Recent Progresses on ITU/MPEG HEVC and 3DVC

杭學鳴教授 國立交通大學 電工程系
李國君副教授 國立成功大學電機工程系
彭文孝助理教授 國立交通大學資訊工程系

Outline

- Part 1: General Background
- Part 2: HEVC – High Efficiency Video Coding (JCT-VC)
- Part 3: 3DVC – 3D Video Coding

  → JCT-3D

Recent Progresses on ITU/MPEG HEVC and 3DVC

Part 1: Background

杭 學 鳴 (H.-M. Hang)
國立交通大學
(National Chiao Tung Univ.)
電子工程學系
(Dept. of Electronic Eng.)
Email: hmhang@mail.nctu.edu.tw

Entertainment Devices in Daily Life

Standards Organizations

- **ITU** – International Telecommunication Union
- **ISO** – International Standardization Organization
- **IEC** – International Electrotechnical Commission

- **ISO/IEC MPEG (MPEG2, MPEG4)**
- **ITU-T VCEG (H.263, H.264)**

Image/Video Standards

- **ISO/IEC JTC1 SC29** – ISO and IEC Joint Technical Committee (on Information Technology) Subcommittee 29 (Coding of audio, picture, multimedia and hypermedia)
  - **Working Group (WG) 1:**
    JBIG (Joint Bi-level Image Group) – 1-bit to 4/5-bit still pictures
    JPEG (Joint Photographic Experts Group) – 8-bit or more still pictures
- **ISO/IEC JTC1 SC29**
  - **WG 11: MPEG** (Moving Picture Experts Group) – Motion pictures
  - **WG 12: MHEG** (Multimedia-Hypermedia Experts Group) – Multi/Hyper-media exchange format

Progress in Image/Video Coding

H.261 (CCITT/ITU;1984-88, 90) – *video (videoconf.)*

→ **JPEG** (1986-89-92) – *image (**Digital Camera**)*

→ MPEG-1 (1988 – 92) – *video (VCD)*

→ **MPEG-2** (1990 – 94) – *video (**DVD, DTV**)*

→ MPEG-4 part 2 (1992 – 98) – *video (Internet, WL)*

→ H.263 (1993 – 96; ver.3: 2000) – *video (WL)*

→ JPEG2000 (1996 – 2001) – *image*

→ **H.264** (**MPEG-4 part 10**) AVC (1998 – 03) *(**WL, HD-DVD**)*

→ AVC Amd. (2003 – 2007) – ***Scalable Video Coding***

→ AVC Amd (-- 2008) – ***Multiview Video Coding***

→ ***High Efficiency Video Coding*** 2012 (H.265?)

→ ***3DVC*** *(H.265 extensions?)*

NCTU & NCKU MPEG Activity

- 1999 -- Tihao Chiang (蔣迪豪), C.J. Tsai (蔡淳仁), Wen Peng (彭文孝) and H.-M. Hang (杭學鳴), NCTU; Chris Lee (李國君), NCKU
- Tihao Chiang : Co-editor, MPEG-4 Part 7 **Optimised Reference Software** (Done)
- C.J. Tsai : Co-editor, MPEG-21 Part 12 **Multimedia Test Bed for Resource Delivery** (Done)
- C. Lee: Reconfigurable Video Codec
- 100+ contributions (input and output documents) in the past 8 years. Dr. Y.-S. Tung (童怡新); **ITRI**
- ***Example:*** **Call for Proposal on Scalable Video Coding** (Feb. 2004) – 2 out of 14 proposals
- ***CfP*****: HEVC proposal**: 2010.2 – one out of 27

MPEG Committee

- Convener: Leonardo Chiariglione
- Standards:
  - -- MPEG-1: done
  - -- MPEG-2: done
  - -- MPEG-4: done?!
  - -- MPEG-7: done?!
  - -- MPEG-21: done?
  - -- MPEG A,B,C,D,E: on-going

MPEG-2:*1996 Emmy for Technical Excellence*

Leonardo

- The Last Talk of Prof. Tanimoto (2012.3)

MPEG Chair Dr. Chiariglione at NCTU (2003.12)

http://www.chiariglione.org

Emerging 3D Entertainment

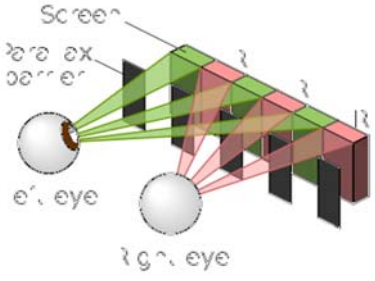
- ***Avatar* (2009 film):** the highest-grossing film of all time in 30 countries (USA, …) (Wiki)

  ← old 3D technology with "new" special effects

- Auto-stereoscopic display (glass-free): Philips (9 views), LG (10 views) …
- 3D gaming: Nintendo 3DS
- Mobile phone:

  HTC Evo 3D,

  LG Optimus 3D



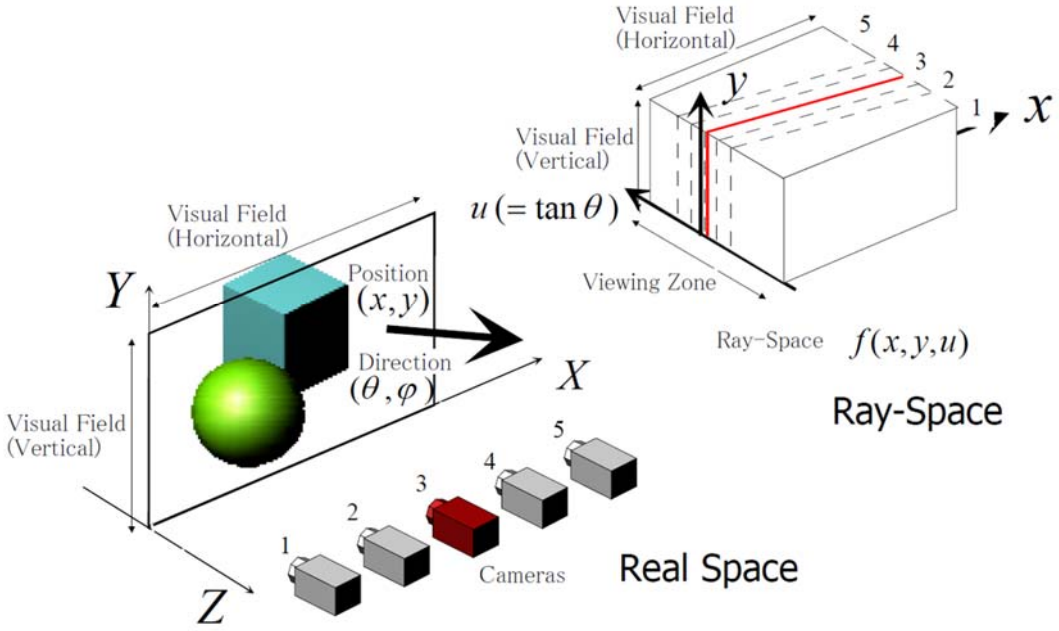
Free-viewpoint TV

- Synthesize a "new" view at "any" 3D location from a given set of views – Virtual-view Synthesis
- 10 years ago, proposed to MPEG by Prof. Masayuki Tanimoto, Nagoya University, Japan.
- His approach is the so-called ***ray space representation***
- Other *equivalent* approach: light field.
- MPEG 1st phase work item: MVC (done)
- MPEG 2nd phase: 3D Video Coding (3DVC)

Matrix "Bullet – Time"

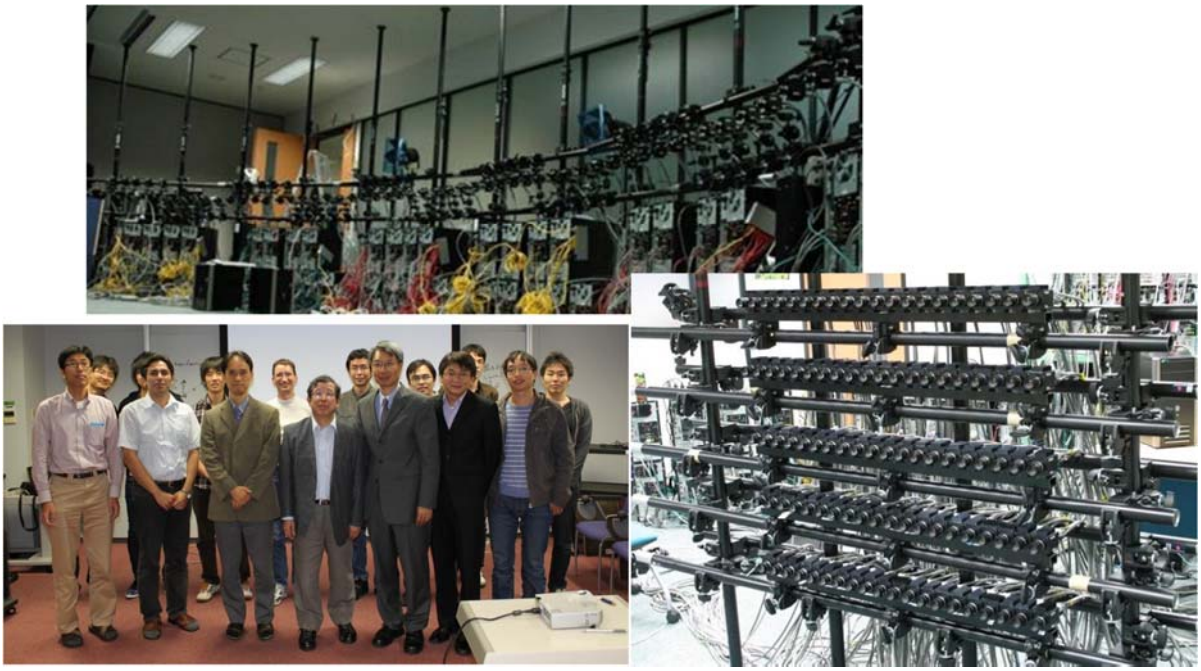
-- 120 cameras

Multi-Camera System Illustration



[Prof. Tanimoto's slice]

Nagoya 100 Camera System



100th MPEG Meeting

- *Brief History*
  - 1st meeting: May 1988 – Hiroshi Yasuda & Leonardo Chiariglione (Ottawa, Canada)
  - 25 years …
  - 100th meeting: April 2012 -- Leonardo Chiariglione (Geneva, Switzerland)

- *Proc. IEEE*, April 2012


INVITED PAPER

Multimedia Standards: Interfaces to Innovation

A history of the Motion Picture Experts Group is provided and its probable future activities are discussed, including understanding 3-D audio–video, machine design, and creating best practices and models.

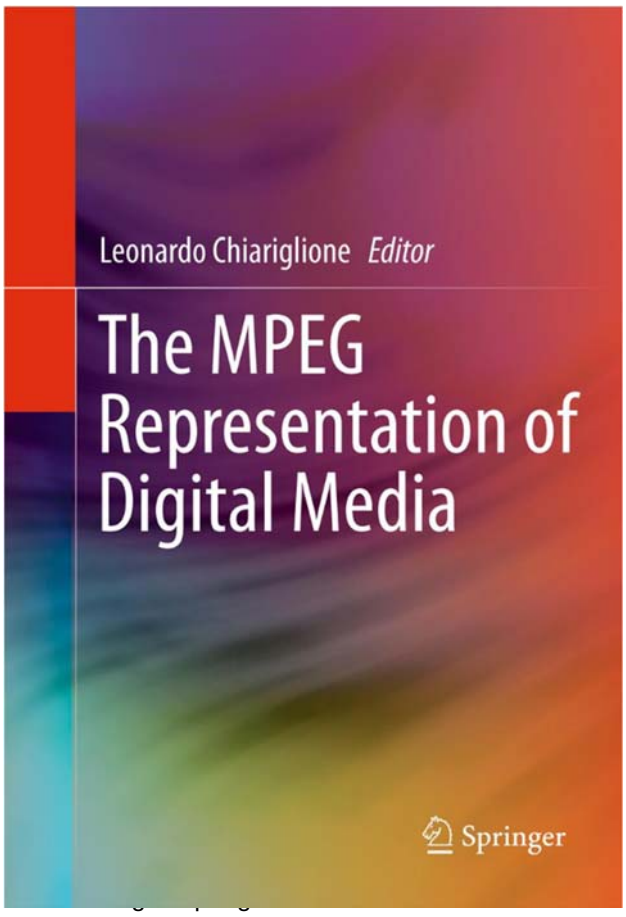
By Leonardo Chiariglione

ABSTRACT | Standardization is concerned with interfaces; industry is concerned with systems. This papers brings the evidence brought by the MPEG standardization group to show how, through the proper management of interface evolution, the constituent industries have been able to achieve product and service interoperability, room for differentiation, and opportunities for innovation in the context of the tectonics shift also known as convergence.

KEYWORDS | Compression; convergence; digital media; standards

same "standard" if C is ever to be able to hav screw into the nut. In the case of nuts and standard is the "thread" which represents th between the nut and the bolt.

Standards play a fundamental role in enabl sified industry. Once a standard has been publ the industry has adopted it—independent ma can build products conforming to it that can i reach a potentially global market. Users can ducts that are more convenient for their different suppliers.



