High Efficiency Video Coding (HEVC)

and its scalable and 3D extensions

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Multimedia Lab

September 21, 2012

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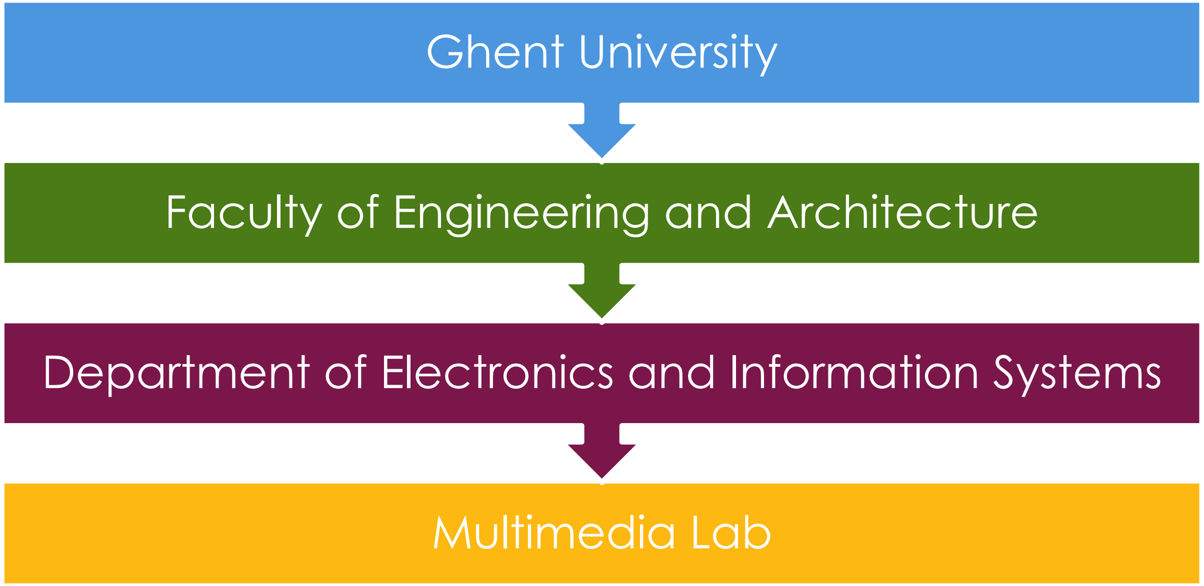
English Channel
Cambridge
Ipswich
Colchester
Beccles
Luton
Woodford Green
Chelmsford
London
Southend-on-Sea
Croydon
Maidstone
Deal
Crawley
Brighton
Hastings
Eastbourne

Ghent University

- founded in 1817
- 11 faculties
  - science, (bio-)engineering, law, medicine, economics, …
- ca. 35,000 students, 1500 professors



IBBT

- IBBT = Interdisciplinary Institute for BroadBand Technology
- IBBT unites about 1000 researchers from Flemish universities specialized in:
  - future media & imaging
  - future Internet
  - security
  - future health
  - digital society
- stimulation of multidisciplinary research and innovation in ICT through projects, start-ups, training, …

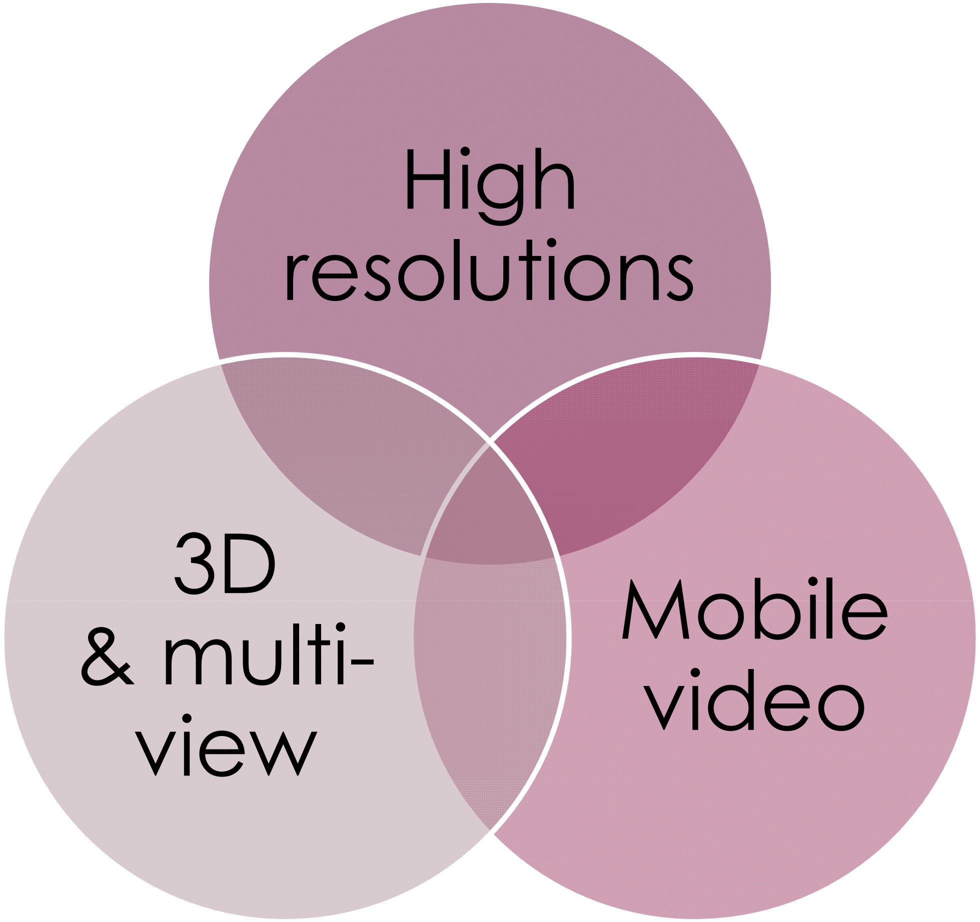
Multimedia Lab

- Research topics
  - Video coding (AVC, SVC, HEVC, DVC)
  - Image/video processing and analysis
  - Game technology and interactive visualization (GPGPU, CUDA)
  - Multimedia content adaptation
  - Metadata technologies
  - Standardization (MPEG, VCEG, VQEG, JCT-VC, JCT-3V, W3C)
- People
  - 1 full professor + 2 part-time lecturers
  - 6 post-docs
  - ca. 20 researchers, spread over the different research topics

Overview

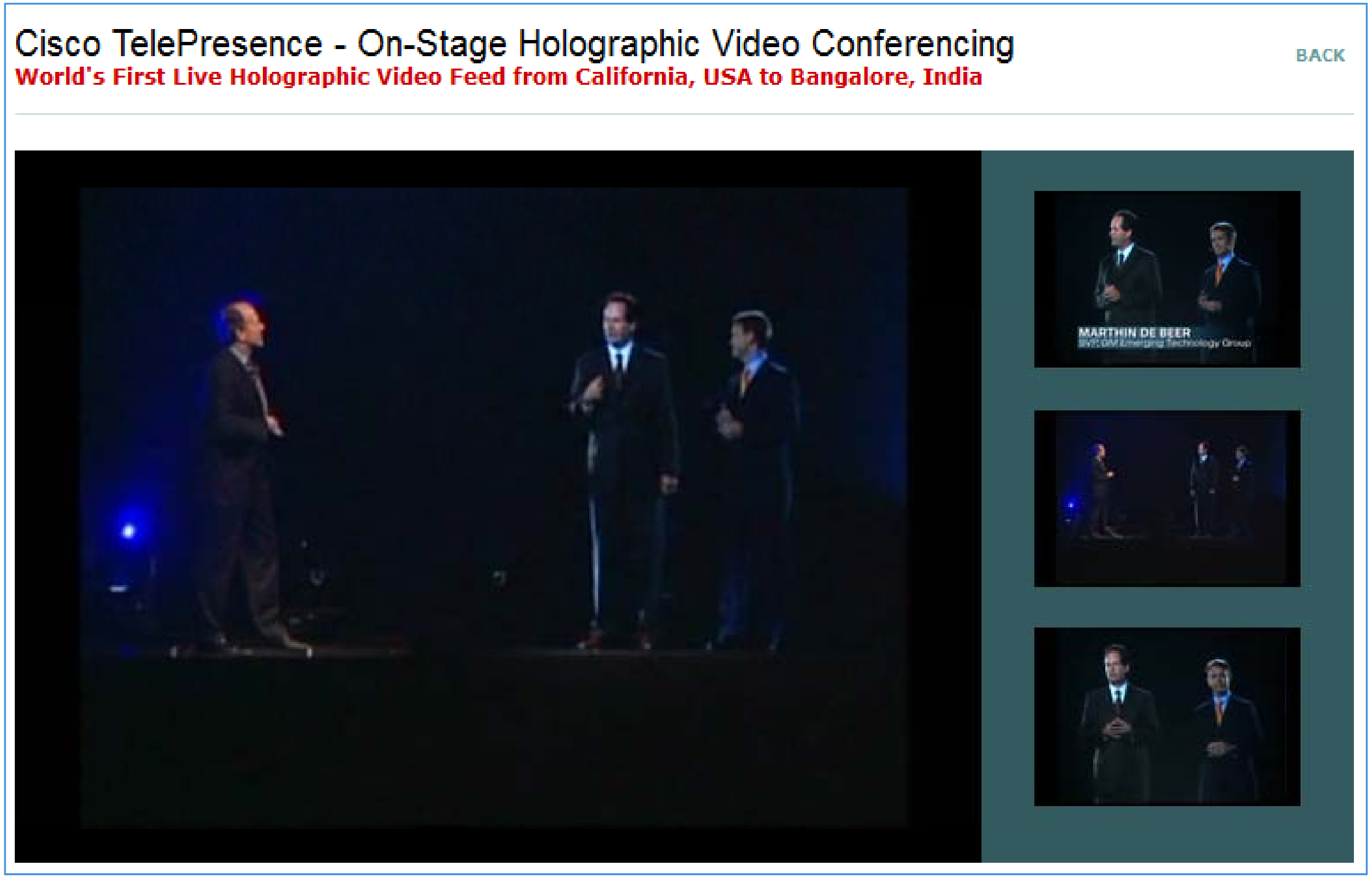
- Introduction
- High-Efficiency Video Coding (HEVC)
- 3D video
- Video adaptation
- Concluding remarks

