "additional loop component" and store the decompressed data.

JCTVC-E187 Cross-verification report on adaptive scaling for reference pictures memory compression (JCTVC-E133) [Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)]

Results confirmed.

JCTVC-E432 Unified scaling for 10-bit to 8-bit reference frame compression [D. Hoang (Zenverge)]

Internal Bit Depth Increase (IBDI) is a technique that can improve the compression efficiency by coding a video sequence at a higher bit-depth. However, the main drawback is that memory storage and bandwidth requirements are increased. Reference frame compression (RFC) techniques have been proposed to reduce the memory storage and bandwidth penalty of IBDI by compressing the reference frames. In addition, RFC can also be used to encode and decode video sequences with bit-depth higher than 8 bits using the same memory footprint as 8-bit video. In summary, Zenverge RFC exhibited average Y BD-rate increase of 1.4% (0.3%) compared to 3.0% (1.0%) for Fixed Rounding and 3.1% (1.7%) for HM 2.0 without IBDI for LD-HE (RA-HE, resp.). Zenverge RFC encoder run times are 102% for both LD-HE and RA-HE configurations. Decoder run times are 113% for both LD-HE and RA-HE.

In class E LD, there was a 5% loss compared to HM anchor with BDI (JCTVC-E133 only had 3.5).

A willingness was expressed to combining the two schemes.

Proponents recommended to unify both approaches.

A more general scheme (N-to-8 bit) would be beneficial.

Further study in AHG was recommended. It is important to investigate "worst case" saving of memory bandwidth saving, which also highly depends on motion comp situation.

JCTVC-E463 Cross Verification for Unified scaling for 10-bit to 8-bit reference frame compression [Guichun Li (??)] [late registration 2011/03/17]

18.17 Parsing robustness and error resilience

JCTVC-E050 Parsing Robustness: Constrained Usage of Temporal MV and MVP Candidates [J.-L. Lin, C.-L. Wu, Y.-W. Chen, Y.-P. Tsai, Y.-W. Huang, S. Lei (MediaTek)]

In this proposal, new syntax elements are proposed in the sequence parameter set (SPS) and the slice header to constrain the use of temporal motion vector (MV) candidates and temporal motion vector predictor (MVP) candidates. The parsing error can thus be controlled within a few pictures instead of uncontrolled propagation to many pictures. The experiment results reported that disabling all temporal candidates causes 2.2% bit rate increase. However, disabling temporal candidates in all reference pictures reportedly reduces the bit rate increase to 1.1% for random access while the parsing error can thus be constrained within non-reference pictures and will not affect other pictures. The results also reported that the proposed control flag in the slice header provides multiple trade-off points between parsing error resilience and coding efficiency. The bit rate increase further reduces to 0.2% and 0.4% while the parsing error propagation is constrained within 16 and 8 pictures respectively.

Flags allow to disable temporal predictor for entire picture or slice.

Reason for flag in SPS: It can be known prior to decoding that this functionality is used.

V1 of the contribution reports results only on partial sequences.

The loss becomes lower when disabling is done selectively: Only for ref pics, for each 4th, 8th, 16th pic etc.

JCTVC-E452 Cross-Verification of Mediatek's Contribution (JCTVC-E050) by Qualcomm [G. Van der Auwera, Y. Zheng, L. Guo, X. Wang, M. Karczewicz (Qualcomm)] [late registration]

JCTVC-E148 An investigation on robust parsing [B. Li (USTC), J. Xu (Microsoft), F. Wu (Microsoft), H. Li (USTC)]

In the current design of HEVC, HM-2.0, temporal MV predictor is used for both AMVP and merge mode. TMVP will improve RD performance but bring parsing problem. This contribution investigates possible solutions and presents a tradeoff method between the coding efficiency and the error robustness. The error concealment results are also shown in this document.

(The presentation slide deck had not been uploaded at the time of its presentation.)

Method 1: Disable TMVP (performance loss as in JCTVC-E050)

Method 2: "code full index": Coding of MVP index without any information of the number of MVP, which may lead to wrong MV, but parsing problem is solved. BR increase 1.2-3% for the different cases (highest in LDLC). A wrong motion vector still causes severe problems in picture quality.

Method 3: mark frames "not used for MVP" (by the advent of a subsequent slice entitled as TIDR slice). TIDR slice and subsequent can be parsed correctly.

TIDR can be used periodically.

Does the correct decoding of MV help when no IDR refresh is made? It would need to be combined properly. Relation with trick modes?

JCTVC-E120 Cross verification of Microsoft proposal JCTVC-E148 on "an investigation on robust parsing" [Minhua Zhou (TI)]

JCTVC-E303 Cross-checking of an investigation on robust parsing results from Microsoft [L. Zhang, Q. Shen, Q. Xie, H. Yu (Huawei)]

JCTVC-E118 A study on HM2.0 bitstream parsing and error resiliency issue [Minhua Zhou, Vivienne Sze (TI)]

The current HM2.0 design is reported to have both bitstream parsing issues and error resiliency issues. This document presents the investigation results and recommends solutions. Specifically 1) encode the merge flag independent of the merge mode MVP list size; 2) remove the temporal MVP from the merge mode; 3) start core experiments on adding high-level flags to allow encoder to disable temporal MVP in both skip mode and motion vector coding, or disable temporal MVP from motion vector coding but still keep in skip mode, for generation of more error resilient bitstreams; 4) continue to study solutions for resolving bitstream parsing issue caused by the MVP list size dependent MVP index coding. Notable investigation results include: 1) MVP list size independent merge flag coding does not cause quality loss, in fact, it leads to small gain in low delay configurations; 2) The quality loss of disabling the temporal MVP in merge mode and motion vector coding is relatively small, 0.4% in RA, 0.3% in RALC, -0.2% in LD and 0.5% in LDLC, respectively; 3) Disabling the temporal MVP in the merge mode leads to quality gain: 0.0% in RA, -0.2% in RALC, -0.1% in LD and -0.4% in LDLC, respectively.

It is emphasized that due to the dependencies in MV decoding (e.g. list construction), CABAC decoding throughput is reduced. This point of view is also expressed by another company (Broadcom).

It was suggested to put this into the mandates of the parsing robustness AHG.

A similar solution as in JCTVC-E148 method 2 is suggested to solve the parsing problem (not cross-checked)

It is reported that by disabling temporal MV in coding but using it in ME (as starting point), the loss is reduced from 2.3 to 1.9%.

It is reported that by keeping the temporal MV coding only for skip (not for coding and merge) the loss is only 0.4%

About 1) encode the merge flag independent of the merge mode MVP list size: Method to do that: Inserting a zero motion vector. (adopted as from JCTVC-E146, see notes in the section discussing that contribution).

JCTVC-E219 Robust solution for the AMVP parsing issue [Edouard Francois, Christophe Gisquet, Guillaume Laroche, Patrice Onno, Nael Ouedraogo (Canon~~??~~)]

This contribution deals with the parsing issue related to the temporal motion prediction of AMVP. AMVP candidates consist not only of spatial MVP candidates but also of temporal MVP candidates from previous reference pictures. Before coding the index of the best MVP candidate, redundant MVPs are removed from the candidates set. This might cause parsing errors when previous reference pictures are lost. In this contribution, two tools were proposed related to the AMVP process. The first tool consists in forcing the availability of a temporal predictor for the Inter, Skip and Merge modes whatever the existence of this predictor. The second tool consists in replacing the duplicate candidates by candidates with different (non-redundant) values.

These two tools have been evaluated in three configurations. Configuration 1 only uses tool 1. Configurations 2 and 3 additionally use tool 2 and correspond to different modes combinations. Coding performance is respectively of 1.3%, 0.8% and 0.4% BD-rate loss.

The lowest loss is when applied on inter MVP, merge and skip.

Encoding time and decoding time (up to 5%) increased. Further simplification is anticipated.

The best solution (combining tool1 and tool2) would need to be adapted w.r.t. the changes due to CE9.

It appears that this could solve the parsing problem w.r.t. error robustness, but not w.r.t. throughput.

Further study (include in CE9?) was recommended.

JCTVC-E261 Cross Verification Report of Canon proposal JCTVC-E219 on Robust solution for the AMVP parsing issue [Laurent Guillo, Ronan Boitard (INRIA)] [late upload / missing prior]

JCTVC-E302 Modification for robust parsing of AMVP [L.Zhang, Q. Shen, Q. Xie, H. Yu (Huawei)]

A method was proposed for robust parsing in advanced motion vector prediction (AMVP). If there are three motion vector predictor (MVP) candidates (including left MVP, above MVP and temporal MVP) all existing, merge the spatial MVP candidates into only one spatial MVP candidate, and one bit needs to be encoded for MVP index. Meanwhile if no spatial MVP exists, no bits should be coded into the stream.

This approach is to use only 2 candidates (merge 2 spatial candidates): Loss reported was 0.5-1.3% (Highest for LDLC). Three variants were discussed (merge left, merge top, average).

There was remarkably high loss in class E LCLD.

An explanation could be that this method still needs to encode 1 bit even if there is only one candidate (which is the case with those sequences of homogeneous motion). Most probably, CABAC resolves this in the case of LDHE.

The parsing issue is not solved for merge/skip; only for AMVP.

Ongoing work is needed on that – and further study was encouraged.

JCTVC-E152 Cross-check report for JCTVC-E302 [J. Xu (Microsoft)] [late upload / missing prior]

JCTVC-E329 Removal of cabac_zero_word for error detection/resilience [Y. Matsuba, V. Sze, M. Zhou (TI)]

The decoder can detect an error in the slice layer by comparing the number decoded bits for the slice with the current NAL unit size. A mismatch indicates that there is an error in the decoded bitstream. In AVC, the encoder inserts a variable number of cabac_zero_words in the slice layer, after end_of_slice_flag=1, which changes the number bits per NAL unit and the above method of error detection cannot be directly used. Before doing a comparison, the decoder must also parse through the bytes after end_of_slice_flag=1 to ensure that they match the cabac_zero_word pattern. Furthermore, cabac_zero_word can cause false alarms for error detection (i.e. when bytes up to and including end_of_slice_flag=1 are correct, but an error occurs in cabac_zero_word). This contribution proposes removing cabac_zero_word from the rbsp_trailing_bits(), and recommends inserting the stuffing bytes outside of the slice_layer (e.g. place a startcode delimiter between slice layer and stuffing bytes).

Currently cabac_zero_word is in the WD, but not in software.

One expert comments that the cabac_zero_word may be important for parallel implementations.

The error issue could also be resolved by checking the rbsp trailing bits.

No action was taken on this at this time, as there may be other ways to this issue.

Frank Bossen suggested the following: The first three bytes in the EBSP for a cabac_zero_word are 0,0,3. If changed to 0,0,2, this would establish a unique pattern. This could be a useful approach.

JCTVC-E451 Impact of Motion Vector Predictor Index Decoding on Parallelization between CABAC and Other Decoder Components [Yong Yu (??)] [late registration / missing prior]

This contribution addresses the following issues caused by motion vector prediction candidate in current HEVC design: parallelizing CABAC decoder and the other components of coders, parsing robustness, extra external memory bandwidth and on chip storage in a general SOC system. It proposes a modification of motion vector prediction candidate index algorithm. The cost of this change is about 0.3% for high efficiency random access category, 0.2% for low delay category. The proposed modification reportedly has no effects on other categories.

(The presentation slide deck for the contribution had not been uploaded at the time of its presentation.)

The numbers of CABAC throughput disadvantage as reported are only related to the part of motion information. How large is the overall disadvantage?

The proposal does not solve the problem of parsing robustness w.r.t. data losses (e.g. skip/merge).

The proposal assumes taking advantage from average throughput even in case of frame variations. One expert mentioned that the contribution does not adress bus bandwidth, amount of initial buffer delay (e.g. the average bit rate cannot be taken advantage from in only I scenario).

Conclusion on parsing topic

Continue the Parsing AHG. The AHG should look at the dependencies introduced in parsing not only w.r.t. robustness under data losses, but also w.r.t. throughput.

Issues to be addressed:

- W.r.t. data losses: Reasonable models for losses that would allow to evaluate prospective methods, interdependency of potential parsing problems with other problems caused by losses (particularly loss of motion and texture data).
- W.r.t. throughput: Propose/develop methods that allow evaluation of throughput disadvantages caused by the dependencies in MV and entropy coding.

18.18 Complexity assessment

JCTVC-E054 Preliminary complexity assessment on ARM [Daniele Alfonso, Andrea C. Ornstein (STMicro)]

This contribution presents the results of a preliminary assessment of HM 2.0 decoder complexity on ARM architecture, in particular a Dual Cortex-A9 CPU integrated in the ST-Ericsson U8500 System-on-Chip. The authors assert that ARM platforms are relevant in the current market status and they propose to conduct further complexity analysis on ST-Ericsson experimental boards.

The experiment was conducted using HM2 software compiled for ARM platform.

The ratio between LC and HE is between 1.2 and 2.2

It is emphasized that the fact that the LC configuration is designed for 8 bit is not really implemented in an optimized way in the HM software.

The largest case ratio is the most relevant, as this reflects probably the worst case decoder runtime.

It would also be interesting to compare the ratios per sequence, but also the overall worst case (e.g. per frame) of HE and LC.

JCTVC-E086 [AHG: Complexity Assessment] Summary of Complexity Assessment for CEs and Three-Level Assessment method [Xing Wen, Oscar C. Au (HKUST), Mona Mathur(STMicro)] [initial version rejected]

Most of CEs established at the Daegu meeting reportedly used their own complexity assessment methods – especially CE7 and CE10. This contribution first reviews the complexity assessment methods used by these CEs. Then, a drafted "Three-Level Complexity Assessment method" is proposed as a starting point toward forming a more general complexity assessment method, which can reportedly provide a standard complexity analysis for all kinds of tools/algorithms.

A participant raises a concern that "gettime" may not be the best tool for runtime assessment.

The document rather provides a list of items that are "best practices".

It was suggested to hold BoG discussions on the subject and potentially set up an AHG again. The BoG report is discussed below.

JCTVC-E497 BOG report on complexity assessment [Daniele Alfonso (STMicro), Xing Wen (HKUST)] [BoG uploaded 2011/03/21]

Starting from contribution JCTVC-E086, a revised version of the Three-Level Complexity Assessment (TLCA) has been drafted, as reported in the next section of the document.

It has been remarked that defining a complexity assessment method that is universally valid for all the possible kinds of contributions is extremely difficult and perhaps not even needed, therefore rather than a set of fixed rules that everybody shall follow, the proposed TLCA is intended to be a set of suggested rules that AHG chairs and CE coordinators should consider, picking the suggestions that are more appropriate for the proposals under consideration.

With regard to hardware complexity, the BOG did not reach consensus about what hardware measures should be reported. It has been agreed that throughput and latency are a first priority. According to some BOG participants, other useful numbers are clock frequency, technology, silicon area and power consumption.

18.19 Additional withdrawn contributions

JCTVC-E094 Withdrawn - duplicate registration for AHG report

JCTVC-E293 Cross-check Report for HKUST's Proposal JCTVC-EXXX by MediaTek [Zhi Zhou, Shan Liu (MediaTek)] [missing]

Withdrawn

JCTVC-E306 Cancelled

JCTVC-E457 CE (??) [late registration / missing]

Seemed to be a misregistration.

19 Plenary Discussions and BoG Reports

19.1 Joint Meeting with MPEG Requirements, MPEG Video and VCEG

19.1.1 Software copyright disclaimer

No objection raised on using the version which is based on BSD license. This is to be implemented in the HM codebase before new commitments are made. Any contributions that are committed to the SVN from now on must include the copyright disclaimer.

19.1.2 Project development

JNB comment to WG11 (M19926) on HEVC development:

"In the JCTVC meeting at Daegu, new functionalities (spatial scalability, etc) were included in the requirement document.

JNB recognizes importance of investigation of new functionalities those could extend use cases of HEVC, however JNB has a concern about impact on the 'core part' of HEVC development. 'Core part' means the part that common test condition and anchors are defined in JCTVC-D600 (m19497). The principal target of HEVC development should be focused on the improvements of coding efficiency and complexity of such 'core part'.

The investigation of new functionalities should be carried out without delaying the schedule of 'core part' of HEVC (FDIS completion at 103rd WG11 meeting)."

The JCT-VC appreciated this input and confirmed that this is in line with the discussions of previous meetings and with current plans.

JCTVC-E502 Scalable enhancement requirements for HEVC [late registration 2011/03/21]

Originally submitted as WG11 document M19968

Aspects of this doc:

- Arguments that convergence of TV, Internet, computer etc. is happening now, increased need for scalability (better than transcoding)
- Various scalabilities to be combined
- Request to set up more specific requirements (temporal, spatial, …)
- Spatial: 1:1.5, may be even more frequently needed than 1:2
- Combination spatial, temporal and SNR (latter with factor 1:2 with given S/T res.)
- Fine granularity may be needed
- View scalability
- Conversion 2D -> 3D: Depth maps

Comments:

- Requirements of extensions must be developed under study of forthcoming applications
- Timeline? Is said to be today.
- Coding efficiency requirement of scalable tools?

VCEG inputs (with origin HHI/Vidyo)

- Coding efficiency should be within margin of 10% compared to single layer
- Multi-view: Concentrate on stereo/3-view. Efficient stereo coding is needed (not more than 50% increase compared to single-view coding)
- Start this work with overlap of one year with phase 1?

Some concerns were expressed about the practicality (looking at the number of contributions).

Certainly the "time efficiency" of presentations could be improved.

Before starting on scalability and multiview, it would be necessary to define test cases (including the collection of test material in the stereo case). This must be aligned with typical application cases.

CfP(s) would be valuable.

Question to parent bodies: How to proceed on this? Appears useful to install AHGs on both sides, who meet jointly and work out application requirements, define test cases as next steps to possibly prepare for a CfP.

19.2 BoG reports

JCTVC-E478 BoG report on extending LCEC to larger block sizes [A. Fuldseth (Cisco), M. Karczewicz (Qualcomm), M. Haque (Sony)] [BoG uploaded 2011/03/18]

Notes recorded elsewhere in this report.

JCTVC-E481 BoG report of CE9: MV Coding and Skip/Merge operations [Benjamin Bross, Joel Jung] [BoG uploaded 2011/03/21]

Notes recorded elsewhere in this report.

JCTVC-E483 BoG on fine granularity slices [Rickard Sjoberg, Shawmin Lei, Yu-Wen Huang, Qiu Shen] [BoG uploaded 2011/03/19]

Notes elsewhere in this report – was reviewed Sunday evening in plenary.

JCTVC-E488 BoG report on padding of unavailable reference samples for intra prediction [Rickard Sjöberg (Ericsson), Changcai Lai (HiSilicon), Keiichi Chono (NEC), Viktor Wahadaniah (Panasonic)] [BoG uploaded 2011/03/19]

Notes recorded elsewhere in this report.

JCTVC-E493 BoG report on Screen Content Coding (SCC) [Oscar Au, Jizheng Xu, Haoping Yu] [BoG uploaded 2011/03/20]

Notes recorded elsewhere in this report.

JCTVC-E494 BoG report on the draft text for the combination of proposals JCTVC-E227, JCTVC-E338 and JCTVC-E344 [J. Sole (Qualcomm), C. Auyeung (Sony), H. Sasai (Panasonic)] [BoG uploaded 2011/03/20]

Notes recorded elsewhere in this report.

JCTVC-E497 BOG report on complexity assessment [Daniele Alfonso (STMicro), Xing Wen (HKUST)] [BoG uploaded 2011/03/21]

Notes recorded elsewhere in this report.

JCTVC-E501 BoG report on subjective viewing test for deblocking filter proposals [Andrey Norkin, Kenneth Andersson, Keiichi Chono, In Suk Chong, Matthias Narroschke, Byengwoo Jeon, David Flynn] [BoG report / uploaded 2011/03/22]

Notes recorded elsewhere in this report.

20 Project planning

20.1 WD drafting and software, and relationship to contributions

The group considered it important to have the full design of proposals documented to enable proper study. Working draft text is also needed for adoption of proposals (at least ordinarily). Contributions need to contain the draft text that is being proposed.

The current WD is still much in a draft status (e.g. no description of LCEC at all). In future meetings, adoptions need to be based on properly drafted working draft text (on normative elements) and HM encoder algorithm descriptions – relative to the existing drafts. Proposal contributions should also provide a software implementation (or at least such software should be made available for study and testing by other participants at the meeting, and software must be made available to cross-checkers in CEs).

20.2 Plans for improved efficiency and contribution consideration

Suggestions for future meetings were as follows:

- No review of normative contributions without text
- Earlier upload deadline to enable greater study prior to the meeting

- Using a clock timer to ensure efficient proposal presentations and discussions

These suggestions are likely to be applied in the future work. In particular, the document deadline for the July 2011 meeting was tentatively planned to be 1 July.

As general guidance, it was suggested to avoid usage of company names in document titles, software modules etc., and not to describe technology by company name. Also experiment responsibilities should name individuals, not companies. AHG reports and CE descriptions/summaries are contributions of individuals, not companies.

20.3 General issues for CEs

Because a draft design and HEVC test model (referred to as the HM) have now been established, group coordinated experiments are now referred to as "core experiments" rather than "tool experiments".

A preliminary CE description is to be approved at the meeting at which the CE plan is established.

It is possible to define sub-experiments within particular CEs, for example designated as CEX.a, CEX.b, etc., for a CEX, where X is the basic CE number.

As a general rule, it was agreed that each CE should be run under the same testing conditions using one software codebase, which should be based on the HM software codebase. An experiment is not to be established as a CE unless there is access given to the participants in (any part of) the CE to the software used to perform the experiments.

The general agreed common conditions for experiments were described in the output document JCTVC-D600.

A deadline of two weeks after the meeting was established for organizations to express their interest in participating in a CE to the CE coordinators and for finalization of the CE descriptions by the CE coordinator with the assistance and consensus of the CE participants.

Final CEs should clearly describe specific tests to be performed, not describe vague activities. Activities of a less specific nature are delegated to Ad Hoc Groups rather than designated as CEs.

Experiment descriptions should be written in a way such that it is understood as a JCT-VC output document (written from an objective "third party perspective", not a company proponent perspective – e.g. referring to methods as "improved", "optimized" etc.). The experiment descriptions should generally not express opinions or suggest conclusions – rather, they should just describe what technology will be tested, how it will be tested, who will participate, etc. Responsibilities for contributions to CE work should identify individuals in addition to company names.

CE descriptions should not contain verbose descriptions of a technology (at least not unless the technology is not adequately documented elsewhere). Instead, the CE descriptions should refer to the relevant proposal contributions for any necessary further detail. However, the complete detail of what technology will be tested must be available – either in the CE description itself or in referenced documents that are also available in the JCT-VC document archive.

Those who proposed technology in the respective context (by this or the previous meeting) can propose a CE or CE sub-experiment. Harmonizations of multiple such proposals and minor refinements of proposed technology may also be considered. Other subjects would not be designated as CEs.

Any technology must have at least one cross-check partner to establish a CE – a single proponent is not enough. It is highly desirable have more than just one proponent and one cross-checker.

It is strongly recommended to plan resources carefully and not waste time on technology that may have little or no apparent benefit – it is also within the responsibility of the CE coordinator to take care of this.

CE participants are obligated to submit a report of the results of their experiment testing and any further analysis of the subject matter. Each participant is required to submit a report – measures will be taken if this principle is violated (especially if repeatedly violated) without good reason.

A summary report written by the coordinator (with the assistance of the participants) is also expected to be provided to the subsequent meeting. The review of the status of the work on the CE at the meeting is expected to rely heavily on the summary report, so it is important for that report to be well-prepared, thorough, and objective.

Non-final CE plan documents were reviewed and given tentative approval during the meeting (in some cases with guidance expressed to suggest modifications to be made in a subsequent revision).

The CE description for each planned CE is described in an associated output document JCTVC-D6xx for CExx, where "xx" is the CE number (xx = 01, 02, etc.). Final CE plans are recorded as revisions of these documents.