MPEG-A,B,C,…

- **MPEG-A** (ISO/IEC 23000) Multimedia Application Formats
- **MPEG-B** (ISO/IEC 23001) MPEG Systems Technologies
- **MPEG-C** (ISO/IEC 23002) MPEG Video Technologies
- **MPEG-D** (ISO/IEC 23003) MPEG Audio Technologies
- **MPEG-E** (ISO/IEC 23004) Multimedia Middleware (M3W)
- **MPEG-H High Efficiency Video Coding (HEVC) -- ITU**
- **MPEG-M** (ISO/IEC 23006) MPEG Extensible Middleware (MXM)
- **MPEG-U** (ISO/IEC 23007) Rich-Media User Interface
- **MPEG-V** (ISO/IEC 23005) Media Context and Control

a video service platform

- WimTV (http://wim.tv/) – A platform and offers services:
  1. Split Content payment (**WimPay**)
  2. Video on demand (**WimVod)**
  3. Live streaming (**WimLive**)
  4. Marketplace (**WimTrade**)
- WimTV enables the economical video services

(from Leonardo's slice)

Gary and *His* Emmy Award

- Gary J. Sullivan (Microsoft) VCEG Chair
- ITU VCEG started in 1984

=> H.261, (H.262), H.263, H.264, H.265

- MPEG/H.264 **AVC** received – ATAS **Primetime Emmy Engineering Award** (Aug. 2008)

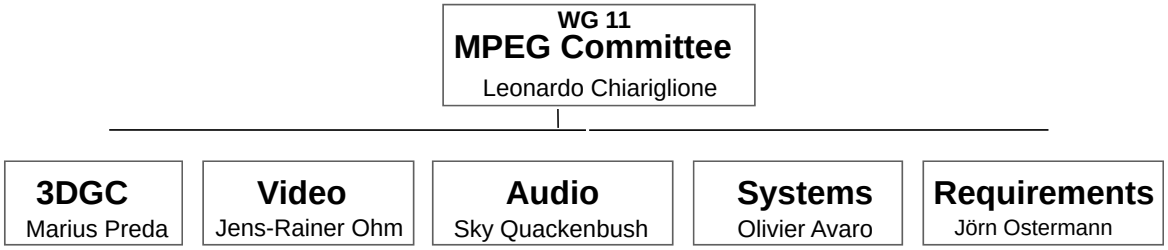
– Paired NATAS **Tech & Eng Emmy Awards** (Jan 2009)

MPEG/VCEG Meetings (2011-13)

	Year	Month	Days	City	Country
97	2011	07	18-22	Torino	Italy
98	2011	11-12	28-02	Geneva	Switzerland
99	2012	02	06-10	San José, CA	USA
100	2012	04-05	30-04	Geneva	Switzerland
101	2012	07	16-20	Stockholm	Sweden
102	2012	10	15-19	Shanghai	China
103	2013	01	21-25	Geneva	Switzerland
104	2013	04	22-26	Incheon	Korea

MPEG Meetings

- 4 meetings a year; 5+ days per meeting
- ~300 participants
- Over 200 companies
- Meetings are divided into groups



- ITU/MPEG HEVC meetings: 200+ participants, 10+ days; two tracks

The MPEG Process

1. **Exploration**
   Search for new technology
2. **Requirements**
   Establish work scope
   Call for Proposals
3. **Competitive phase**
   Do Homework
   Response to CfP
   Initial technology selection
4. **Collaborative phase**
   Core Experiments
   Working Drafts
5. **Standardization**
   Ballots
   National Body Comments
6. **Amendment**
   Adding new technology
7. **Corrigenda**
   Corrective actions
8. **New subdivisions**
   Add new non-compatible technology

Stages of Standardization

WD - Working Draft
CD - Committee Draft
FCD - Final Committee Draft
FDIS© - Final Draft International Standard
IS © - International Standard
© indicates ISO copyright

PDAM - Proposed Draft Amendment
FPDAM - Final Proposed Draft Amendment
FDAM © - Final Draft Amendment
AMD © - Amendment

Recent Progresses on ITU/MPEG HEVC and 3DVC

Part 2: HEVC

彭 文 孝 (W.-H. Peng)
國立交通大學
(National Chiao Tung Univ.)
資訊工程學系
(Dept. of Computer Sci.)
Email: wpeng@cs.nctu.edu.tw

Outline

- HEVC Project Overview
- Performance and Complexity
- HEVC Tool Features
- Scalable Extension to HEVC
- Concluding Remarks

The MPEG Vision

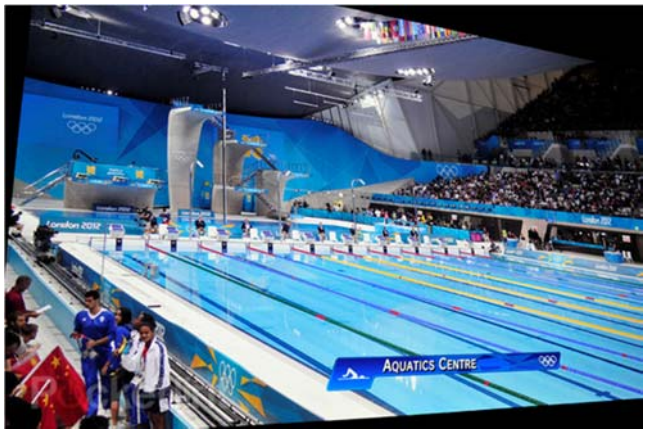
- *Three years ago in 2009, it was expected*
  - -- **Ultra-HD** (e.g., 4kx2k) video will emerge
  - -- **Mobile HD** applications will become popular
  - -- Video bitrate using current technology will go up faster than the network infrastructure
- *Now, we see …*

London 2012 Olympic Games

- Immersive experience in **Super Hi-Vision**
- 16 times the resolution of Full HD (1080p)

Pioneered by NHK & BBC

7680x4320



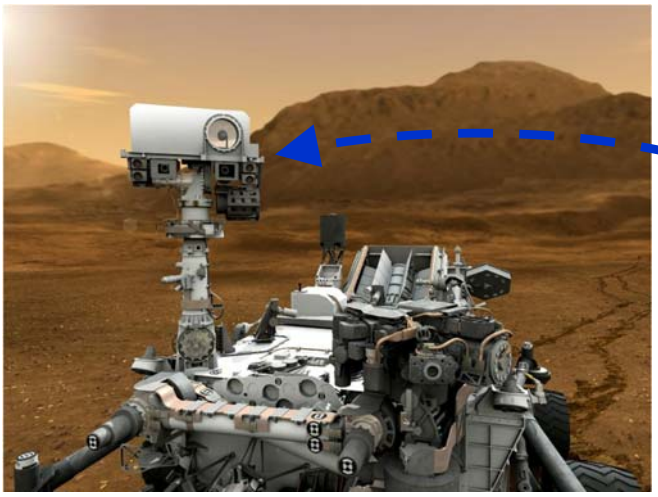
Mobile HD Era

Desire HD	iPhone 4S	Galaxy SIII	New iPad	808 Pureview
800x480	960x640	**1280x720**	**2kx1.5k**	640x480
8M,**720p**	8M,**1080p**	8M,**1080p**	5M,**1080p**	**41M**,**1080p**

2010 **2011** **2012**

HD Video “Everywhere”

Even on the ***Mars*** *. . .*



Curiosity Rover

[Two Mastcam Camera Heads]
- Image Capturing: 1200x1200
- Video Recording: **1280x720/10p**

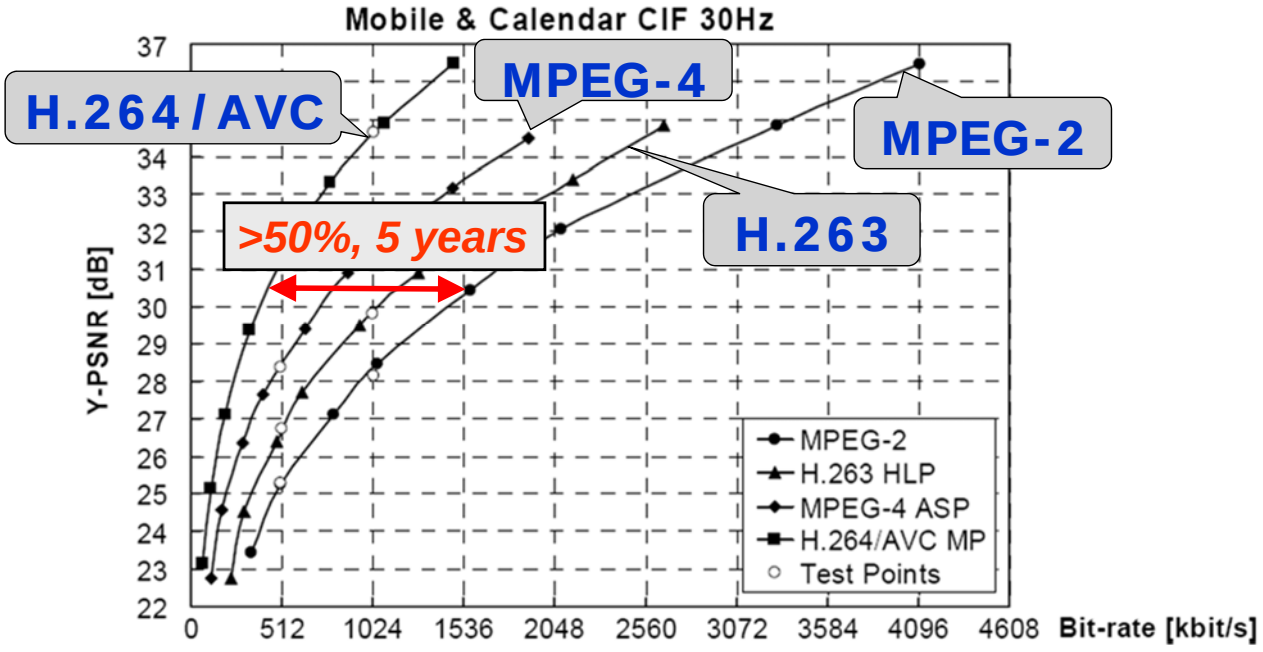
NASA, http://www.nasa.gov/mission_pages/msl/multimedia/gallery/pia14175.html
MSSS, http://www.msss.com/science/msl-mastcam-instrument-description.php

Go beyond Full HD

High Efficiency Video Coding (HEVC)

- The latest draft video coding standard developed by a joint team of experts from ISO/IEC MPEG and ITU-T VCEG
- **Goal:** substantially better performance than the H.264/AVC standard, especially in coding HD and Ultra-HD video
- **International Standard** (IS) in 2013; currently in DIS stage

Moore's Law of Video Coding



T. Wiegand, H. Schwarz, A. Joch, F. Kossentini, G. Sullivan, "Rate-Constrained coder control and comparison of video coding standards", IEEE Trans. CSVT, 2003

Timeline

- **2005:** VCEG Exploration
- **2009:** MPEG Call-for-Evidences
- **2010/01:** VCEG & MPEG formed Joint Collaborative Team on Video Coding (JCT) → **Final Call-for-Proposals (CfP)**
- **2010/04:** 1st JCT Meeting (Dresden, Germany) → **27 proposals received**
- **2010/10:** Working Draft and HM-1.0
- **2012/07:** **Draft International Standard** (DIS)

Call-for-Proposals by the Numbers

- **27** proposals
- **145** test cases -- 2 weeks to complete 1 round of simulation using 120 CPU cores
- **800** observers -- 4 weeks to rate all proposals (FUB Italy; EPFL Switzerland)
- **9'576.40** CHF ($10K) per proposal

Test Conditions

- All Intra (**AI**), Random Access (**RA**), Low Delay (**LD**)
- High Efficiency vs. Low Complexity
- 24 Sequences (4 rate points each)

	Setting	Resolution	Fps	# of Seqs
Class A	AI, RA	2560x1600	30	4
Class B	AI, RA, LD	1920x1080	24, 50, 60	5
Class C	AI, RA, LD	832x480	30, 50, 60	4
Class D	AI, RA, LD	416x240	30, 50, 60	4
Class E	AI, LD	1280x720	60	3
Class F	AI, RA, LD	480p, 720p	20, 30, 50	4

8kx4k 10-bit Sequences

- Contributed by NHK

Nebuta Festival
300 frames, 60 fps

Steam Locomotive Train
300 frames, 60 fps

Participants

TI & MIT	RWTH Aachen	NHK & Mitsubishi
Hitachi	SK telecom, Sejong Univ. &	**NCTU**
Sony	Sungkyunkwan Univ.	Samsung & BBC
NEC	France Telecom, NTT, NTT	BBC & Samsung
Sharp	DOCOMO, Panasonic &	Renesas
Intel	Technicolor	ETRI
Mitsubishi	Fujitsu	
JVC	Fraunhofer HHI	
MediaTek	Toshiba	
LG	Microsoft	
Huawei &	Tandberg, Ericsson & Nokia	
Hisilicon	RIM	
	Qualcomm	