Introduction



Introduction

- Immersive experiences & telepresence



Introduction

- “Entering the Zettabyte Era”
  - white paper by Cisco
- Sor
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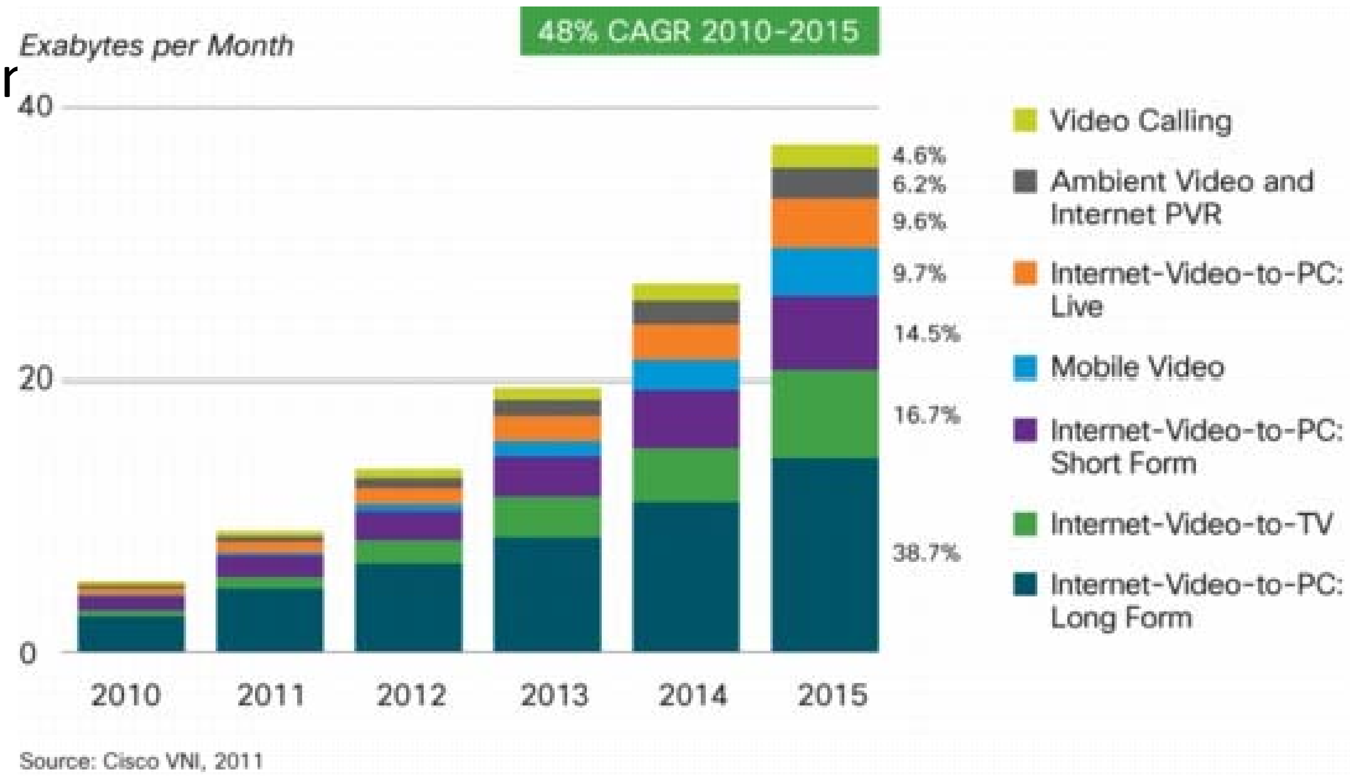
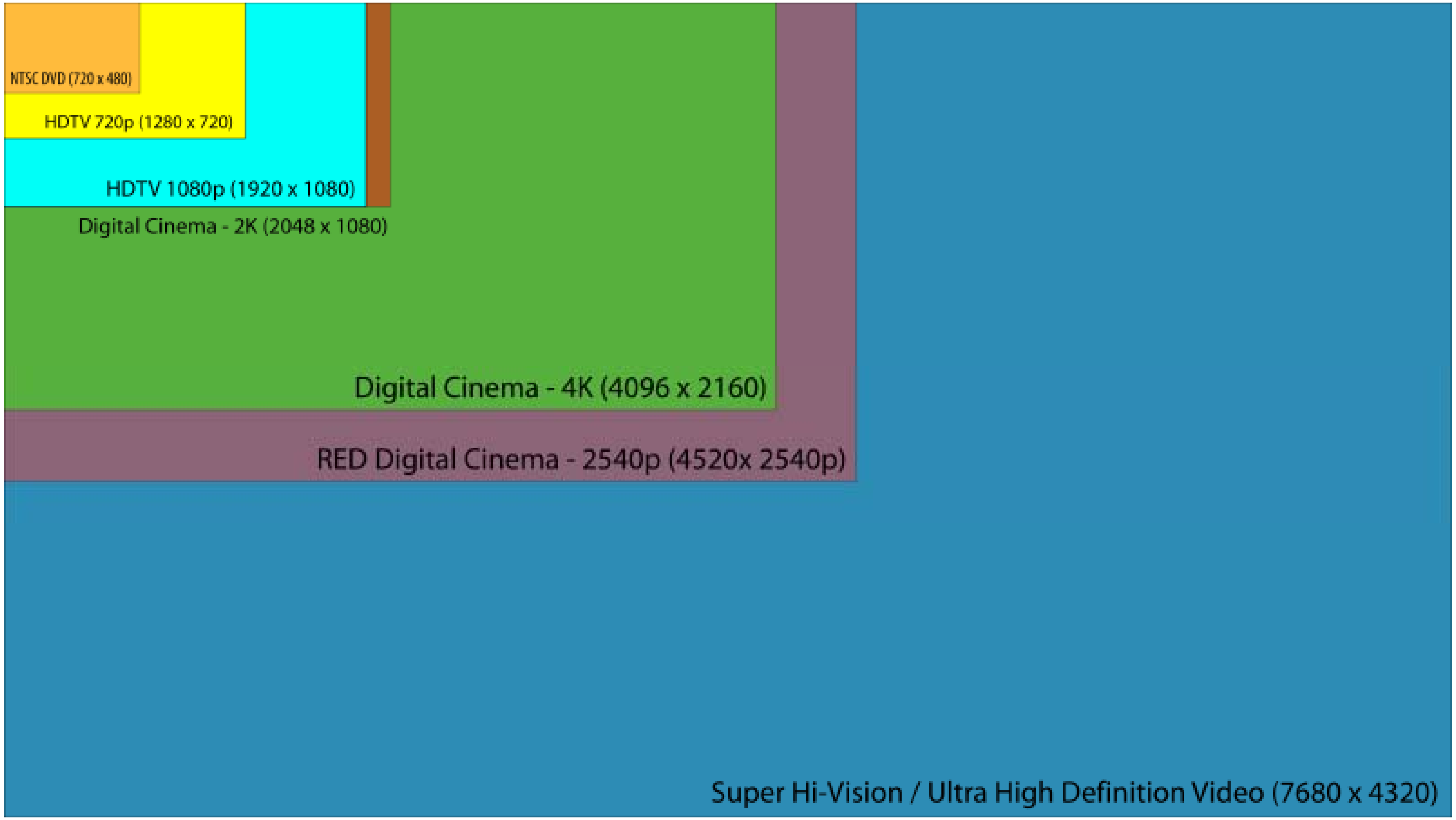


Ultra High Definition Video (UHDV)



Introduction

Sharp shows off the world's first Super Hi-Vision 85-inch LCD with 16x more detail than 1080p

By Richard Lawler posted May 19th 2011 5:39AM

BBC to Test Ultra High-Definition TV at London 2012 Olympics

BBC and NHK will use the world's only Super Hi-Vision equipment to film a variety of Olympic sports and broadcast them to the public.

By Jeff Bertolucci | PC World | *19 July 12*

Introduction

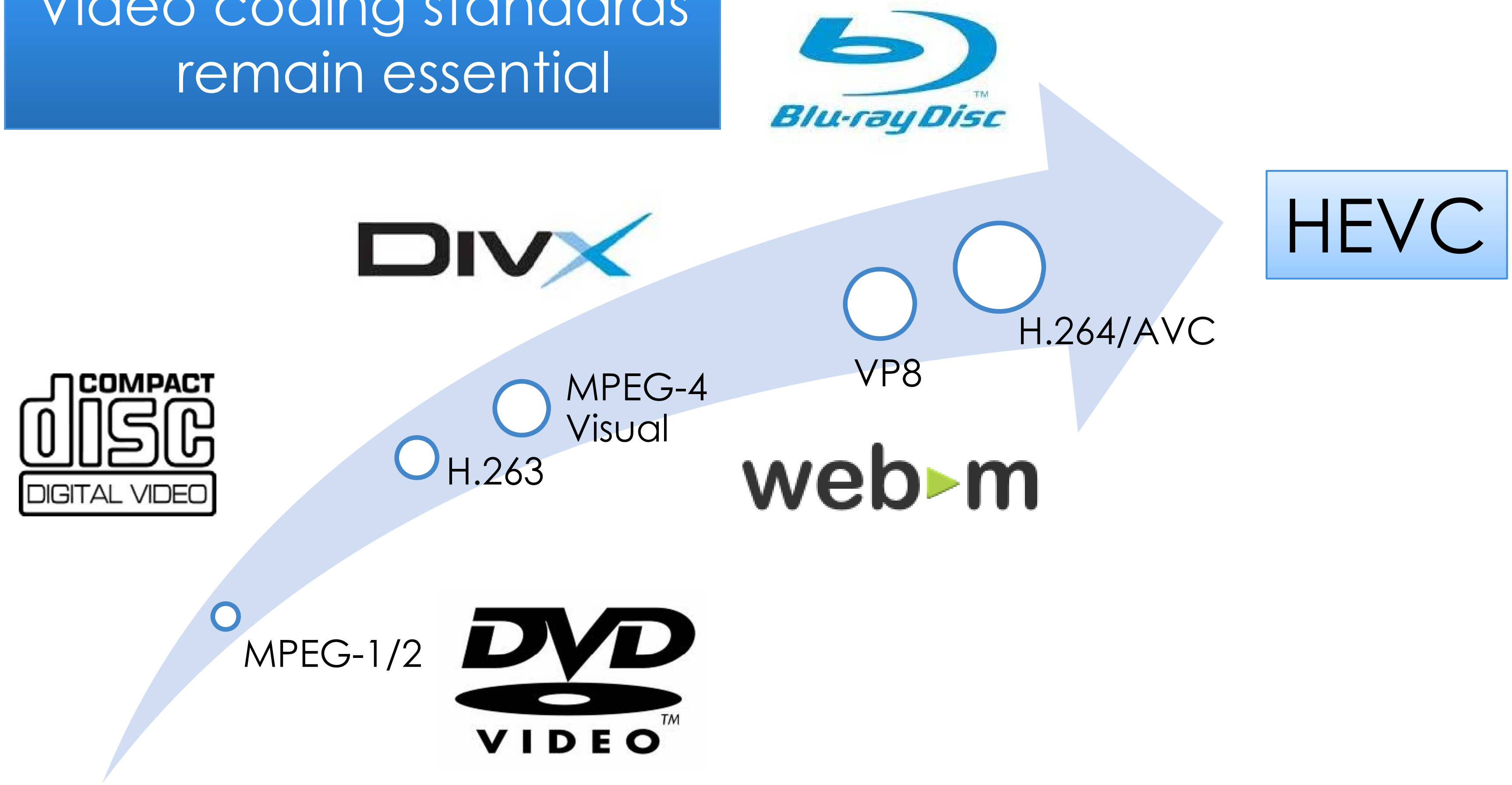
NHK shows downsized Super Hi-Vision video camera