It must be understood that the JCT-VC is not obliged to consider the test methodology or outcome of a CE as being adequate. Good results from a CE do not impose an obligation on the group to accept the result (e.g., if the expert judgment of the group is that further data is needed or that the test methodology was flawed).

Discussion about CEs (recorded in Tuesday morning plenary):

- CEs should be better focused.
- Should admission to CEs be better controlled – raising the bar?
- No ideal solution to this currently – it is up to the discretion of the CE coordinator and the consensus in the CE group to achieve this.
- One expert suggests that a CE should be run in a way that the proponent only provides software and two independent parties investigate it.
- No change to current rules, but it is emphasized that the coordinators should implement through their responsibility that the experimentation done in a CE gives reasonable evidence. CEs with confusing results have hardly any chances to lead to adoption decisions.

Further discussion notes recorded Wednesday:

- Only qualified JCT-VC members can participate in a CE
- Suggestion to make participation in a CE possible without commitment of submitting an input doc to the next meeting.
- All software, results, documents produced in the CE should be announced and made available to all CE participants in a timely manner.

These three points were agreed by the JCT-VC.

20.4 Alternative procedure for handling complicated feature adoptions

An alternative procedure to follow for more complicated feature adoptions was outlined in group discussions:

1. Run CE + provide software + text -> if successful
2. Adopt to HM, including refinements of software and text (both normative & non-normative) -> if successful
3. Adopt to WD and common conditions

Of course, we have the freedom (e.g. for simple things) to skip step 2.

20.5 Common Conditions for HEVC Coding Experiments

Preferred Common Conditions for experiment testing that are intended to be appropriate for both CEs and other experiments were selected by the group and described in output document JCTVC-D600.

20.6 Software development

The software coordinator had already started integrating bug fixes on top of HM 1.0 software. As there are substantial changes relative to TMuC 0.9, it was recommended that participants start studying and implementing their technology based on HM 1.0 immediately, considering the short time period until the 5th meeting. The software version HM 2.0, which is intended to become the basis of CE experimentation, will be available 2 weeks after the meeting. HM 2.1 (including adoptions which appear less relevant in CEs) will follow later.

A version of the software should be available within 2 weeks that should be suitable for CEs.

21 Establishment of ad hoc groups

The ad hoc groups established to progress work on particular subject areas until the next meeting are described in the table below. The discussion list for all of these ad hoc groups will be the main JCT-VC reflector (jct-vc@lists.rwth-aachen.de).

Title and Email Reflector	Chairs	Mtg
JCT-VC project management (AHG1) (jct-vc@lists.rwth-aachen.de) • Coordinate overall JCT-VC interim efforts • Report on project status to JCT-VC reflector • Provide report to next meeting on project coordination status	G. J. Sullivan, J.-R. Ohm (co-chairs)	N
HEVC Draft and Test Model editing (AHG2) (jct-vc@lists.rwth-aachen.de) • Produce and finalize JCTVC-E602 HEVC Test Model 3 (HM 3) Encoder Description • Produce and finalize JCTVC-E603 HEVC text specification Working Draft 3 • Gather and address comments for refinement of these documents • Coordinate with the Software development and HM software technical evaluation AhG to address issues relating to mismatches between software and text	T. Wiegand, K. McCann (co-chairs), B. Bross, W.-J. Han, J.-R. Ohm, S. Sekiguchi, G. J. Sullivan (vice chairs)	N

Software development and HM software technical evaluation (AHG3) (jct-vc@lists.rwth-aachen.de) • Coordinate development of the HM software and its distribution to JCTVC members • Produce documentation of software usage for distribution with the software • Prepare and deliver HM 3.0 software version and the reference configuration encodings according to JCTVC-E700 based on common conditions suitable for use in most core experiments (expected within three weeks after the meeting). • Prepare and deliver HM 3.1 software (and possibly additional "dot" version software releases) and appropriate software branches that include additional items not integrated into the 3.0 version (expected within three weeks after the 3.0 software release). • Coordinate with HEVC Draft and Test Model editing AhG to identify any mismatches between software and text	F. Bossen (chair), D. Flynn, K. Sühring (vice chairs)	N
Slice support development and characterization (AHG4) (jct-vc@lists.rwth-aachen.de) • Identify and work to resolve issues relating to the draft text description of slice functionality and the associated reference software functionality • Study technical proposals relating to slice structured coding • Study the coding efficiency and loss resilience impact of slice-structured coding • Identify and discuss additional issues relating to slice-structured coding	R. Sjöberg (chair), Y. Chen, M. Horowitz, K. Kazui, A. Segall (vice chairs)	N
Spatial transforms (AHG5) (jct-vc@lists.rwth-aachen.de) • Study the ("core" and additional) transforms in the HM design, including compression performance, computational complexity, dynamic range, clipping, storage requirements, etc. • Discuss transform-related Core Experiments, and identify potential synergies or incompatibilities related to the tools being tested in the CEs. • Report the results and conclusions of these studies, discussions and experiments to the JCT-VC.	P. Topiwala (chair), M. Budagavi, R. Cohen, R. Joshi (vice chairs)	N

In-loop and post-processing filtering (AHG6) (jct-vc@lists.rwth-aachen.de) • Study enhancement schemes of in-loop filtering, including de-blocking/de-banding/de-noising filters, and adaptive Wiener-based filters including variants with various inputs, and combination of filters • Study trade-offs and characteristics of filter designs including complexity and subjective and objective performance • Discuss relationships and evaluation procedures for the filtering techniques • Identify possibilities for harmonization of enhanced in-loop filtering technologies • Study the relationship between in-loop and post-processing filtering	T. Yamakage (chair), K. Chono, Y. J. Chiu, I. S. Chong, M. Narroschke (vice chairs)	N
Coding block structures (AHG7) (jct-vc@lists.rwth-aachen.de) • Study techniques of HM relating to coding block structure • Characterize the trade-offs involved in coding block structure issues, including complexity, redundancy and compression performance aspects • Identify opportunities for harmonization and simplification of coding block structure	K. Panusopone (chair), W.-J. Han, T. K. Tan, T. Wiegand (vice chairs)	N
Reference pictures memory compression (AHG8) (jct-vc@lists.rwth-aachen.de) • Study motion compensation memory access bandwidth of HM design and proposed reference picture memory compression schemes • Study reference picture memory compression schemes proposed for the HM design • Study data format alignment between reference picture memory compression and display processing • Study the visual quality impact of reference picture memory compression • Report on conclusions reached	K. Chono (chair), T. Chujoh, D. Hoang, C. S. Lim, A. Tabatabai, M. Zhou (vice chairs)	N

Entropy coding (AHG9) (jct-vc@lists.rwth-aachen.de) • Study the entropy coding complexity and compression characteristics of CABAC, CAVLC, PIPE/V2V, and other entropy coding designs • Consider the potential for harmonization of HE and LC entropy coding designs • Characterize entropy coding throughput, memory, silicon area, power requirements, etc. • Study interdependencies between entropy coding and other processes and the consequences of these interdependencies • Study parallel context processing, syntax-element partitioning, and other parallelism approaches for entropy coding • Study and develop approaches for hardware and software evaluation of entropy coding methods • Identify and discuss additional issues on entropy coding	M. Budagavi (chair), G. Martin-Cocher, A. Segall, W. Wan (vice chairs)	N
Quantization (AHG10) (jct-vc@lists.rwth-aachen.de) • Study quantization issues in HM design, including step size control, RDOQ, etc. • Study trade offs and characteristics of quantization design, including coding efficiency and complexity • Study the impact of quantization on subjective quality • Study proposed quantization schemes such as adaptive quantization level (AQL), quantization matrix support, and adaptive reconstruction offsets, and their effects • Study adequacy of current mapping of QP to quantizer step-size for rate control at different coding levels (LCU, slice, frame, etc.)	M. Budagavi (chair), M. Karczewicz, G. Martin-Cocher, K. Sato (vice-chairs)	N
Video test material selection (AHG11) (jct-vc@lists.rwth-aachen.de) • Identify, collect, and make available a variety of video sequence test material • Study the coding performance and characteristics of test materials • Identify and recommend appropriate test materials and corresponding test conditions for use in HEVC development	T. Suzuki (chair)	N

Complexity assessment (AHG12) (jct-vc@lists.rwth-aachen.de) • Summarize and evaluate the various complexity assessment methods with regard to: ▪ computational complexity, ▪ parallelism, ▪ memory bandwidth, ▪ memory capacity, ▪ dynamic range requirements, ▪ any other aspects of complexity identified as being of interest. • Develop and propose a set of general measurement metrics. • Develop and propose a metric for measuring the parallelizability of proposed parallel algorithms. • Identify criteria to determine the hardware implementability of key hardware modules. • Identify bottlenecks in the current design with regard to implementation complexity.	D. Alfonso (chair), J. Ridge, X. Wen (vice chairs)	N
Screen content coding (AHG13) (jct-vc@lists.rwth-aachen.de) • To coordinate the submission, evaluation and selection of "screen content" video test material • To study characteristics of screen content video • Analyze the effects of existing and proposed coding technology on screen content video • To study and establish evaluation methods, test conditions, and metrics for coding of screen content video • Study technology that may be particularly well suited to the coding of screen content video • Study use cases in which screen content video is prevalent and identify potential associated technical implications	O. Au (chair), J. Xu, H. Yu (vice chairs)	N

Loss robustness (AHG14) (jct-vc@lists.rwth-aachen.de) • Study the degree of loss robustness of the HM design and identify deficiencies • Identify and study the interdependencies in the HM design in relation to loss robustness, and the potential consequences of these interdependencies • Identify techniques and conditions for testing the loss robustness of the design. • Investigate solutions to improve loss robustness • Investigate the trade-off between coding efficiency and loss robustness • Discuss related Core Experiments, and identify potential synergies or incompatibilities related to the tools being tested in the CEs	S. Wenger (chair), M. Coban, Y. W. Huang, P. Onno, J. Xu (vice chairs)	N
High-level syntax (AHG15) (jct-vc@lists.rwth-aachen.de) • Study NAL unit header, sequence parameter set, picture parameter set, proposed additional types of parameter sets, and slice header syntax designs • Study and identify needs for SEI messages and VUI • Study possible improvements to the reference picture list construction processes • Study possible simplifications and improvements to reference picture marking process (e.g., the need of the processes for generating and handling of "non-existing" pictures) • Study the hypothetical reference decoder behaviour • Assist in software development and text drafting for the high-level syntax in the HEVC design	Y. K. Wang (chair), J. Boyce, Y. Chen, M. Hannuksela, K. Kazui, T. Schierl, R. Sjöberg, T. K. Tan W. Wan (vice chairs)	N
Decoder motion vector derivation (AHG16) (jct-vc@lists.rwth-aachen.de) • Study the techniques of decoder side motion vector derivation to improve video compression • Investigate inference processing techniques such as optical-flow at the decoder side • Study the performance/complexity tradeoffs of uni/bi-predictional-based methods to derive motion vector information at decoder side • Study complexity and performance of parallel processing for decoder-side inference techniques to improve video compression	Y.-J. Chiu (chair), E. Alshina, H. Yu (vice chairs)	N

Scalable coding investigation (AHG17) (jct-vc@lists.rwth-aachen.de) • Investigate hooks that would be needed for support of bitstream scalability in HEVC syntax • Study the applicability and effectiveness (e.g., relative to simulcast and single-layer coding) of scalability tools • Study potential experimental conditions for evaluation of scalable video coding technologies	J. Boyce (chair), J. Kang, K. Minoo, W. Wan, Y.-K. Wang (vice chairs)	N
Weighted prediction (AHG18) (jct-vc@lists.rwth-aachen.de) • Develop software for support of weighted prediction (WP) in HEVC in the same way as in AVC for study toward support of WP capability. • Discuss and develop analysis software for estimating weighting parameters for explicit WP. • Discuss and develop common conditions to test WP and illumination compensation (IC) tools in general, including test sequences and encoding configurations. • Study technical proposals related to WP and IC in general, evaluate their gains, complexity, and interactions with existing HM design tools.	P. Bordes, T. K. Tan (co-chairs)	N
Alternative LCU scan processing (AHG19) (jct-vc@lists.rwth-aachen.de) • Study technical proposals related to alternative LCU scan processing, such as wavefront scanning and tile structuring. • Study interactions and combinations of alternative LCU scan ordering related technical proposals • Study the coding efficiency impact of alternative LCU scan structured coding • Study the use alternative LCU scan processing for high-level parallelism • Study the use of alternative LCU scan procesing for ultra low delay.	M. Horowitz (chair), F. Henry, A. Segall (vice chairs)	N
Chroma format support (AHG20) (jct-vc@lists.rwth-aachen.de) • Study aspects of the technical design and software that need modification to support non-4:2:0 chroma formats. • Assist and advise in the work of removing implicit assumptions of 4:2:0 formatting from the WD and software (where feasible, without introducing technical design changes).	D. Flynn (chair), D. Hoang, K. McCann (vice chairs)	N

22 Output documents

The following documents were agreed to be produced or endorsed as outputs of the meeting. Names recorded below indicate those responsible for document production.

Note: JCTVC-C404 will remain as our approved software guidelines.

JCTVC-E447 HEVC Reference Software Manual [F Bossen (DOCOMO USA Labs), D Flynn (BBC), K Sühring (HHI)] [late registration]

JCTVC-E600 Meeting Report of 5th JCT-VC Meeting [G. J. Sullivan, J.-R. Ohm]

JCTVC-E602 High Efficiency Video Coding (HEVC) Test Model 3 (HM 3) Encoder Description [K. McCann (primary), B. Bross, W.-J. Han, S. Sekiguchi, G. J. Sullivan] (WG 11 N 12000)

JCTVC-E603 High Efficiency Video Coding (HEVC) text specification Working Draft 3 [T. Wiegand (primary), B. Bross, W.-J. Han, G. J. Sullivan, J.-R. Ohm] (WG 11 N 12001)

JCTVC-E700 Common HM test conditions and software reference configurations [F. Bossen]

Note: Some aspects included were:

- Adding configs for low-delay P (not used in most CEs, see discussion of JCTVC-E361 above)
- Software HM3.0 availability expected April 15

JCTVC-E701 Core Experiment 1: Motion Data Storage Reduction [J. Jung (primary), Y. W. Huang, P. Onno]

JCTVC-E702 Core Experiment 2: Motion Partitioning and OBMC [X. Zheng (primary), P. Bordes, P. Chen, I.-K. Kim]

JCTVC-E703 Core Experiment 3: Motion Compensation Interpolation [E. Alshina, T. Chujoh]

JCTVC-E704 Core Experiment 4: Quantization [K. Sato (primary), M. Budagavi, K. Chono, M. Coban, X. Li]

JCTVC-E705 Core Experiment 5: CAVLC Entropy Coding Improvement [X. Wang, P. Wu]

JCTVC-E706 Core Experiment 6: Intra prediction improvements [A. Tabatabai (primary), M. Budagavi, K. Chono, J. Rajan, A. Segall, H. Yu]

Several subjects are in this CE (parallelism, perhaps cross-component prediction, SDIP, DCIM)

Extra time with be provided to finalize with respect to the HM "3.0+SDIP" software branch (3.0+2wks) that will include SDIP.

There will also be a "3.0+ALFshapes" branch and a "3.1" (incl. PCM) branch.

JCTVC-E707 Core Experiment 7: Additional transforms [R. Cohen (primary), F. Fernandes, R. Joshi, C. Yeo]

JCTVC-E708 Core Experiment 8: Non-deblocking loop filtering [T. Yamakage (primary), I. S. Chong, M. Narroschke]

(Runtime numbers should also be provided with ALF off to get information about the complexity of the current configuration and the modifications.)

JCTVC-E709 Core Experiment 9: MV Coding and Skip/Merge Operation [Y. W. Huang (primary), B. Bross, W. J. Chien, I. K. Kim]

JCTVC-E710 Core Experiment 10: Core Transforms [P. Topiwala (primary), M. Budagavi, A. Fuldseth, R. Joshi, I.-K. Kim]

In group discussion, one aspect discussed was whether to remove in B2.5 the "optional" aspect of hardware-based evaluation – i.e. to potentially make this mandatory. However, some companies may not like to do this if it relates to internal IP. This was expected to be further clarified in the finalization of the CE plan.

JCTVC-E711 Core Experiment 11: Coefficient Scanning and Coding [V. Sze (primary), J. Chen, T. Nguyen, K. Panusopone, J. Sole]

JCTVC-E712 Core Experiment 12: Deblocking Filter [A. Norkin (primary), X. Guo, B. Jeon, M. Narroschke]

23 Future meeting plans, expressions of thanks, and closing of the meeting

Future meeting plans were established according to the following guidelines:

- Meeting under ITU-T SG 16 auspices when it meets (starting meetings on the Tuesday or Wednesday of the first week and closing it on the Tuesday or Wednesday of the second week of such meeting), and
- Otherwise meeting under ISO/IEC JTC 1/SC 29/WG 11 auspices when it meets (starting meetings on the Wednesday or Thursday prior to such meetings and closing it on the last day of the WG 11 meeting).

Some specific future meeting plans were established as follows:

- 14-22 July 2011 under WG 11 auspices in Torino, IT.
- 22-30 November 2011 under ITU-T auspices in Geneva, CH.
- 1-10 February 2012 under WG 11 auspices in San José, USA.

The ITU was thanked for its excellent hosting of the 5th meeting of the JCT-VC, and for providing the viewing equipment.

The JCT-VC meeting was closed at approximately 13:52 on Wednesday 23 March 2011.

Annex A to JCT-VC report:
List of documents

JCT-VC number	MPEG number	Created	First upload	Last upload	Title	Source
JCTVC-E001	m19924	2011-03-11 06:33:46	2011-03-16 03:58:25	2011-03-16 03:58:25	JCT-VC AHG report: Project management	G. J. Sullivan, J.-R. Ohm (AHG chairs)

hhh

JCT-VC number	MPEG number	Created	First upload	Last upload	Title	Source
JCTVC-E001	m19924	2011-03-11 06:33:46	2011-03-16 03:58:25	2011-03-16 03:58:25	JCT-VC AHG report: Project management	G. J. Sullivan, J.-R. Ohm (AHG chairs)
JCTVC-E002	m20106	2011-03-15 00:12:23	2011-03-16 10:23:47	2011-03-16 10:23:47	JCT-VC AHG report: HEVC Draft and Test Model editing	K. McCann, T. Wiegand (co-chairs), B. Bross, W.-J. Han, J.-R. Ohm, J. Ridge, S. Sekiguchi, G. J. Sullivan (vice chairs)
JCTVC-E003	m20020	2011-03-14 09:31:30	2011-03-30 19:52:42	2011-03-30 19:52:42	JCT-VC AHG Report: Software development and HM software technical evaluation	F Bossen, K Sühring, D Flynn
JCTVC-E004	m19775	2011-03-10 17:22:23	2011-03-16 00:46:22	2011-03-16 09:28:15	JCT-VC AHG report: Slice support development and characterization	R. Sjoberg (Ericsson), Y. Chen (Qualcomm), M. Horowitz (eBrisk), K. Kazui (Fujitsu), A. Segall (Sharp)

JCTVC-E005	m19977	2011-03-12 00:46:51	2011-03-12 00:47:06	2011-03-17 10:05:40	JCT-VC AHG report: Spatial transforms	Pankaj Topiwala, Madhukar Budagavi, Rajan Joshi, Robert Cohen
JCTVC-E006	m19733	2011-03-10 11:30:51	2011-03-15 00:54:29	2011-03-16 16:26:45	JCT-VC AHG report: In-loop and post-processing filtering	T. Yamakage (Toshiba), K. Chono (NEC), Y. J. Chiu (Intel), I. S. Chong (Qualcomm), M. Narroschke (Panasonic)
JCTVC-E007	m20084	2011-03-14 22:43:37	2011-03-15 20:28:56	2011-03-15 20:37:18	JCT-VC AHG report: Coding block structures	K. Panusopone, W.-J. Han, T. K. Tan, T. Wiegand
JCTVC-E008	m20122	2011-03-15 11:28:36	2011-03-15 11:29:01	2011-03-16 16:35:40	JCT-VC AHG report: Reference pictures memory compression	Keiichi Chono, Takeshi Chujoh, ChongSoon Lim, Ali Tabatabai, Minhua Zhou
JCTVC-E009	m20010	2011-03-14 04:55:44	2011-03-15 09:11:30	2011-03-16 12:45:09	JCT-VC AHG report: Entropy coding	M. Budagavi, G. Martin-Cocher, A. Segall (AHG Chairs)
JCTVC-E010	m20011	2011-03-14 04:58:10	2011-03-15 09:10:19	2011-03-15 09:10:19	JCT-VC AHG report: Quantization	M. Budagavi, K. Sato, G. Martin-Cocher (AHG Chairs)
JCTVC-E011	m20147	2011-03-16 10:00:51	2011-03-16 10:01:08	2011-03-16 10:01:08	JCT-VC AHG report: Video test material selection	Teruhiko Suzuki
JCTVC-E012	m19546	2011-03-07 11:14:35	2011-03-09 18:02:11	2011-03-09 18:02:11	JCT-VC AHG report: Complexity assessment	Daniele Alfonso, Justin Ridge, Xing Wen
JCTVC-E013	m20149	2011-03-16 11:09:30	2011-03-16 11:11:08	2011-03-16 16:04:21	JCT-VC AHG report: Parsing robustness	J. Xu (Microsoft), M. Coban (Qualcomm), Y.-W. Huang (MediaTek), J. Jung (Orange Labs), P. Onno (Canon Research Centre France)
JCTVC-E014	m19591	2011-03-09 08:09:26	2011-03-14 19:56:04	2011-03-14 19:56:04	JCT-VC AHG report: Screen content coding (SCC)	Oscar Au, Jizheng Xu, Haoping Yu
JCTVC-E015	m20148	2011-03-16 10:48:09	2011-03-16 10:49:24	2011-03-16 10:49:24	JCT-VC AHG report: Motion compensation interpolation	K. Ugur, E. Alshina, P. Chen, T. Chujoh (AhG Chairs)
JCTVC-E016	m19883	2011-03-11 02:25:06	2011-03-16 15:44:44	2011-03-16 16:03:14	JCT-VC AHG report: High-level syntax	Y.-K. Wang (Huawei), J. Boyce (Vidyo), Y. Chen (Qualcomm), K. Kazui (Fujitsu), T. Schierl (Fraunhofer HHI), R. Sjöberg (Ericsson), T. K. Tan (NTT DOCOMO)
JCTVC-E017	m19585	2011-03-09 06:34:32	2011-03-11 10:57:06	2011-03-21 19:44:17	JCT-VC AHG report: Decoder-side motion vector derivation (DMVD)	Yi-Jen Chiu, Elena Alshina, Haoping Yu
JCTVC-E018	m19645	2011-03-10	2011-03-15	2011-03-15	JCT-VC AHG report: Scalable coding investigation	J. Boyce, J. Kang, W. Wan, Y.-