1st JCT-VC Meeting

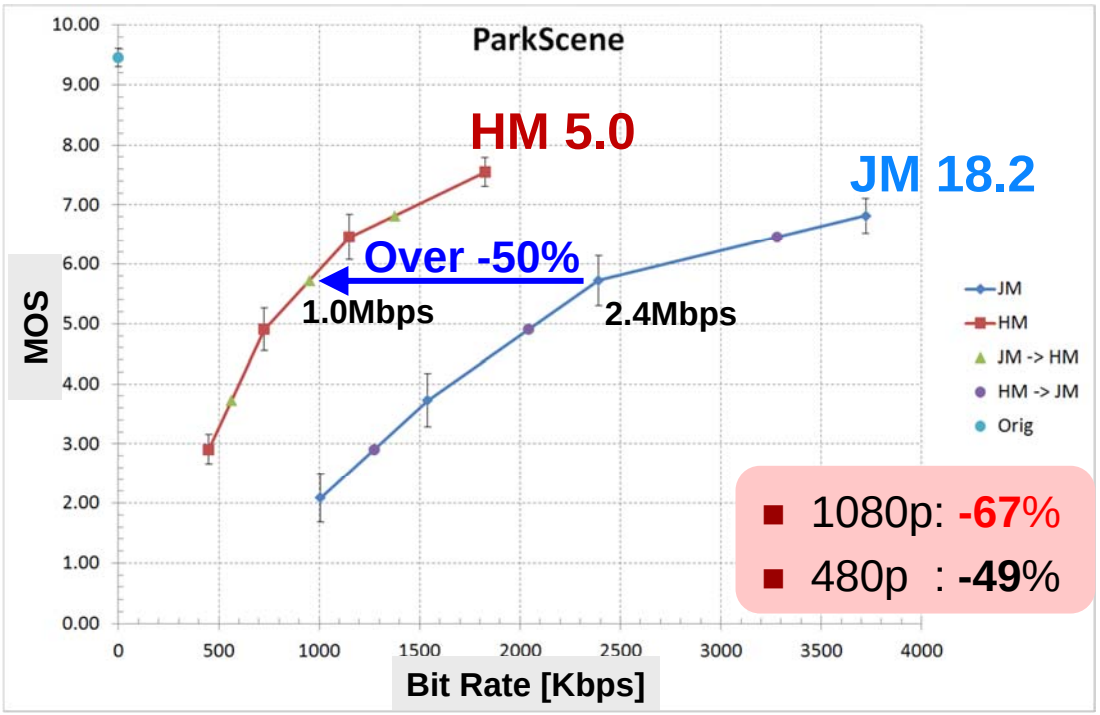
250+ Participants (Dresden, Germany)

Proposals to CfP

- All proposals basically **conceptually similar to** AVC (and prior standards)
  - Block-based
  - Variable block sizes
  - Block motion compensation
  - Fractional-pel motion vectors
  - Spatial intra prediction
  - Spatial transform of residual difference
  - Integer-based transform designs
  - Arithmetic or VLC-based entropy coding
  - In-loop filtering to form final decoded picture

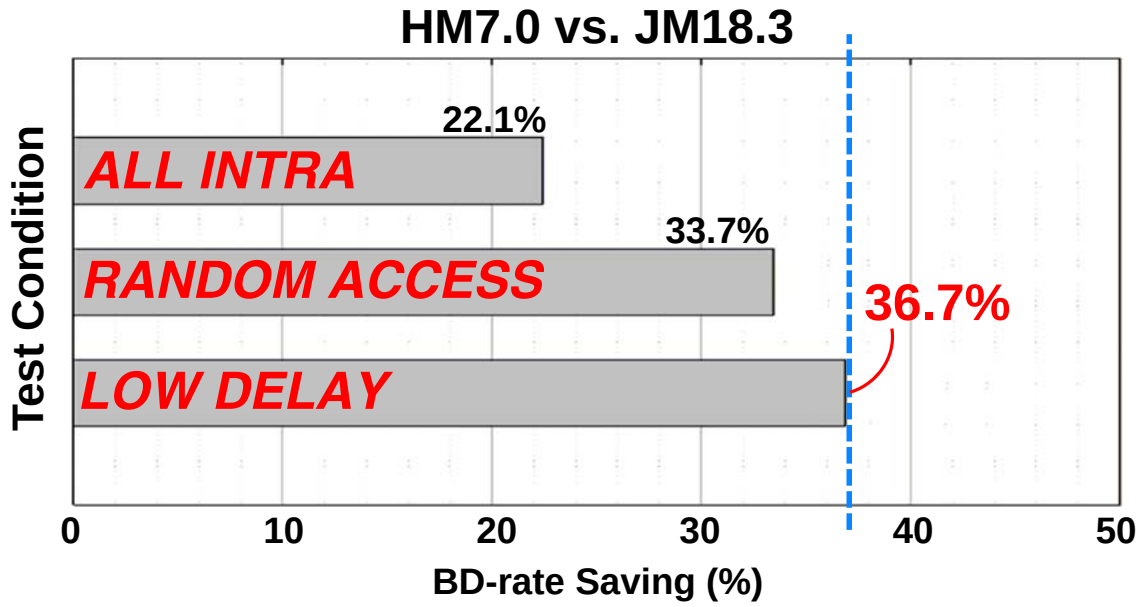
After two years of work …

Subjective Assessment



J. R. Ohm, G. J. Sullivan, F. Bossen, T. Wiegand, V. Baroncini, M. Wien, and J. Xu,"JCT-VC AHG report: HM subjective quality investigation (AHG22)", JCTVC-H0022, San José, CA, Feb., 2012.

Objective Measurement (1/2)



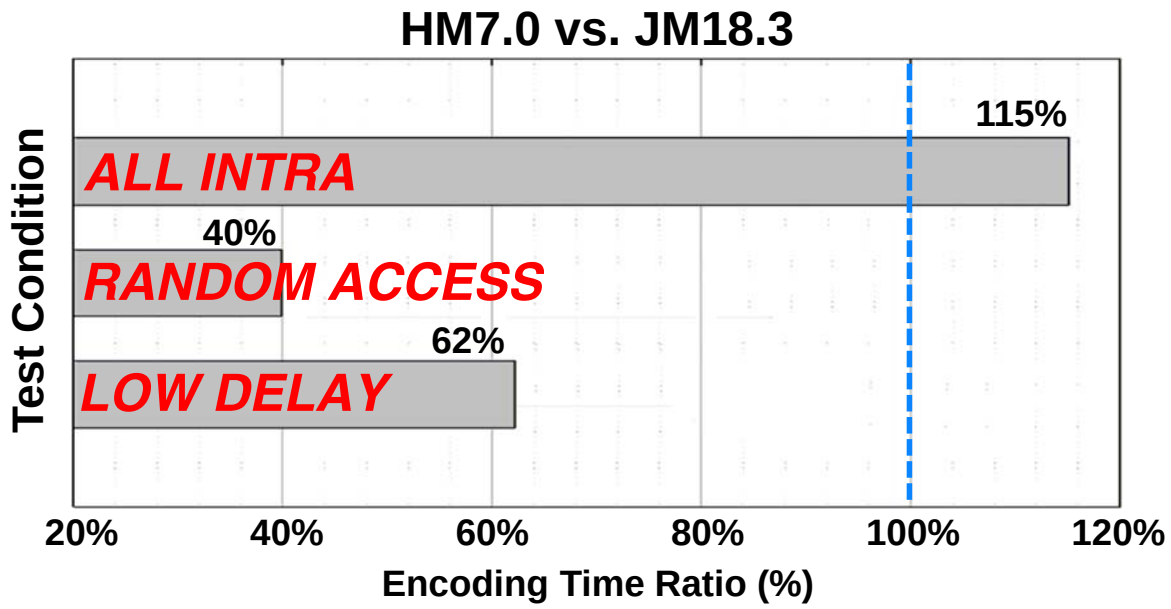
B. Li, G. J. Sullivan, and J. Xu,"Comparison of Compression Performance of HEVC Draft 7 with AVC High Profile", JCTVC-J0236, Stockholm, SE, July, 2012.

Objective Measurement (2/2)

Class	Resolution	All Intra	Radom Access	Low Delay
		Y BD-Rate	Y BD-Rate	Y BD-Rate
A	2500x1600	-23.7	-36.7	
B	1080p	-22.8	-39.7	-42.1
C	480p	-19.9	-30.0	-32.3
D	240p	-16.7	-27.2	-29.1
E	720p	-29.1		-43.7
F	480p, 720p	-22.8	-25.6	-28.8

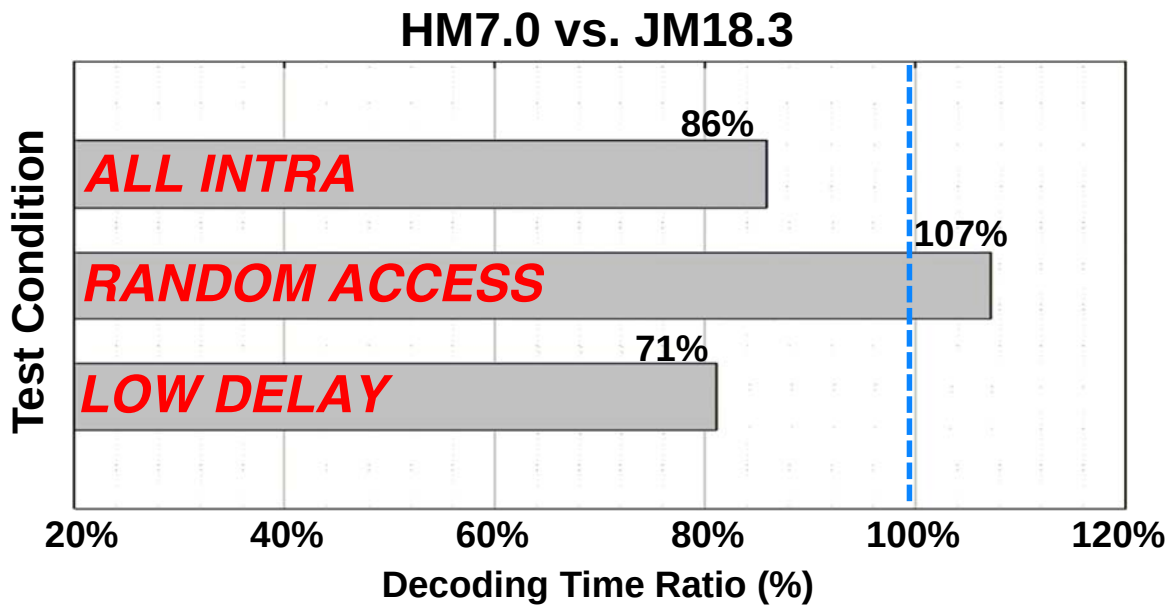
(Minus sign means coding gain)

Encoding Time Ratio



B. Li, G. J. Sullivan, and J. Xu,"Comparison of Compression Performance of HEVC Draft 7 with AVC High Profile", JCTVC-J0236, Stockholm, SE, July, 2012.

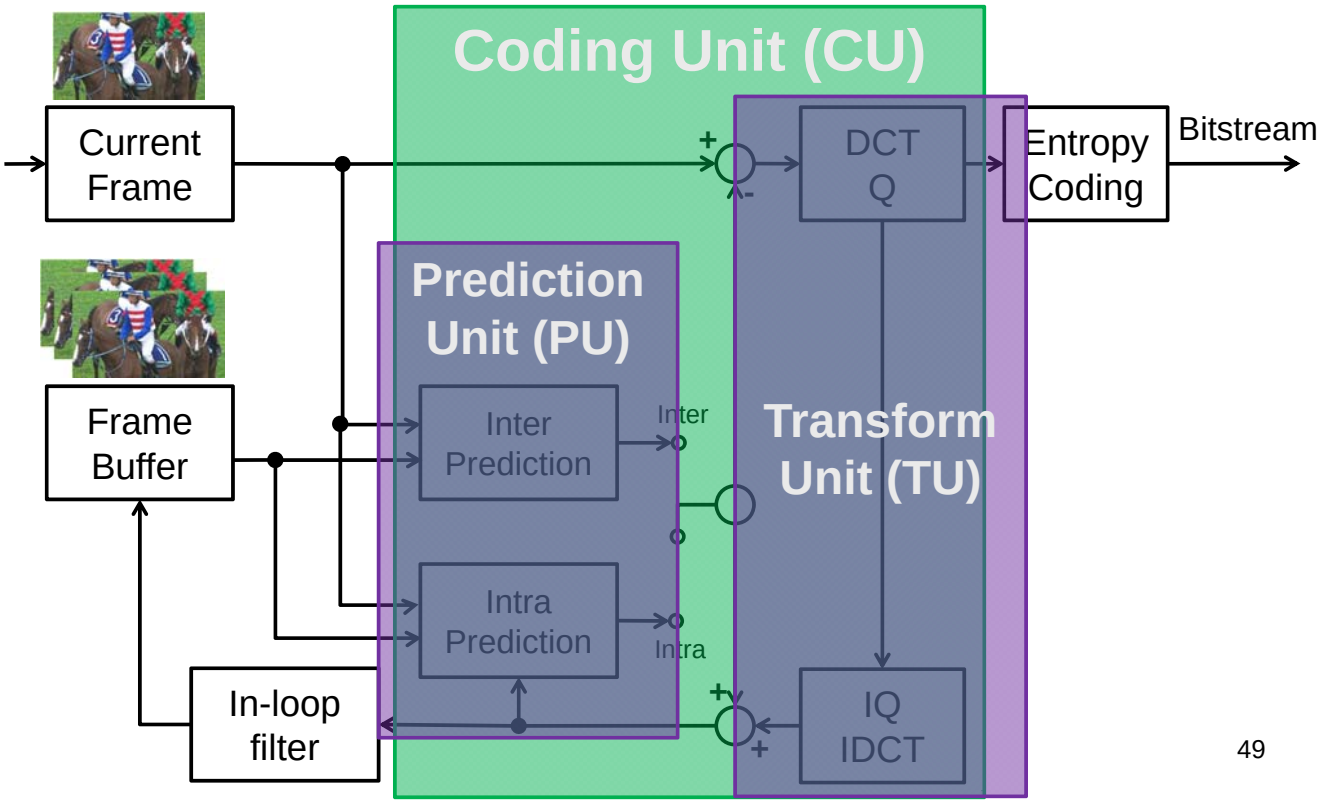
Decoding Time Ratio



B. Li, G. J. Sullivan, and J. Xu,"Comparison of Compression Performance of HEVC Draft 7 with AVC High Profile", JCTVC-J0236, Stockholm, SE, July, 2012.