May 28, 2012 by Nancy Owano report

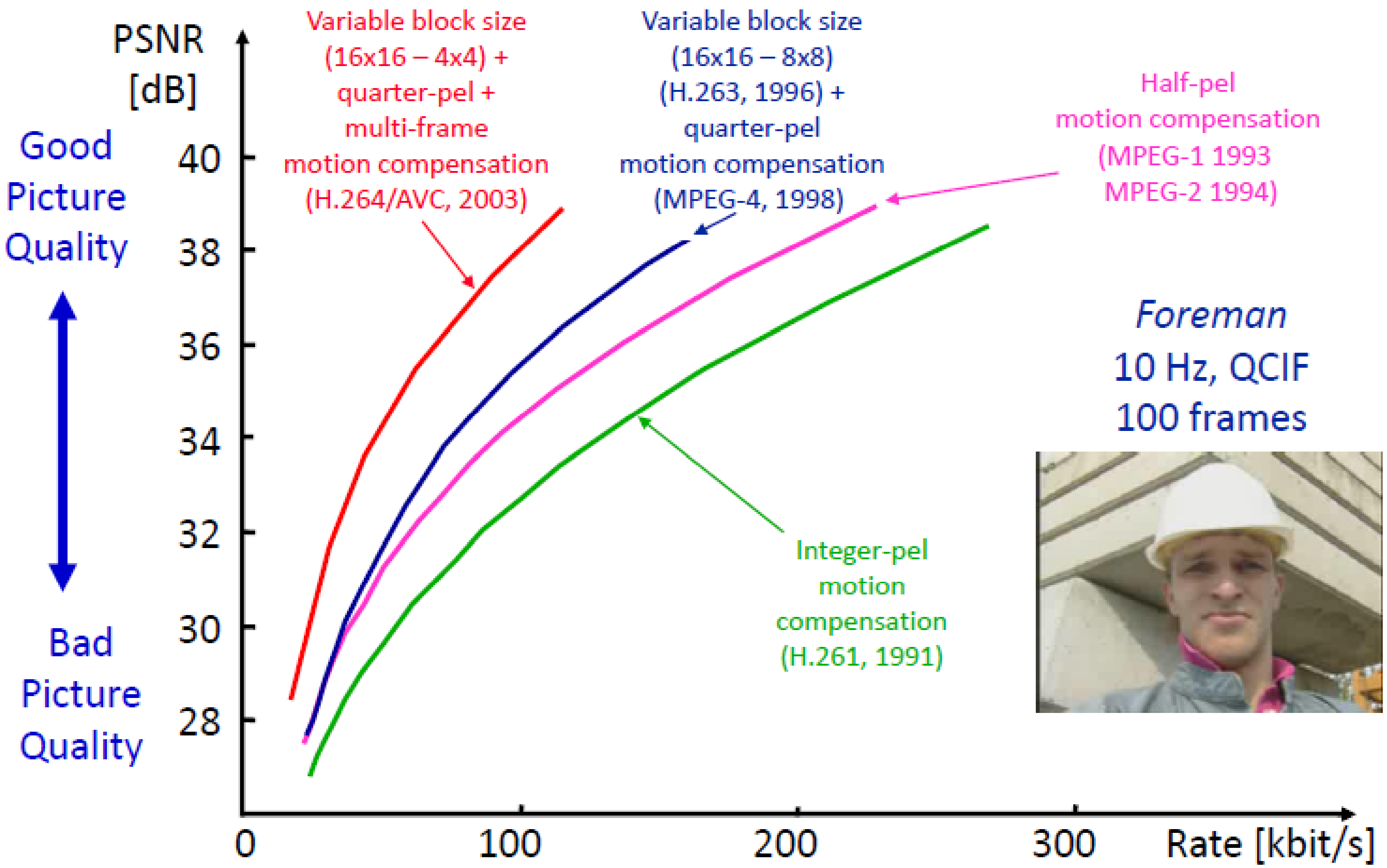
(Phys.org) -- NHK this week placed on exhibit a shoulder-mount camera, developed in cooperation with Hitachi, capable of shooting what NHK calls super high vision (SHV) video in 7680×4320 resolution. Super Hi-Vision is NHK's preferred name for ultra high definition television (UHDTV). The powerful prototype was part of NHK Scientific & Technology Research Laboratories (STRL) Open House event in Japan earlier this week. The camera is an innovative development, as a compact Ultra High Definition camera using a single-chip color imaging sensor to produce "closest to being there" video. NHK says that the compact head is compatible with commercially-offered still camera lenses.

Video coding standards

Video coding standards remain essential



Video coding standards



G. J. Sullivan, ICCE 2011

Overview

- Introduction
- High-Efficiency Video Coding (HEVC)
- 3D video
- Video adaptation
- Concluding remarks

High Efficiency Video Coding (HEVC)

- New video coding standard under development
- Project launched in 2010
- Joint Collaborative Team on Video Coding (**JCT-VC**)
  - collaboration of ISO/IEC MPEG and ITU-T VCEG

- Significant improvements were demonstrated in subjective evaluations over H.264/AVC (April 2010 meeting)
  - **comparable quality at half the bit rate**

High Efficiency Video Coding (HEVC)

- 10^{th} JCT-VC meeting (July 2012)
  - eighth version of HEVC test model (HM 8.0) software available
  - real-time 720p decoders have been demonstrated on mobile devices (iPad, Samsung smartphone)
  - software e.g. via subversion at https://hevc.hhi.fraunhofer.de/svn/svn_HEVCSoftware/trunk
- Timeline
  - Committee Draft (CD) in February 2012
  - Draft International Standard (DIS) in July 2012
  - Final Draft International Standard (FDIS) in January 2013

High Efficiency Video Coding (HEVC)

- Very active project – high interest from industry
  - several meetings passed the ‘kilodocument’ milestone (1000+ contributions per meeting)

High Efficiency Video Coding (HEVC)

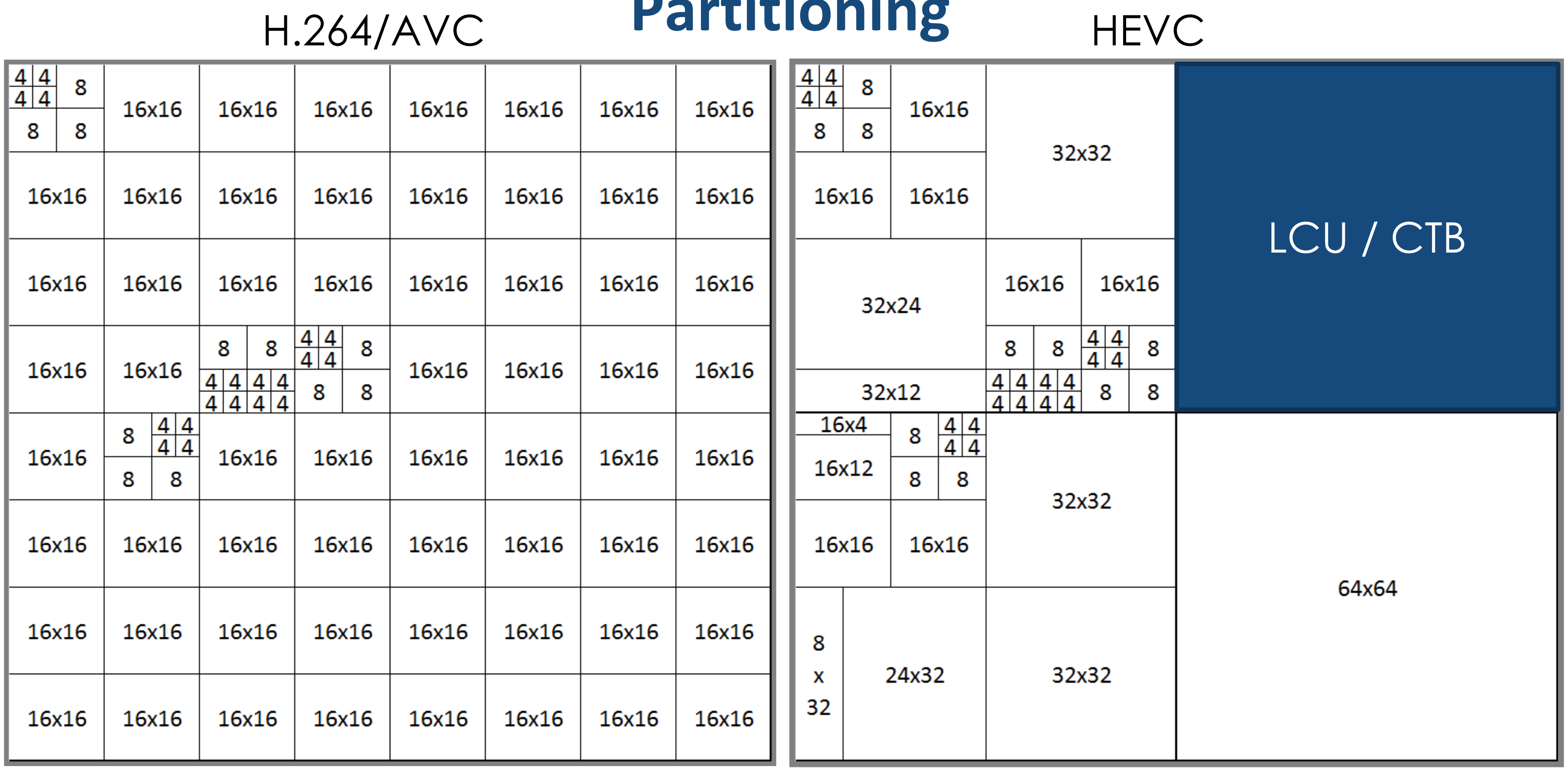
- JCT-VC meeting at Geneva (300+ participants per meeting)

High Efficiency Video Coding (HEVC)