		00:19:12	18:46:46	18:46:46		K. Wang
JCTVC-E021	m19588	2011-03-09 07:23:48	2011-03-11 10:57:52	2011-03-16 14:08:55	CE1: Summary report of core experiment on decoder-side motion vector derivation (DMVD)	Yi-Jen Chiu (Intel), Haoping Yu (Huawei), Yu-Wen Huang (MediaTek), Shun-ichi Sekiguchi (Mitsubishi Electric), Wen-Hsiao Peng (NCTU)
JCTVC-E022	m19903	2011-03-11 03:47:32	2011-03-11 07:05:23	2011-03-22 18:26:29	CE2: Summary Report of core experiment on Flexible Motion Partitioning	X Zheng, P. Bordes, P. Chen, I.-K Kim
JCTVC-E023	m19600	2011-03-09 08:45:07	2011-03-15 03:42:47	2011-03-16 05:42:23	CE3: Summary report of core experiment on interpolation for MC (Luma)	T.Chujoh, E.Alshina
JCTVC-E024	m19547	2011-03-07 17:00:02	2011-03-15 22:06:26	2011-03-19 15:09:19	CE4: Summary report of core experiment on slice boundary processing and fine granularity	Y.-W. Huang (MediaTek), I.-K. Kim (Samsung)
JCTVC-E025	m19908	2011-03-11 04:03:30	2011-03-16 01:33:27	2011-03-16 01:33:27	CE5: Summary report of low complexity entropy coding improvements	X. Wang, I.K. Kim, P. Wu
JCTVC-E026	m19896	2011-03-11 02:57:40	2011-03-11 08:44:28	2011-03-19 18:40:05	CE6: Intra Prediction Improvements Summary Report	Ali Tabatabai, Keiichi Chono, Muhammed Coban, Marta Mrak, Akiyuki Tanizawa
JCTVC-E027	m19543	2011-03-04 00:02:10	2011-03-16 11:02:11	2011-03-17 20:31:57	CE7: Summary report of core experiment on alternative transforms	R. Cohen, C. Yeo, R. Joshi, F. Fernandes
JCTVC-E028	m19725	2011-03-10 11:03:38	2011-03-15 01:27:54	2011-03-16 14:06:28	CE8: Non-deblocking Loop Filtering - Summary Report	T. Yamakage (Toshiba), I. S. Chong (Qualcomm), M. Narroschke (Panasonic)
JCTVC-E029	m19746	2011-03-10 13:10:15	2011-03-15 09:38:14	2011-03-17 17:58:09	CE9: Summary report of core experiment 9 on MV Coding and Skip/Merge operations	Joel Jung, Benjamin Bross, Peisong Chen, Woo-Jin Han
JCTVC-E030	m19976	2011-03-12 00:42:34	2011-03-12 00:42:52	2011-03-17 10:04:54	CE10: Summary report for CE on core transform design	Pankaj Topiwala, Madhukar Budagavi, Rajan Joshi, Arild Fuldseth, Ilkoo Kim
JCTVC-E031	m19568	2011-03-08 17:40:03	2011-03-15 14:50:29	2011-03-17 21:19:09	CE11: Summary report of core experiment on coefficient scanning and coding	V. Sze (TI), K. Panusopone (Motorola Mobility), J. Chen (Samsung), T. Nguyen (Fraunhofer HHI), M. Coban (Qualcomm)
JCTVC-E032	m19649	2011-03-10 02:18:39	2011-03-16 08:44:39	2011-03-21 01:30:48	CE12: Summary report of core experiment on deblocking filtering	Andrey Norkin (Ericsson), Byeungwoo Jeon (SKKU), Matthias Narroschke (Panasonic)
JCTVC-E033	m19548	2011-03-07 17:03:49	2011-03-15 22:08:59	2011-03-15 22:08:59	CE13: Summary report of core experiment on sample adaptive offset	Y.-W. Huang (MediaTek)

JCTVC-E034	m19549	2011-03-07 17:05:13	2011-03-15 23:34:57	2011-03-15 23:34:57	CE14: Summary report of core experiment on intra mode coding	S. Lei (MediaTek), M. Karczewicz (Qualcomm)
JCTVC-E041	m19545	2011-03-04 17:53:28	2011-03-04 18:20:13	2011-03-20 12:15:10	Weighted Prediction	Philippe Bordes (Technicolor)
JCTVC-E042	m19550	2011-03-07 17:06:26	2011-03-10 19:20:40	2011-03-19 15:14:22	Unified End-Of-Slice Detection for LCEC and CABAC	C.-W. Hsu, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E043	m19551	2011-03-07 17:08:26	2011-03-10 19:25:02	2011-03-19 15:19:01	CE4 Subset1: Leaf-CU-Aligned Slices	C.-W. Hsu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E044	m19552	2011-03-07 17:09:48	2011-03-10 19:26:54	2011-03-19 15:31:35	CE4 Subset2: Slice Boundary Filter	C.-W. Hsu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E045	m19553	2011-03-07 17:11:17	2011-03-10 19:28:55	2011-03-19 15:38:04	CE4 Subset3: Slice Common Information Sharing	C.-Y. Tsai, C.-W. Hsu, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E046	m19554	2011-03-07 17:12:29	2011-03-10 19:30:56	2011-03-19 15:44:22	CE8 Subtest 2: Adaptation between Pixel-based and Region-based Filter Selection	C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E047	m19555	2011-03-07 17:15:05	2011-03-10 19:32:53	2011-03-19 15:51:37	CE8 Subtest 3: Adaptation between ALF and AO	C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W Huang, S. Lei (MediaTek), M. Karczewicz, I. S. Chong (Qualcomm), T. Yamakage, T. Chujoh, T. Watanabe (Toshiba)
JCTVC-E048	m19556	2011-03-07 17:17:11	2011-03-10 19:34:56	2011-03-19 15:59:16	CE9: Results of Experiments M-Series	J.-L. Lin, Y.-W. Chen, Y.-P. Tsai, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E049	m19557	2011-03-07 17:18:20	2011-03-10 19:36:56	2011-03-23 00:21:26	CE13: Sample Adaptive Offset with LCU-Independent Decoding	C.-M. Fu, C.-Y. Chen, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E050	m19558	2011-03-07 17:19:35	2011-03-10 19:39:35	2011-03-20 12:36:42	Parsing Robustness: Constrained Usage of Temporal MV and MVP Candidates	J.-L. Lin, C.-L. Wu, Y.-W. Chen, Y.-P. Tsai, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E051	m19559	2011-03-07 17:20:56	2011-03-10 19:41:34	2011-03-20 12:37:49	Quantization: Sub-LCU Delta QP	T.-D. Chuang, C.-Y. Chen, Y.-L. Chang, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E052	m19560	2011-03-07 17:22:08	2011-03-10 19:43:18	2011-03-19 21:17:20	Removal of Duplicated Combinations of Reference Picture Indices for Forward Bi-Prediction	T.-D. Chuang, J.-L. Lin, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E053	m19561	2011-03-07 17:23:23	2011-03-10 19:45:04	2011-03-10 19:45:04	Unified Syntax of Reference Picture List Reordering	C.-W. Hsu, J.-L. Lin, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E054	m19562	2011-03-07	2011-03-09	2011-03-09	Preliminary complexity assessment on ARM	Daniele Alfonso, Andrea C.

		18:46:51	18:03:06	18:03:06		Ornstein (STMicro)
JCTVC-E055	m19563	2011-03-08 08:28:44	2011-03-10 17:50:08	2011-03-21 19:10:26	Evaluation of decoder-side motion estimation within HM 2.0	Sven Klomp, Jörn Ostermann
JCTVC-E056	m19564	2011-03-08 10:27:40	2011-03-09 07:09:48	2011-03-09 07:09:48	Necessity of Quantization Matrices Compression in HEVC	Kazushi Sato, Hironari Sakurai(Sony)
JCTVC-E057	m19565	2011-03-08 10:34:36	2011-03-10 13:10:31	2011-03-20 21:48:40	Pulse code modulation mode for HEVC	Keiichi Chono, Hirofumi Aoki, Yuzo Senda (NEC)
JCTVC-E058	m19566	2011-03-08 11:22:07	2011-03-10 11:45:00	2011-03-12 05:40:27	CE9: Cross-check Result of Test I&J&S	Kazushi Sato(Sony)
JCTVC-E059	m19567	2011-03-08 11:25:30	2011-03-10 15:47:18	2011-03-19 19:11:09	Modifications of temporal mv compression and temporal mv predictor	S. Park, J. Park, B. Jeon (LGE)
JCTVC-E060	m19569	2011-03-09 00:21:43	2011-03-10 20:20:42	2011-03-18 14:07:44	CE8 Subtest 5: Luma ALF with reduced vertical filter size	M. Budagavi, V. Sze, M. Zhou (TI)
JCTVC-E061	m19571	2011-03-09 02:11:56	2011-03-10 15:23:44	2011-03-18 08:27:47	Requirements of very low delay applications	K.Kazui, J.Koyama, S.Shimada, A.Nakagawa (Fujitsu)
JCTVC-E062	m19572	2011-03-09 02:18:45	2011-03-10 15:30:10	2011-03-18 08:29:33	Improvement on simplified motion vector prediction	K.Kazui, S.Shimada, J.Koyama, A.Nakagawa (Fujitsu)
JCTVC-E063	m19573	2011-03-09 02:20:31	2011-03-11 00:33:27	2011-03-16 11:53:37	CE4 Subset3: Cross-verification of MediaTek's slice common information sharing by Fujitsu	K.Kazui (Fujitsu)
JCTVC-E064	m19574	2011-03-09 02:40:15	2011-03-10 13:51:05	2011-03-18 10:06:36	Improvement to AMVP/Merge process	Yusuke Itani, Shun-ichi Sekiguchi, Kohtaro Asai, Tokumichi Murakami (Mitsubishi Electric)
JCTVC-E065	m19575	2011-03-09 02:50:00	2011-03-15 18:20:54	2011-03-15 18:20:54	CE8 subtest4: Cross-verification on Low Complexity ALF design	Shun-ichi Sekiguchi, Kazuo Sugimoto (Mitsubishi Electric)
JCTVC-E066	m19576	2011-03-09 02:52:38	2011-03-10 13:54:26	2011-03-10 13:54:26	Cross-verification report on PCM mode(JCTVC-E057)	Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric)
JCTVC-E067	m19577	2011-03-09 02:54:38	2011-03-17 06:05:33	2011-03-17 06:05:33	CE6.b1: Cross-verification report on Short Distance Intra Prediction (JCTVC-E278)	Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric)
JCTVC-E068	m19578	2011-03-09 02:56:43	2011-03-10 13:54:53	2011-03-10 13:54:53	CE6.g: verification report on number of intra prediction directions	Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric)
JCTVC-E069	m19579	2011-03-09 02:58:37	2011-03-10 13:56:14	2011-03-23 00:24:13	CE6.f: LUT-based adaptive filtering on intra prediction samples	Kazuo Sugimoto, Akira Minezawa, Shun-ichi Sekiguchi (Mitsubishi Electric), Kazuhisa Iguchi, Yoshiaki Shishikui (NHK)

JCTVC-E070	m19580	2011-03-09 03:35:09	2011-03-10 10:14:26	2011-03-10 10:14:26	CE12 Subset2: Cross-verification of Panasonic's proposal JCTVC-E224	Ikeda Masaru, Suzuki Teruhiko (Sony)
JCTVC-E071	m19581	2011-03-09 03:40:01	2011-03-10 10:35:29	2011-03-10 10:35:29	CE12 Subset1: Cross-verification of MediaTek's proposal JCTVC-E079	Ikeda Masaru, Suzuki Teruhiko (Sony)
JCTVC-E072	m19582	2011-03-09 04:24:09	2011-03-10 11:22:10	2011-03-17 18:43:29	CE5: Adaptive Coding of InterPredMode Syntax Elements	Wen Zhang, Ming Li, Ping Wu (ZTE)
JCTVC-E073	m19583	2011-03-09 04:37:35	2011-03-10 04:50:39	2011-03-22 17:52:03	Quantization matrix for HEVC	Junichi Tanaka, Yoshitaka Morigami, Teruhiko Suzuki (Sony)
JCTVC-E074	m19584	2011-03-09 06:31:19	2011-03-10 23:57:22	2011-03-16 05:26:57	CE7: Mode Dependent 2-step Transform for Intra Coding	Youji Shibahara, Takahiro Nishi (Panasonic)
JCTVC-E075	m19586	2011-03-09 06:43:05	2011-03-11 00:05:52	2011-03-11 00:05:52	CE7: Cross Check Report for Qualcomm, Toshiba, I2R and Huawei's proposal (JCTVC-E098) by Panasonic	Youji Shibahara, Takahiro Nishi (Panasonic),
JCTVC-E076	m19587	2011-03-09 06:44:11	2011-03-11 00:18:24	2011-03-14 11:26:19	CE7: Cross Check Report for Samsung's proposal (JCTVC-E380) by Panasonic	Youji Shibahara, Takahiro Nishi (Panasonic)
JCTVC-E077	m19589	2011-03-09 08:03:46	2011-03-09 08:12:26	2011-03-09 08:12:26	CE6.c: Cross-check report on Differential Coding of Intra Modes (DCIM)	Yasuko Sugito, Atsuro Ichigaya
JCTVC-E078	m19590	2011-03-09 08:07:36	2011-03-10 13:57:29	2011-03-18 14:45:29	CE3: Region-based adaptive interpolation filter	Shohei Matsuo, Yukihiro Bandoh, Takeshi Ito, Seishi Takamura, Hirohisa Jozawa (NTT)
JCTVC-E079	m19592	2011-03-09 08:34:03	2011-03-10 23:35:51	2011-03-21 11:58:10	CE12 Subtest 1: Improved Deblocking Filter	J. An, Q. Huang, X. Guo, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E080	m19593	2011-03-09 08:34:09	2011-03-10 21:36:56	2011-03-19 17:10:31	Adaptive Inter Mode Coding for LCEC	X. Zhang, S. Liu, S. Lei (MediaTek)
JCTVC-E081	m19595	2011-03-09 08:36:13	2011-03-10 17:59:23	2011-03-20 10:52:18	Syntax and Structure for Coding and Utilizing Partition Types	S. Liu, X. Zhang, S. Lei (MediaTek)
JCTVC-E082	m19596	2011-03-09 08:36:18	2011-03-10 17:51:51	2011-03-11 14:59:03	CE1: Cross check results for contribution JCTVC-E084	Sven Klomp, Jörn Ostermann (Univ. Hannover)
JCTVC-E083	m19597	2011-03-09 08:37:59	2011-03-10 21:56:51	2011-03-20 10:53:57	Evaluations and Suggestions about TU Representation	S. Liu, Z. Zhou, S. Lei (MediaTek)
JCTVC-E084	m19598	2011-03-09 08:39:08	2011-03-11 08:01:47	2011-03-15 20:44:07	CE1: Report of self-derivation motion estimation techniques at video decoder side on HM2.0	Yi-Jen Chiu, Lidong Xu, Wenhao Zhang, Hong Jiang (Intel)
JCTVC-E085	m19599	2011-03-09 08:40:15	2011-03-10 19:55:25	2011-03-20 10:55:57	Method and Syntax for Partial CU Merge	S. Liu, X. Zhang, S. Lei (MediaTek)
JCTVC-E086	m19601	2011-03-09	2011-03-11	2011-03-21	[AHG: Complexity Assessment] Summary of Complexity Assessment for	Xing Wen, Oscar C. Au

		08:46:09	18:27:36	03:14:22	CEs and Three-Level Assessment method	(HKUST), Mona Mathur(STMicro)
JCTVC-E087	m19602	2011-03-09 08:55:59	2011-03-10 08:14:23	2011-03-10 08:14:23	CE4-subset1: Cross-check result of Huawei's fine granularity slice partition (JCTVC-E298)	M. Shima (Canon)
JCTVC-E088	m19603	2011-03-09 08:57:39	2011-03-10 23:37:02	2011-03-18 09:59:26	CE14 Subtest 1: Intra Most Probable Mode Coding for Luma	M. Guo, X. Guo, S. Lei (MediaTek)
JCTVC-E089	m19604	2011-03-09 08:58:10	2011-03-10 08:15:18	2011-03-10 08:15:18	CE4-subset2: Cross-check result of Huawei's intra coding improvements for slice boundary blocks (JCTVC-E283)	M. Shima (Canon)
JCTVC-E090	m19605	2011-03-09 09:04:10	2011-03-10 23:37:38	2011-03-19 07:12:29	Adaptive CU Depth Range	X. Li, J. An, X. Guo, S. Lei (MediaTek)
JCTVC-E091	m19606	2011-03-09 09:05:13	2011-03-10 23:38:26	2011-04-11 15:11:16	Adaptive De-Quantization Offset	X. Li, X. Guo, S. Lei (MediaTek)
JCTVC-E092	m19607	2011-03-09 09:10:01	2011-03-10 23:39:06	2011-03-19 07:42:23	Motion Vector Decimation for Temporal Prediction	X. Guo, J. Lin, Y.-W. Huang, S. Lei (MediaTek)
JCTVC-E093	m19608	2011-03-09 09:49:25	2011-03-15 18:22:01	2011-03-15 18:22:01	CE1 Subtest1: Cross-verification on Candidate-based DMVD without MV refienement	Shun-ichi Sekiguchi, Yusuke Itani (Mitsubishi Electric)
JCTVC-E094	m19609	2011-03-09 09:56:44			Withdrawn - duplicate registration for AHG report	
JCTVC-E095	m19610	2011-03-09 10:16:00	2011-03-11 03:54:22	2011-03-19 07:04:19	Unified motion vector removal process for AMVP	Shigeru Fukushima, Masayoshi Nishitani, Toru Kumakura, Motoharu Ueda
JCTVC-E096	m19611	2011-03-09 10:17:48	2011-03-11 03:54:59	2011-03-19 07:05:06	Partition size based selection for motion vector compression	Shigeru Fukushima, Masayoshi Nishitani, Motoharu Ueda, Kazumi Arakage, Hideki Takehara
JCTVC-E097	m19612	2011-03-09 10:18:46	2011-03-11 03:55:29	2011-03-19 07:05:41	Temporal predictor restriction harmonized with motion vector compression	Hideki Takehara, Shigeru Fukushima (JVC)
JCTVC-E098	m19613	2011-03-09 10:54:40	2011-03-11 01:31:57	2011-03-17 09:08:53	CE7: Mode dependent intra residual coding	R. Joshi, P. Chen, M. Karczewicz (Qualcomm), A. Tanizawa, J. Yamaguchi (Toshiba), C. Yeo, Y. H. Tan (I2R), H. Yang, H. Yu (Huawei)
JCTVC-E099	m19614	2011-03-09 10:55:27	2011-03-10 11:31:36	2011-03-16 06:14:58	CE7: Cross-check of Samsung's proposal on alternative transforms (E125)	C. Yeo, Y. H. Tan (I2R)
JCTVC-E100	m19615	2011-03-09 11:01:19	2011-03-10 11:34:20	2011-03-10 11:34:20	CE11: Cross-check of Qualcomm’s proposal on adaptive scans	C. Yeo (I2R)
JCTVC-E101	m19616	2011-03-09 11:05:17	2011-03-10 11:37:21	2011-03-19 16:01:25	Simplified AMVP candidate derivation for Inter and Merge modes	C. Yeo, Y. H. Tan, Z. Li (I2R)

JCTVC-E102	m19617	2011-03-09 11:18:31	2011-03-10 09:42:34	2011-03-10 09:42:34	CE9: Skip/Merge Simplification with Reduced Candidate Set (Test L)	Y. H. Tan, C. Yeo, Z. Li (I2R),
JCTVC-E103	m19618	2011-03-09 11:20:23	2011-03-10 09:43:10	2011-03-11 01:57:15	CE9: Cross-check of Test D from HHI (JCTVC-E204)	Y. H. Tan, C. Yeo (I2R),
JCTVC-E104	m19619	2011-03-09 11:22:06	2011-03-10 09:43:41	2011-03-20 09:04:51	RQT depth selection	Y. H. Tan, C. Yeo, H. L. Tan, Z. Li (I2R)
JCTVC-E105	m19620	2011-03-09 11:35:37	2011-03-11 04:27:55	2011-03-11 04:27:55	CE14 Subtest 1: Cross-check report from Institute for Infocomm Research	H. L. Tan, Y. H. Tan, C. Yeo (I2R),
JCTVC-E106	m19621	2011-03-09 11:44:05	2011-03-11 04:33:50	2011-03-11 04:33:50	Cross-check of Motorola's proposal on reduced context selection for CABAC	H. L. Tan, C. Yeo (I2R)
JCTVC-E107	m19622	2011-03-09 14:34:12	2011-03-10 16:33:20	2011-03-17 18:18:31	CE7.6: Simplified adaptive transform selection	Atsuro Ichigaya, Yasuko Sugito, Shinichi Sakaida, (NHK)
JCTVC-E108	m19623	2011-03-09 17:49:32	2011-03-11 05:18:13	2011-03-19 18:01:52	CE8 Subtest 3: Loop filter with directional similarity mapping	P. Lai, F. C. A. Fernandes (Samsung)
JCTVC-E109	m19624	2011-03-09 18:04:20	2011-03-11 07:08:39	2011-03-17 12:28:17	CE8 Subtest 3: Cross-check of MediaTek, Qualcomm, Toshiba's proposal (JCTVC-E047) on adaptation between ALF and AO	P. Lai, F. C. A. Fernandes (Samsung)
JCTVC-E110	m19625	2011-03-09 18:07:27	2011-03-10 13:19:02	2011-03-10 13:19:02	Report of CE6 e.1.d: Adding plane mode to UDI	Guichun Li, Lingzhi Liu, Nam Ling, Jianhua Zheng, Philipp Zhang
JCTVC-E111	m19626	2011-03-09 18:10:58	2011-03-11 04:17:51	2011-03-15 20:12:36	CE8 Subtest 2: Cross-check of Qualcomm's proposal (JCTVC-E323) on block-based filter adaptation and directional features	P. Lai, F. C. A. Fernandes (Samsung)
JCTVC-E112	m19627	2011-03-09 18:21:46	2011-03-10 13:47:00	2011-03-10 13:47:00	Cross check Report for LG's CE6.e proposals	Guichun Li, Lingzhi Liu, Nam Ling, Jianhua Zheng, Philipp Zhang
JCTVC-E113	m19628	2011-03-09 18:36:45	2011-03-10 16:59:30	2011-03-21 16:49:35	Using MPS to encode extended UDI mode numbers for robustness	Guichun Li, Lingzhi Liu, Nam Ling, Jianhua Zheng, Yongbing Lin, Philipp Zhang
JCTVC-E114	m19629	2011-03-09 18:37:04	2011-03-09 18:44:01	2011-03-10 15:07:29	Cross verification of LG proposal JCTVC-E059 on modifications of temporal mv compression and temporal mv predictor	Minhua Zhou
JCTVC-E115	m19630	2011-03-09 18:46:13	2011-03-10 06:21:24	2011-03-17 15:57:57	Evaluation results on merge mode in HM2.0	Minhua Zhou
JCTVC-E116	m19631	2011-03-09 18:48:22	2011-03-10 06:22:44	2011-03-10 06:22:44	CE9: Simplified upper/left MVP calculation based on JCTVC-D055	Minhua Zhou
JCTVC-E117	m19632	2011-03-09 18:50:25	2011-03-10 06:23:58	2011-03-10 06:23:58	Evaluation results on motion vector storage compression	Minhua Zhou
JCTVC-E118	m19633	2011-03-09 18:51:33	2011-03-11 05:57:46	2011-03-19 22:04:13	A study on HM2.0 bitstream parsing and error resiliency issue	Minhua Zhou, Vivienne Sze