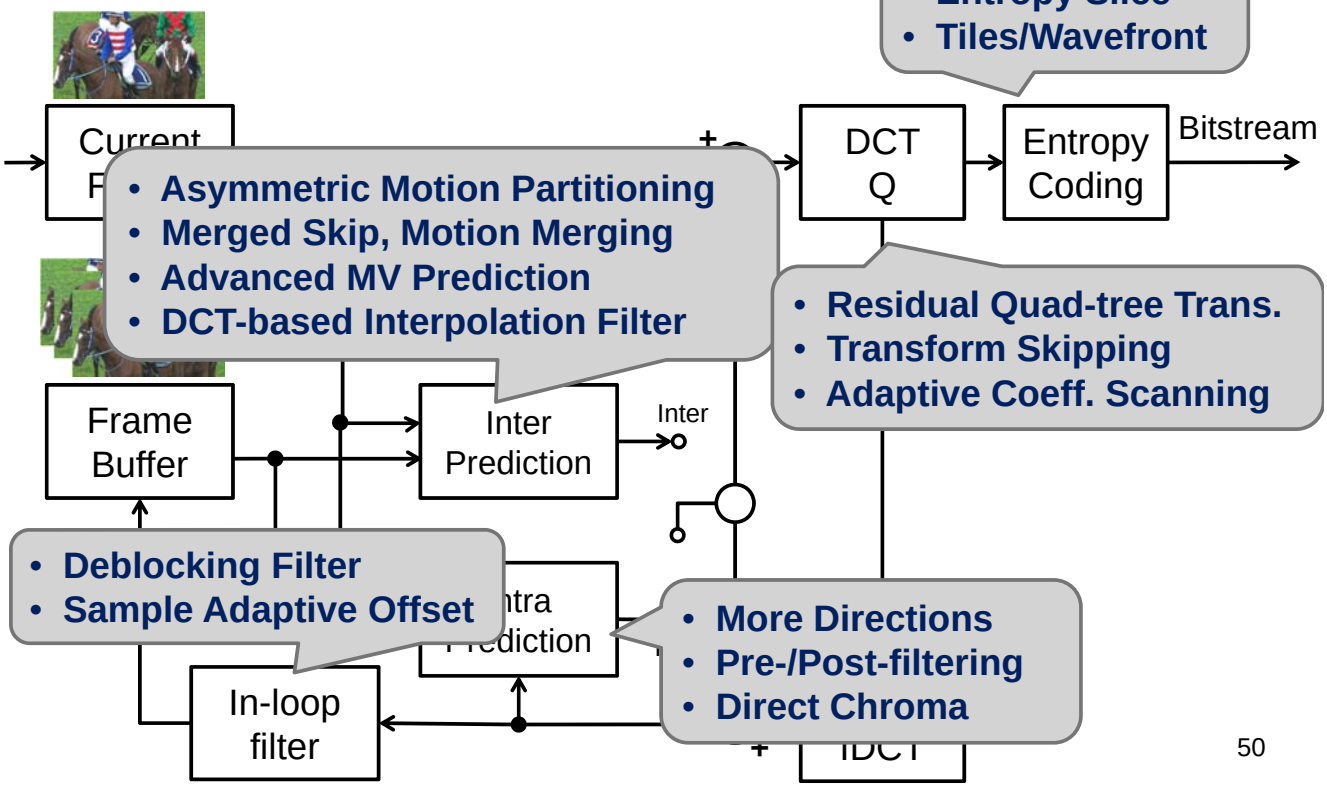
HEVC Tool Features

HEVC Tool Features



HEVC Tool Featu

- CABAC
- Entropy Slice
- Tiles/Wavefront



- Asymmetric Motion Partitioning
- Merged Skip, Motion Merging
- Advanced MV Prediction
- DCT-based Interpolation Filter

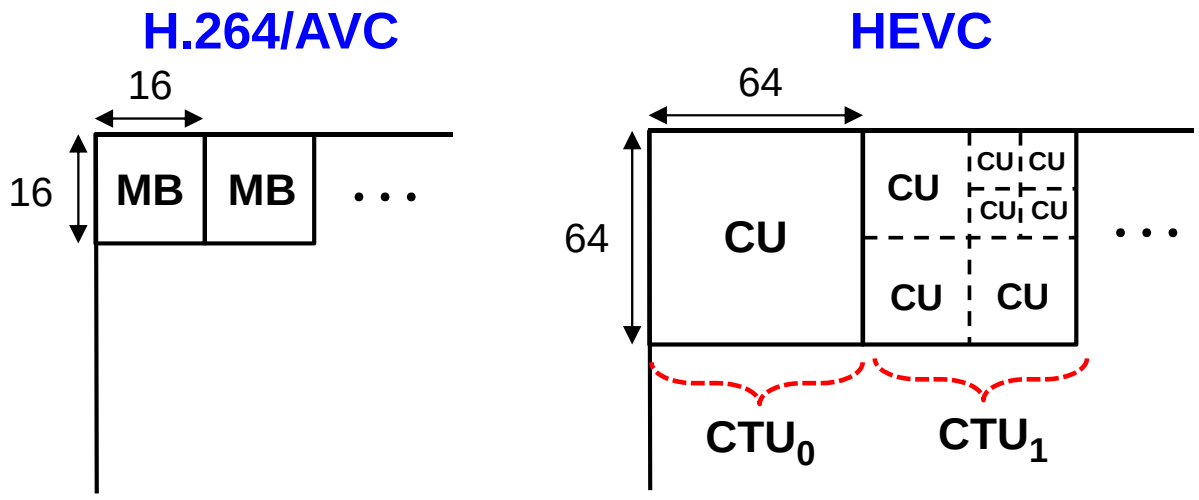
- Residual Quad-tree Trans.
- Transform Skipping
- Adaptive Coeff. Scanning

- Deblocking Filter
- Sample Adaptive Offset

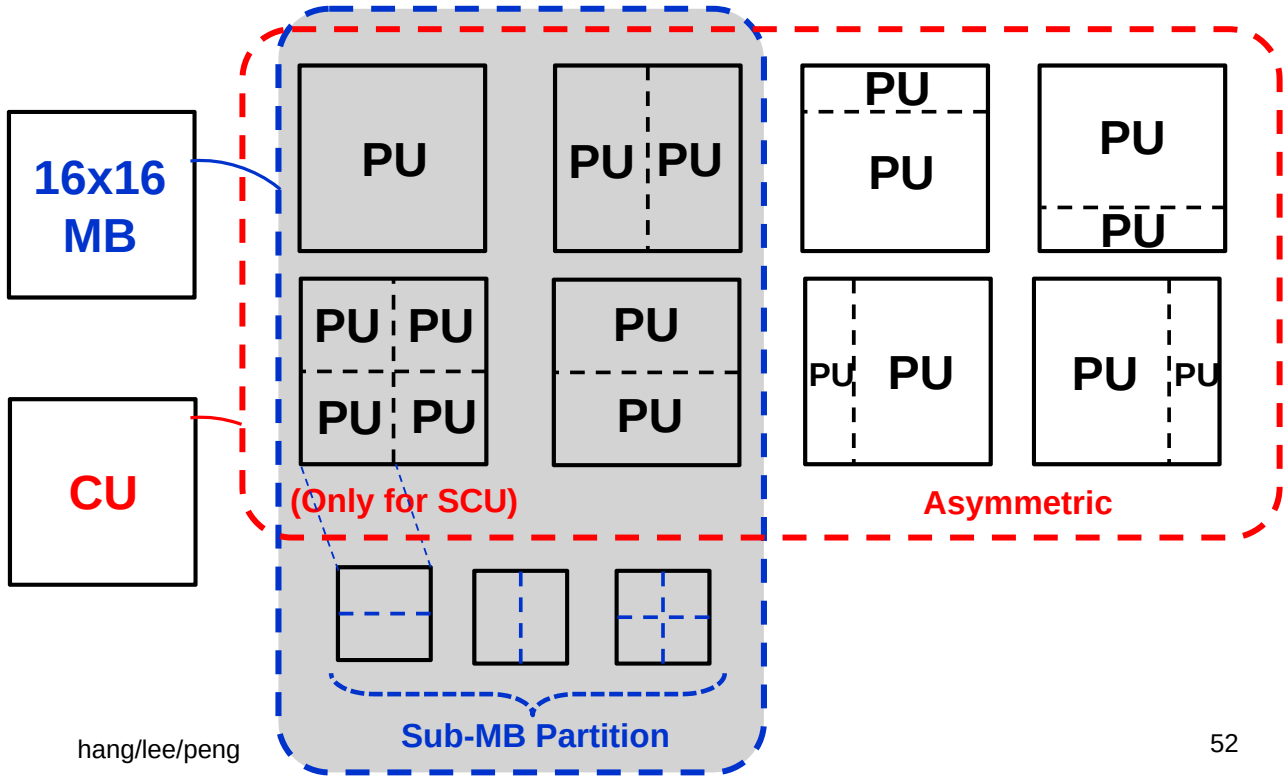
- More Directions
- Pre-/Post-filtering
- Direct Chroma

Coding Unit

- Basic unit for coding, conceptually similar to macroblock but now can be of variable size

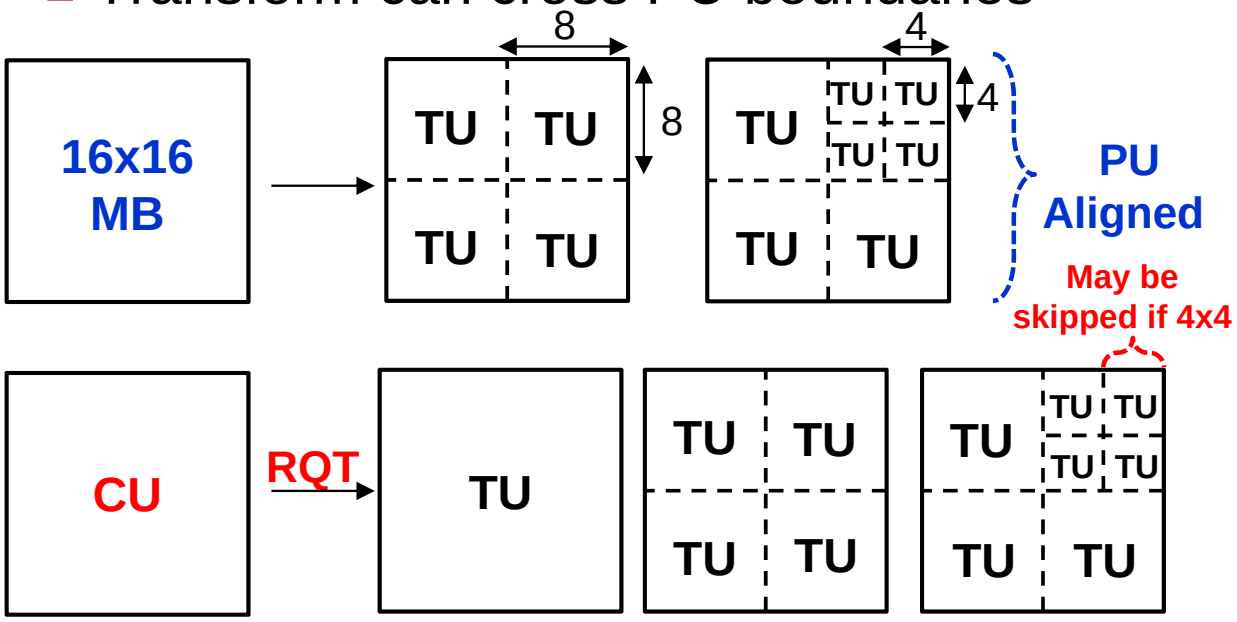


Prediction Unit



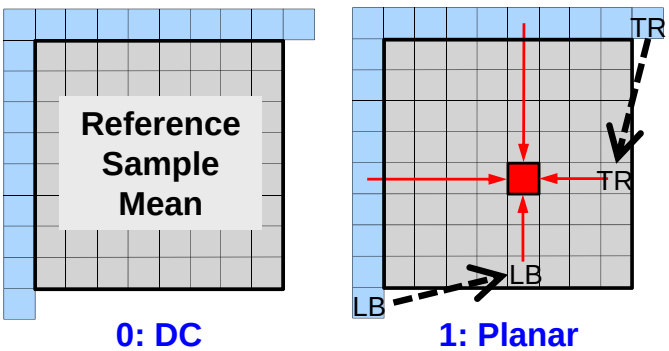
Transform Unit

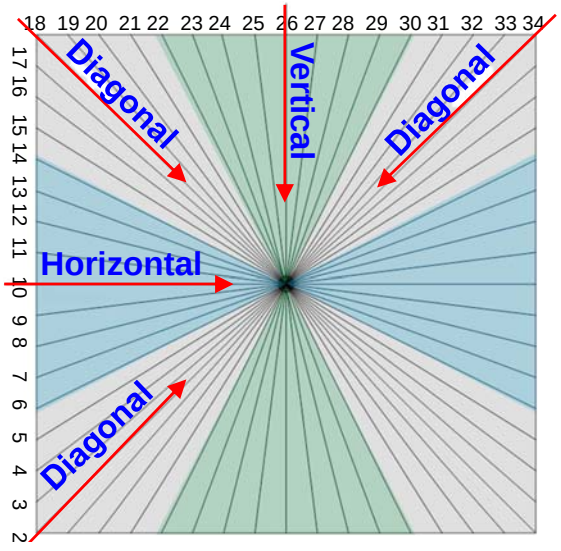
- Residual Quad-tree Transform (RQT)
- Transform can cross PU boundaries