New features

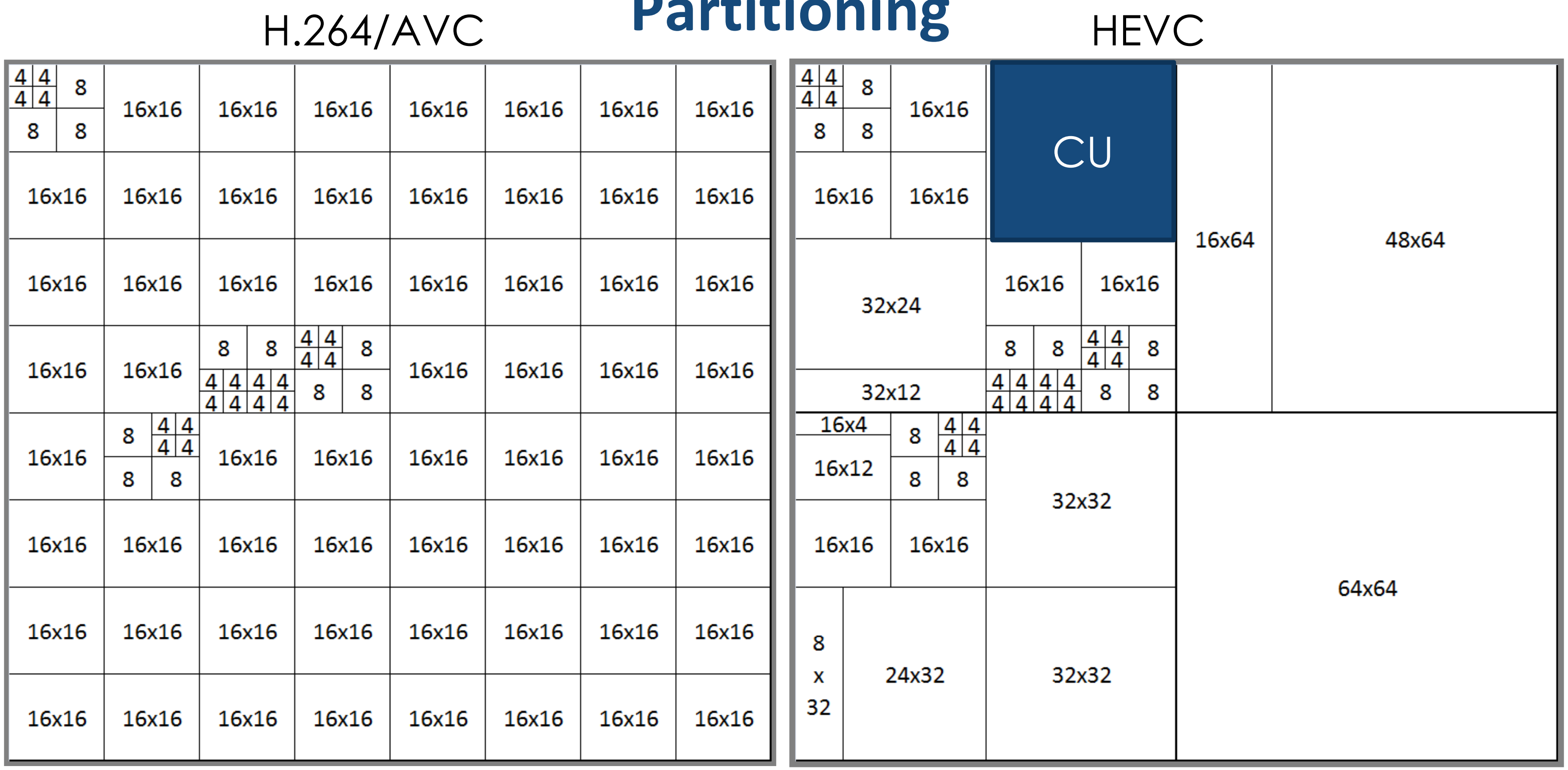
Adaptive loop filter (ALF)	Sample adaptive offset (SAO)	64x64 to 8x8 Coding units
Intra prediction (35 modes)	Residual quad-tree	Internal bit depth increase (IBDI)
Adaptive motion vector prediction	Large-size transforms (32x32 to 4x4)	Tiles & wavefronts

Partitioning



- Macroblock is replaced by 'Largest Coding Unit' (LCU) / Coding Tree Block = 64x64 pixels
- Coding Unit (CU) = square
- Prediction Unit (PU)
- Transform Unit (TU)

Partitioning



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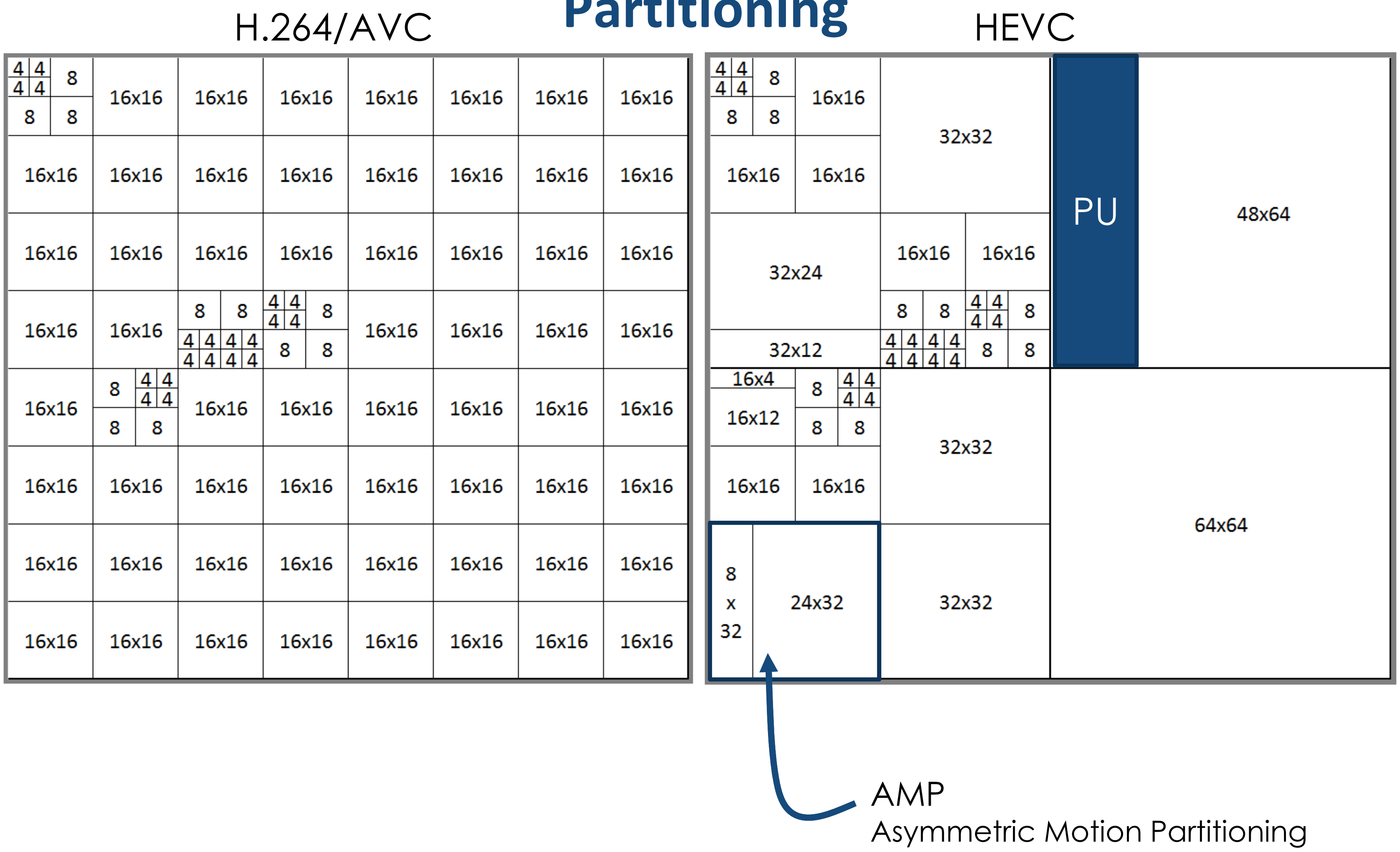
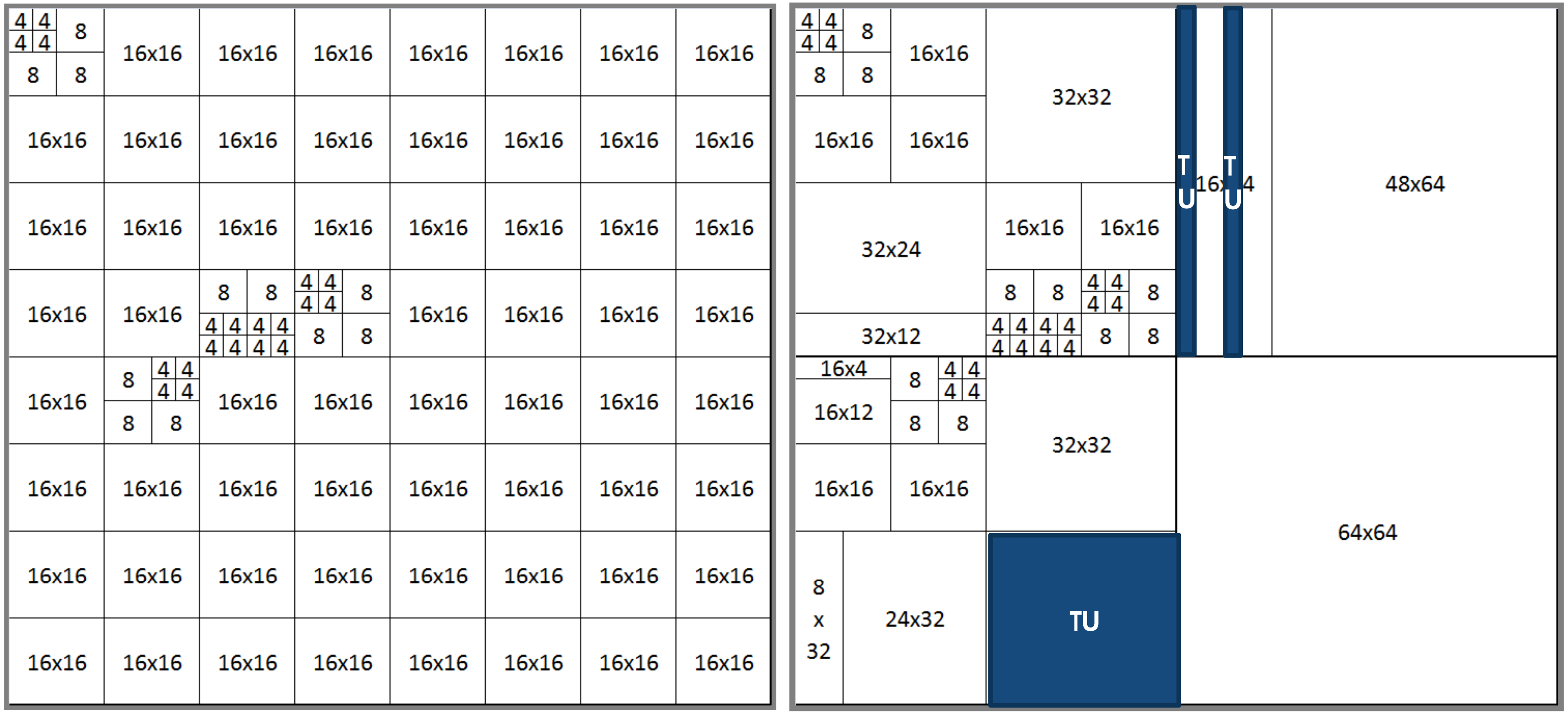