JCTVC-E119	m19634	2011-03-09 19:17:20	2011-03-10 06:24:59	2011-03-10 06:24:59	A study on unification of JCTVC-D273 and JCTVC-D164 in HM2.0 software	Minhua Zhou (TI)
JCTVC-E120	m19635	2011-03-09 20:17:57	2011-03-10 06:49:40	2011-03-10 06:49:40	Cross verification of Microsoft proposal JCTVC-E148 on "an investigation on robust parsing"	Minhua Zhou (TI)
JCTVC-E121	m19636	2011-03-09 20:28:28	2011-03-10 23:31:21	2011-03-15 15:29:47	CE11: Cross-verification of HHI's Coding of Transform Coefficient Levels with Golomb-Rice Codes (JCTVC-E253)	J. Zan, D. He (RIM)
JCTVC-E122	m19637	2011-03-09 20:39:25	2011-03-11 04:05:39	2011-03-11 04:05:39	Cross-verification of Mitsubishi proposal on Improvement to AMVP/Merge process	Minhua Zhou (TI)
JCTVC-E123	m19638	2011-03-09 23:28:31	2011-03-11 07:22:03	2011-03-16 05:42:09	CE7 : Cross Check Report for Mode Dependent Intra Residual Coding (JCTVC-E098) by Samsung	Ankur Saxena, Felix Fernandes, Elena Alshina, Vadim Seregin (Samsung)
JCTVC-E124	m19639	2011-03-09 23:31:26	2011-03-11 07:10:46	2011-03-13 03:20:03	CE 6e : Cross Check for DoCoMo's Proposal JCTVC-E321 on Planar mode experiments and results	Ankur Saxena, Felix Fernandes (Samsung)
JCTVC-E125	m19640	2011-03-09 23:50:30	2011-03-11 07:41:11	2011-03-20 13:10:09	CE7: Mode-dependent DCT/DST without 4*4 full matrix multiplication for intra prediction	Ankur Saxena, Felix Fernandes, (Samsung)
JCTVC-E126	m19641	2011-03-10 00:00:18	2011-03-10 23:16:54	2011-03-10 23:16:54	CE7 Tool 1: Cross Check Report for Mode Dependent Intra Residual Coding (JCTVC-E098) by BBC	Andrea Gabriellini, Marta Mrak (BBC)
JCTVC-E127	m19642	2011-03-10 00:07:15	2011-03-10 23:17:25	2011-03-10 23:17:25	CE7 Tool 2: Cross Check Report for Samsung's Mode-dependent DCT/DST (JCTVC-E125) by BBC	Andrea Gabriellini, Marta Mrak (BBC)
JCTVC-E128	m19643	2011-03-10 00:14:46	2011-03-10 17:14:26	2011-03-14 05:27:13	CE3: Results on Bi/Single MC interpolation filter	Kenji Kondo, Teruhiko Suzuki (Sony)
JCTVC-E129	m19644	2011-03-10 00:16:46	2011-03-10 17:19:06	2011-03-18 18:48:48	Memory bandwidth reduction MC filter	Kenji Kondo, Teruhiko Suzuki (Sony),
JCTVC-E130	m19646	2011-03-10 00:20:25	2011-03-10 23:52:48	2011-03-16 19:27:20	CE6.b.2: Report on Combined Intra Prediction with Parallel Intra Coding by BBC and Sharp	Marta Mrak, Andrea Gabriellini (BBC), Jie Zhao, Andrew Segall (Sharp)
JCTVC-E131	m19647	2011-03-10 00:41:26	2011-03-10 13:32:10	2011-03-10 13:32:10	CE14.1: Results for DOCOMO's proposal and cross verification of MediaTek's implementation for the most probable mode signalling for luma.	TK Tan (NTT DOCOMO)
JCTVC-E132	m19648	2011-03-10 02:04:47	2011-03-11 01:05:12	2011-03-11 01:05:12	CE11: Cross-check report of Qualcomm's Adaptive Coefficient Scanning for LCEC (JCTVC-D374) by SHARP	Y.Yasugi, T. Yamamoto (SHARP)
JCTVC-E133	m19650	2011-03-10 02:30:38	2011-03-10 09:30:17	2011-03-15 08:28:13	Adaptive scaling for reference pictures memory compression	T.Chujoh, T.Yamakage (Toshiba)
JCTVC-E134	m19651	2011-03-10 02:31:03	2011-03-10 12:14:12	2011-03-11 02:59:42	CE3: Non-uniform tap length filtering for bidirectional prediction	T.Chujoh, K.Kanou, T.Yamakage (Toshiba)
JCTVC-E135	m19652	2011-03-10 02:31:22			Withdrawn	

JCTVC-E136	m19653	2011-03-10 02:35:49	2011-03-10 02:38:09	2011-03-10 02:38:09	CE14: Test Results for Intra Mode Coding by Multiple Mode Candidates	Wenpeng Ding
JCTVC-E137	m19654	2011-03-10 02:36:00	2011-03-11 07:27:45	2011-03-11 07:27:45	CE8.2: Cross-check result of Qualcomm's Block based adaptive loop filter (JCTVC-E323) by Sharp	T.Ikai, T.Yamazaki(SHARP)
JCTVC-E138	m19655	2011-03-10 02:38:34	2011-03-11 07:28:40	2011-03-11 07:28:40	CE8.3: Cross-check result of Samsung's Loop filter with directional similarity mapping (JCTVC-E108) by Sharp	T.Ikai, T.Yamazaki(SHARP)
JCTVC-E139	m19656	2011-03-10 02:39:07	2011-03-14 09:31:30	2011-03-21 04:01:28	Test Material for Screen Content coding	Wenpeng Ding
JCTVC-E140	m19657	2011-03-10 02:45:10	2011-03-11 07:29:20	2011-03-17 17:43:12	CE8.1: DF-combined adaptive loop filter	T.Ikai, T.Yamazaki(SHARP)
JCTVC-E141	m19658	2011-03-10 02:45:54	2011-03-11 07:29:58	2011-03-17 20:36:15	CE8.2: Region-based adaptive loop filter using two-dimensional feature	T.Ikai, T.Yamazaki (SHARP)
JCTVC-E142	m19659	2011-03-10 03:28:38	2011-03-10 14:43:56	2011-03-17 19:45:30	Dynamic range restriction of temporal motion vector	S.-C. Lim, H. Y. Kim, J. Kim, J. Lee, J. S. Choi (ETRI)
JCTVC-E143	m19660	2011-03-10 04:05:25	2011-03-11 08:49:03	2011-03-21 13:09:47	CE5: Counter based adaptation for LCEC	L. Guo (Qualcomm), B. Li (USTC), X. Wang (Qualcomm), M. Karczewicz (Qualcomm), J. Xu (Microsoft)
JCTVC-E144	m19661	2011-03-10 04:05:50	2011-03-11 08:49:38	2011-03-22 14:41:59	CE12 Subset 1: Deblocking for large size blocks	Z. Shi (USTC), X. Sun (Microsoft), J. Xu (Microsoft)
JCTVC-E145	m19662	2011-03-10 04:06:10	2011-03-11 08:54:57	2011-03-11 08:54:57	Intra and inter coding tools for screen contents	C. Lan (Xidian Univ.), X. Peng (USTC), J. Xu (Microsoft), F. Wu (Microsoft)
JCTVC-E146	m19663	2011-03-10 04:06:26	2011-03-11 08:59:15	2011-03-22 15:34:13	On merge candidate construction	B. Li (USTC), J. Xu (Microsoft), F. Wu (Microsoft), H. Li (USTC)
JCTVC-E147	m19664	2011-03-10 04:06:43	2011-03-11 08:51:38	2011-03-19 09:00:14	On motion information compression	B. Li (USTC), J. Xu (Microsoft), F. Wu (Microsoft), H. Li (USTC)
JCTVC-E148	m19665	2011-03-10 04:06:57	2011-03-11 08:53:04	2011-03-11 08:53:04	An investigation on robust parsing	B. Li (USTC), J. Xu (Microsoft), F. Wu (Microsoft), H. Li (USTC)
JCTVC-E149	m19666	2011-03-10 04:10:38	2011-03-14 13:23:49	2011-03-14 13:23:49	CE6.a: Cross-check report for JCTVC-E286	J. Xu (Microsoft)
JCTVC-E150	m19667	2011-03-10 04:11:20	2011-03-16 19:23:48	2011-03-16 19:23:48	CE11.B: Cross-check report for JCTVC-E296	B. Li (USTC), J. Xu (Microsoft)
JCTVC-E151	m19668	2011-03-10 04:11:45	2011-03-16 15:43:58	2011-03-16 15:43:58	CE12: Cross-check report for JCTVC-E417	Z. Shi (USTC), J. Xu (Microsoft)
JCTVC-E152	m19669	2011-03-10 04:12:08	2011-03-16 15:54:45	2011-03-16 15:54:45	Cross-check report for JCTVC-E302	B. Li (USTC), J. Xu (Microsoft)

JCTVC-E153	m19670	2011-03-10 04:12:31	2011-03-14 13:31:39	2011-03-16 18:52:55	Cross-check report of adaptive CU depth range (JCTVC-E090)	B. Li (USTC), J. Xu (Microsoft)
JCTVC-E154	m19671	2011-03-10 05:00:43	2011-03-10 14:45:09	2011-03-16 06:46:29	CE1: Report of DMVD-based Bi-prediction	C.-C. Chen, C.-L. Lee, W.-H. Peng, H.-M. Hang (NCTU/ITRI)
JCTVC-E155	m19672	2011-03-10 05:17:37	2011-03-10 12:33:26	2011-03-11 02:39:56	CE9: Verification of TI's proposal (JCTVC-E116)	A.Fujibayashi, T.K Tan(NTT DOCOMO), F. Bossen(DOCOMO USA Labs)
JCTVC-E156	m19673	2011-03-10 05:19:13	2011-03-11 07:25:42	2011-03-20 08:24:42	Simplification of transform coefficient coding in LCEC	Y. Yasugi, T Yamamoto (SHARP)
JCTVC-E157	m19674	2011-03-10 05:21:39	2011-03-10 12:37:20	2011-03-10 12:37:20	Cross verification of Unified motion vector removal process for AMVP(JCTVC-E095)	A. Fujibayashi(NTT DOCOMO), F. Bossen(DOCOMO USA Labs)
JCTVC-E158	m19676	2011-03-10 05:53:09	2011-03-11 13:32:50	2011-03-14 01:48:31	CE9 : Cross-verification of experiment M11, M12, M19, M20, M21, M29, M30 and M31 (JCTVC-E048)	J. Park, S. Park, B. Jeon
JCTVC-E159	m19677	2011-03-10 06:37:29	2011-03-10 12:20:12	2011-03-14 03:10:53	CE5: Cross-check report of Microsoft and Qualcomm's Counter based adaptation for LCEC	J. Lim, B. Jeon (LGE)
JCTVC-E160	m19678	2011-03-10 06:38:51	2011-03-10 14:13:29	2011-03-16 17:58:48	CE5: Modified Joint Coding on Prediction Mode Signaling	J. Lim, B. Jeon (LGE)
JCTVC-E161	m19679	2011-03-10 06:53:08	2011-03-11 07:07:54	2011-03-11 07:08:49	CE6.a: Cross-check of Bi-Intra Prediction using Slope Information from Sejong University and SKT (JCTVC-D287) by SHARP	T. Yamamoto (SHARP)
JCTVC-E162	m19680	2011-03-10 06:53:12	2011-03-11 07:09:43	2011-03-11 07:09:43	CE6.e: Cross-check of Planar Intra Prediction (1.f+2.a+3.b and 1.f+2.b+3.b) by SHARP	T. Yamamoto (SHARP)
JCTVC-E163	m19681	2011-03-10 07:02:00	2011-03-10 14:13:58	2011-03-10 14:13:58	Cross-verification of Microsoft proposal JCTVC-E147 on motion information compression	Minhua Zhou (TI)
JCTVC-E164	m19682	2011-03-10 07:26:09	2011-03-10 15:35:06	2011-03-10 15:35:06	CE11: Cross-check report for Qualcomm's proposal JCTVC-D262 on Parallel Context Processing for the significance map	Hisao Sasai, Takahiro Nishi (Panasonic)
JCTVC-E165	m19683	2011-03-10 07:31:16	2011-03-10 15:14:30	2011-03-14 05:35:41	CE6.e: Cross verification of SCU's proposal (JCTVC-E110) on Planar Intra Prediction (1.d)	Yongjoon Jeon (LG Electronics)
JCTVC-E166	m19684	2011-03-10 07:33:20	2011-03-10 15:15:11	2011-03-14 05:37:24	CE6.e: Report on Planar Intra Prediction by LG	Yongjoon Jeon, , Seungwook Park, , Joonyoung Park, , Byeongmoon Jeon
JCTVC-E167	m19685	2011-03-10 07:34:07			Withdrawn	
JCTVC-E168	m19686	2011-03-10 07:34:34	2011-03-10 15:15:51	2011-03-14 05:38:05	Cross verification of Nokia's proposal (JCTVC-E174) on Unified Planar Intra Prediction	Yongjoon Jeon (LG)
JCTVC-E169	m19687	2011-03-10 07:35:13	2011-03-10 10:23:46	2011-03-12 02:58:26	X-Check of E-156: Simplification of transform coefficient coding in LCEC	Kazushi Sato (Sony)

JCTVC-E170	m19688	2011-03-10 07:37:37	2011-03-11 09:25:18	2011-03-17 18:51:13	CE6.a : Bi-Intra Prediction using Slope information	Chan-Won Seo (Sejong Univ.), Jong-Ki Han (Sejong Univ.), Jeongyeon Lim (SKT)
JCTVC-E171	m19689	2011-03-10 07:40:09	2011-03-11 00:57:07	2011-03-11 00:57:07	CE12: Verification results of Ericsson's Proposal JCTVC-E276	T. Yamakage, S. Asaka (Toshiba)
JCTVC-E172	m19690	2011-03-10 07:44:09	2011-03-12 00:29:06	2011-03-12 00:29:06	Cross-check report for Sony's proposal on Context Reduction (JCTVC-E344)	Hisao Sasai, Takahiro Nishi (Panasonic),
JCTVC-E173	m19691	2011-03-10 07:45:05	2011-03-10 11:41:17	2011-03-10 11:41:17	CE8.1: Verification results of Sharp's Proposal JCTVC-E140	T. Yamakage, T. Watanabe (Toshiba)
JCTVC-E174	m19692	2011-03-10 07:58:09	2011-03-10 22:37:21	2011-03-10 22:37:21	Unified planar intra prediction	Jani Lainema, Kemal Ugur, Oguz Bici (Nokia)
JCTVC-E175	m19693	2011-03-10 08:03:10	2011-03-11 02:24:07	2011-03-11 02:24:07	CE8.3: Verification results of Samsung's Proposal JCTVC-E108	T. Yamakage, T. Watanabe (Toshiba)
JCTVC-E176	m19694	2011-03-10 08:05:59	2011-03-10 08:10:03	2011-03-10 08:10:03	Test sequences for screen content coding	Xingyu Zhang, Oscar C. Au, Xing Wen, Jingjing Dai (HKUST)
JCTVC-E177	m19695	2011-03-10 08:16:26	2011-03-11 02:27:09	2011-03-11 02:27:09	Verification results of TI's Proposal on Chroma ALF (JCTVC-E287)	T. Yamakage, T. Watanabe (Toshiba)
JCTVC-E178	m19696	2011-03-10 08:21:57	2011-03-15 05:55:23	2011-03-15 05:55:23	CE5: cross check report of qualcomm and microsoft's JCTVC-E143	Wen Zhang, Lei Wang
JCTVC-E179	m19697	2011-03-10 08:22:17	2011-03-11 03:39:11	2011-03-11 03:39:11	CE7: Cross check report of Panasonic's proposal (Tool5 : JCTVC-E074) from Toshiba	A. Tanizawa, J. Yamaguchi (Toshiba)
JCTVC-E180	m19698	2011-03-10 08:23:32	2011-03-15 05:08:11	2011-03-15 05:08:11	CE5: cross check report of LGE's JCTVC-E160	wen zhang, lei wang, ,
JCTVC-E181	m19699	2011-03-10 08:46:08	2011-03-10 15:26:00	2011-03-19 12:16:26	CE12 Subset2: Parallel deblocking filter	Ikeda Masaru, Tanaka Junichi, Suzuki Teruhiko (Sony)
JCTVC-E182	m19700	2011-03-10 08:51:24			Cross-check of MediaTek's proposal on TU Representation (JCTVC-E083)	Ketan Tang, Oscar C. Au, Xing Wen, Jingjing Dai, Chao Pang, Feng Zou
JCTVC-E183	m19701	2011-03-10 09:14:54	2011-03-10 14:14:06	2011-03-16 08:15:31	Cross-verification report of proposal on RQT root location (JCTVC-E364)	Keiichi Chono, Hirofumi Aoki, Yuzo Senda
JCTVC-E184	m19702	2011-03-10 09:16:58	2011-03-10 14:14:28	2011-03-10 14:14:28	CE6: Cross-verification report of LUT-based intraprediction filtering (JCTVC-E069)	Keiichi Chono, Hirofumi Aoki, Yuzo Senda
JCTVC-E185	m19703	2011-03-10 09:19:00	2011-03-10 14:15:10	2011-03-10 14:15:10	CE6: Cross-verification report of planar intra prediction (JCTVC-D235)	Keiichi Chono, Hirofumi Aoki, Yuzo Senda,
JCTVC-E186	m19704	2011-03-10 09:20:41	2011-03-10 14:15:35	2011-03-10 14:15:35	CE6: Cross-verification report of planar intra prediction (JCTVC-D326)	Keiichi Chono, Hirofumi Aoki, Yuzo Senda
JCTVC-E187	m19705	2011-03-10	2011-03-10	2011-03-10	Cross-verification report on adaptive scaling for reference pictures	Keiichi Chono, Hirofumi Aoki,

		09:23:47	14:16:08	14:16:08	memory compression (JCTVC-E133)	Yuzo Senda
JCTVC-E188	m19706	2011-03-10 09:26:55	2011-03-11 11:41:31	2011-03-17 09:00:00	CE3 : Switching interpolation filter scheme	T. Yoshino, S. Naito (KDDI)
JCTVC-E189	m19707	2011-03-10 09:28:35	2011-03-10 14:16:56	2011-03-13 13:13:04	Cross-verification report on memory bandwidth reduction MC filter (JCTVC-E129)	Keiichi Chono, Hirofumi Aoki, Yuzo Senda,
JCTVC-E190	m19708	2011-03-10 09:29:17	2011-03-11 07:39:24	2011-03-18 18:32:22	Adaptive loop filtering using directional activity	K. Kawamura, T. Yoshino, S. Naito (KDDI)
JCTVC-E191	m19709	2011-03-10 09:32:08	2011-03-10 14:17:49	2011-03-15 14:57:20	Cross-verification report on temporal predictor restriction method harmonized with motion vector compression (JCTVC-E097)	Keiichi Chono, Hirofumi Aoki, Yuzo Senda,
JCTVC-E192	m19710	2011-03-10 09:34:34	2011-03-10 13:11:25	2011-03-21 16:08:01	Proposal of enhanced PCM coding in HEVC	Keiichi Chono, Hirofumi Aoki, Viktor Wahadaniah, ChongSoon Lim
JCTVC-E193	m19711	2011-03-10 10:01:25	2011-03-10 12:36:27	2011-03-10 12:36:27	CE8.1: Deblocking parameter adjustment for 1-input ALF	T. Yamakage, S. Asaka, T. Watanabe, T. Chujoh (Toshiba), C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek), M. Karczewicz, I. S. Chong (Qualcomm)
JCTVC-E194	m19712	2011-03-10 10:07:44	2011-03-10 12:24:38	2011-03-16 11:18:55	Unified Chroma Filter Shape with Luma for ALF	T. Yamakage, T. Watanabe, T. Chujoh (Toshiba), C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W. Huang, S. Lei (MediaTek), M. Karczewicz, I.S. Chong (Qualcomm)
JCTVC-E195	m19713	2011-03-10 10:12:32	2011-03-11 10:38:01	2011-03-11 10:38:01	CE3:Cross-check for NTT's proposal on Region-Based Adaptive Interpolation Filter (JCTVC-E078)	T. Yoshino, S. Naito (KDDI)
JCTVC-E196	m19714	2011-03-10 10:25:00	2011-03-10 19:53:02	2011-03-19 17:14:28	Wavefront Parallel Processing	Félix Henry, Stéphane Pateux, ,
JCTVC-E197	m19715	2011-03-10 10:46:56	2011-03-10 13:30:10	2011-03-19 15:35:16	Comments on Common Test Conditions for ALF	Ming Li, Ping Wu, Lei Wang, Wen Zhang (ZTE)
JCTVC-E198	m19716	2011-03-10 10:50:07	2011-03-10 10:54:14	2011-03-17 09:27:27	Sub-LCU level delta QP signaling	M. Kobayashi, M. Shima (Canon)
JCTVC-E199	m19717	2011-03-10 10:50:18	2011-03-10 13:11:06	2011-03-13 13:05:47	Cross verification of pulse code modulation mode for HEVC (JCTVC-E057)	Kenji Kondo, Teruhiko Suzuki (Sony),
JCTVC-E200	m19718	2011-03-10 10:53:27	2011-03-10 13:11:49	2011-03-13 13:06:41	CE3: Cross verification of non-uniform tap length filtering for bidirectional prediction (JCTVC-E134)	Kenji Kondo, Teruhiko Suzuki (Sony), ,
JCTVC-E201	m19719	2011-03-10 10:54:47	2011-03-10 23:41:06	2011-03-22 15:56:32	Context Dependent Intra Mode Coding	M. Guo, X. Guo, S. Lei (MediaTek)

JCTVC-E202	m19720	2011-03-10 10:56:33	2011-03-10 11:05:34	2011-03-18 10:11:03	Support for Sub-LCU-Level QP in HEVC	Masato Shima (Canon), Sung-Chang Lim (ETRI), Yu-Wen Huang (MediaTek), Chong Soon Lim (Panasonic), Kazushi Sato (Sony), Madhukar Budagavi (TI),
JCTVC-E203	m19721	2011-03-10 11:02:42	2011-03-11 02:35:47	2011-03-17 16:27:38	Constrained intra prediction scheme for flexible-sized prediction units in HEVC	Viktor Wahadaniah, ChongSoon Lim, SueMonThet Naing (Panasonic)
JCTVC-E204	m19722	2011-03-10 11:03:08	2011-03-10 22:38:13	2011-03-15 16:15:55	CE9: Results of Tests B, C, D and T	Benjamin Bross
JCTVC-E205	m19723	2011-03-10 11:03:21	2011-03-17 14:49:44	2011-03-17 14:49:44	CE3: Cross-check for KDDI's proposal on Switching interpolation filter scheme (JCTVC-E188)	Shohei Matsuo, Yukihiro Bandoh, Takeshi Ito, Seishi Takamura, Hirohisa Jozawa, ,
JCTVC-E206	m19724	2011-03-10 11:03:30	2011-03-10 13:58:05	2011-03-19 11:35:37	In-loop filter based on non-local means filter	Masaaki Matsumura, Yukihiro Bandoh, Seishi Takamura, Hirohisa Jozawa,
JCTVC-E207	m19726	2011-03-10 11:10:12	2011-03-11 03:39:54	2011-03-11 03:39:54	CE6.b.2: Cross check report of BBC's proposal (JCTVC-E130) from Toshiba	A. Tanizawa, T. Shiodera (Toshiba)
JCTVC-E208	m19727	2011-03-10 11:10:34	2011-03-11 03:40:30	2011-03-11 03:40:30	CE6.d: Cross check report of Sharp's proposal (JCTVC-E315) from Toshiba	A. Tanizawa, T. Shiodera (Toshiba)
JCTVC-E209	m19728	2011-03-10 11:10:57	2011-03-11 03:41:00	2011-03-11 03:41:00	CE6.e: Cross check report of combination with (1.a+2.b+3.a) for Planar intra prediction from Toshiba	A. Tanizawa, T. Shiodera (Toshiba)
JCTVC-E210	m19729	2011-03-10 11:11:16	2011-03-11 03:41:30	2011-03-11 03:41:30	CE14 subtest 1: Cross check report of BUT's proposal (JCTVC-E136) from Toshiba	A. Tanizawa, T. Shiodera (Toshiba)
JCTVC-E211	m19730	2011-03-10 11:13:47	2011-03-11 03:45:07	2011-03-16 07:37:24	Modified motion vector memory compression	T. Shiodera, A. Tanizawa, T. Chujoh, T. Yamakage (Toshiba)
JCTVC-E212	m19731	2011-03-10 11:17:39	2011-03-10 14:18:29	2011-03-10 14:18:29	Cross-verification report on constrained intra prediction scheme for flexible-sized prediction units (JCTVC-E203)	Keiichi Chono, Hirofumi Aoki, Yuzo Senda
JCTVC-E213	m19732	2011-03-10 11:18:17	2011-03-11 04:21:46	2011-03-16 07:21:59	CE1: Cross-verification report of NCTU's proposal (JCTVC-E154) by JVC KENWOOD	Motoharu Ueda, Satoru Sakazume,
JCTVC-E214	m19734	2011-03-10 11:41:15	2011-03-11 02:40:24	2011-03-17 16:29:53	Cross-verification report on pulse code modulation mode for HEVC (JCTVC-E057)	Viktor Wahadaniah, ChongSoon Lim (Panasonic)
JCTVC-E215	m19735	2011-03-10 11:41:32	2011-03-10 23:57:26	2011-03-22 01:29:22	Prediction-based QP derivation	Hirofumi Aoki, Keiichi Chono, Yuzo Senda (NEC)
JCTVC-E216	m19736	2011-03-10 11:45:52	2011-03-11 05:43:16	2011-03-19 06:54:47	Bi-prediction by single motion vector using decoder-side inter-reference ME	Motoharu Ueda, ,
JCTVC-E217	m19737	2011-03-10	2011-03-10	2011-03-18	Improved dQP Calculation Method	C. Pang, O. C. Au, F. Zou, J.