Intra Prediction

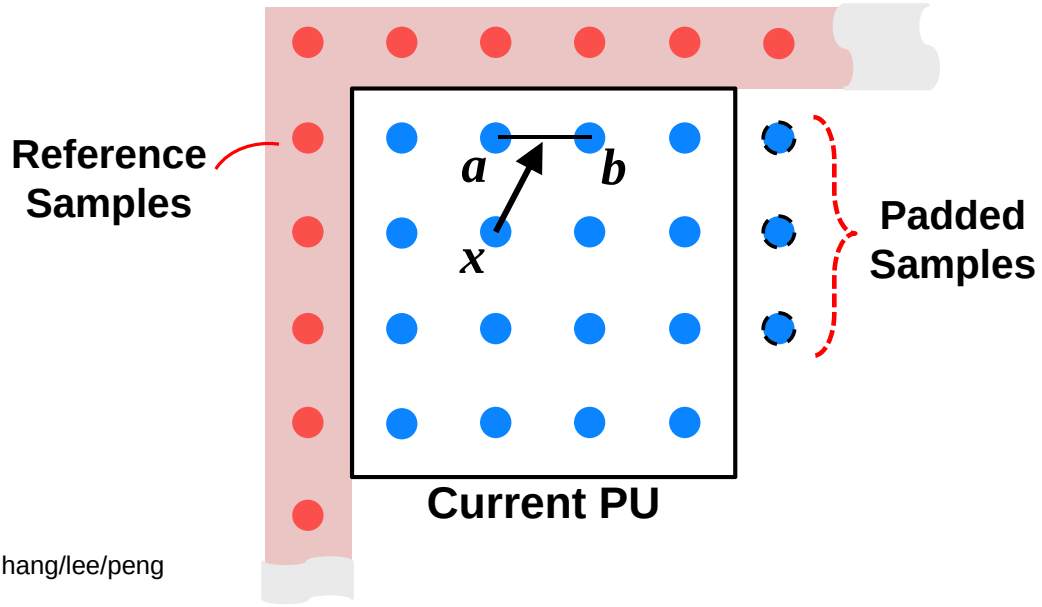
- More directions (up to 33)
- Adaptive pre-filtering of reference pixels
- Boundary smoothing for DC/Ver./Hor. modes
- Direct mode for Chroma





Lossless Coding

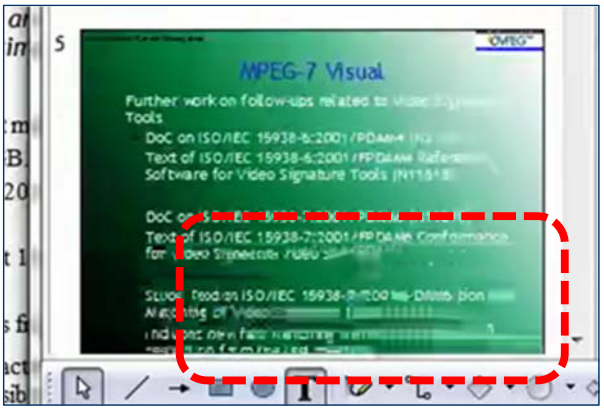
- Skip transform, quantization and in-loop filtering
- **Ex:** Sample-based angular intra prediction



Transform Skipping

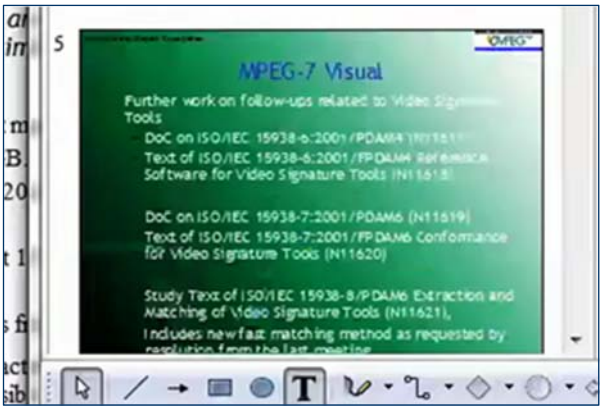
- Only applicable to **Intra** blocks with 4x4 TU
- Prove useful in coding **Screen Content Video**

TS Disabled



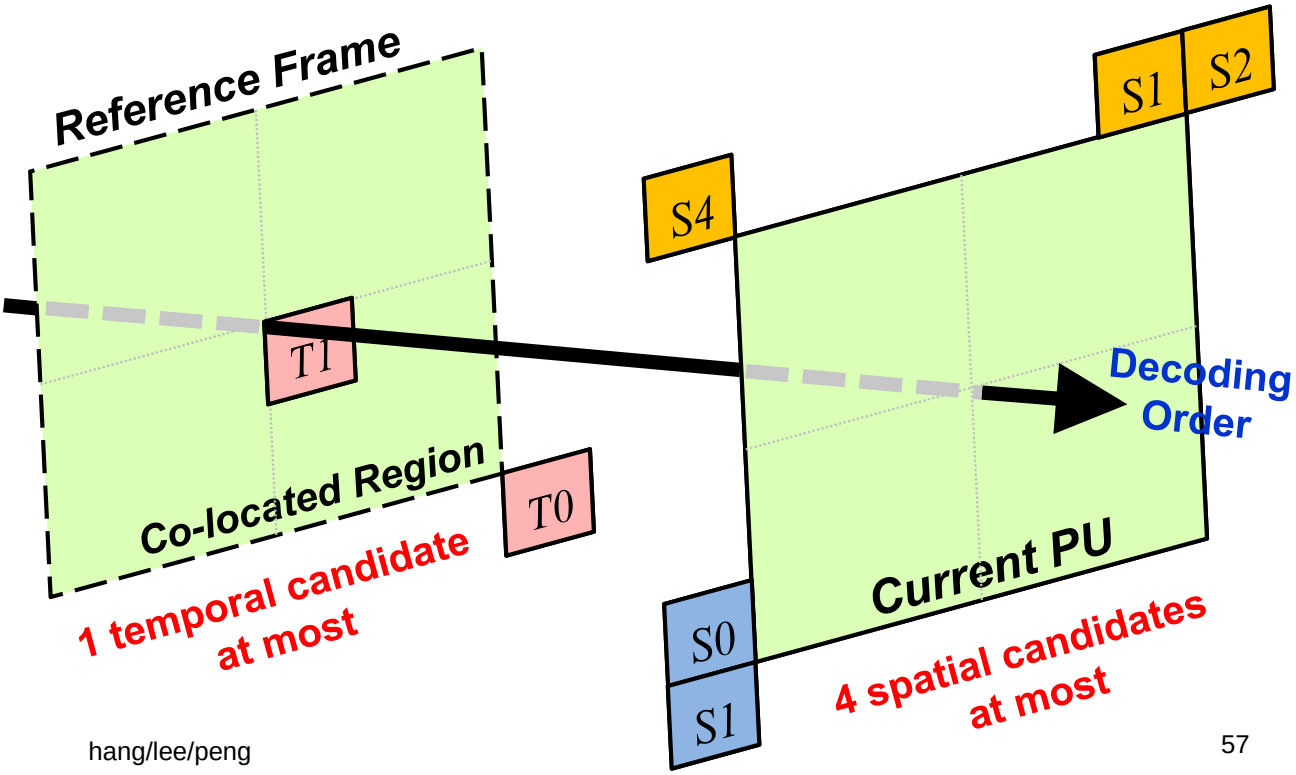
(QP37, 608.4Kbps, 34.8dB)

TS Enabled

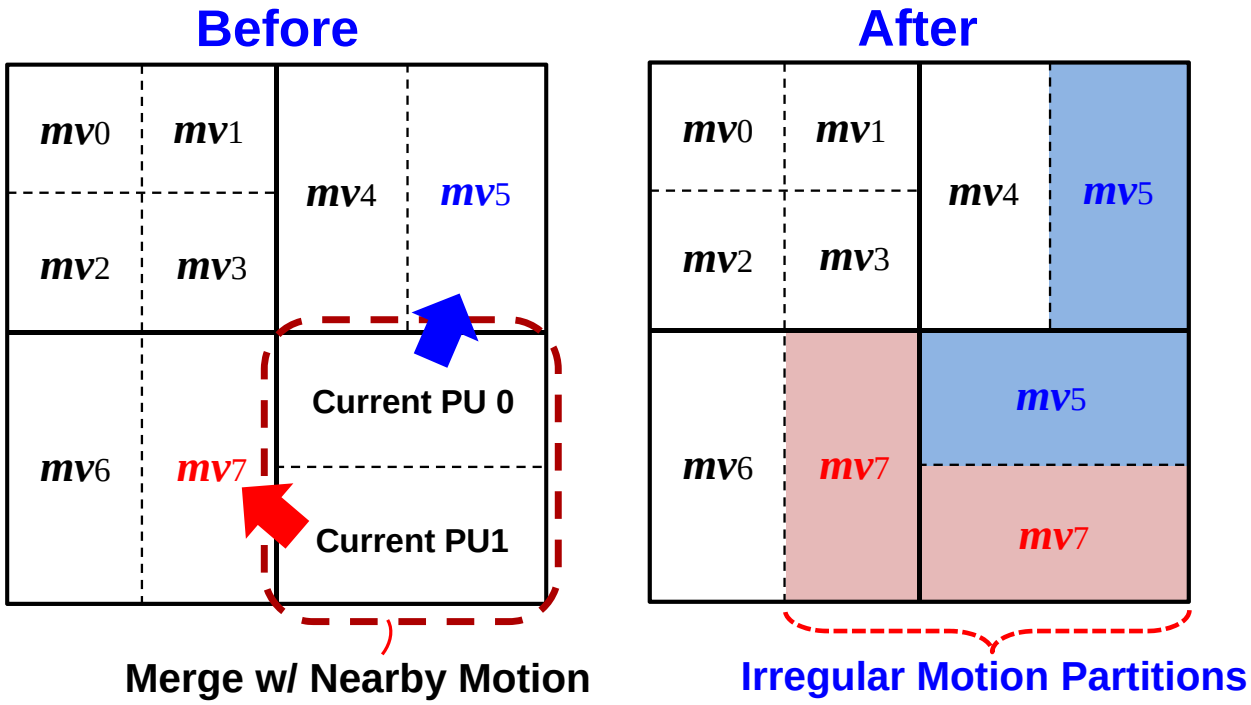


(QP36, 600.8Kbps, 36.1dB)

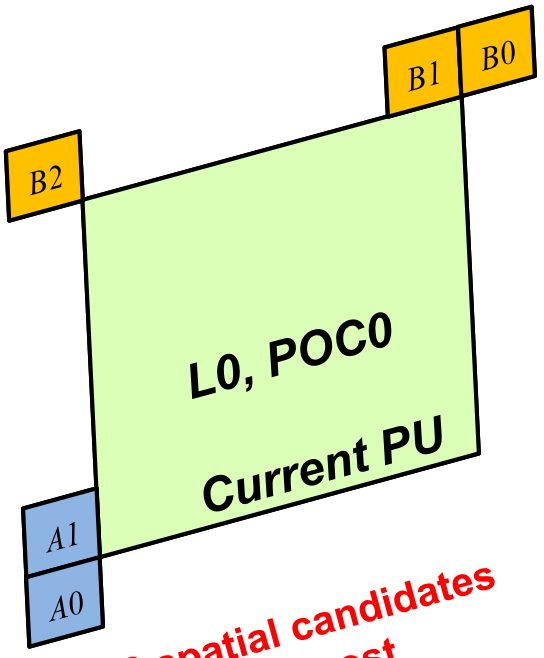
Motion Merging (1/2)



Motion Merging (2/2)



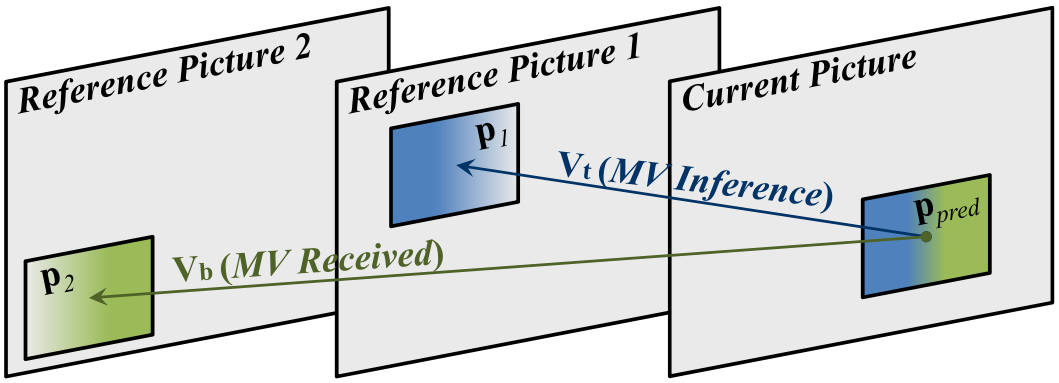
Advanced Motion Vector Prediction



Priority	A0 L0 POC1	A1 L0 POC0	B0 Intra n/a	B1 L1 POC0	B2 L0 POC0
Ref. Picture & Ref. List	n/a	A1	n/a	n/a	B2
Ref. Picture	n/a	n/a	n/a	B1	n/a
Ref. List (MvScaling)	A0	n/a	n/a	n/a	n/a
N/A (MvScaling)	n/a	n/a	n/a	n/a	n/a

Low-Overhead Bi-Prediction

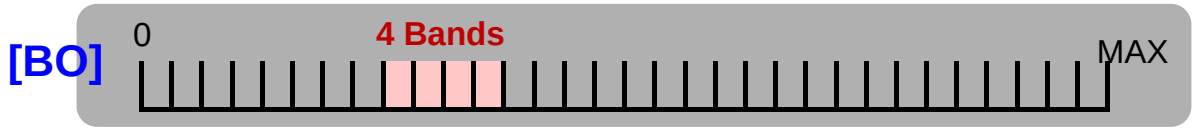
- First proposed by **NCTU**, now a tool in HEVC