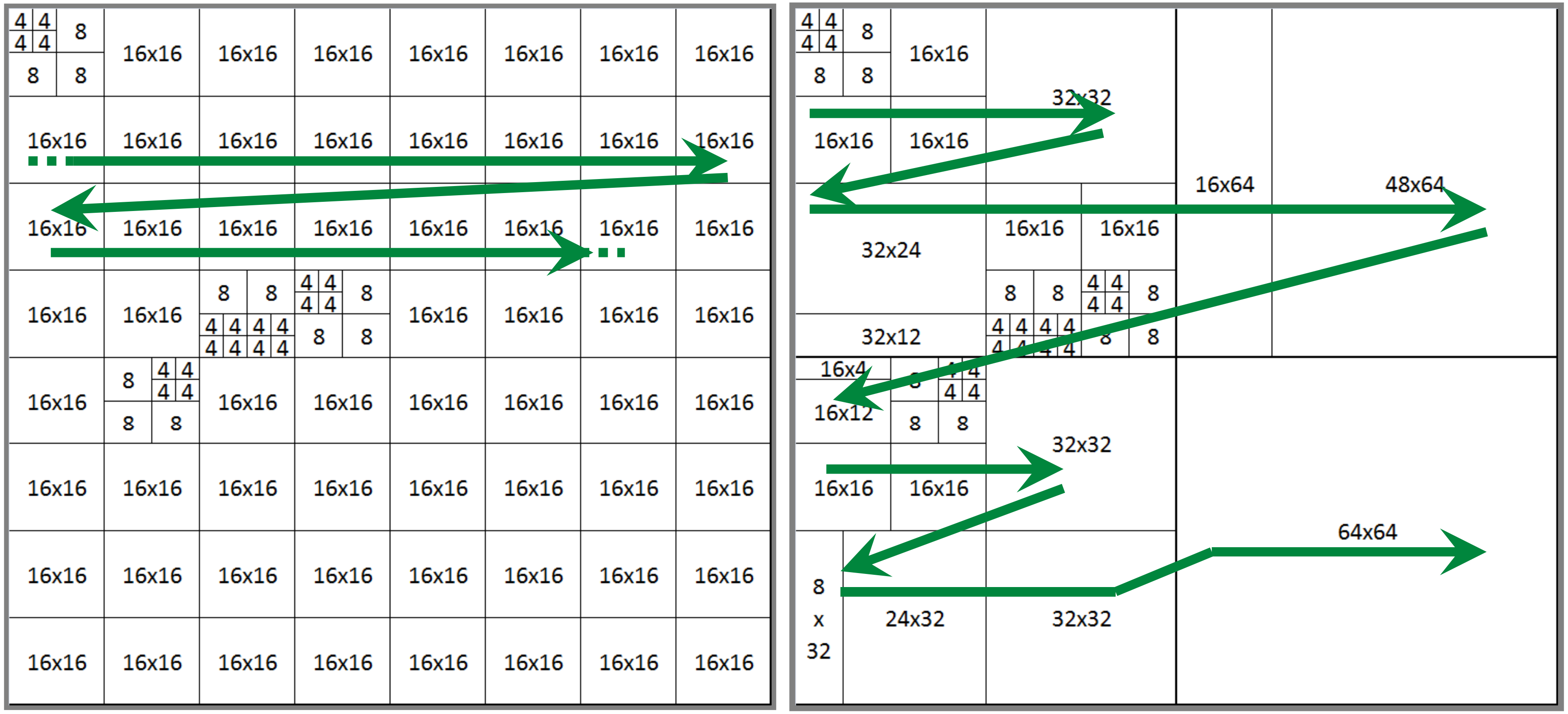
Partitioning

NSQT: Non Square QuadTree



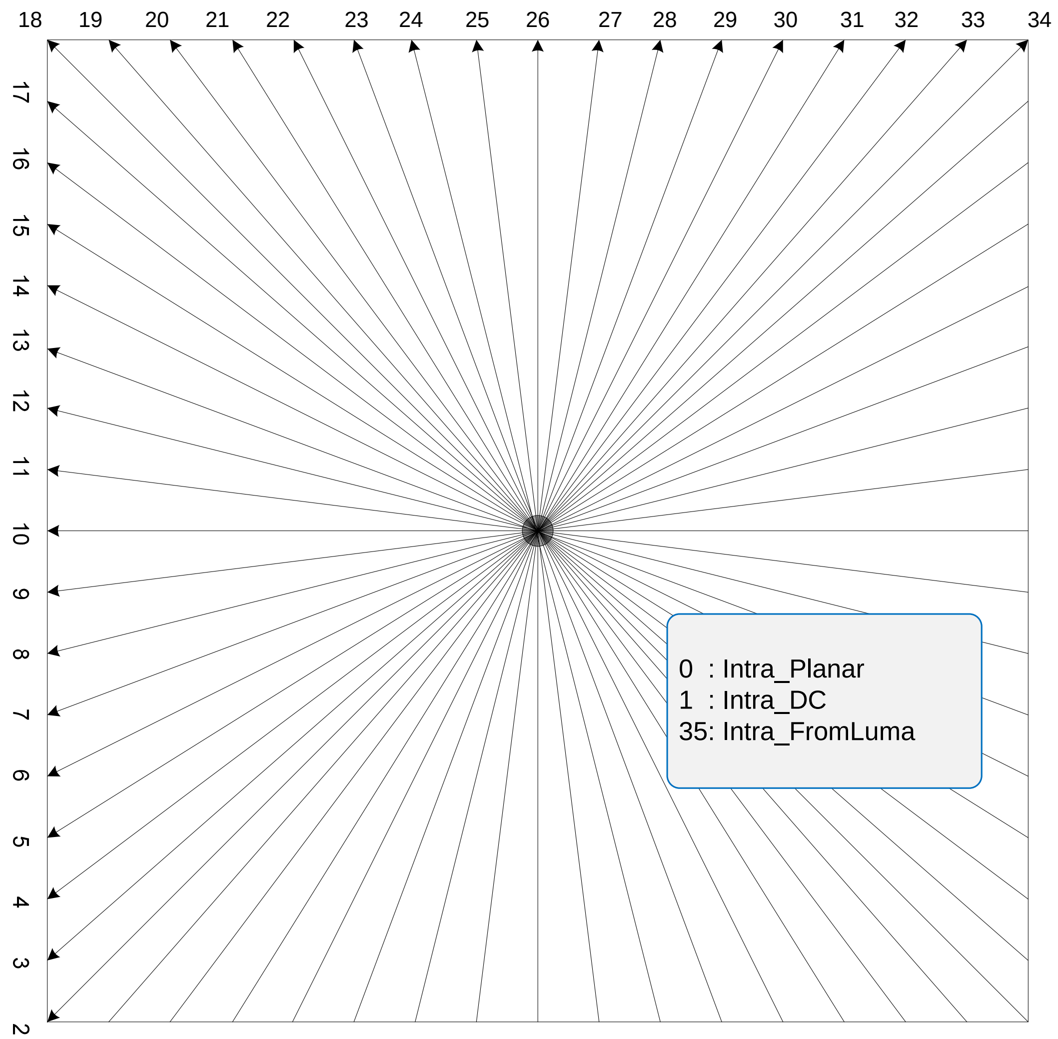
- MB → Largest Coding Unit (LCU) = 64x64
- Coding Unit (CU) = square
- Prediction Unit (PU)
- Transform Unit (TU)

H.264/AVC HEVC



- LCU: raster scan
- others: Z-scan

Intra prediction modes



Loop Filters

- **Deblocking filter (DF)**
  - improve visual quality (and prediction performance)
  - smoothing sharp edges between transform units
- **Sample Adaptive Offset (SAO)**
  - classify reconstructed pixels into different categories
  - reduce the distortion (restore edges) by adding an offset for each category of pixels
- **Adaptive Loop Filter (ALF)**
  - block based Wiener filter
  - filtering coefficient are signalled in the bitstream
  - estimates original signal from signal corrupted by additive (coding) noise

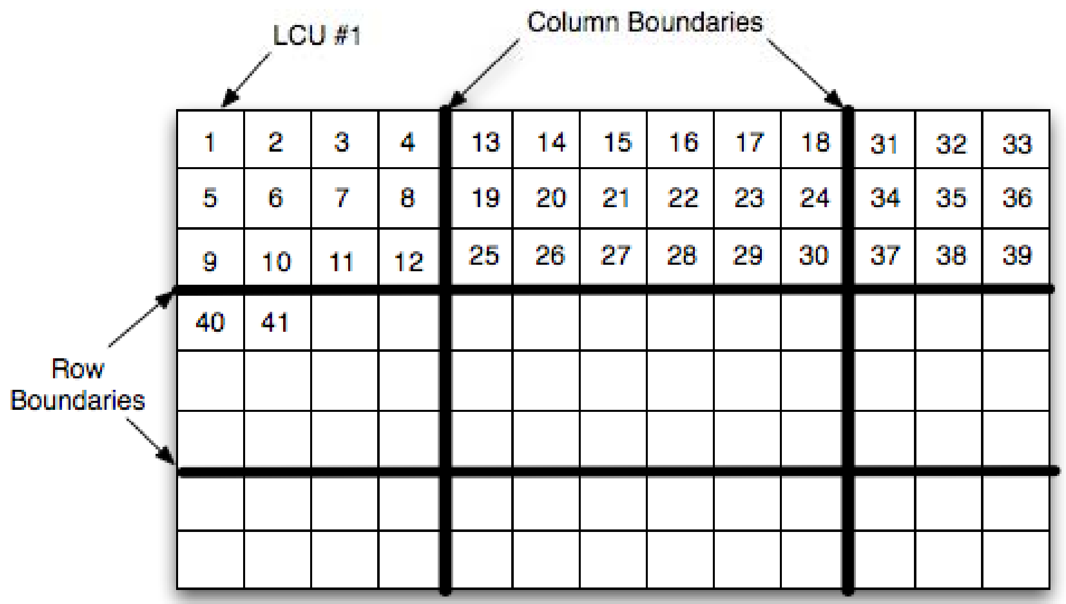
Feature	Slices	Entropy Slices	Tiles	WPP
Independent parsing (of a partition)	✓	✓	✓(independent) x (dependent)	✓ (with some LCU delay)
Independent decoding	✓	x	✓(independent) x (dependent)	✓ (with some LCU delay)
LCU order changing	x	x	✓	x
Overhead	Slice header	Short Slice header	Byte offsets	Byte offsets