		11:50:15	11:53:35	10:59:50		Dai, X. Wen(HKUST),
JCTVC-E218	m19738	2011-03-10 11:54:46	2011-03-10 19:37:46	2011-03-10 19:37:46	CE9: Cross verification of experiments G and H by Canon	Patrice Onno (Canon)
JCTVC-E219	m19740	2011-03-10 12:03:26	2011-03-10 21:08:19	2011-03-18 16:06:33	Robust solution for the AMVP parsing issue	Guillaume Laroche, Christophe Gisquet, Patrice Onno, Edouard Francois, Nael Ouedraogo, Julien Ricard (Canon)
JCTVC-E220	m19741	2011-03-10 12:06:07	2011-03-14 10:23:31	2011-03-31 04:27:53	Preliminary Implementation on Sub-LCU-Level DeltaQP	Kazushi Sato, Jun Xu (Sony)
JCTVC-E221	m19743	2011-03-10 12:09:45	2011-03-10 20:55:29	2011-03-16 14:37:01	On memory compression for motion vector prediction	Guillaume Laroche, Patrice Onno, Edouard Francois, Christophe Gisquet, Nael Ouedraogo, Tangi POIRIER (Canon),
JCTVC-E222	m19744	2011-03-10 12:19:39	2011-03-11 14:28:30	2011-03-18 15:58:27	Slices modifications for HEVC	Nael Ouedraogo, Patrice Onno, Guillaume Laroche, Edouard Francois, Christophe Gisquet, (Canon)
JCTVC-E223	m19745	2011-03-10 12:21:18	2011-03-10 14:52:27	2011-03-14 10:25:53	Single Interpolation for Multi-sample Prediction (SIMP) for Intra Coding	J. Lee, S.-C. Lim, H. Lee, D. S. Jun, H. Y. Kim (ETRI),
JCTVC-E224	m19747	2011-03-10 13:48:09	2011-03-10 19:00:19	2011-03-17 11:09:22	CE12.2: Results for parallel deblocking filter decisions	Matthias Narroschke, , Thomas Wedi
JCTVC-E225	m19748	2011-03-10 14:04:53	2011-03-10 18:25:28	2011-03-17 14:57:06	Line Memory Reduction for ALF Decoding	Semih Esenlik, Matthias Narroschke, Thomas Wedi, ,
JCTVC-E226	m19749	2011-03-10 14:36:19	2011-03-10 23:19:16	2011-03-20 15:52:40	Parallel Context Processing for Significance map using block-based context updates	Hisao Sasai, Takahiro Nishi (Panasonic),
JCTVC-E227	m19750	2011-03-10 14:40:56	2011-03-10 15:50:38	2011-03-18 09:42:59	CE11: Context size reduction for the significance map	Hisao Sasai, Takahiro Nishi (Panasonic),
JCTVC-E228	m19751	2011-03-10 14:50:16	2011-03-10 15:08:59	2011-03-16 08:23:51	CE9: Cross-check report of experiment C by Panasonic	Toshiyasu Sugio, Takahiro Nishi (Panasonic),
JCTVC-E229	m19752	2011-03-10 14:53:29	2011-03-10 15:09:31	2011-03-16 08:24:27	CE9: Cross-check report of experiment M22-M26 by Panasonic	Toshiyasu Sugio, Takahiro Nishi (Panasonic),
JCTVC-E230	m19753	2011-03-10 14:56:16	2011-03-10 15:09:51	2011-03-16 08:25:01	CE9: Experiment A, I, J and S Modified derivation process of reference index for skip mode and temporal motion vector predictor	Toshiyasu Sugio, Takahiro Nishi (Panasonic),
JCTVC-E231	m19754	2011-03-10 15:00:16	2011-03-10 15:10:25	2011-03-19 16:28:07	Modified motion vector compression method	Toshiyasu Sugio, Takahiro Nishi (Panasonic), ,
JCTVC-E232	m19755	2011-03-10 15:02:06	2011-03-11 12:25:20	2011-03-14 14:17:29	CE1: Cross-verification report of NCTU's proposal (JCTVC-E154) by TUB	Michael Tok, Andreas Krutz (Tech. Univ. Berlin)

JCTVC-E233	m19756	2011-03-10 15:05:34	2011-03-10 15:31:56	2011-03-15 09:24:07	Verification results of CE8: eBrisk Video's contribution on ALF (JCTVC-E342)	M. Budagavi (TI)
JCTVC-E234	m19757	2011-03-10 15:06:05	2011-03-10 15:41:56	2011-03-15 09:29:13	Verification results of CE8: Samsung's contribution on ALF (JCTVC-E108)	M. Budagavi (TI)
JCTVC-E235	m19758	2011-03-10 15:06:33	2011-03-10 17:17:05	2011-03-15 10:04:53	Verification results of CE10: Samsung/FastVDO's contribution on core transform - normal QP range (JCTVC-E277)	M. Budagavi (TI)
JCTVC-E236	m19759	2011-03-10 15:07:07	2011-03-10 19:44:17	2011-03-15 21:07:15	Verification results of CE10: Qualcomm's contribution on core transform - low and high QP range (JCTVC-E370)	M. Budagavi (TI)
JCTVC-E237	m19760	2011-03-10 15:07:18	2011-03-10 20:05:49	2011-03-10 20:05:49	Verification results of Toshiba, MediaTek, Qualcomm's contribution on chroma ALF (JCTVC-E194)	M. Budagavi (TI)
JCTVC-E238	m19761	2011-03-10 15:08:07	2011-03-11 05:35:50	2011-03-13 23:39:06	Verification results of MediaTek's contribution on sub-LCU delta QP (JCTVC-E051)	M. Budagavi (TI),
JCTVC-E239	m19762	2011-03-10 15:08:51	2011-03-10 21:29:49	2011-03-15 09:32:39	Verification results of CE6.b1: short distance intra prediction (SDIP) (JCTVC-E278)	M. Budagavi, V. Sze (TI),
JCTVC-E240	m19763	2011-03-10 15:22:16	2011-03-10 15:26:05	2011-03-14 14:50:49	Reducing size of the LCEC coefficient coding tables	Jani Lainema, Kemal Ugur (Nokia),
JCTVC-E241	m19764	2011-03-10 15:26:12	2011-03-11 08:04:31	2011-03-17 21:32:17	Low complexity bi-predictive interpolation with 6-tap DCT-IF filter	K. Ugur, J. Lainema (Nokia)
JCTVC-E242	m19766	2011-03-10 15:28:10	2011-03-10 15:50:11	2011-03-10 15:50:11	On clipping in bi-directional averaging	K. Ugur, J. Lainema (Nokia)
JCTVC-E243	m19767	2011-03-10 15:28:51	2011-03-10 21:04:33	2011-03-18 10:52:35	Transform design for HEVC with 16 bit intermediate data representation	A. Fuldseth, G. Bjøntegaard (Cisco), M. Sadafale, M. Budagavi (TI),
JCTVC-E244	m19768	2011-03-10 15:29:42	2011-03-10 16:27:01	2011-03-17 15:53:30	CE3: Cross-check of Sony's proposal E128	K. Ugur (Nokia)
JCTVC-E245	m19769	2011-03-10 15:30:20	2011-03-10 21:05:18	2011-03-16 16:31:06	CE5: Cross-check of Sony's contribution JCTVC-E319	A. Fuldseth (Cisco)
JCTVC-E246	m19770	2011-03-10 15:41:50	2011-03-10 16:34:59	2011-03-10 16:34:59	CE9: Cross-check of experiment B (HHI JCTVC-E204), M27 and M28 (MediaTek JCTVC-E048)	Joel Jung, Jean-Marc Thiesse (Orange - FT)
JCTVC-E247	m19772	2011-03-10 16:35:51	2011-03-11 14:34:42	2011-03-14 12:49:07	CE8 Subtest2: Cross-check Results for Proposal JCTVC-E046	Semih Esenlik, Matthias Narroschke (Panasonic)
JCTVC-E248	m19773	2011-03-10 16:39:46	2011-03-16 16:12:29	2011-03-17 10:19:12	CE3: Cross-check Results for the Proposal of eBrisk (JCTVC-E284)	Semih Esenlik, Thomas Wedi (Panasonic)
JCTVC-E249	m19774	2011-03-10 16:49:11	2011-03-12 08:45:07	2011-03-12 08:45:07	CE3: Cross-check of Motorola Mobility's proposal JCTVC-E358	Haricharan Lakshman (Fraunhofer HHI),
JCTVC-E250	m19776	2011-03-10 17:25:12	2011-03-10 18:04:30	2011-03-10 18:04:30	CE9: Cross-check of Test A (Panasonic JCTVC-E230)	Benjamin Bross

JCTVC-E251	m19777	2011-03-10 17:30:47	2011-03-10 19:02:26	2011-03-17 11:08:55	Decisions for deblocking	Matthias Narroschke, , Thomas Wedi
JCTVC-E252	m19778	2011-03-10 17:35:39	2011-03-10 17:39:19	2011-03-11 10:54:51	CE2: Cross-check report of Non Rectangular Motion Partitioning (NMRP) + Overlapped Block Motion Compensation (OBMC), proposal JCTVC-E373	Laurent Guillo, Ronan Boitard
JCTVC-E253	m19779	2011-03-10 17:47:41	2011-03-11 16:08:22	2011-03-11 16:08:22	CE11: Coding of transform coefficient levels with Golomb-Rice codes	T. Nguyen (Fraunhofer HHI)
JCTVC-E254	m19780	2011-03-10 17:56:42			withdraw	
JCTVC-E255	m19781	2011-03-10 17:56:49	2011-03-11 16:08:40	2011-03-11 16:08:40	CE11: Cross-check of JCTVC-E296 (JCTVC-D311) Adaptive coefficients scanning for inter-frame coding	T. Nguyen (Fraunhofer HHI)
JCTVC-E256	m19783	2011-03-10 18:14:35	2011-03-11 01:11:59	2011-03-11 01:11:59	CE12 subset 1: Cross verification of MediaTek's deblocking by Ericsson	Kenneth Andersson, Andrey Norkin, Rickard Sjöberg (Ericsson AB)
JCTVC-E257	m19784	2011-03-10 18:33:53	2011-03-10 19:03:46	2011-03-14 18:37:48	CE12: Cross-check results of the parallel deblocking filter of Sony (JCTVC-E181)	Matthias Narroschke, Semih Esenlik, ,
JCTVC-E258	m19785	2011-03-10 18:41:16	2011-03-10 18:48:13	2011-03-16 18:56:29	Improvement of inter mode coding and split flags coding for LCEC	Virginie Drugeon, Thomas Wedi, Matthias Narroschke,
JCTVC-E259	m19786	2011-03-10 18:42:23	2011-03-16 14:34:52	2011-03-17 12:09:24	CE2: Cross-check report of test 2a and 2b	M. Winken
JCTVC-E260	m19787	2011-03-10 18:43:29	2011-03-11 00:15:08	2011-03-17 11:17:14	CE4 Subset1: Ericsson fine granularity slices	R. Sjoberg, P. Wennersten (Ericsson),
JCTVC-E261	m19788	2011-03-10 18:51:33	2011-03-17 12:43:34	2011-03-17 12:43:34	Cross Verification Report of Canon proposal JCTVC-E219 on Robust solution for the AMVP parsing issue	Laurent Guillo, Ronan Boitard
JCTVC-E262	m19789	2011-03-10 19:28:28	2011-03-10 19:30:31	2011-03-22 09:14:25	Intra Encoding acceleration by simplification of RDOQ	Glenn Van Wallendael, Sebastiaan Van Leuven, Jan De Cock, Rik Van de Walle (Ghent University - IBBT),
JCTVC-E263	m19790	2011-03-10 19:34:21	2011-03-12 15:21:27	2011-03-12 15:21:27	CE6.b.2: Cross-check report of Combined Intra Prediction with Parallel Intra Coding (JCTVC-E130) from Ghent University-IBBT	Glenn Van Wallendael, Sebastiaan Van Leuven, Jan De Cock, Rik Van de Walle (Ghent University - IBBT),
JCTVC-E264	m19791	2011-03-10 19:50:27	2011-03-11 16:40:46	2011-03-11 16:40:46	CE5: Cross Verification of JCTVC-E143 Proposed by Microsoft and Qualcomm	C.-Y. Chen, Y.-W. Huang (MediaTek)
JCTVC-E265	m19792	2011-03-10 19:52:08	2011-03-11 16:43:12	2011-03-11 16:43:12	CE8 Subtest 3: Cross Verification of JCTVC-E108 Proposed by Samsung	C.-Y. Chen, Y.-W. Huang (MediaTek)
JCTVC-E266	m19793	2011-03-10 19:54:28	2011-03-12 07:57:38	2011-03-19 10:37:34	CE6.a.4: Chroma intra prediction by reconstructed luma samples	J. Chen, V. Seregin, W.-J. Han (Samsung), J. Kim, J. Moon

						(LGE),
JCTVC-E267	m19794	2011-03-10 19:55:03	2011-03-11 16:45:38	2011-03-11 16:45:38	CE9: Cross Verification of Experiment N Proposed by LG and Qualcomm in JCTVC-E350	Y.-W. Chen, J.-L. Lin, Y.-W. Huang (MediaTek)
JCTVC-E268	m19795	2011-03-10 19:56:13	2011-03-12 08:03:32	2011-03-16 01:04:57	CE14.1: Cross-verification of the most probable mode signalling for luma (JCTVC-E131)	J. Chen (Samsung)
JCTVC-E269	m19796	2011-03-10 19:56:17	2011-03-11 16:48:28	2011-03-11 16:48:28	Cross Verification of JCTVC-E059 Proposed by LG	Y.-W. Chen, J.-L. Lin, Y.-W. Huang (MediaTek)
JCTVC-E270	m19797	2011-03-10 19:57:33	2011-03-12 07:17:53	2011-03-16 00:52:21	CE12.1: Cross-verification of the deblocking filter from Ericsson (JCTVC-E276) by Samsung	V. Seregin, J. Chen (Samsung),
JCTVC-E271	m19798	2011-03-10 19:58:42	2011-03-12 08:01:10	2011-03-16 14:33:16	CE6.b1: Cross-verification of Short Distance Intra Prediction Method (JCTVC-E278) by Samsung	J. Chen, V. Seregin, W.-J. Han (Samsung),
JCTVC-E272	m19799	2011-03-10 20:00:06	2011-03-12 06:51:30	2011-03-12 06:51:30	CE4: Cross-verification on slice-boundary filtering - Subset2 case1 and case2	I.-K. Kim (Samsung),
JCTVC-E273	m19800	2011-03-10 20:01:43	2011-03-12 08:16:31	2011-03-14 04:07:01	CE9: Cross-verification on M01, M02, M03, M07 and M10 of JCTVC-E048	I.-K. Kim, T. Lee (Samsung),
JCTVC-E274	m19801	2011-03-10 20:03:05	2011-03-12 07:13:26	2011-03-13 08:33:21	CE10: Cross-verification on Cisco/TI's transform (JCTVC-E243)	I.-K. Kim, T. Lee (Samsung),
JCTVC-E275	m19802	2011-03-10 20:04:28	2011-03-12 07:01:20	2011-03-12 07:01:20	CE10: Cross-verification on Qualcomm's transform (JCTVC-E370)	I.-K. Kim, T. Lee(Samsung),
JCTVC-E276	m19803	2011-03-10 20:06:44	2011-03-11 00:59:26	2011-03-19 12:55:35	CE12.1: Ericsson deblocking filter	Andrey Norkin, Kenneth Andersson, Rickard Sjöberg (Ericsson)
JCTVC-E277	m19804	2011-03-10 20:06:51	2011-03-12 10:51:06	2011-03-17 19:38:41	CE10: Fast integer transform based on modified Loeffler's factorization	I.-K. Kim, T. Lee, J. Chen, V. Seregin, Y. Hong, W.-J. Han (Samsung), P. Topiwala (FastVDO),
JCTVC-E278	m19805	2011-03-10 20:09:56	2011-03-11 00:10:21	2011-03-23 10:06:23	CE6.b1 Report on Short Distance Intra Prediction Method	X. Cao (Tsinghua), X. Peng (USTC), C. Lai (HiSilicon), Y. Wang (Tsinghua), Y. Lin (HiSilicon), J. Xu (Microsoft), L. Liu (HiSilicon), J. Zheng (HiSilicon), Y. He (Tsinghua), H. Yu (Huawei), F. Wu (Microsoft), ,
JCTVC-E279	m19806	2011-03-10 20:13:06	2011-03-11 00:01:04	2011-03-22 21:20:43	Extensible High Layer Syntax for Scalability	J. Boyce, D. Hong, S. Wenger (Vidyo)
JCTVC-E280	m19807	2011-03-10 20:13:07	2011-03-10 23:04:02	2011-03-19 15:16:32	Picture Orientation Information	S. Wenger, J. Boyce, D. Hong (Vidyo)

JCTVC-E281	m19808	2011-03-10 20:13:10	2011-03-10 23:04:22	2011-03-17 14:12:39	Slice parameter set	S. Wenger, J. Boyce (Vidyo)
JCTVC-E282	m19809	2011-03-10 20:13:11	2011-03-16 07:37:53	2011-03-18 09:30:04	Cross check of JCTVC-E081	A. Abbas, J. Boyce (Vidyo)
JCTVC-E283	m19810	2011-03-10 20:17:09	2011-03-11 00:16:47	2011-03-16 13:09:56	CE4 Subset2: Report of Intra Coding Improvements for Slice Boundary Blocks	Y. Lin (HiSilicon), C. Lai (HiSilicon), J. Zheng (HiSilicon), L. Liu (HiSilicon), ,
JCTVC-E284	m19811	2011-03-10 20:17:32	2011-03-10 20:49:03	2011-03-16 19:06:47	An Adaptive Interpolation Filtering Technique	Faouzi Kossentini, Nader Mahdi, Hsan Guermazi, Mohammed Ali Ben Ayed
JCTVC-E285	m19812	2011-03-10 20:18:33	2011-03-11 10:06:10	2011-03-11 10:06:10	CE9: Cross-check of Test O (Qualcomm JCTVC-E350)	Benjamin Bross
JCTVC-E286	m19813	2011-03-10 20:21:44	2011-03-11 00:18:03	2011-03-16 13:08:43	CE6 Subset A: Report of Improved Intra prediction for positive directions in UDI	Y. Lin (HiSilicon), C. Lai (HiSilicon), J. Zheng (HiSilicon), L. Liu (HiSilicon),
JCTVC-E287	m19814	2011-03-10 20:22:35	2011-03-11 01:13:40	2011-03-17 21:59:33	Chroma ALF with reduced vertical filter size	M. Budagavi, V. Sze, M. Zhou (TI)
JCTVC-E288	m19815	2011-03-10 20:25:26	2011-03-12 02:13:30	2011-03-19 17:56:58	Loop filtering with directional features	P. Lai, F. C. A. Fernandes (Samsung)
JCTVC-E289	m19816	2011-03-10 20:26:52	2011-03-11 00:19:03	2011-03-19 13:20:36	Simplified Planar Intra Prediction	Y. Lin (HiSilicon), L. Liu (HiSilicon), J. Zheng (HiSilicon), C. Lai (HiSilicon), ,
JCTVC-E290	m19817	2011-03-10 20:30:26	2011-03-11 00:19:58	2011-03-11 00:19:58	CE6.a: Cross-check Report for CE6.a.2 Sejong's Bi-Intra Prediction	J. Zheng (HiSilicon), Y. Lin (HiSilicon), H. Yu (Huawei),
JCTVC-E291	m19818	2011-03-10 20:34:38	2011-03-16 23:45:22	2011-03-16 23:45:22	Cross-check Report for I2R's Proposal JCTVC-E104 by MediaTek	Zhi Zhou, Shan Liu (MediaTek),
JCTVC-E292	m19819	2011-03-10 20:34:47	2011-03-11 00:20:42	2011-03-12 16:53:40	Simplification and improvement of merge mode coding	S. Li (Tsinghua), X. Zheng (HiSilicon), Y. He (Tsinghua), ,
JCTVC-E293	m19820	2011-03-10 20:36:09			Withdrawn	
JCTVC-E294	m19821	2011-03-10 20:39:37	2011-03-11 05:30:30	2011-03-16 19:11:35	CE1: Huawei report on DMVD in HM2.0	S. Lin (Huawei), M. Yang (Huawei), H. Yu (Huawei), ,
JCTVC-E295	m19822	2011-03-10 20:41:56	2011-03-11 05:34:51	2011-03-15 20:07:26	Cross-check report for Microsoft's proposal JCTVC-EXXX	M. Yang (Huawei), ,
JCTVC-E296	m19823	2011-03-10 20:44:21	2011-03-11 05:36:54	2011-03-16 19:05:55	CE11: Adaptive coefficients scanning for inter-frame coding	J. Song (Huawei), M. Yang (Huawei), H. Yang (Huawei), H. Yu (Huawei), ,