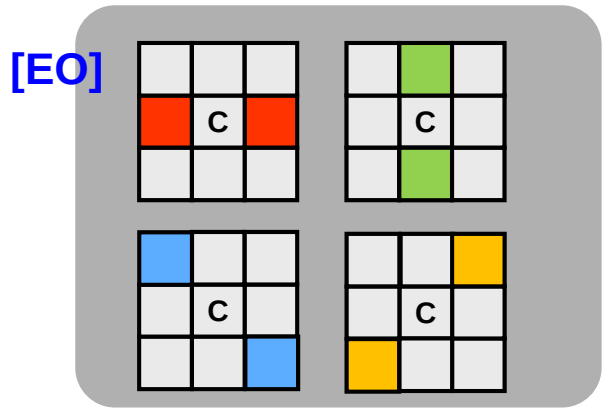


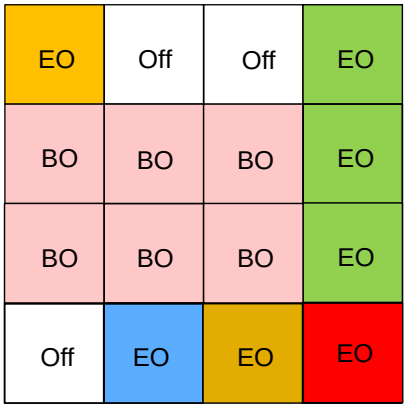
	NTT Docomo	NCTU
MV Inference	AMVP for Vt (in L0)	Motion Merging for Vt
Block ME	Dependent Search for Vb (in L1)	Dependent Search for Vb

Sample Adaptive Offset (MediaTek)

- Sample-adaptive DC compensation
- **Band Offset (BO):** intensity-based sample classification
- **Edge Offset (EO):** edge-based sample classification



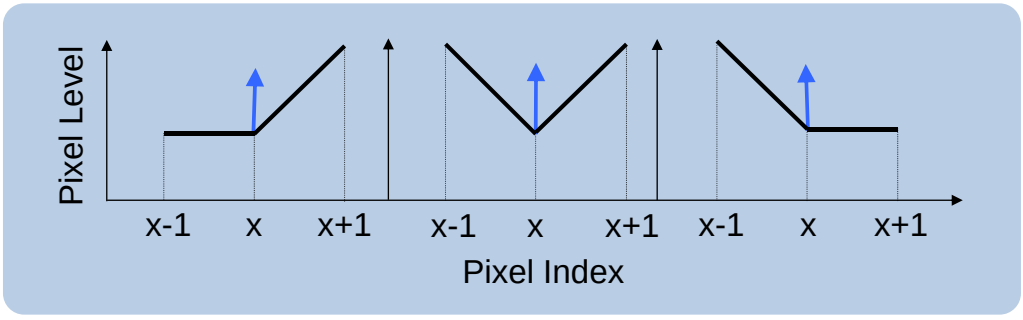




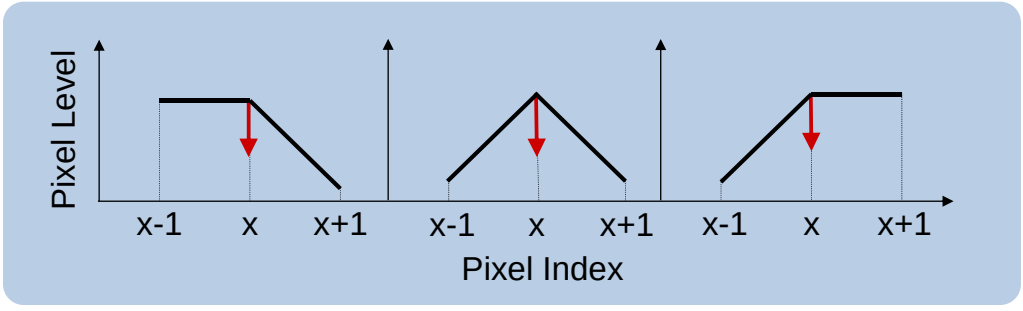
LCUs in a Frame

Edge Offset (EO)

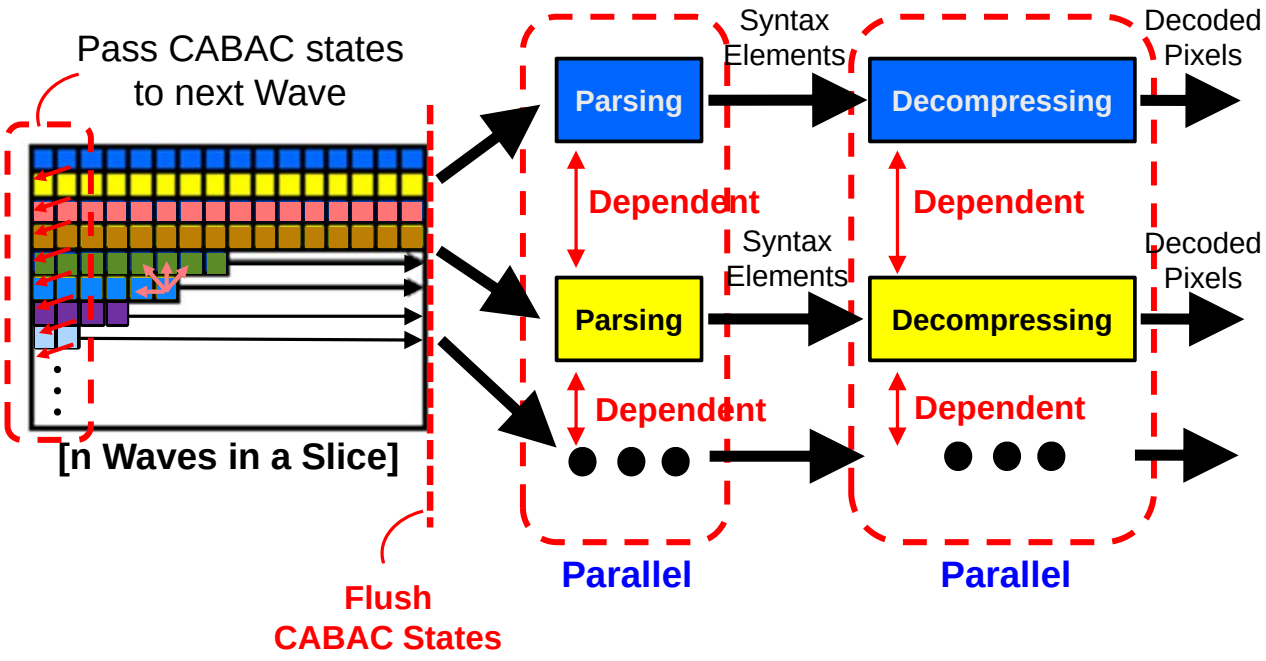
I. Positive Edge Offset



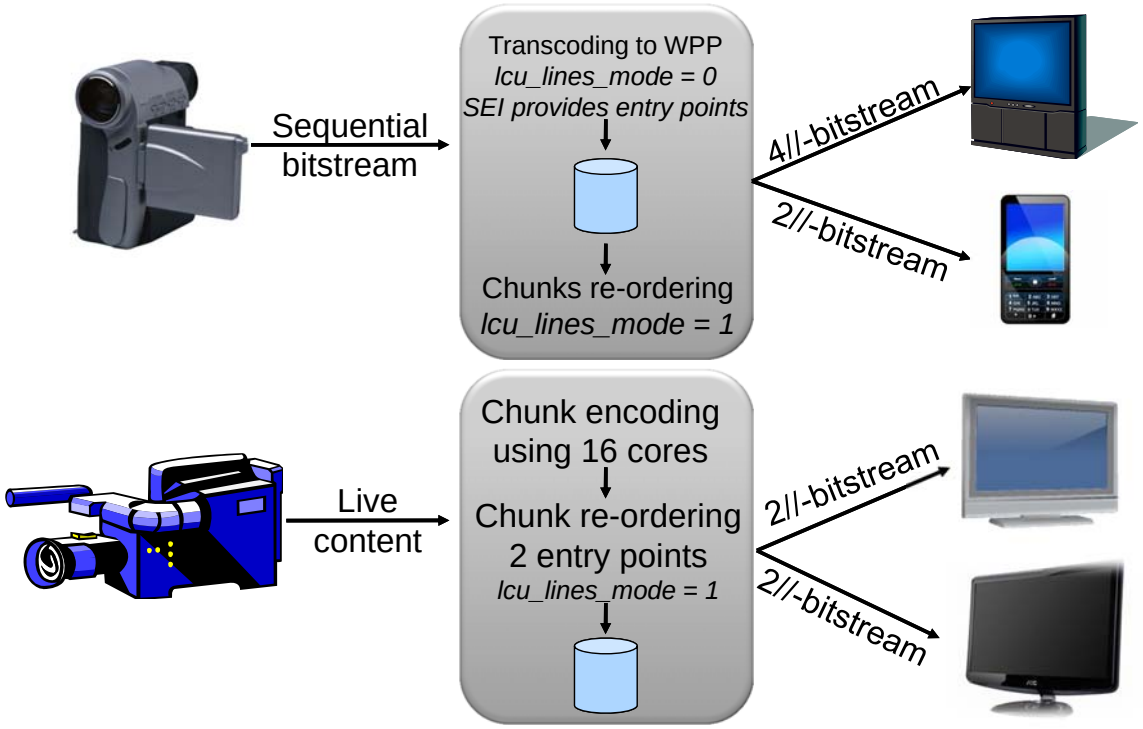
II. Negative Edge Offset



Wavefront Parallel Processing (WPP)



WPP Use Case



More parallel-friendly designs

- Tiles/Entropy Slices
- Diagonal scan to replace zigzag scan
- Parallel merge group
- Motion data compression/storage
- …

HE10 vs. Main

Tools	High Efficiency (10-bit Codec)	Main Profile (8-bit Codec)
CU Size	8x8~64x64	16x16~64x64
PU Partition	Symmetric/**Asymmetric**	
TU Partition	RQT	
MV Prediction	AMVP, MRG, MRG-Skip	
Intra Prediction	DC, Planar, 33 Directions, **DM**	
Transform	DCT 4x4~32x32, DST/**Skip** 4x4 (Intra)	
Interpolation Filter	DCT-IF	
In-loop Filter	De-blocking, SAO	
Entropy Coding	CABAC (**Tiles, WPP**)	

* Only **Main Profile** is adopted in the Draft

Scalable Extension to HEVC

HEVC Scalable Extension

- **Goal**: adding scalability to HEVC
  - Spatial Scalability
  - Intra-only Spatial Scalability
  - SNR Scalability
  - Coding Standard Spatial Scalability (AVC BL)
- Timeline
  - 2012/07: Final Call-for-Proposals (N12957)
  - 2012/10: Evaluation of Proposals (**Objective & Informal Expert Viewing Tests**)
  - 2013/04: Working Draft
  - 2014/06: **Final Draft Standard**

CfP Test Conditions

- 7 Sequences, 4 BL & 4 EL Rate Points

	EL Resolution	BL Resolution		# of Seqs
		1.5x	2x	
Class A+	**3840x2048**		1920x1024	1
	3840x2160		1920x1080	1
Class B	1920x1080	1280x720	960x540	5

Concluding Remarks

Concluding Remarks

- **Ultra-HD** video is for real!
- HEVC is near completion and will be finalized by **mid-2013** as International Standard (**MPEG-H/H.265**)
- **50%** rate savings as compared to AVC has been achieved for the same **visual quality**
- Substantial extensions are under way to address **Scalable** and **3-D** video

Recent Progresses on 3DVC

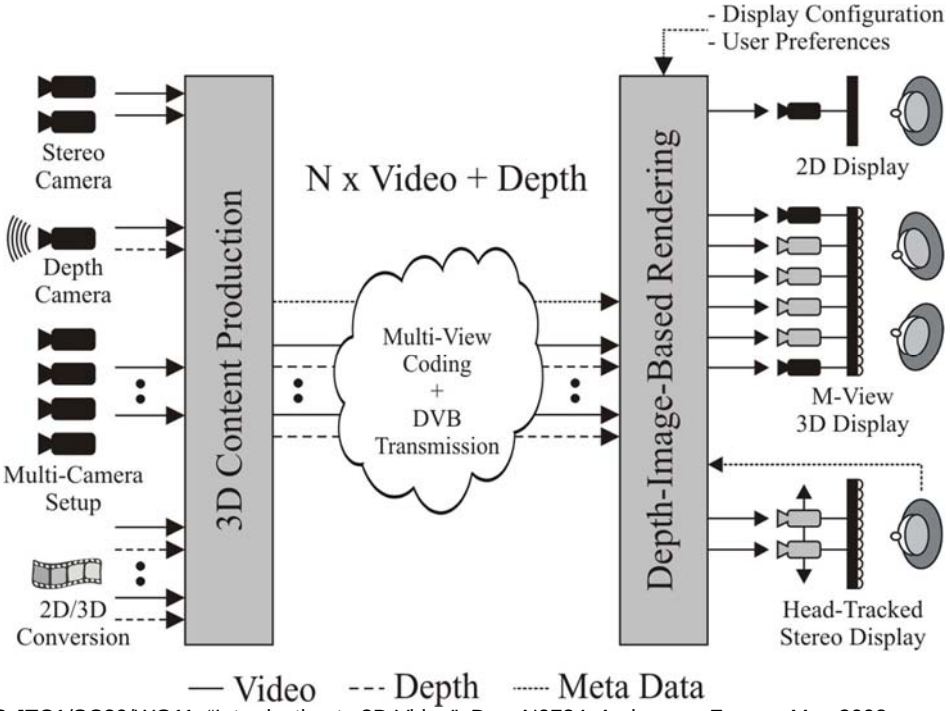
Part 3: 3D Video Coding

李 國 君 (G. G. Lee)
國立成功大學
(National Cheng Kung Univ.)
電機工程學系
(Dept. of Electrical Eng.)
Email: clee@mail.ncku.edu.tw