HEVC Main Profile

• 4:2:0 chroma subsampling	(chroma_format_idc =1)
• 8 bit	(bit_depth_luma=8 ; bit_depth_chroma=8)
• No ALF	(adaptive_loop_filter_enabled_flag=0)
• Luma to chroma prediction	(chroma_pred_from_luma_enabled_flag=0)
• No inter 4x4	(inter_4x4_enabled_flag=0)
• No AMP	(asymmetric_motion_partitions_enabled_flag=0)
• No NSQT	(non_square_quadtree_enabled_flag=0)
• LCU size = [16,64]	(Log2CtbSize in range from 4 to 6)
• Slices on LCU boundary	(SliceGranularity=0)
• Tiles allowed, no WPP	(tiles_or_entropy_coding_sync_idc=0 or 1)
• No entropy slices	(entropy_slice_flag=0)

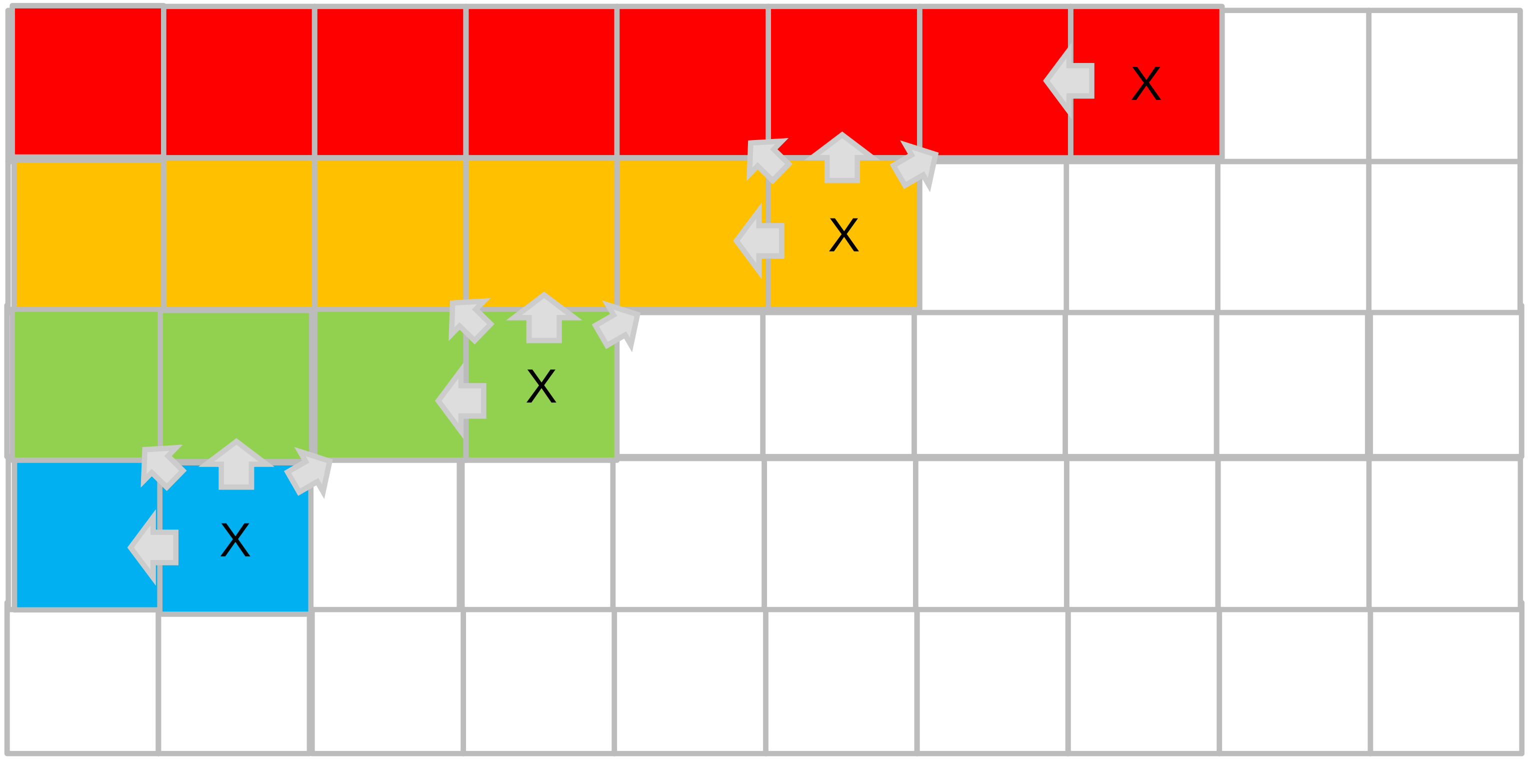
High Efficiency Video Coding (HEVC)

- Increased interest in hardware-friendliness
  - design of transforms, filters etc.
  - introduction of tiles (on top of slices)
    - encoder-side (massive) parallelism



High Efficiency Video Coding (HEVC)

- Increased interest in hardware-friendliness
  - wavefront parallel processing (WPP)
  - lossless transcoding possible between WPP and non-WPP streams



High Efficiency Video Coding (HEVC)

- Current status
  - bit rate reduction compared to H.264/AVC High Profile

	All Intra	Random Access	Low Delay
Class A	−23.4%	−36.9%	
Class B	−22.8%	−39.5%	−41.1%
Class C	−20.3%	−30.4%	−32.5%
Class D	−16.9%	−28.2%	−29.7%
Class E	−28.8%		−42.9%
Class F	−22.7%	−26.0%	−29.9%
Average	−22.2%	−32.5%	−35.1%

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- 3D video
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3D video

Stereoscopic 3D

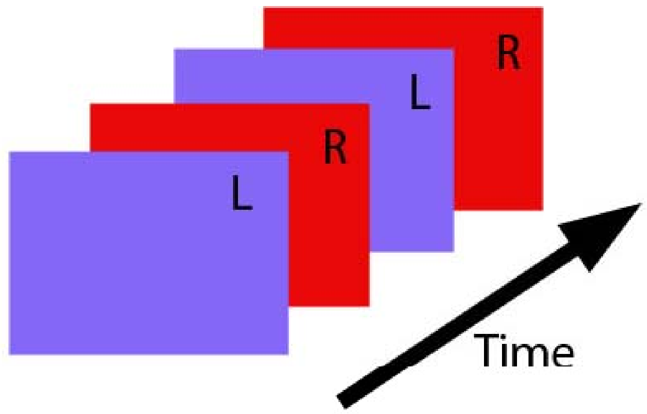
- Passive glasses
  - polarization
  - cinema
  - LG, Philips Easy 3D, …

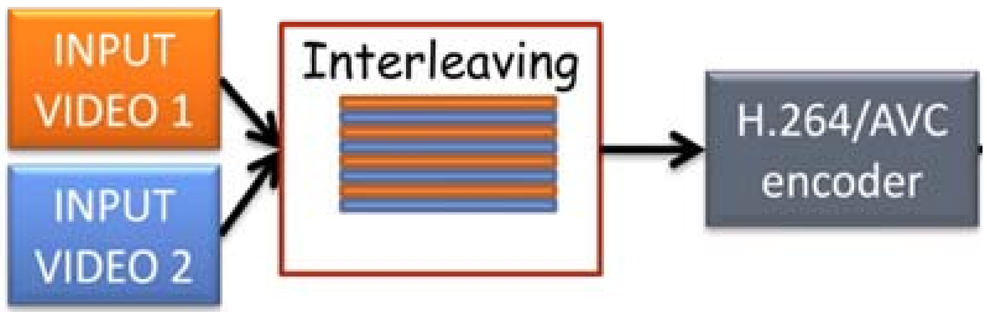
- Active glasses
  - requires communication path between display and glasses (IR)
  - NVIDIA 3D Vision, Philips 3D Max, Samsung, …

Stereoscopic 3D

- Stereo video coding options

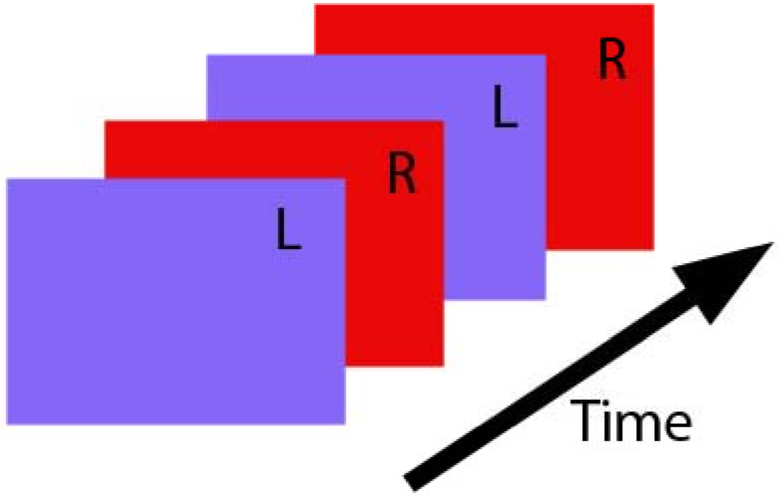
- Full resolution
  - frame sequential
  - interleaving
  - MVC extension of H.264/AVC
- Half resolution
  - frame packing