JCTVC-E297	m19824	2011-03-10 20:47:34	2011-03-11 08:12:41	2011-03-12 04:19:46	Cross-verification of Nokia's contribution Reducing size of the LCEC coefficient coding tables (JCTVC-E240)	L. Guo, X. Wang, M. Karczewicz (Qualcomm), ,
JCTVC-E298	m19825	2011-03-10 20:49:18	2011-03-11 05:28:56	2011-03-15 11:06:46	CE4 Subset1: Report on fine granularity slice partition	Q. Shen (Huawei), Q. Xie (Huawei), H. Yu (Huawei), ,
JCTVC-E299	m19826	2011-03-10 20:49:37	2011-03-11 06:54:11	2011-03-11 06:54:11	Cross-check result of MediaTek's AQO (JCTVC-E091)	Yi-Jen Chiu, Lidong Xu, Wenhao Zhang, Hong Jiang, ,
JCTVC-E300	m19827	2011-03-10 20:50:27	2011-03-10 21:50:25	2011-03-10 21:50:25	CE11: Cross check of Qualcomm JCTVC-D262 on parallel context processing for the significance map in high coding efficiency	Cheung Auyeung (Sony)
JCTVC-E301	m19828	2011-03-10 20:52:58	2011-03-11 05:35:56	2011-03-15 11:04:18	CE4 Subset1: Cross-check report for Ericsson's Fine granularity slices	Q. Shen (Huawei), Q. Xie (Huawei), H. Yu (Huawei), ,
JCTVC-E302	m19829	2011-03-10 20:54:47	2011-03-11 05:32:34	2011-03-15 11:08:30	Modification for robust parsing of AMVP	L. Zhang (Huawei), Q. Shen (Huawei), Q. Xie (Huawei), H. Yu (Huawei), ,
JCTVC-E303	m19830	2011-03-10 20:57:20	2011-03-11 05:37:46	2011-03-15 11:11:15	Cross-checking of an investigation on robust parsing results from Microsoft	L. Zhang (Huawei), Q. Shen (Huawei), Q. Xie (Huawei), H. Yu (Huawei), ,
JCTVC-E304	m19831	2011-03-10 20:57:53	2011-03-11 04:21:56	2011-03-18 19:14:16	Overlapped Block Motion Compensation for Regular Block Partitions	L. Guo, P. Chen, R. Joshi, M. Karczewicz (Qualcomm)
JCTVC-E305	m19832	2011-03-10 21:01:19	2011-03-11 04:07:33	2011-03-18 13:55:36	Video Test Material Submission for "Screen Content" Coding Experiments: Scrolling Text, Overlays, Editing, and Window Switching	G. Cook, W. Gao, D. Wang, J. Zhou, H. Yu (Huawei), ,
JCTVC-E306	m19833	2011-03-10 21:05:38			CE7: Adaptive Combined Wavelet/DCT Transform	Y. Weng
JCTVC-E307	m19835	2011-03-10 21:16:22	2011-03-11 10:10:29	2011-03-18 09:00:35	Improved motion vector decimation	I.-K. Kim, T. Lee (Samsung)
JCTVC-E308	m19836	2011-03-10 21:23:47	2011-03-10 22:10:06	2011-03-10 22:10:06	Cross-check of motion vector compression by JVC KENWOOD (JCTVC-E096)	Tomoyuki Yamamoto, Andrew Segall
JCTVC-E309	m19837	2011-03-10 21:29:39	2011-03-10 23:04:35	2011-03-17 14:13:39	Parameter set updates using conditional replacement	S. Wenger (Vidyo),
JCTVC-E310	m19838	2011-03-10 21:57:01	2011-03-16 15:47:43	2011-03-16 15:47:43	CE12 Subset1: Cross-verification of Ericsson's proposal JCTVC-E276	Q. Huang, J. An, X. Guo (MediaTek)
JCTVC-E311	m19839	2011-03-10 21:58:53	2011-03-16 15:48:18	2011-03-16 15:48:18	CE12 Subset1: Cross-verification of Microsoft's proposal JCTVC-E144	J. An, X. Guo (MediaTek)
JCTVC-E312	m19840	2011-03-10 22:00:55	2011-03-10 23:09:46	2011-03-13 05:28:52	CE12 Subset 2: Cross-Verification of Panasonic's Parallel Deblocking Contribution (JCTVC-E224) by Qualcomm	G. Van der Auwera, I. S. Chong, M. Karczewicz (Qualcomm)
JCTVC-E313	m19841	2011-03-10 22:02:21	2011-03-10 23:44:31	2011-03-16 15:55:48	CE14 Subset 1: Cross-verification of NTTDOCOMO's Proposal JCTVC-E131	M. Guo, X. Guo (MediaTek)
JCTVC-E314	m19842	2011-03-10	2011-03-10	2011-03-13	CE12 Subset 2: Cross-Verification of Sony's Parallel Deblocking	G. Van der Auwera, I. S. Chong,

		22:08:20	23:12:03	05:31:46	Contribution (JCTVC-E181) by Qualcomm	M. Karczewicz (Qualcomm)
JCTVC-E315	m19843	2011-03-10 22:19:52	2011-03-11 07:22:45	2011-03-16 20:02:34	CE6.d Parallel Prediction Unit for Parallel Intra Coding	Jie Zhao, Andrew Segall, ,
JCTVC-E316	m19844	2011-03-10 22:28:17	2011-03-13 13:46:01	2011-03-14 03:32:23	CE2: Test results of asymmetric motion partition (AMP) with overlapped block motion compensation (OBMC)	I.-K. Kim (Samsung), P. Chen, L. Guo (Qualcomm)
JCTVC-E317	m19845	2011-03-10 22:31:46	2011-03-10 22:34:39	2011-03-10 22:34:39	CE6.e: Nokia report on planar intra prediction	Jani Lainema, Kemal Ugur, Oguz Bici (Nokia), ,
JCTVC-E318	m19846	2011-03-10 22:40:34	2011-03-11 06:31:26	2011-03-22 12:27:11	Differential Coding of Intra Modes	Ehsan Maani, Ali Tabatabai, Tomoyuki Yamamoto, Akiyuki Tanizawa, Virginie Drugeon,
JCTVC-E319	m19847	2011-03-10 22:49:56	2011-03-11 06:20:28	2011-03-12 00:50:56	CE5: Improvements on transform coefficients coding in LCEC	Jun Xu, Munsi Haque, Ali Tabatabai (Sony)
JCTVC-E320	m19848	2011-03-10 22:59:54	2011-03-11 06:40:31	2011-03-16 15:52:22	Parametric Adaptive Loop Filter	Ehsan Maani, Wei Liu, ,
JCTVC-E321	m19849	2011-03-10 23:02:18	2011-03-11 05:53:19	2011-03-20 11:59:26	CE6.e/f: Planar mode experiments and results	Sandeep Kanumuri (DOCOMO USA Labs), Frank Bossen (DOCOMO USA Labs), ,
JCTVC-E322	m19850	2011-03-10 23:16:30	2011-03-11 06:24:34	2011-03-16 10:54:50	CE5: Cross-verification of Qualcomm's coefficient coding for LCEC by Sony	Jun Xu, Munsi Haque, Ali Tabatabai, ,
JCTVC-E323	m19851	2011-03-10 23:27:13	2011-03-11 07:51:13	2011-03-18 00:10:27	CE8 Subtest 2: Block based adaptive loop filter	I. S. Chong, M. Karczewicz (Qualcomm), C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W Huang, S. Lei (MediaTek), T. Yamakage, T. Chujoh, T. Watanabe (Toshiba)
JCTVC-E324	m19852	2011-03-10 23:35:30	2011-03-11 04:47:52	2011-03-17 21:54:15	Joint Algorithm-Architecture Optimization of CABAC	V. Sze (MIT), A. Chandrakasan (MIT)
JCTVC-E325	m19853	2011-03-10 23:37:38	2011-03-11 03:52:26	2011-03-12 07:23:35	CE8 Subset 2: Cross-Verification of Sharp's Adaptive loop filter by Qualcomm	I. S. Chong, M. Karczewicz (Qualcomm)
JCTVC-E326	m19854	2011-03-10 23:38:27	2011-03-10 23:56:05	2011-03-10 23:56:05	CE11: Cross-verification of HHI's (JCTVC-D336) Coding of transform coefficient levels with Golomb-Rice codes	V. Sze (TI)
JCTVC-E327	m19855	2011-03-10 23:38:59	2011-03-11 03:53:00	2011-03-11 03:53:00	CE8 Subset 3: Cross-Verification of Samsung's Adaptive loop filter by Qualcomm	I. S. Chong, M. Karczewicz (Qualcomm)
JCTVC-E328	m19856	2011-03-10 23:39:16	2011-03-11 00:28:44	2011-03-17 18:54:08	CE3: Cross-check of JCTVC-D285 results from KDDI	Faouzi Kossentini, Hsan Guermazi, ,
JCTVC-E329	m19857	2011-03-10 23:39:53	2011-03-10 23:57:32	2011-03-20 12:29:20	Removal of cabac_zero_word for error detection/resilience	Y. Matsuba, V. Sze, M. Zhou (TI)

JCTVC-E330	m19858	2011-03-10 23:43:48	2011-03-11 04:48:27	2011-03-21 14:25:17	Reduced neighboring dependency in context selection of significant_coeff_flag for parallel processing	V. Sze, M. Budagavi (TI)
JCTVC-E331	m19859	2011-03-10 23:44:04	2011-03-11 03:53:51	2011-03-12 07:19:54	CE8 Subset 4: Cross-Verification of SONY's Adaptive loop filter by Qualcomm	I. S. Chong, M. Karczewicz (Qualcomm)
JCTVC-E332	m19860	2011-03-10 23:46:12	2011-03-11 03:54:25	2011-03-12 07:21:26	CE13: Cross-Verification of MediaTek's adaptive offset	I. S. Chong, M. Karczewicz (Qualcomm)
JCTVC-E333	m19861	2011-03-10 23:58:41	2011-03-11 02:53:08	2011-03-18 18:46:25	Transform Dynamic Range Analysis	Louis Kerofsky, Kiran Misra, Andrew Segall, ,
JCTVC-E334	m19862	2011-03-11 00:03:05	2011-03-11 01:07:33	2011-03-16 12:32:17	CE8.1: Cross-verification of proposal on deblocking parameter adjustment for 1-input ALF (E193) by Ericsson	Andrey Norkin (Ericsson)
JCTVC-E335	m19863	2011-03-11 00:06:03	2011-03-11 12:01:50	2011-03-19 18:20:26	Unified scans for the significance map and coefficient level coding in high coding efficiency	J. Sole, R. Joshi, M. Karczewicz (Qualcomm)
JCTVC-E336	m19864	2011-03-11 00:16:31	2011-03-11 07:24:08	2011-03-11 07:24:08	Cross Check of ETRI's Proposal on Dynamic Range Restriction of Temporal Motion Vector JCTVC-E142	Jie Zhao, Andrew Segall
JCTVC-E337	m19865	2011-03-11 00:18:27	2011-03-11 07:25:19	2011-03-11 07:25:19	Cross Check of Toshiba's Proposal on Modified MV Memory Compression (JCTVC-E211)	Jie Zhao, Andrew Segall, ,
JCTVC-E338	m19866	2011-03-11 00:22:42	2011-03-11 11:42:33	2011-03-17 19:46:36	CE11: Parallel Context Processing for the significance map in high coding efficiency	J. Sole, R. Joshi, M. Karczewicz (Qualcomm),
JCTVC-E339	m19867	2011-03-11 00:24:39	2011-03-11 00:27:53	2011-03-20 10:48:17	On num_reorder_frames and max_dec_frame_buffering	R. Sjoberg (Ericsson),
JCTVC-E340	m19868	2011-03-11 00:38:37	2011-03-11 00:47:16	2011-03-16 21:59:16	CE8: Cross-check of JCTVC-D039 results from TI	Faouzi Kossentini, Hsan Guermazi
JCTVC-E341	m19869	2011-03-11 00:49:22	2011-03-11 00:52:33	2011-03-11 00:52:33	Approximation Quality of Integer Transforms	Mathias Wien, ,
JCTVC-E342	m19870	2011-03-11 01:00:09	2011-03-11 01:07:57	2011-03-14 22:32:16	Adaptive Loop Filtering Using Two Filter Shapes	Faouzi Kossentini, Hsan Guermazi, Nader Mahdi, Mohammed Ali BenAyed,
JCTVC-E343	m19871	2011-03-11 01:06:11	2011-03-11 11:47:55	2011-03-19 08:04:59	Extended Motion Vector Prediction for Bi predictive Mode	Y. Zheng, W.-J. Chien, M. Karczewicz (Qualcomm)
JCTVC-E344	m19872	2011-03-11 01:08:20	2011-03-11 04:10:14	2011-03-18 12:52:40	Context reduction of the last transform position in JCTVC-D262 for CE11.1	Cheung Auyeung, Wei Liu (Sony)
JCTVC-E345	m19873	2011-03-11 01:13:27	2011-03-11 01:48:25	2011-03-19 09:33:27	NAL unit header and sub-bitstream extraction	Y.-K. Wang (Huawei)
JCTVC-E346	m19874	2011-03-11 01:15:43	2011-03-11 01:49:19	2011-03-19 09:34:19	Reuse of AVC SEI messages	Y.-K. Wang (Huawei)
JCTVC-E347	m19875	2011-03-11 01:15:45	2011-03-11 08:00:12	2011-03-11 09:32:43	CE3:Cross-verification of SONY's Luma Interpolation Contribution (JCTVC-E128 and case 0 of JCTV-E129)	L. Guo, I.-S. Chong, M. Karczewicz (Qualcomm)

JCTVC-E348	m19876	2011-03-11 01:17:27	2011-03-11 01:49:55	2011-03-19 09:34:52	On reference picture list construction for uni-predicted partitions	Y.-K. Wang, Z. Wu (Huawei),
JCTVC-E349	m19877	2011-03-11 01:30:53	2011-03-11 08:07:07	2011-03-11 08:07:07	CE2: Cross-verification of Asymmetric Motion Partitioning with OBMC and Non-Square TU from Tsinghua, Huawei &HiSilicon, Microsoft and USTC (JCTVC-EXXX)	L. Guo, Peisong Chen, M. Karczewicz (Qualcomm)
JCTVC-E350	m19878	2011-03-11 01:40:58	2011-03-11 11:42:17	2011-03-15 19:20:40	CE9 Subtests N and O: Improvement on AMVP	J. Park, S. Park, B. Jeon (LG Electronics), Y. Zheng, W. Chien, M. Karczewicz (Qualcomm)
JCTVC-E351	m19879	2011-03-11 01:49:11	2011-03-11 01:51:36	2011-03-14 20:58:42	CE3: Cross-Verification of Toshiba's Contribution (JCTVC-E134) by Qualcomm	G. Van der Auwera, I. S. Chong, M. Karczewicz (Qualcomm)
JCTVC-E352	m19880	2011-03-11 02:11:56	2011-03-13 10:46:07	2011-03-13 10:46:07	Cross Check of Panasonic's Proposal on Modified Motion Vector Compression Method (JCTVC-E231)	Jie Zhao, Andrew Segall, ,
JCTVC-E353	m19881	2011-03-11 02:12:08	2011-03-12 00:39:45	2011-03-12 02:47:35	CE10: Fast Core Transforms, Proposal 1	Pankaj Topiwala, Wei Dai, Ilkoo Kim,
JCTVC-E354	m19882	2011-03-11 02:15:19	2011-03-11 04:49:11	2011-03-13 04:01:10	Further study on entropy coding	V. Sze, M. Budagavi (TI)
JCTVC-E355	m19884	2011-03-11 02:27:25	2011-03-14 23:57:05	2011-03-14 23:57:05	CE3: Cross-check report from Motorola Mobility for Toshiba's interpolation filter (JCTVC-E134)	J. Lou, K. Panusopone, L. Wang (Motorola Mobility)
JCTVC-E356	m19885	2011-03-11 02:28:09	2011-03-12 00:33:16	2011-03-12 00:33:16	CE10: Cross-check report from Motorola Mobility for FastVDO/Samsung's fast integer transform (JCTVC-E353)	J. Lou, K. Panusopone, L. Wang (Motorola Mobility)
JCTVC-E357	m19886	2011-03-11 02:28:34	2011-03-14 22:27:36	2011-03-14 22:27:36	CE11: Cross-check report from Motorola Mobility for Qualcomm's adaptive coefficient scanning for LCEC (JCTVC-E392)	J. Lou, K. Panusopone, L. Wang (Motorola Mobility)
JCTVC-E358	m19887	2011-03-11 02:29:52	2011-03-15 22:26:47	2011-03-15 22:26:47	CE3: Report on Motorola Mobility's interpolation filter for HEVC	J. Lou, K. Minoo, D. Baylon, K. Panusopone, L. Wang (Motorola Mobility)
JCTVC-E359	m19888	2011-03-11 02:30:47	2011-03-16 04:31:10	2011-03-16 04:31:10	Motorola Mobility's adaptive interpolation filter	J. Lou, K. Minoo, D. Baylon, K. Panusopone, L. Wang (Motorola Mobility)
JCTVC-E360	m19889	2011-03-11 02:30:58	2011-03-11 02:37:32	2011-03-22 18:04:41	Cross-Verification of ETRI's Contribution (JCTVC-E223) by Qualcomm	G. Van der Auwera, X. Wang, M. Karczewicz (Qualcomm)
JCTVC-E361	m19890	2011-03-11 02:31:29	2011-03-16 04:31:36	2011-03-17 17:33:01	Supporting one list only coding for HM	J. Lou, K. Minoo, D. Baylon, K. Panusopone, L. Wang (Motorola Mobility)
JCTVC-E362	m19891	2011-03-11 02:31:59	2011-03-13 21:25:12	2011-03-18 18:47:57	On context selection for significant_coeff_flag coding	J. Lou, K. Panusopone, L. Wang (Motorola Mobility)
JCTVC-E363	m19892	2011-03-11 02:32:41	2011-03-14 22:25:02	2011-03-20 15:37:20	Motorola Mobility's adaptive scan	K. Panusopone, Y. Yue, L. Wang (Motorola Mobility)

JCTVC-E364	m19893	2011-03-11 02:33:16	2011-03-14 22:39:56	2011-03-23 10:31:21	Proposal on RQT root location	K. Panusopone, X. Fang, L. Wang (Motorola Mobility)
JCTVC-E365	m19894	2011-03-11 02:34:03	2011-03-15 20:52:54	2011-03-19 18:16:04	Evaluation of RQT in HM and related TU representation	K. Panusopone (Motorola Mobility), K. Chono (NEC), Y.H. Tan (I2R), M. Zhou (TI)
JCTVC-E366	m19895	2011-03-11 02:52:57	2011-03-11 22:35:34	2011-03-14 07:47:34	CE10: Crosscheck of Cisco/TI's contribution (JCTVC-E243) on core transforms - normal QP range	R. Joshi (Qualcomm)
JCTVC-E367	m19897	2011-03-11 02:59:22	2011-03-11 22:36:31	2011-03-11 22:36:31	CE10: Crosscheck of Samsung's fast integer transforms based on Loeffler factorization (JCTVC-E277) - high and low QP range	R. Joshi (Qualcomm)
JCTVC-E368	m19898	2011-03-11 03:01:53	2011-03-11 22:37:23	2011-03-14 07:48:31	Crosscheck of Sharp's contribution (JCTVC-E411) on enforcing the 16-bit inverse transform dynamic range	R. Joshi (Qualcomm),
JCTVC-E369	m19899	2011-03-11 03:06:28	2011-03-11 04:05:17	2011-03-13 05:33:34	CE6.f: Cross-Verification of Mitsubishi/NHK's LUT-Based Intra Prediction Filtering Contribution (JCTVC-E069) by Qualcomm	G. Van der Auwera, M. Coban, M. Karczewicz (Qualcomm)
JCTVC-E370	m19900	2011-03-11 03:08:51	2011-03-11 11:12:18	2011-03-17 07:03:14	CE10: Scaled orthogonal integer transforms supporting recursive factorization structure	R. Joshi, Y. Reznik, J. Sole, M. Karczewicz (Qualcomm)
JCTVC-E371	m19901	2011-03-11 03:11:28	2011-03-11 09:27:16	2011-03-13 15:17:35	CE6.c: Cross-check of Differential Coding of Intra Modes (DCIM, JCTVC-E318) by Sejong University	Chan-Won Seo (Sejong Univ.), Jong-Ki Han (Sejong Univ.), Jeongyeon Lim (SKT)
JCTVC-E372	m19902	2011-03-11 03:14:46	2011-03-11 09:55:52	2011-03-11 09:55:52	Cross-Verification: Simplified Planar Intra Prediction (HiSilicon, JCTVC-E289)	Chan-Won Seo, Jong-Ki Han (Sejong Univ.), Jeongyeon Lim (SKT)
JCTVC-E373	m19904	2011-03-11 03:52:27	2011-03-16 17:24:48	2011-03-22 18:29:00	CE2: Test results of non-rectangular motion partitioning (NRMP) with overlapped block motion compensation (OBMC)	X. Zheng, H. Yu (Huawei & HiSilicon), P. Bordes, L. Guo, P Chen
JCTVC-E374	m19905	2011-03-11 03:57:01	2011-03-11 07:06:17	2011-03-16 16:32:00	CE2: Unified solution of flexible motion partitioning	P. Bordes, P. Chen, I.-K Kim, L. Guo, H. Yu, X. Zheng
JCTVC-E375	m19906	2011-03-11 03:59:16	2011-03-11 04:04:27	2011-03-19 18:12:56	Design consideration for compatibility with AVC NAL units	ChongSoon Lim, Viktor Wahadaniah (Panasonic)
JCTVC-E376	m19907	2011-03-11 04:03:29	2011-03-11 07:06:46	2011-03-19 22:01:57	Asymmetric Motion Partition with OBMC and Non-Square TU	Y. Yuan (Tsinghua), X. Zheng (HiSilicon), X. Peng (USTC), L. Liu (HiSilicon), Y. Wang (Tsinghua), X. Cao (Tsinghua), J. Xu (Microsoft), C. Lai (HiSilicon), J. Zheng (HiSilicon), Y. He (Tsinghua), H. Yu (Huawei)
JCTVC-E377	m19909	2011-03-11 04:13:31	2011-03-11 04:18:17	2011-03-23 06:21:29	Limiting Chroma Transform Depth in Residue Quad Tree (RQT)	L. Guo, X. Wang, P. Chen, Y. Chen, M. Karczewicz

						(Qualcomm)
JCTVC-E378	m19910	2011-03-11 04:23:52	2011-03-12 07:53:59	2011-03-15 19:26:10	Cross-verification for Sony's test (JCTVC-E129) by Samsung	E. Alshina, J. Chen, W.-J. Han (Samsung)
JCTVC-E379	m19911	2011-03-11 04:27:49	2011-03-12 07:40:16	2011-03-12 07:40:16	CE7: Cross-verification for Panasonic's test (JCTVC-E074) by Samsung	E. Alshina, A. Saxena, W.-J. Han (Samsung),
JCTVC-E380	m19912	2011-03-11 04:31:18	2011-03-12 07:34:15	2011-03-17 13:01:46	CE7: Experimental results of ROT by Samsung	E. Alshina, A. Alshin, F. Fernandes, A. Saxena, V. Seregin, Z. Ma, W.-J. Han (Samsung)
JCTVC-E381	m19913	2011-03-11 04:33:44	2011-03-11 10:22:02	2011-03-19 21:29:49	Improvement of inter prediction direction and reference frame index combined coding in LCEC	J. Chen, T. Lee, Y. Park (Samsung)
JCTVC-E382	m19914	2011-03-11 04:42:18	2011-03-11 05:39:03	2011-03-13 21:09:00	Cross check of TI proposal JCTVC-E330 on context simplification of significance map	Ali Tabatabai, Cheung Auyeung (Sony)
JCTVC-E383	m19915	2011-03-11 04:43:05	2011-03-11 10:54:54	2011-03-20 17:29:14	CE5: coefficient coding with LCEC for large block	M. Karczewicz, X. Wang, W.-J.Chien (Qualcomm)
JCTVC-E384	m19916	2011-03-11 04:48:03	2011-03-11 11:40:22	2011-03-16 12:03:53	LCEC coefficient coding table reduction	M. Karczewicz, X. Wang, W.-J. Chien (Qualcomm)
JCTVC-E385	m19917	2011-03-11 04:48:06	2011-03-11 05:40:09	2011-03-14 07:06:35	CE13: Cross checking of case 3 and case 4 of JCTVC-E049 on adaptive offset proposed by MediaTek	Ali Tabatabai, Cheung Auyeung, Ehsan Maani (Sony)
JCTVC-E386	m19918	2011-03-11 04:57:06	2011-03-11 04:59:50	2011-03-21 12:50:25	IDCT pruning	M. Budagavi (TI)
JCTVC-E387	m19919	2011-03-11 04:57:14	2011-03-11 09:31:33	2011-03-14 23:13:14	CE5: Crosscheck of Sony's contribution (JCTVC-E319) on LCEC transform coefficient coding	X. Wang, L. Guo, M. Karczewicz (Qualcomm)
JCTVC-E388	m19921	2011-03-11 06:01:24	2011-03-12 07:46:48	2011-03-13 08:17:31	CE3: Cross-verification for Motorola Mobility's test by Samsung	E. Alshina, J. Chen, W.-J. Han (Samsung),
JCTVC-E389	m19922	2011-03-11 06:03:03	2011-03-13 08:24:31	2011-03-13 08:24:31	CE13: Cross-verification for MediaTek's test (JCTVC-E049) by Samsung	E. Alshina, I.-K. Kim, W.-J. Han (Samsung),
JCTVC-E390	m19925	2011-03-11 06:37:23	2011-03-11 06:53:51	2011-03-11 06:53:51	The art of writing standards: Some "shalls" and "shoulds" for better quality interop specs	G. J. Sullivan (Microsoft)
JCTVC-E391	m19927	2011-03-11 07:03:06	2011-03-11 08:36:32	2011-03-19 12:57:37	CU-Level QP Prediction	Muhammed Coban, Wei-Jung Chien, Marta Karczewicz (Qualcomm)
JCTVC-E392	m19928	2011-03-11 07:19:43	2011-03-11 07:22:08	2011-03-17 18:53:28	CE11: Adaptive Coefficient Scanning for LCEC	X.Wang, L. Guo, M. Coban, M. Karczewicz (Qualcomm)
JCTVC-E393	m19929	2011-03-11 07:22:42	2011-03-11 10:03:40	2011-03-11 10:03:40	CE5: Cross-verification of ZTE proposal on Inter prediction mode coding for LCEC (JCTVC-E072)	W.-J. Chien, X. Wang, M. Karczewicz (Qualcomm)
JCTVC-E394	m19930	2011-03-11	2011-03-11	2011-03-11	CE4: Cross-verification of MediaTek proposal on slice granularity (JCTVC-	P. Chen (Qualcomm)