Outline

- 3D Video System
  - Applications of 3D Video Coding
  - 3D Rendering Capability versus Bit Rate
  - 3DV Experimental Framework
- Call for Proposal Activities of 3DVC
  - 3DV Test Model based on AVC (3DV-ATM)
  - 3DV Test Model based on HEVC (3DV-HTM)
  - Some Coding Tools Involved Depth Information
- Standardization Tracks Considered in 3D Video Coding

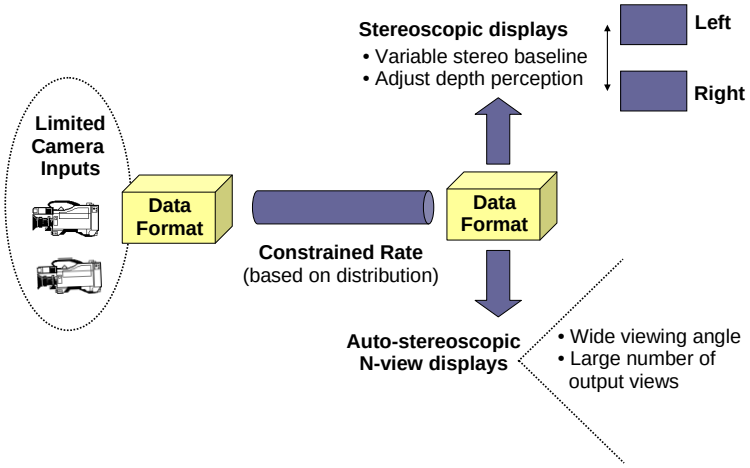
3D Video System



*: ISO/IEC JTC1/SC29/WG11, "Introduction to 3D Video", Doc. N9784, Archamps, France, May 2008.

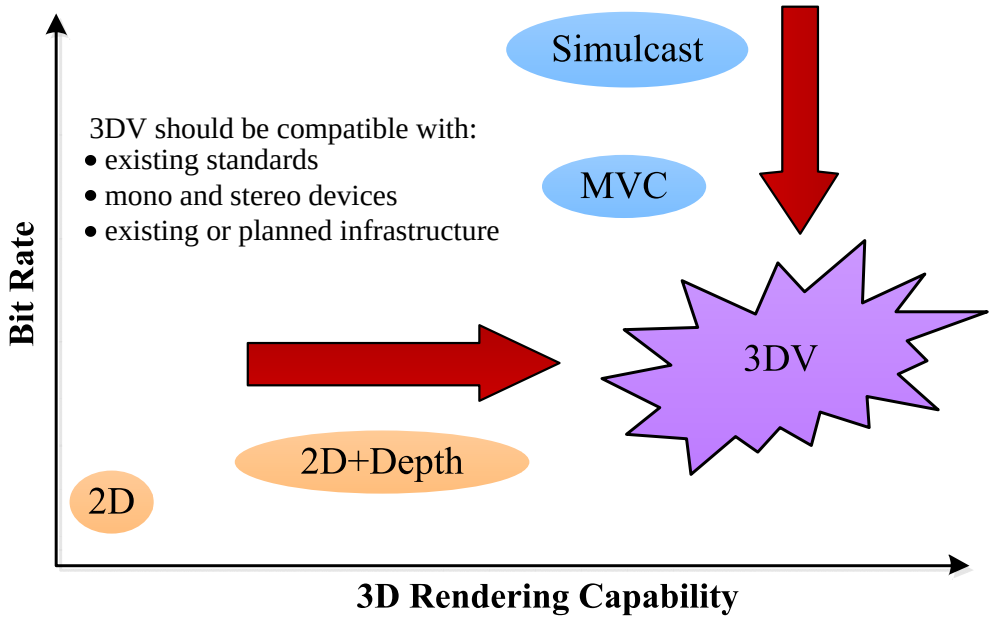
Applications of 3D Video Coding

- Two specific application scenarios:
  - Enabling stereo devices to cope with varying display types and sizes, and different viewing preferences.
  - High-quality auto-stereoscopic displays



*: ISO/IEC JTC1/SC29/WG11, "Vision on 3D Video", Doc. N10357, Lausanne, Switzerland, February 2009.

3D Rendering Capability versus Bit Rate



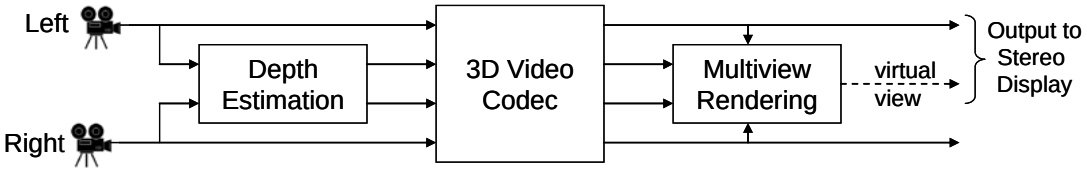
*: ISO/IEC JTC1/SC29/WG11, "Vision on 3D Video", Doc. N10357, Lausanne, Switzerland, February 2009.

3D Video Coding Progress

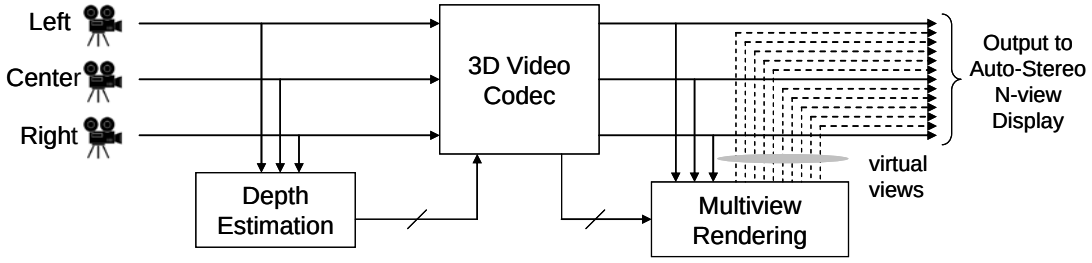
- Totally 20 ad hoc group meeting on
  - Free-viewpoint TV (in the past)
  - 3D video coding (in the past)
- Joint Cooperation Team on 3D Video (Now)
  - 1st JCT-3V at MPEG 101th meeting.
- Standardization Tracks Considered in 3D Video Coding
  - MVC compatible extension including depth
  - AVC compatible video-plus-depth extension
  - HEVC 3D extensions

3DV Experimental Framework

- Advanced stereoscopic processing



- Auto-stereoscopic display



ISO/IEC JTC1/SC29/WG11, “Report on Experimental Framework for 3D Video Coding”, Doc. N11631, Guangzhou, China, October 2010

What is the Difference from Traditional Video Coding?

- Traditional Video Coding
  - Texture data only
  - Quality assessment: BD-PSNR, BD-rate
- 3D Video Coding
  - Texture and **depth** data
  - Quality assessment: **subjective-viewing**, BD-PSNR, BD-rate

Call for Proposal Activities of 3DVC (1/2)

- MPEG 98th meeting: responses of call for proposal
- Test Categories
  - AVC-Compatible: forward compatibility with AVC
  - HEVC-Compatible: forward compatibility with HEVC
- Totally 23 proposals
  - 12 proposal for AVC-compatible
  - 11 proposal for HEVC-compatible

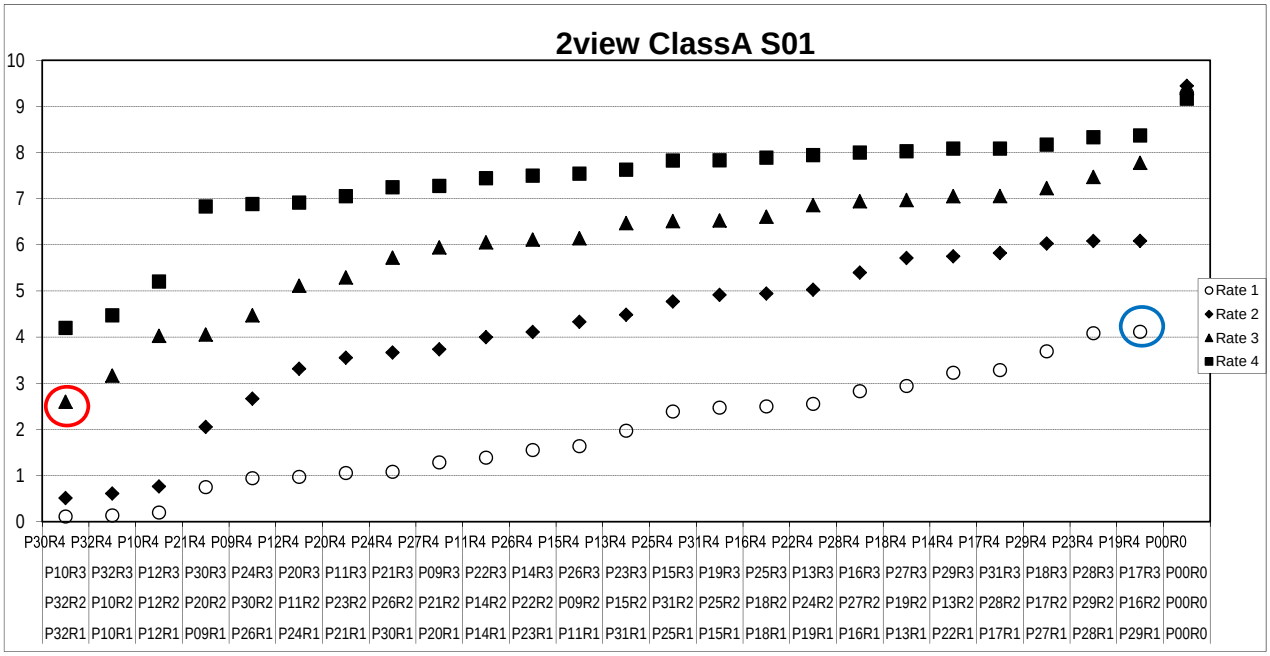
ISO/IEC JTC1/SC29/WG11, "3DVC_adHoc_group_report", Doc. M21469, Geneva, Switzerland, November, 2012

Call for Proposal Activities of 3DVC (2/2)

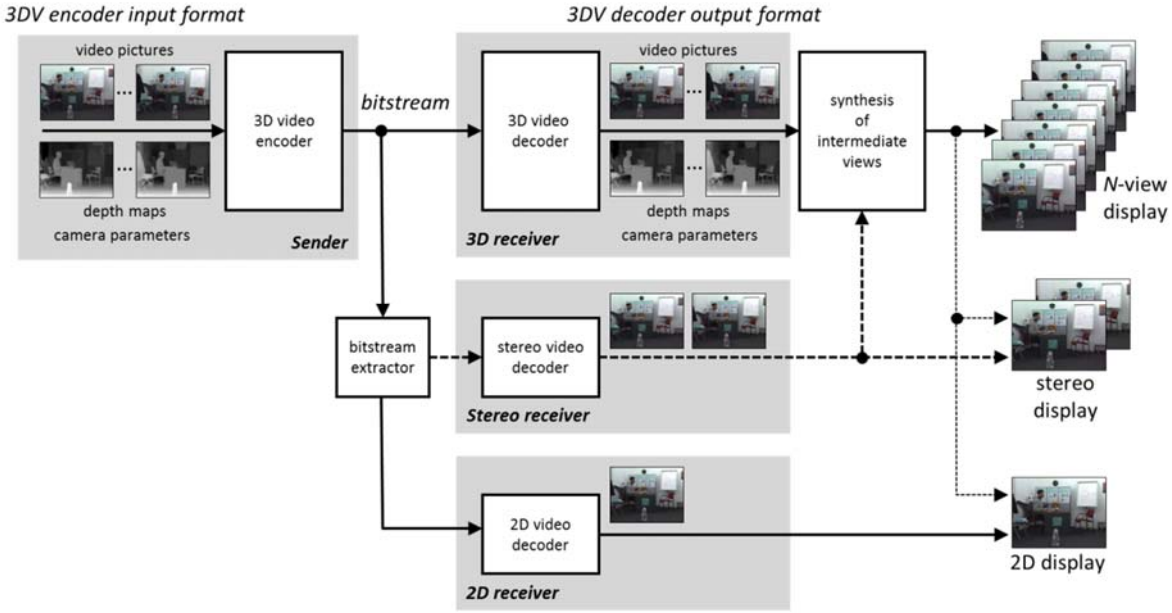
AVC: 12 proposals	HEVC: 11 proposals
Fraunhofer HHI	Fraunhofer HHI*2
Sony	Sony
Mitsubishi	Ericsson
Nokia	Disney Research Zurich and Fraunhofer HHI
Samsung	Samsung*2
Sharp	LG Electronics
NTT	RWTH Aachen Univ
NICT	Poznan University
Qualcomm Incorporated	ETRI & Kwangwoon Univ
Nagoya University	
Philips & 'Ghent University – IBBT'	
Zhejiang University	