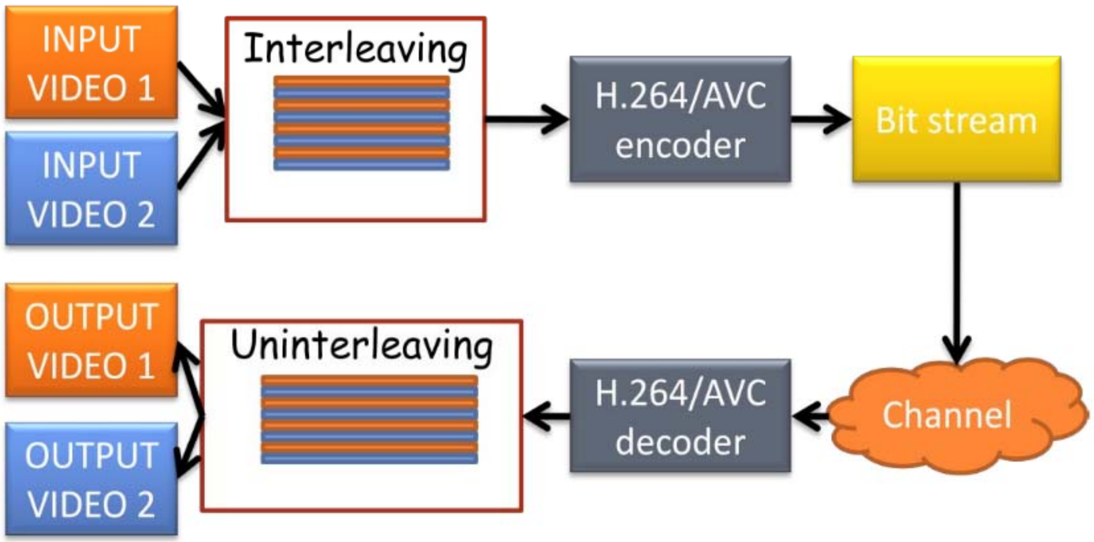
Stereoscopic 3D

- **Frame sequential 3D coding**
  - frame rate increase
  - high-level (SEI) signaling in H.264/AVC



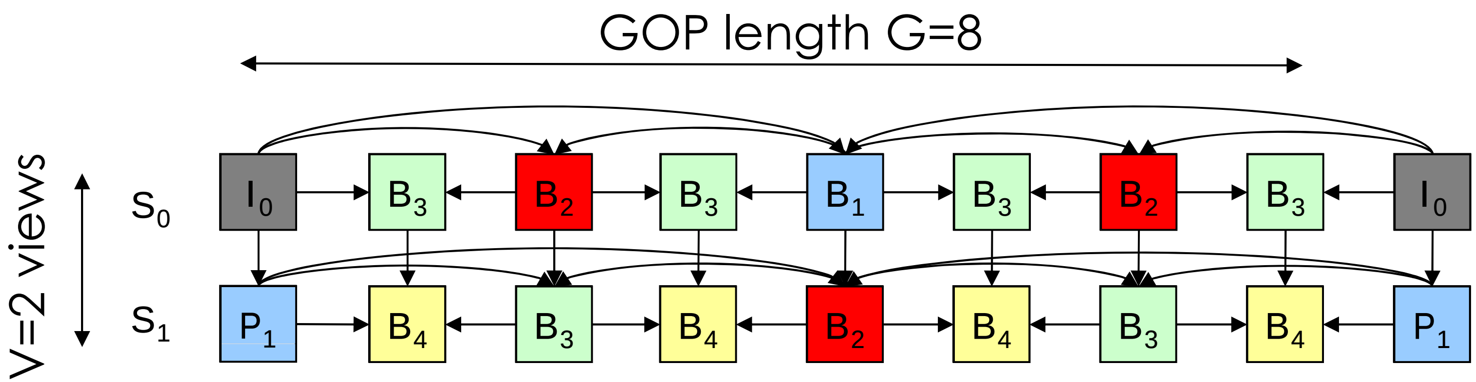
Stereoscopic 3D

- **Interleaving**
  - stereo video SEI message in H.264/AVC
  - frames with double (vertical) resolution



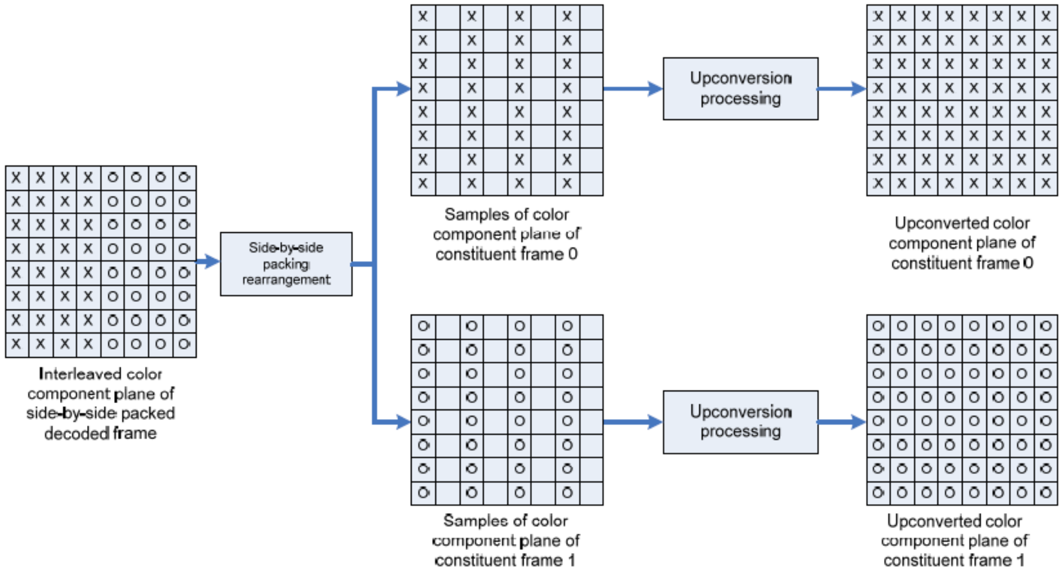
Stereoscopic 3D

- Multi-view Video Coding (**MVC**) extension of H.264/AVC
  - exploit inter-view correlation
  - Stereo High Profile
  - finalized in 2009 by Joint Video Team of MPEG and VCEG



Stereoscopic 3D

- **Frame compatible** arrangements
  - merge L and R at half resolution into one frame
    - downsampling before encoding, upsampling after decoding
    - e.g., side by side



Multi-view 3D

view 0

view 1

view 2

view 3

Multi-view 3D

How to capture this?

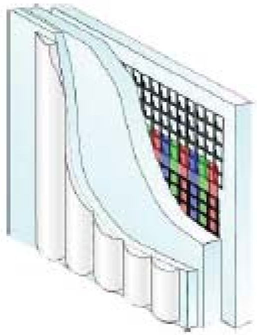
Microsoft
Research Asia

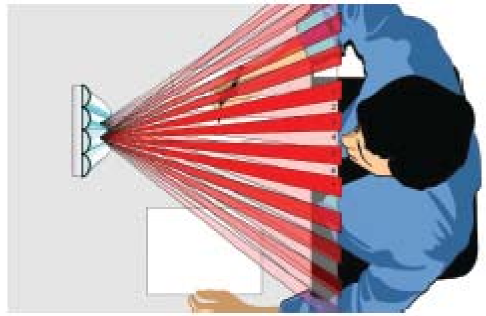
Multi-view 3D

How to visualize this?

ays

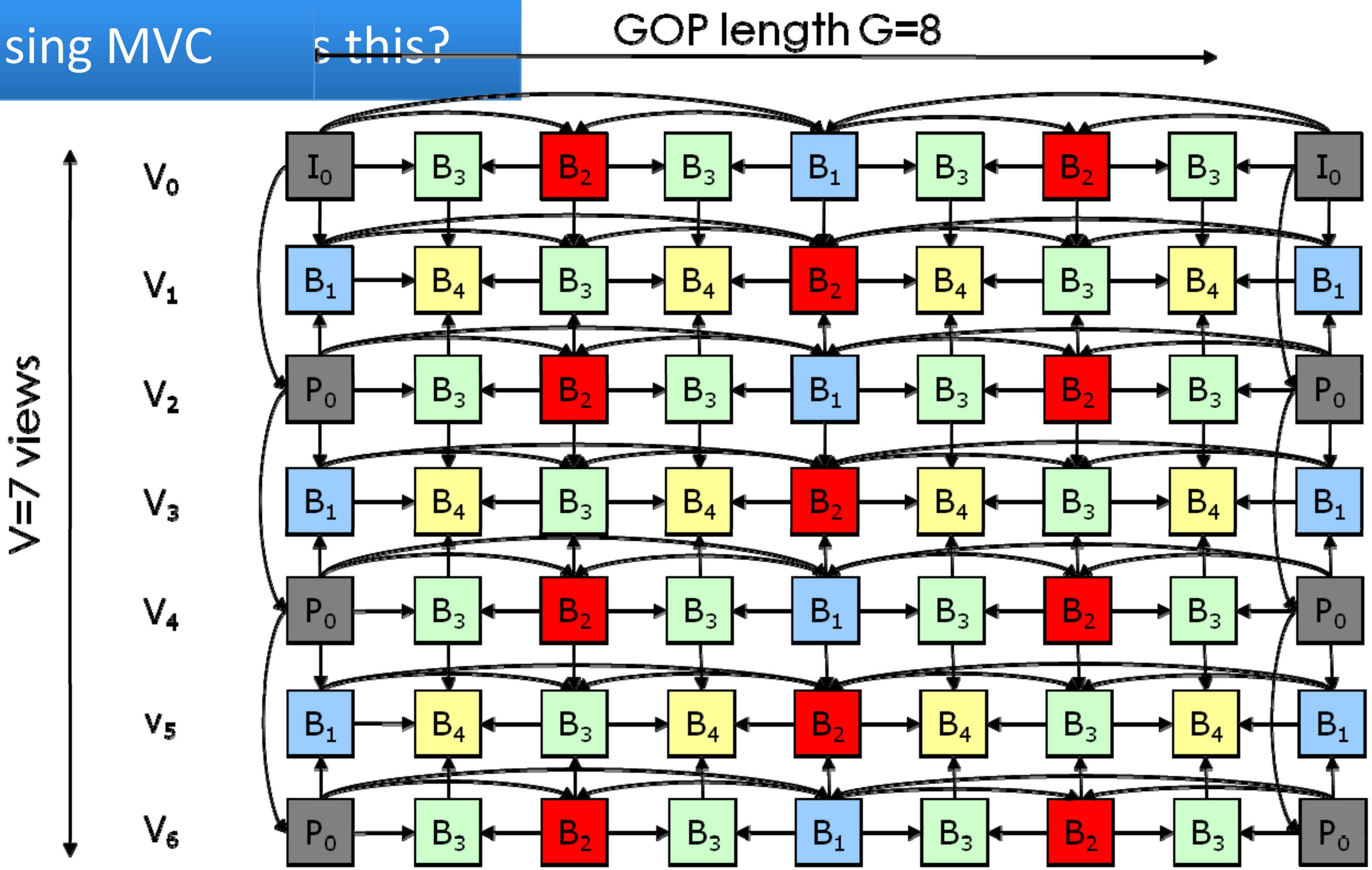
- lenticular displays
- 9-view / 28-view