		07:33:17	09:08:02	09:08:02	E043)	
JCTVC-E395	m19931	2011-03-11 07:33:31	2011-03-11 07:36:28	2011-03-14 03:43:53	HM2 Chroma Intra Coding Description	Ali Tabatabai, Shawmin Lei, Oscar Au,
JCTVC-E396	m19932	2011-03-11 07:43:51	2011-03-11 11:45:06	2011-03-19 08:06:05	Unified Motion Vector Predictor Selection for Merge and AMVP	Y. Zheng, W.-J. Chien, M. Karczewicz (Qualcomm)
JCTVC-E397	m19933	2011-03-11 07:47:19	2011-03-11 07:49:19	2011-03-13 07:04:00	CE6.c: Cross-Verification of Differential Coding of Intra Modes (JCTVC-E318)	G. Van der Auwera, M. Coban, M. Karczewicz (Qualcomm)
JCTVC-E398	m19934	2011-03-11 07:47:19	2011-03-11 12:10:09	2011-03-11 12:10:09	On Temporal Motion Prediction used for Merge and AMVP	Y. Zheng, W.-J. Chien, M. Karczewicz (Qualcomm)
JCTVC-E399	m19935	2011-03-11 07:50:40	2011-03-11 08:33:56	2011-03-11 08:33:56	Sliding Window for Temporal Scalability	Ying Chen, Marta Karczewicz (Qualcomm)
JCTVC-E400	m19936	2011-03-11 07:52:53	2011-03-11 08:34:29	2011-03-11 08:34:29	Comments on Clean Decoding Refresh Pictures	Ying Chen, Coban Muhammed, Peisong Chen, Marta Karczewicz,
JCTVC-E401	m19937	2011-03-11 07:54:48	2011-03-11 08:34:56	2011-03-17 10:25:32	Slice Design with Fine Granularity	Peisong Chen, Ying Chen, Xianglin Wang, Marta Karczewicz, ,
JCTVC-E402	m19938	2011-03-11 07:57:22	2011-03-12 01:31:17	2011-03-12 01:31:17	Cross-check of I2R's Simplified AMVP candidate derivation (JCTVC-E101) by Qualcomm	J. Sole, M. Coban (Qualcomm),
JCTVC-E403	m19939	2011-03-11 08:09:00	2011-03-12 01:21:24	2011-03-12 01:21:24	CE11: Cross-check of Panasonic's context size reduction for the significance map (JCTVC-E227) by Qualcomm	J. Sole (Qualcomm),
JCTVC-E404	m19940	2011-03-11 08:12:04	2011-03-11 08:17:46	2011-03-20 18:23:55	CE5: LCEC coded block flag coding under residual quadtree	P. Chen, X. Wang, W. Chien, M. Karczewicz (Qualcomm), B. Li, J. Xu (Microsoft)
JCTVC-E405	m19941	2011-03-11 08:21:12	2011-03-15 11:00:54	2011-03-15 11:00:54	Cross Verification of JCTVC-E042 Proposed by MediaTek	Q. Shen (Huawei)
JCTVC-E406	m19942	2011-03-11 08:27:43	2011-03-11 08:30:16	2011-03-12 01:17:54	CE6: Cross verification of Microsoft, Huawei, Hisilicon's Short Distance Intra Prediction Method (Part 2) JCTVC-E278	Muhammed Coban, ,
JCTVC-E407	m19943	2011-03-11 08:36:22	2011-03-11 08:51:17	2011-03-17 12:52:02	HM2.0 Chroma Intra Coding Description for WD2	Xun Guo (MediaTek), Ali Tabatabai (Sony), Oscar Au (HKUST)
JCTVC-E408	m19946	2011-03-11 08:44:28	2011-03-11 09:31:12	2011-03-31 19:57:11	Tiles	Arild Fuldseth (Cisco), Michael Horowitz (eBrisk), Minhua Zhou (TI)
JCTVC-E409	m19947	2011-03-11 08:52:52	2011-03-11 09:54:53	2011-03-19 15:09:56	New results for periodic inits for wavefront coding functionality	Kiran Misra, Andrew Segall (Sharp)
JCTVC-E410	m19948	2011-03-11	2011-03-17	2011-03-17	Cross Check of Canon's Proposal on Memory Compression for Motion	Jie Zhao, Andrew Segall, ,

		08:54:00	18:56:06	18:56:06	Vector Prediction (JCTVC-E221)	
JCTVC-E411	m19949	2011-03-11 09:02:55	2011-03-11 09:06:09	2011-03-19 19:37:14	Enforcing the 16-bit inverse transform dynamic range	Kiran Misra, Louie Kerofsky, Andrew Segall, ,
JCTVC-E412	m19950	2011-03-11 09:10:49	2011-03-12 07:23:30	2011-03-19 15:32:40	Tiles for Parallel Decoding	Kiran Misra, Andrew Segall, ,
JCTVC-E413	m19952	2011-03-11 09:25:07	2011-03-12 02:24:43	2011-03-17 21:10:45	CE7: Cross-verification of NHK's (JCTVC-E107) Simplified Adaptive Transform Selection	R. Cohen, A. Vetro, H. Sun(MERL)
JCTVC-E414	m19953	2011-03-11 09:48:29	2011-03-19 12:46:09	2011-03-19 12:46:09	Cross verification of Tiles (JCTVC-E408)	Kiran Misra, Andrew Segall, ,
JCTVC-E415	m19954	2011-03-11 09:50:10	2011-03-18 12:52:06	2011-03-18 12:52:06	Cross verification of Wavefront Parallel Processing (JCTVC-E196)	Kiran Misra, Andrew Segall,
JCTVC-E416	m19955	2011-03-11 09:55:15	2011-03-18 18:19:06	2011-03-18 18:19:06	CE10: Cross check of FastVDO/Samsung's fast integer transform	Kiran Misra, Louie Kerofsky, Andrew Segall, ,
JCTVC-E417	m19956	2011-03-11 10:11:06	2011-03-15 04:15:24	2011-03-21 20:36:44	CE12 Subset1: SKT/SKKU Deblocking Filter	Jungyoup Yang, Kwanghyun Won, Byeungwoo Jeon (SKKU), Jeongyeon Lim (SK Telecom),
JCTVC-E418	m19957	2011-03-11 10:16:59	2011-03-12 05:24:55	2011-03-12 05:24:55	CE12 Subset1: Cross-verification Results of Ericsson Deblocking Filter (JCTVC-E276) by SKT/SKKU	Jungyoup Yang, Kwanghyun Won, Byeungwoo Jeon, Jeongyeon Lim, ,
JCTVC-E419	m19958	2011-03-11 10:21:24	2011-03-12 05:25:51	2011-03-12 05:25:51	CE9: Cross-verification Results of Experiment L for I2R Proposal (JCTVC-E102) by SKKU	Jungyoup Yang, Kwanghyun Won, Byeungwoo Jeon
JCTVC-E420	m19959	2011-03-11 10:46:44	2011-03-11 22:38:32	2011-03-14 07:49:18	CE7: Crosscheck of Samsung's ROT results (JCTVC-E380)	R. Joshi (Qualcomm)
JCTVC-E421	m19960	2011-03-11 10:50:25	2011-03-11 10:51:19	2011-03-20 21:17:59	Crosscheck of Cisco's Tiles Proposal (JCTVC-E408)	Muhammed Coban, ,
JCTVC-E422	m19961	2011-03-11 11:12:41	2011-03-11 11:19:41	2011-03-19 18:22:08	NAL unit header concept with support for bit stream scalability	R. Sjoberg, T. Rusert, Z. Wu (Ericsson)
JCTVC-E423	m19962	2011-03-11 11:34:46	2011-03-18 13:14:46	2011-03-18 13:14:46	Cross verification of new results for periodic inits for wavefront coding functionality (JCTVC-E409)	Félix Henry, ,
JCTVC-E424	m19963	2011-03-11 12:48:43	2011-03-11 16:07:59	2011-03-11 16:07:59	Cross-check results for MIT's proposal JCTVC-E324	T. Nguyen, M. Preiß (Fraunhofer HHI)
JCTVC-E425	m19964	2011-03-11 15:11:15	2011-03-13 14:22:37	2011-03-19 10:07:05	Fast encoder control for RQT	Mischa Siekmann, Heiko Schwarz, Benjamin Bross, Detlev Marpe, Thomas Wiegand
JCTVC-E426	m19965	2011-03-11 15:15:41	2011-03-16 10:11:16	2011-03-19 08:55:44	Experimental results of 4 taps/5 bits Chroma DCTIF in HM2.0	Elena Alshina, Jianle Chen, Alexander Alshin, Nikolay Shlyakhov, Woo-Jin Han,

JCTVC-E427	m19966	2011-03-11 15:50:13	2011-03-13 02:29:43	2011-03-16 12:21:39	Cross-check of MediaTek's proposal (JCTVC-E080) on Adaptive Inter Mode Coding for LCEC	P. Lai, F. C. A. Fernandes (Samsung),
JCTVC-E428	m19967	2011-03-11 16:22:38	2011-03-12 08:15:05	2011-03-21 15:09:30	Low Complexity Embedding of Information in Transform Coefficients	R. Cohen, S. Rane, A. Vetro, H. Sun (MERL),
JCTVC-E429	m19969	2011-03-11 18:32:29	2011-03-11 18:34:48	2011-03-11 18:34:48	On Profile signaling	David Singer (Apple)
JCTVC-E430	m19973	2011-03-11 21:27:17	2011-03-11 21:29:13	2011-03-11 21:29:13	Cross-verification of Panasonics (JCTVC-E226) Parallel Context Processing For Significance Map by Block-based context updates	V. Sze (TI)
JCTVC-E431	m19974	2011-03-11 21:41:25	2011-03-11 21:48:15	2011-03-18 15:55:45	Spatial Scalability for HEVC	Koohyar Minoo, David Baylon, Ajay Luthra (Motorola Mobility)
JCTVC-E432	m19978	2011-03-12 01:30:17	2011-03-12 01:32:57	2011-03-20 09:07:57	Unified scaling for 10-bit to 8-bit reference frame compression	D. Hoang (Zenverge)
JCTVC-E433	m19979	2011-03-12 04:38:15	2011-03-12 04:42:37	2011-03-12 04:42:37	Proposed text of JCTVC-D260 for WD2	Cheung Auyeung, Wei Liu (Sony)
JCTVC-E434	m19980	2011-03-12 04:51:29	2011-03-16 10:00:07	2011-03-16 10:00:07	CE5: Cross Verification of JCTVC-E383 Proposed by Qualcomm	J.-L. Lin, Y.-W. Chen, Y.-W. Huang (MediaTek)
JCTVC-E435	m19982	2011-03-12 05:53:23	2011-03-12 09:23:35	2011-03-20 10:27:20	QuYK	Gergely Korodi, Dake He (RIM)
JCTVC-E436	m19983	2011-03-12 06:21:39	2011-03-13 04:53:31	2011-03-18 11:00:50	Sub-LCU QP representation	C. Pang, O. C. Au, J. Dai, F. Zou, X. Wen(HKUST),
JCTVC-E437	m19984	2011-03-12 07:36:15	2011-03-16 07:39:20	2011-03-16 07:39:20	On intra prediction	Jane Zhao, Andrew Segall (Sharp)
JCTVC-E438	m19986	2011-03-13 04:37:47	2011-03-13 04:42:21	2011-03-13 04:42:21	Cross-verification of simplification and improvement of merge mode coding (JCTVC-E292)	P Chen, Y. Zheng, Marta Karczewicz, ,
JCTVC-E439	m19987	2011-03-13 06:37:08	2011-03-15 02:44:46	2011-03-15 02:44:46	CE6.g: Cross-verification report for Mitsubishi Electric's proposal (JCTVC-E068) by Peking Univ.	Liang Zhao, Li Zhang, Siwei Ma, Debin Zhao, ,
JCTVC-E440	m19988	2011-03-13 11:52:56	2011-03-16 08:52:20	2011-03-16 08:52:20	CE1: Cross-check result of Huawei's STDM (JCTVC-E294)	Yi-jen Chiu, Lidong Xu, Wenhao Zhang, Hong Jiang, ,
JCTVC-E441	m19990	2011-03-13 15:24:44	2011-03-17 18:14:07	2011-03-17 18:14:07	Cross-verification of Overlapped Block Motion Compensation for Regular Block Partition (JCTVC-E304)	X. Zheng, ,
JCTVC-E442	m19993	2011-03-13 18:20:15	2011-03-13 18:33:28	2011-03-13 18:33:28	Cross-verification of MediaTek proposal on motion vector decimation (JCTVC-E092) and context dependent intra mode coding (JCTVC-E201)	P. Chen, M. Karczewicz, ,
JCTVC-E443	m19994	2011-03-13 22:29:14	2011-03-13 22:46:25	2011-03-13 22:46:25	Cross-verification of MediaTek's proposal on Reduction in Combinations of Reference Picture Indices for Bi-Prediction (JCTVC-E052)	W.-J. Chien, M. Karczewicz (Qualcomm)
JCTVC-E444	m20008	2011-03-14 02:49:19	2011-03-14 03:52:45	2011-03-14 03:52:45	CE10: Cross-check of Qualcomm's proposal on scaled orthogonal integer transforms (E370)	C. Yeo (I2R)

JCTVC-E445	m20013	2011-03-14 07:04:35	2011-03-16 04:04:10	2011-03-16 12:40:09	Cross-check of MediaTek's proposal on partial Merge (JCTVC-E085)	Y. H. Tan, C. Yeo (I2R)
JCTVC-E446	m20019	2011-03-14 09:13:26	2011-03-14 13:24:41	2011-03-19 14:52:28	Coefficient coding table improvement in LCEC	Seongwan Kim, Jaeho Lee, Sangyoun Lee (Yonsei Univ.)
JCTVC-E447	m20021	2011-03-14 09:33:51	2011-03-15 16:24:22	2011-03-15 16:24:22	HEVC Reference Software Manual	F Bossen, D Flynn, K Sühring
JCTVC-E448	m20036	2011-03-14 15:22:16	2011-03-14 15:48:41	2011-03-14 15:48:41	Cross-check of Qualcomm's proposal on LCEC coefficient coding table reduction (JCTVC-E384)	Jani Lainema, Kemal Ugur (Nokia)
JCTVC-E449	m20116	2011-03-15 07:39:17	2011-03-16 20:06:27	2011-03-16 20:06:27	Cross Check of Motorola Mobility's Interpolation Filter	Jie Zhao, Andrew Segall
JCTVC-E450	m20121	2011-03-15 10:15:59	2011-03-15 11:07:47	2011-03-15 11:07:47	CE6 e: Cross check of experiment 1f+2b+3b (LG - JCTVC-Exxx)	Joel Jung, Elie Mora
JCTVC-E451	m20124	2011-03-15 19:01:25	2011-03-16 15:39:18	2011-03-16 15:39:18	Title: Impact of Motion Vector Predictor Index Decoding on Parallelization between CABAC and Other Decoder Components	Yong Yu
JCTVC-E452	m20125	2011-03-15 19:09:42	2011-03-15 23:59:05	2011-03-15 23:59:05	Cross-Verification of Mediatek's Contribution (JCTVC-E050) by Qualcomm	G. Van der Auwera, Y. Zheng, L. Guo, X. Wang, M. Karczewicz (Qualcomm)
JCTVC-E453	m20127	2011-03-15 23:00:00	2011-03-16 08:10:56	2011-03-18 06:10:35	CE8 Subtest 5: Cross Verification of JCTVC-E287 Proposed by TI	T.-D. Chuang, C.-Y. Chen, Y.-W. Huang (MediaTek)
JCTVC-E454	m20128	2011-03-15 23:02:17	2011-03-19 19:01:11	2011-03-19 19:01:11	Cross Verification of JCTVC-E396 Proposed by Qualcomm	J.-L. Lin, Y.-W. Chen, Y.-W. Huang (MediaTek)
JCTVC-E455	m20129	2011-03-15 23:04:21	2011-03-19 19:00:35	2011-03-20 16:13:36	Cross Verification of JCTVC-E398 Proposed by Qualcomm	J.-L. Lin, Y.-W. Chen, Y.-W. Huang (MediaTek)
JCTVC-E456	m20130	2011-03-15 23:12:39	2011-03-18 06:16:01	2011-03-20 16:12:00	CE9: Cross Verification of Experiment T Proposed by HHI in JCTVC-E204	Y.-W. Chen, J.-L. Lin, Y.-W. Huang (MediaTek)
JCTVC-E457	m20132	2011-03-16 00:55:03			Withdrawn - erroneous registration	
JCTVC-E458	m20133	2011-03-16 01:17:00	2011-03-16 01:19:33	2011-03-16 01:19:33	CE5: Cross-verification of LCEC coded block flag coding under residual quadtree (JCTVC-E404)	Jianle Chen, Vadim Seregin
JCTVC-E459	m20134	2011-03-16 01:32:35	2011-03-16 16:33:35	2011-03-16 16:33:35	Cross-verification report for Samsung's contribution on motion vector decimation (JCTVC-E307)	Hirofumi Aoki, Keiichi Chono, Yuzo Senda,
JCTVC-E460	m20135	2011-03-16 02:09:14	2011-03-16 02:18:11	2011-03-16 02:18:11	CE7: Cross-check of mode-dependent DCT/DST (restricted to 4x4 TUs) for intra coding (JCTVC-E125)	S. Kanumuri, F. Bossen (DOCOMO USA Labs)
JCTVC-E461	m20139	2011-03-16 05:13:16	2011-03-16 05:15:57	2011-03-16 05:15:57	CE7: Cross-check report for Samsung's proposal on adaptive DST/DCT transform (JCTVC-E125) by Panasonic	Youji Shibahara, Takahiro Nishi (Panasonic)
JCTVC-E462	m20150	2011-03-16 11:24:14	2011-03-17 09:32:24	2011-03-17 09:32:24	Cross Verification of JCTVC-E343 Proposed by Qualcomm	J. Park, Y. Choi, S. Park, B. Jeon

JCTVC-E463	m20153	2011-03-16 14:51:29	2011-03-16 16:26:30	2011-03-18 18:47:55	Cross Verification for Unified scaling for 10-bit to 8-bit reference frame compression	Guichun Li
JCTVC-E464	m20154	2011-03-16 19:05:25	2011-03-16 19:31:43	2011-03-16 19:31:43	CE2: Cross-verification of Asymmetric Motion Partition with OBMC and Non-Square TU (JCTVC-E376)	L. Guo, P. Chen, M. Karczewicz (Qualcomm)
JCTVC-E465	m20156	2011-03-16 20:48:13	2011-03-16 21:35:12	2011-03-16 21:35:12	Verification results of CE8: Panasonic's contribution on ALF “Line memory reduction for ALF decoding” (JCTVC-E225)	Faouzi Kossentini, Nader Mahdi
JCTVC-E466	m20162	2011-03-17 00:40:55	2011-03-17 00:46:19	2011-03-17 00:46:19	Cross-Verification of Samsung’s Contribution (JCTVC-E288) by Qualcomm	Y. Zheng
JCTVC-E467	m20165	2011-03-17 09:14:44	2011-03-18 09:53:55	2011-03-18 09:53:55	CE12 Subset1: Cross-check of SKT/SKKU’s proposal on Deblocking Filter (JCTVC-E417)	Y. H. Tan, C. Yeo (I2R)
JCTVC-E468	m20167	2011-03-17 10:49:34	2011-03-19 12:26:33	2011-03-19 12:26:33	CE6.a.4: Cross-check report for JCTVC-E266	J. Xu (Microsoft)
JCTVC-E469	m20168	2011-03-17 12:14:02	2011-03-17 12:25:50	2011-03-17 12:25:50	Cross checking of MediaTek proposal JCTVC-E080 on adaptive inter mode coding for LCEC	Cheung Auyeung, Ali Tabatabai, (Sony)
JCTVC-E470	m20170	2011-03-17 14:24:08	2011-03-17 18:03:39	2011-03-18 11:04:18	Combined proposal JCTVC-E196 and JCT-VCE409	Félix Henry (Orange Labs), Kiran Misra (Sharp), Stéphane Pateux (Orange Labs), Andrew Segall (Sharp)
JCTVC-E471	m20171	2011-03-17 15:03:36	2011-03-17 15:13:18	2011-03-17 15:13:18	Cross-verification of Nokia proposal JVCTV-E242 on clipping in bi-directional averaging	Minhua Zhou
JCTVC-E472	m20173	2011-03-17 18:47:10	2011-03-18 18:14:42	2011-03-18 18:14:42	Cross Check of CE10: Qualcomm’s Proposal on Scaled Transform -- 16bit Low and High QP Range (JCTVC-E370)	Jie Zhao, Andrew Segall
JCTVC-E473	m20174	2011-03-17 19:14:29	2011-03-17 19:23:20	2011-03-17 19:23:20	Verification of JCTVC-E335: Scans for coefficient level coding with CABAC	F. Bossen (DOCOMO USA Labs)
JCTVC-E474	m20175	2011-03-17 21:17:36	2011-03-20 16:11:20	2011-03-20 16:11:20	Cross Verification of JCTVC-E470 Proposed by Orange Labs and Sharp	C.-Y. Tsai, C.-W. Hsu, Y.-W. Huang (MediaTek)
JCTVC-E475	m20177	2011-03-17 22:54:22	2011-03-18 08:50:12	2011-03-18 08:50:12	Cross Verification of Combination of JCTVC-E046 and JCTVC-E323	J. Xu (Microsoft)
JCTVC-E476	m20179	2011-03-18 00:46:06	2011-03-18 07:23:28	2011-03-18 07:23:28	Cross-Verification of Panasonic’s Contribution (JCTVC-E251) by Qualcomm	G. Van der Auwera
JCTVC-E477	m20183	2011-03-18 10:46:00	2011-03-18 10:51:41	2011-03-18 10:51:41	Comparison of BD-rates and run-times of entropy coders in HM-2.0	
JCTVC-E478	m20184	2011-03-18 11:53:09	2011-03-18 16:25:54	2011-03-18 16:25:54	BoG report on extending LCEC to larger block sizes	A. Fuldseth (Cisco), M. Karczewicz (Qualcomm), M. Haque (Sony),
JCTVC-E479	m20185	2011-03-18 12:53:07	2011-03-18 12:56:01	2011-03-18 12:57:58	Cross-verification of Yonsei university’s proposal on coefficient coding table improvement in LCEC (JCTVC-E446)	Jianle Chen, Sunil Lee, Jeonghoon Park