81

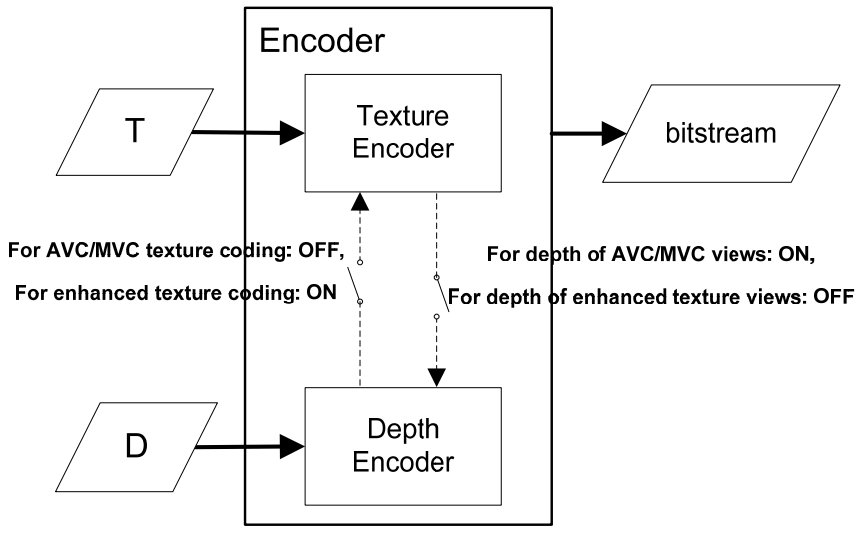
3DVC Evaluation Results



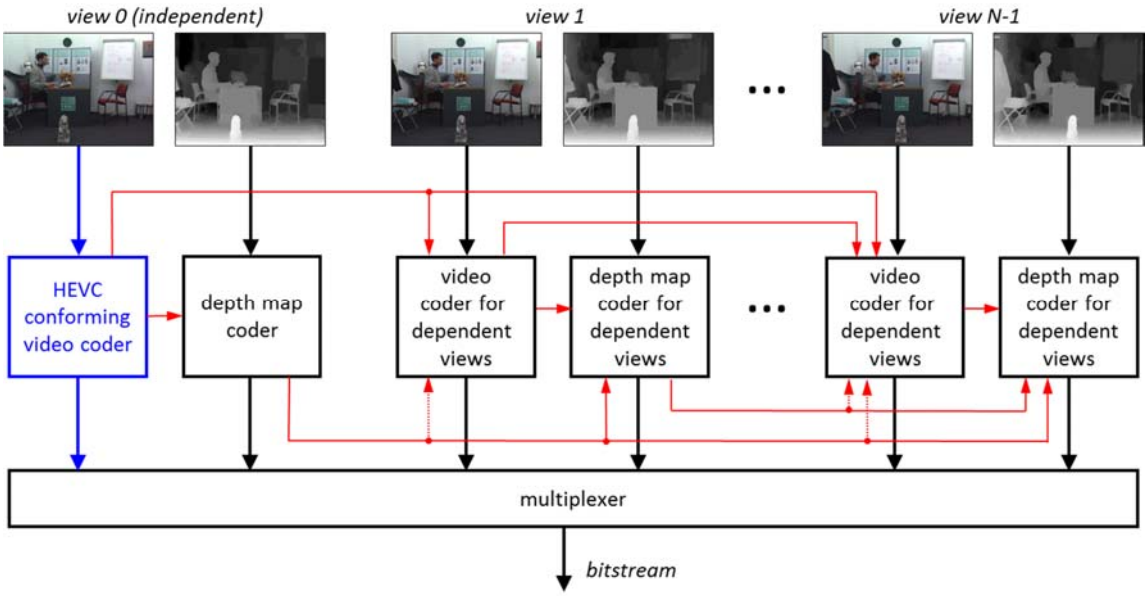
Data Format and System Description of 3D Video Coding



Coding structure of 3DV-ATM

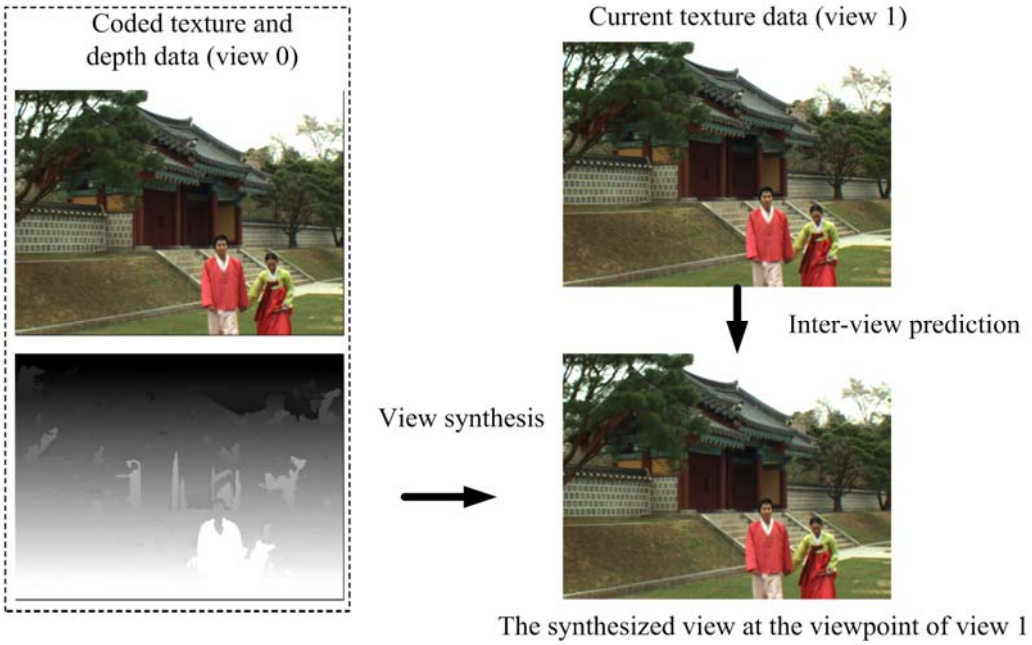


Coding structure of 3DV-HTM



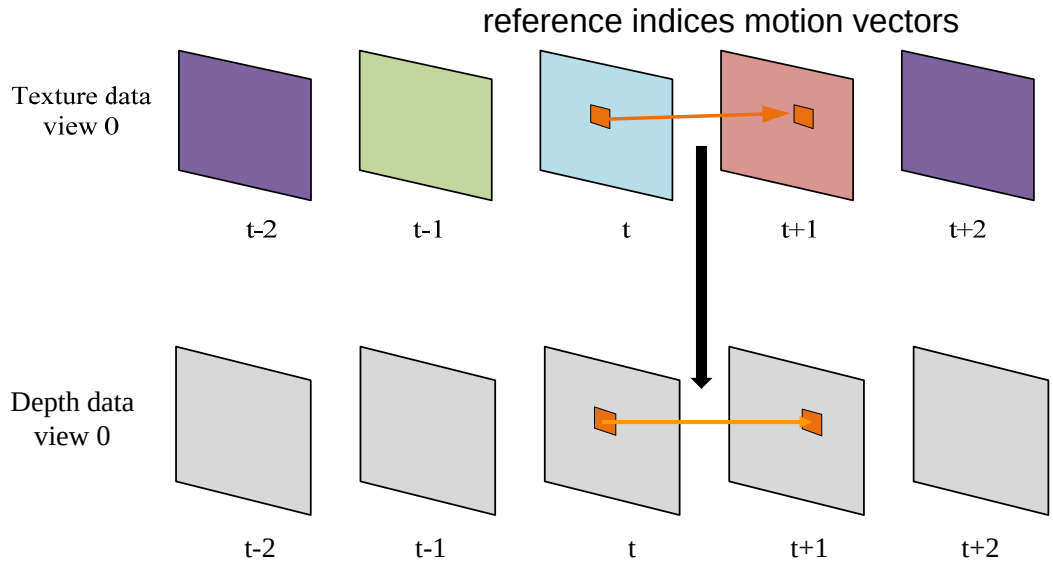
Some Coding Tools Involved Depth Information (1/4)

- View synthesis prediction



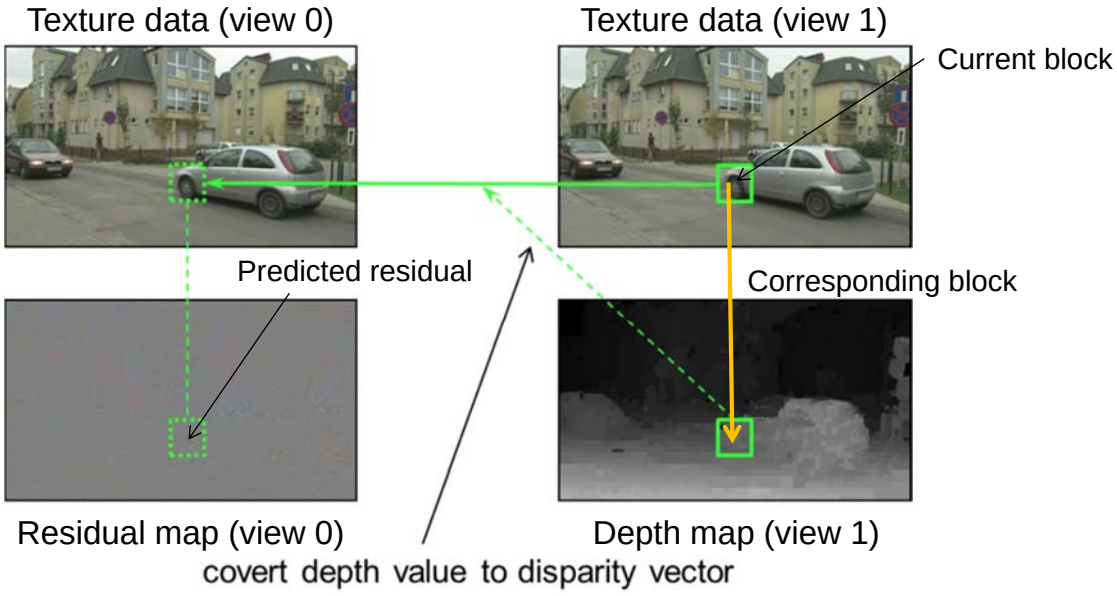
Some Coding Tools Involved Depth Information (2/4)

- Motion prediction from texture to depth



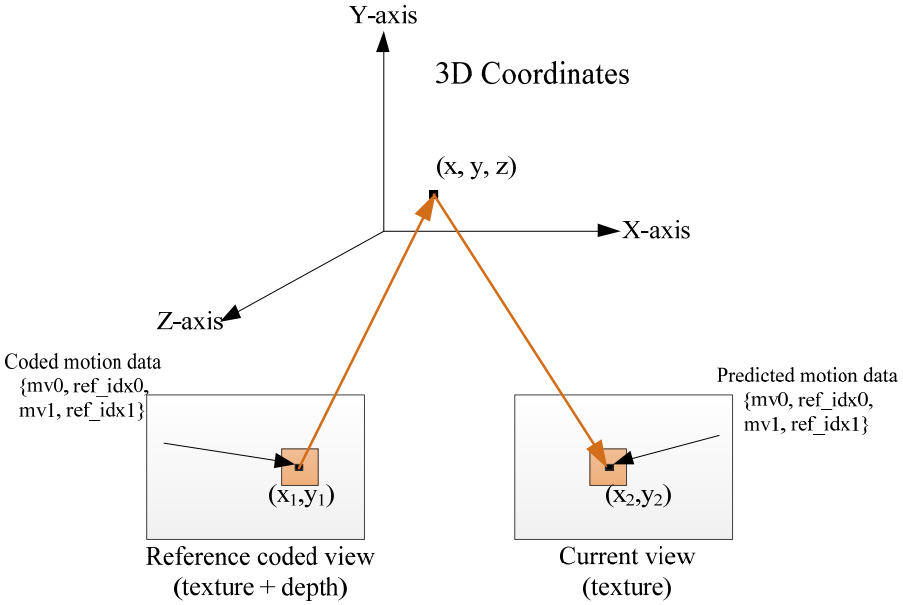
Some Coding Tools Involved Depth Information (3/4)

- Inter-view residual prediction



Some Coding Tools Involved Depth Information (4/4)

- Depth-based motion parameter prediction



Standardization Tracks Considered in 3D Video Coding

- MVC compatible extension including depth
- AVC compatible video-plus-depth extension
- HEVC 3D extensions

MVC Compatible Extension Including Depth

- Timeline for standardization:
  - 2011/12: Working Draft (WD)
  - 2012/02: Proposed Draft Amendment (PDAM)
  - 2012/05: Draft Amendment (DAM)
  - **2012/10: Final Draft Amendment (FDAM)**

AVC Compatible Video-plus-depth Extension

- Expected coding efficiency improvements
  - **30-40%** relative to existing AVC/MVC technology
- Expected timeline for standardization:
  - 2012/02: Working Draft (WD1)
  - 2012/05: Working Draft (WD2)
  - 2012/07: Working Draft (WD3)
  - **2012/10: Proposed Draft Amendment (PDAM)**
  - 2013/01: Draft Amendment (DAM)
  - 2013/07: Final Draft Amendment (FDAM)

HEVC 3D Extensions

- Expected coding efficiency improvements
  - **40-60%** relative to the base specification of HEVC
- Expected timeline for standardization:
  - 2012/05: Working Draft (WD1)
  - 2012/07: Working Draft (WD2)
  - **2012/10: Working Draft (WD3)**
  - 2013/01: Proposed Draft Amendment (PDAM)
  - 2013/07: Draft Amendment (DAM)
  - 2014/01: Final Draft Amendment (FDAM)

Thank you for your attention