JCTVC-E480	m20188	2011-03-18 14:52:20	2011-03-19 03:13:39	2011-03-19 03:13:39	BoG Report on Transforms	R. Cohen
JCTVC-E481	m20194	2011-03-18 18:37:42	2011-03-21 18:43:13	2011-03-23 12:52:53	BoG report of CE9: MV Coding and Skip/Merge operations	Benjamin Bross, Joel Jung
JCTVC-E482	m20198	2011-03-19 08:57:31	2011-03-19 09:27:54	2011-03-19 09:27:54	Cross-check report for JCTVC-E113	J. Xu (Microsoft)
JCTVC-E483	m20199	2011-03-19 09:37:10	2011-03-19 13:15:23	2011-03-23 11:56:31	BoG on fine granularity slices	Rickard Sjoberg, Shawmin Lei, Yu-Wen Huang, Qiu Shen
JCTVC-E484	m20200	2011-03-19 09:43:13	2011-03-19 09:49:07	2011-03-19 09:49:07	Cross Check Report for Intra Encoding Acceleration by Simplification of RDOQ (JCTVC-E262) by BBC	Andrea Gabriellini, Marta Mrak (BBC)
JCTVC-E485	m20201	2011-03-19 09:50:27	2011-03-19 21:24:09	2011-03-20 11:43:32	Report on fix of CBF for RDOQ	T. Nguyen, M. Siekmann
JCTVC-E486	m20202	2011-03-19 12:10:53	2011-03-19 12:15:42	2011-03-19 12:15:42	Verification result of Sony's Preliminary Implementation on Sub-LCU-Level DeltaQP (JCTVC-E220)	M. Shima (Canon)
JCTVC-E487	m20203	2011-03-19 15:48:24	2011-03-21 12:57:45	2011-03-21 12:57:45	CE8 Subtest 5: Cross-check of eBrisk+TI's proposal (JCTVC-E492) with vertical length-5 filters	P. Lai, J. Chen, F. C. A. Fernandes (Samsung)
JCTVC-E488	m20204	2011-03-19 16:35:14	2011-03-19 16:48:39	2011-03-20 16:24:35	BoG report and proposal on padding of unavailable reference samples for intra prediction	Rickard Sjöberg (Ericsson), Changcai Lai (HiSilicon), Keiichi Chono (NEC), Viktor Wahadaniah (Panasonic)
JCTVC-E489	m20208	2011-03-20 10:37:26	2011-03-20 16:09:36	2011-03-21 12:13:48	Modification to JCTVC-E227 in CE11 for reduced dependency with MDCS	V. Sze (TI), H. Sasai (Panasonic)
JCTVC-E490	m20209	2011-03-20 11:44:44	2011-03-20 11:54:46	2011-03-20 20:13:21	Simplifying decoder mismatch checking	David Flynn
JCTVC-E491	m20213	2011-03-20 12:14:20	2011-03-20 16:55:01	2011-03-23 11:55:11	Cross-check report for TI's proposal on Modification to JCTVC-E227 (JCTVC-E489)	Hisao Sasai (Panasonic)
JCTVC-E492	m20215	2011-03-20 14:30:43	2011-03-20 16:11:18	2011-03-21 16:10:20	CE8 Subset 5: Results on combination of JCTVC-E342 + JCTVC-E060	F. Kossentini, H. Guermazi, N. Mahdi, M. A. BenAyed, M. Budagavi, V. Sze, M. Zhou,
JCTVC-E493	m20216	2011-03-20 16:22:31	2011-03-20 16:24:41	2011-03-20 16:24:41	BoG report on Screen Content Coding (SCC)	Oscar Au, Jizheng Xu, Haoping Yu
JCTVC-E494	m20222	2011-03-20 19:48:23	2011-03-20 22:02:59	2011-03-22 00:17:28	BoG report on the draft text for the combination of proposals JCTVC-E227, JCTVC-E338 and JCTVC-E344	J. Sole (Qualcomm), C. Auyeung (Sony), H. Sasai (Panasonic)
JCTVC-E495	m20225	2011-03-21 12:41:37	2011-03-22 16:52:02	2011-03-22 16:52:02	Cross-check results for Samsung's proposal JCTVC-E381 from HiSilicon	C.Lai(HiSilicon)
JCTVC-E496	m20226	2011-03-21	2011-03-21	2011-03-21	Results for a straight forward combination of parallel deblocking	M. Narroschke (Panasonic), M.

		13:16:36	13:22:34	21:08:04	techniques JCTVC-E224 and item 2 of JCTVC-E181	Ikeda (Sony)
JCTVC-E497	m20227	2011-03-21 14:16:26	2011-03-21 18:29:38	2011-03-21 18:29:38	BOG report on complexity assessment	Daniele Alfonso(STMicro), Xing Wen(HKUST),
JCTVC-E498	m20230	2011-03-21 15:56:59	2011-03-21 16:04:08	2011-03-21 16:04:08	Cross-check result of MediaTek's MV decimation for temporal prediction (JCTVC-E092)	Lidong Xu, Yi-jen Chiu, Wenhao Zhang, Hong Jiang
JCTVC-E499	m20231	2011-03-21 16:46:03	2011-03-21 20:38:44	2011-03-21 20:38:44	Cross check of JCTVC-E492, Results on combination of JCTVC-E342 + JCTVC-E060	A. Abbas, J. Boyce
JCTVC-E500	m20232	2011-03-21 19:20:39	2011-03-21 19:32:48	2011-03-21 19:32:48	Cross-check report of SKT/SKKU Deblocking Filter (JCTVC-E417)	J. Kim, M. Kim(KAIST), S. Cho(ETRI)
JCTVC-E501	m20233	2011-03-22 02:46:50	2011-03-22 09:09:53	2011-03-22 11:15:39	BoG report on subjective viewing test for deblocking filter proposals	Andrey Norkin, Kenneth Andersson, Keiichi Chono, In Suk Chong, Matthias Narroschke, Byengwoo Jeon, David Flynn, Teruhiko Suzuki
JCTVC-E502	m20238	2011-03-22 12:24:14	2011-03-22 12:48:03	2011-03-22 12:48:03	Scalable enhancement requirements for HEVC	
JCTVC-E503	m20239	2011-03-22 12:29:42	2011-03-22 20:06:46	2011-03-22 20:06:46	Cross-check report of JCTVC-E266	M. Budagavi (TI)
JCTVC-E504	m20245	2011-03-22 20:52:59	2011-03-22 20:55:43	2011-03-22 20:55:43	Cross-check report of proposal E494	C. Yeo (I2R)
JCTVC-E505	m20252	2011-03-23 11:27:52	2011-03-23 11:32:47	2011-03-23 11:32:47	Description and result of the combination of JCTVC-E323 and JCTVC-E046	I. S. Chong, M. Karczewicz (Qualcomm), C.-Y. Chen, C.-M. Fu, C.-Y. Tsai, Y.-W Huang, S. Lei (MediaTek), T. Yamakage, T. Chujoh, T. Watanabe (Toshiba)
JCTVC-E600	m20272	2011-04-15 03:13:32	2011-07-14 09:02:26	2011-07-14 09:02:26	Meeting report of the fifth meeting of the Joint Collaborative Team on Video Coding (JCT-VC), Geneva, CH, 16-23 March 2011	Gary J. Sullivan, Jens-Rainer Ohm
JCTVC-E602	m20270	2011-03-29 19:49:46	2011-06-02 13:26:44	2011-07-10 21:23:52	HEVC Test Model 3 (HM 3) Encoder Description	K. McCann, S. Sekiguci, B. Bross, W.-J. Han
JCTVC-E603	m20271	2011-03-29 19:58:12	2011-03-30 12:22:15	2011-06-27 14:32:31	WD3: Working Draft 3 of High-Efficiency Video Coding	T. Wiegand, B. Bross, W.-J. Han, J.-R. Ohm, G. J. Sullivan
JCTVC-E700	m20235	2011-03-22 11:47:13	2011-04-25 19:58:16	2011-04-25 19:58:16	Common test conditions and software reference configurations	F. Bossen
JCTVC-E701	m20236	2011-03-22 11:55:52	2011-03-22 16:28:42	2011-04-15 14:42:25	Description of Core Experiment 1 (CE1): Motion Data Storage Reduction	Joel Jung, Patrice Onno
JCTVC-E702	m20247	2011-03-22 21:46:39	2011-03-23 10:31:18	2011-04-09 07:30:56	Description of Core Experiment 2 (CE2): Motion Partitioning and OBMC	Xiaozhen Zheng, P. Bordes, P. Chen, I.-K Kim

JCTVC-E703	m20242	2011-03-22 15:13:46	2011-03-22 15:20:23	2011-04-11 15:53:21	Description of Core Experiment 3 (CE3): Motion Compensation Interpolation	Elena Alshina, Takeshi Chujoh
JCTVC-E704	m20249	2011-03-23 09:18:55	2011-03-31 06:26:17	2011-06-29 06:54:04	Description of Core Experiment 4 (CE4): Quantization	K. Sato (Sony), M. Budagavi (TI), H. Aoki (NEC), M. Coban (Qualcomm), X. Li (MediaTek)
JCTVC-E705	m20246	2011-03-22 21:20:14	2011-03-22 21:22:42	2011-04-09 00:49:08	Description of Core Experiment 5 (CE5): CAVLC Entropy Coding Improvements	X. Wang, P. Wu
JCTVC-E706	m20250	2011-03-23 09:28:34	2011-03-23 09:29:18	2011-05-19 05:21:07	Description of Core Experiment 6 (CE6): Intra Prediction Improvement	Ali Tabatabai [Sony], Madhukar Budagavi [TI], Keiichi Chono [NEC], Joshi Rajan [Qualcomm], Andrew Segall [Sharp], Haoping Yu [Huawei],
JCTVC-E707	m20244	2011-03-22 15:59:10	2011-03-22 21:23:17	2011-06-29 01:59:42	Description of Core Experiment 7 (CE7): Additional Transforms	R. Cohen, C. Yeo, R. Joshi, F. Fernandes
JCTVC-E708	m20241	2011-03-22 14:46:37	2011-03-23 00:33:49	2011-05-06 01:45:57	Description of Core Experiment 8 (CE8): Non-deblocking loop filtering	T. Yamakage (Toshiba), Y. W. Huang (MediaTek), I. S. Chong (Qualcomm), T. Ikai (Sharp), M. Narroschke (Panasonic), W. L. Lai (Samsung), A. Tabatabai (SONY), M. Budagavi (TI), F. Kossentini (eBrisk Video),
JCTVC-E709	m20251	2011-03-23 10:47:31	2011-03-23 11:08:03	2011-05-24 16:08:49	Description of Core Experiment 9 (CE9): MV Coding and Skip/Merge Operations	Y.-W. Huang (MediaTek), B. Bross (HHI), M. Zhou (TI), W.-J. Chien (Qualcomm), I.-K. Kim (Samsung)
JCTVC-E710	m20234	2011-03-22 10:56:49	2011-03-22 10:58:34	2011-04-10 14:40:19	Description of Core Experiment 10 (CE10): Core Transform Design	P. Topiwala, M. Budagavi, A. Fuldseth, R. Joshi, I.-K. Kim,
JCTVC-E711	m20240	2011-03-22 12:30:03	2011-03-23 11:16:11	2011-04-11 05:30:06	Description of Core Experiment 11 (CE11): Coefficient scanning and coding	V. Sze, J. Chen, T. Nguyen, K. Panusopone, J. Sole,
JCTVC-E712	m20237	2011-03-22 12:08:22	2011-03-23 12:24:38	2011-04-08 22:44:27	Description of Core Experiment 12 (CE12): Deblocking filtering	Andrey Norkin, Xun Guo, Byeungwoo Jeon, Matthias Narroschke

Annex B to JCT-VC report:
List of meeting participants

The participants of the ~~third~~ fifth meeting of the JCT-VC, according to the badge pick-up records collected by the meeting host (approximately 225 in total), were as follows:

1. Fujibayashi Akira (NTT DOCOMO,Inc.)
2. Daniele Alfonso (STMicroelectronics)
3. Elena Alshina (Samsung Electronics)
4. Peter Amon (Siemens AG)
5. Ping An (Shanghai University)
6. Kenneth Andersson (LM Ericsson)
7. Kohtaro Asai (Mitsubishi Electric Corporation)
8. Oscar Au (HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY)
9. Gun Bang (ETRI)
10. Joeri Barbarien (IBBT (Interdisciplinary Institute for Broadband Technology))
11. Oguz Bici (Nokia)
12. Lazar Bivolarsky (Skype, Inc.)
13. Gisle Bjontegaard (Cisco Systems Norway)
14. Ronan Boitard (INRIA RENNES)
15. Philippe Bordes (Technicolor)
16. Frank Bossen (DOCOMO USA Labs)
17. Stephen Botzko (Polycom)
18. Jill Boyce (Vidyo, Inc.)
19. Benjamin Bross (Fraunhofer HHI)
20. Madhukar Budagavi (Texas Instruments Inc.)
21. Jeon Byeongmoon (LG Electronics)
22. Lai Changcai (Huawei Technologies Co., Ltd.)
23. Chun-Chi Chen (ITRI International/NCTU)
24. Chun-Fu Chen (ITRI)
25. Jianle Chen (Samsung Electronics Co., Ltd.)
26. Weizhong Chen (Huawei technologies CO.,LTD)
27. Ying Chen (Qualcomm)
28. Auyeung Cheung (Sony Electronics Inc)
29. Wei-Jung Chien (Qualcomm)
30. Yi-Jen Chiu (Intel Corp.)
31. Seunghyun Cho (Electronics and Telecommunications Research Institute)
32. Kiho Choi (Hanyang University)
33. In Suk Chong (Qualcomm Inc.)
34. Keiichi Chono (NEC)
35. Gordon Clare (orange labs france telecom)
36. Muhammed Coban (Qualcomm)
37. Robert Cohen (Mitsubishi Electric)
38. Gregory Cook (Huawei Technologies (USA))
39. Jingjing Dai (Hong Kong University of Science and Technology)
40. Thomas Davies (Cisco Systems)
41. Jan De Cock (Ghent University - IBBT)
42. Stefan Döhla (Fraunhofer Institut IIS)
43. Virginie Drugeon (Panasonic R&D Center Germany)
44. Semih Esenlik (Panasonic Corporation)
45. Pascal Eymery (Allegro DVT)
46. Felix Fernandes (Samsung)
47. Roberto Flaiani (MINISTRY OF COMMUNICATIONS)
48. David Flynn (BBC Research & Development)
49. Chad Fogg (Harmonic Inc.)
50. Edouard Francois (Canon Inc.)
51. Deliang Fu (The MIIT of P.R.China)

52. Shigeru Fukushima (JVC KENWOOD Holdings, Inc.)
53. Arild Fuldseth (Cisco Systems Norway)
54. Wen Gao (Huawei Technologies (USA))
55. Lutz Goldmann (EPFL/STI/IEL/GR-EB)
56. Xun Guo (MediaTek (Beijing) Inc.)
57. Woo-Jin Han (Samsung Electronics)
58. Miska Hannuksela (Nokia Corporation)
59. Munsi Haque (Sony Electronics Inc.)
60. Dake He (Research In Motion)
61. Félix Henry (Orange Labs)
62. Dzung Hoang (Zenverge)
63. Soongi Hong (Yonsei University)
64. Sung-Wook Hong (Sejong University)
65. Yingjie Hong (ZTE Corporation)
66. Michael Horowitz (eBrisk Video, Inc.)
67. Yu-Wen Huang (MediaTek)
68. Tan Hui Li (Institute for Infocomm Research)
69. Atsuro Ichigaya (NHK)
70. Marc Jacobs (IBBT (Interdisciplinary Institute for Broadband Technology))
71. Fabian Jaeger (RWTH Aachen University)
72. Byeungwoo Jeon (Sungkyunkwan University)
73. Ali Jerbi (Cisco)
74. Jie Jia (LG Electronics China R&D Center)
75. Rajan Joshi (Qualcomm)
76. Joel Jung (Orange Labs)
77. Tae-Young Jung (Chips & Media)
78. Jung Won Kang (ETRI (Electronics & Telecommunications Research Institute))
79. Mukta Kar (Cable Television Laboratories)
80. Marta Karczewicz (Qualcomm)
81. Kimihiko Kazui (FUJITSU LABORATORIES LTD.)
82. Thomas Kernen (Cisco Systems)
83. Louis Kerofsky (Sharp Corporation)
84. Abdellatif Khindouf (ALLEGRO DVT)
85. Hae Kwang Kim (Sejong University)
86. Hui Yong Kim (ETRI (Electronics and Telecommunications Research Institute))
87. Il-Koo Kim (Samsung Electronics Co., Ltd.)
88. Jaeil Kim (Korea Advanced Institute of Science and Technology)
89. Seongwan Kim (Yonsei University)
90. Sven Klomp (Leibniz Universität Hannover)
91. Masaaki Kobayashi (Canon Inc.)
92. Kenji Kondo (Sony corporation)
93. Gergely Korodi (Research In Motion)
94. Faouzi Kossentini (eBrisk Video Inc.)
95. Adi Kouadio (EBU Technical)
96. Jumpei Koyama (FUJITSU LABORATORIES LTD.)
97. Peter Kuhn (European Patent Office)
98. Polin Lai (Samsung)
99. Jani Lainema (Nokia)
100. Guillaume Laroche (Canon INC)
101. Chulhee Lee (Yonsei Univ.)
102. Gwo Giun (chris) Lee (ITRI)
103. Jaeho Lee (Yonsei university)
104. Jaejoon Lee (Samsung Electronics)
105. Jinho Lee (ETRI)
106. Ju Ock Lee (Sejong University)
107. Sangyoun Lee (Yonsei university)
108. Shawmin Lei (MediaTek Inc.)
109. Cui Li (Hanyang university)
110. Guichun Li (Huawei Technologies)
111. Ming Li (ZTE Corporation)
112. Xiang Li (MediaTek (Beijing) Inc.)
113. Chong Soon Lim (Panasonic Singapore Laboratories)
114. Jaehyun Lim (LG Electronics)
115. Jeongyeon Lim (SK Telecom)

116. Sung-Chang Lim (ETRI (Electronics and Telecommunications Research Institute))
117. Shan Liu (MediaTek USA)
118. Ajay Luthra (Motorola Mobility)
119. Siwei Ma (Peking University)
120. Detlev Marpe (Fraunhofer HHI)
121. Gaëlle Martin-Cocher (Research in Motion)
122. Pierre Marty (ALLEGRO DVT)
123. Ikeda Masaru (Sony Corporation)
124. Ken Mccann (ZetaCast / Samsung)
125. Holger Meuel (Leibniz Universität Hannover)
126. Akira Minezawa (Mitsubishi Electric Corporation)
127. Koohyar Minoo (Motorola Mobility Inc.)
128. Kiran Misra (Sharp Corporation)
129. Marta Mrak (British Broadcasting Corporation)
130. Ohji Nakagami (Sony Corporation)
131. Matthias Narroschke (Panasonic)
132. Tung Nguyen (Fraunhofer HHI)
133. Takahiro Nishi (Panasonic)
134. Andrey Norkin (Ericsson)
135. Chakib Nouira (Telnet Inc)
136. Jens-Rainer Ohm (RWTH Aachen University)
137. Patrice Onno (Canon Inc.)
138. Krit Panusopone (Motorola Mobility)
139. Dong-Jin Park (Chips&Media,Inc.)
140. Jeonghoon Park (SAMSUNG ELECTRONICS Co., Ltd.)
141. Joonyoung Park (LG electronics)
142. Seungwook Park (LG Electronics)
143. Chris Payson (Broadcom Corporation)
144. Wen-Hsiao Peng (ITRI International)
145. Mohamad Raad (RaadTech Consulting)
146. Arturo Rodriguez (Cisco Systems)
147. Thomas Rusert (Ericsson AB)
148. Hashimoto Ryoji (Renesas Electronics)
149. Mangesh Sadafale (Texas Instruments)
150. Shinichi Sakaida (NHK)
151. Jesus Sampedro (Polycom)
152. Hisao Sasai (Panasonic Corporation)
153. Kazushi Sato (Sony Corp.)
154. Nicholas Saunders (Broadcast & Professional Research Labs, Sony Europe Ltd.)
155. Ankur Saxena (Samsung Telecommunications America)
156. Heiko Schwarz (Fraunhofer Gesellschaft zur Förderung der angewandten Forschung)
157. Andrew Segall (Sharp Corporatoin)
158. Shun-Ichi Sekiguchi (Mitsubishi Electric Corporation)
159. Chanwon Seo (Sejong University)
160. Suman Sharma (Intel Corporation)
161. Karl Sharman (Broadcast & Professional Research Labs, Sony Europe Ltd.)
162. Bz (bazhong) Shen (Broadcom)
163. Qiu Shen (Huawei Technologies Co., Ltd)
164. Youji Shibahara (Panasonic Corporation)
165. Masato Shima (Canon Inc.)
166. John Sievers (LifeSize Communications)
167. Donggyu Sim (Kwangwoon University)
168. Rickard Sjoberg (Ericsson)
169. Joel Sole (Qualcomm)
170. Eunyong Son (LG Electronics)
171. Karsten Suehring (Fraunhofer HHI)
172. Toshiyasu Sugio (Panasonic Corporation)
173. Gary Sullivan (Microsoft Corp.)
174. Huifang Sun (Mitsibishi Electric Research labs)
175. Jaewon Sung (LG Electronics)
176. Teruhiko Suzuki (Sony Corp.)
177. Yoshinori Suzuki (NTT DOCOMO, Inc.)
178. Vivienne Sze (Texas Instruments)

179. Ali Tabatabai (Sony Electronics)
180. Seishi Takamura (NTT Cyber Space Laboratories)
181. Thiow Keng Tan (NTT DOCOMO, Inc)
182. Yih Han Tan (Institute for Infocomm Research)
183. Jean-Marc Thiesse (Orange Labs)
184. Herbert Thoma (Fraunhofer IIS)
185. Ikai Tomohiro (Sharp Corporation)
186. Pankaj Topiwala (FastVDO LLC)
187. Alexandros Tourapis (Dolby Laboratories / Magnum Semiconductor)
188. Motoharu Ueda (JVC KENWOOD Holdings, Inc.)
189. Kemal Ugur (Nokia)
190. Glenn Van Wallendael (Ghent University - IBBT - Multimedia Lab)
191. Anthony Vetro (Mitsubishi Electric)
192. Jerome Vieron (ATEME)
193. Viktor Wahadaniah (Panasonic Corporation)
194. Wade Wan (Broadcom Corporation)
195. Jian Wang (Polycom Inc.)
196. Lu Wang (The Hong Kong Applied Science and Technology Research Institute Company Limited)
197. Xianglin Wang (Qualcomm, Inc.)
198. Ye-Kui Wang (Huawei Technologies)
199. Thomas Wedi (Panasonic)
200. Krzysztof Wegner (Poznan University of Technology)
201. Xing Wen (HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY)
202. Stephan Wenger (Vidyo, Inc.)
203. Thomas Wiegand (Fraunhofer HHI)
204. Mathias Wien (RWTH Aachen University)
205. Kwanghyun Won (Sungkyunkwan University)
206. Ping Wu (ZTE (UK) Ltd)
207. Jizheng Xu (Microsoft Corp.)
208. Tomoo Yamakage (Toshiba) [Remotely]
209. Tomoyuki Yamamoto (SHARP Corporation)
210. Mingyuan Yang (HUAWEI Technologies CO., LTD)
211. Sehoon Yea (LG Electronics)
212. Chuohao Yeo (Institute for Infocomm Research)
213. Peng Yin (Dolby Laboratories Inc.)
214. Jeon Yongjoon (LG Electronics)
215. Sunmi Yoo (Kwangwoon University)
216. Tomonobu Yoshino (KDDI)
217. Haoping Yu (Huawei Technologies (USA))
218. Lu Yu (The MIIT of P.R.China)
219. Xiang Yu (Research in Motion)
220. Yong Yu (Broadcom Corp)
221. Li Zhang (Peking University)
222. Ximin Zhang (MediaTek)
223. Xiaozhen Zheng (Huawei Technologies Co., Ltd.)
224. Minhua Zhou (Texas Instruments Inc)
225. Xiaosong Zhou (Apple Inc.)
226. Xingguo Zhu (Zhejiang University)