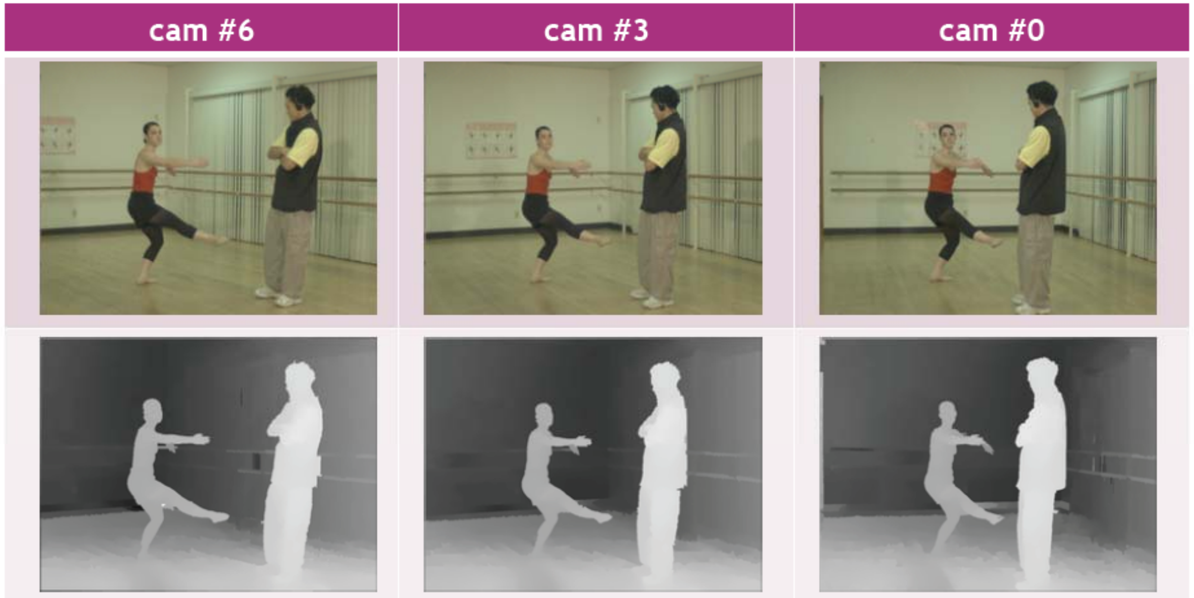
Multi-view 3D

using MVC s this?



Multi-view 3D

- Use of **depth maps**
  - limited number of transmitted views
    - with corresponding depth maps
  - intermediate views can be synthesized from texture & depth maps
  - multi-view + depth (MVD)



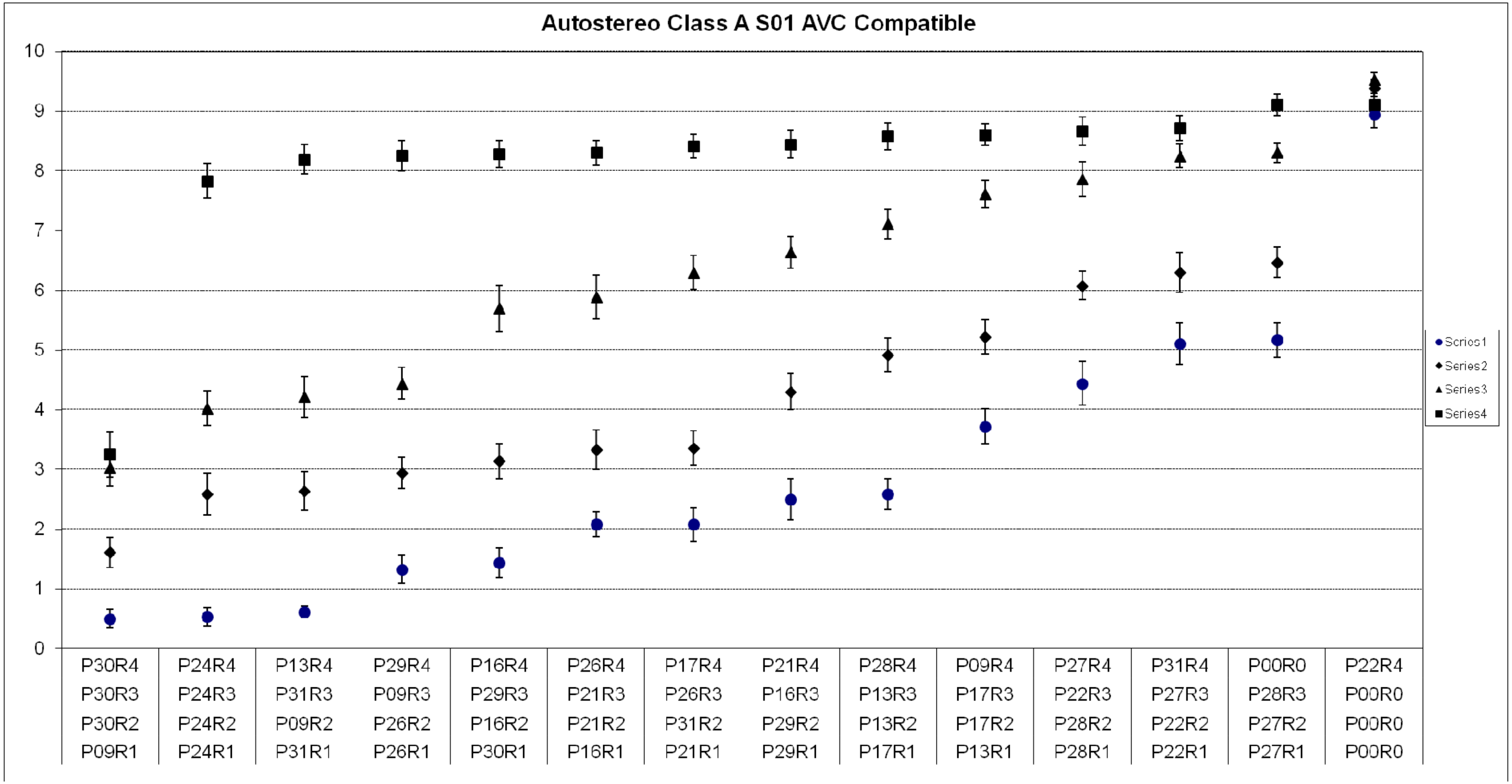
3D video coding in MPEG

- Call for Proposals in MPEG (2011)
  - 23 proponents responded
  - large subjective evaluation
    - mean opinion scores (MOS) of ~900 viewers
    - labs in Europe, North America and Asia
    - both for stereoscopic and autostereoscopic displays

- New collaboration between ITU-T VCEG and ISO/IEC MPEG
  - Joint Collaborative Team on 3D Video (JCT-3V)

3D video coding

- Subjective evaluations - example



3D video coding

- 3 standardization tracks currently ongoing

MVC extension (HP)

- fast track
- extend MVC with depth map coding
- stereo compatibility

H.264/AVC extension (EHP)

- ‘slower’ track
- more complex tools
- at least mono compatibility

HEVC extension (HTM)

- in line with HEVC standardization
- complex tools possible

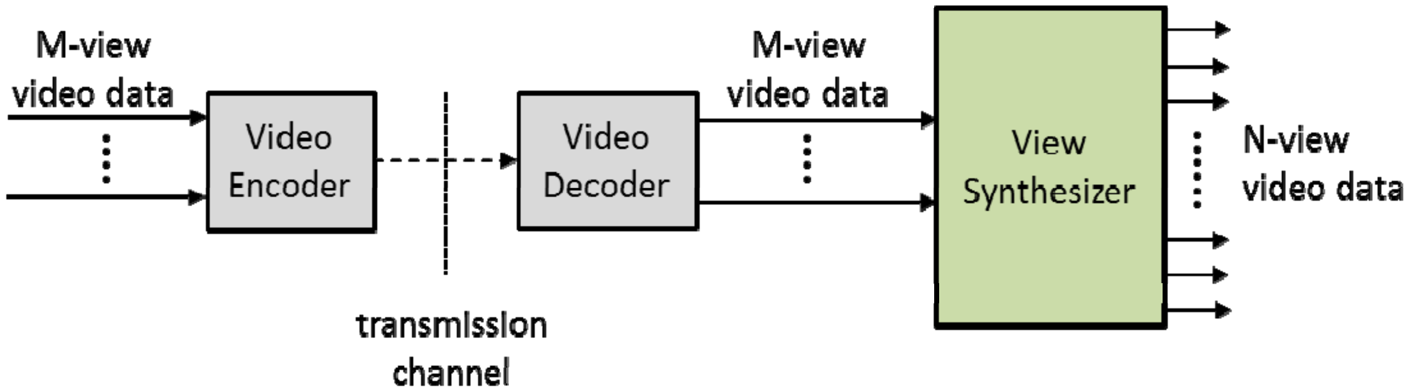
3D video coding

- Status of 3D standardization
  - HP: MVC extension (high-level)
  - EHP: AVC extension (low-level coding tools)
  - MVHEVC: HEVC extension (high-level)
  - HTM: HEVC extension (low-level coding tools)

EHP	-10,70%		
MVHEVC	-47,97%	-41,79%	
HTM	-53,63%	-48,25%	-11,50%
BD-rate gain over	HP	EHP	MVHEVC

3D video coding

- Other options considered
  - hybrid schemes
    - e.g., AVC+HEVC
    - avoids introducing 'yet another standard'
  - no depth map coding
    - depth maps generated at decoder side
    - proposal by Disney Research Zurich



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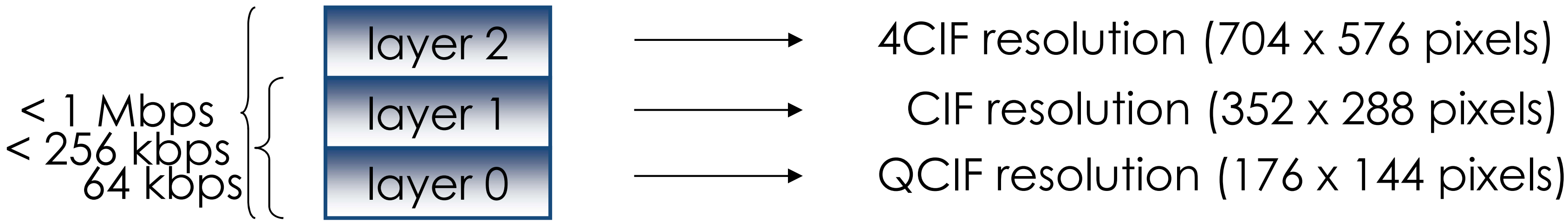
Video adaptation

- Digital video is distributed to a wide variety of devices, and sent over different types of networks
  - solutions for adaptation of video are required

- Several options available (which can be combined)
  - scalable video coding
  - transcoding
  - adaptive streaming

Video adaptation

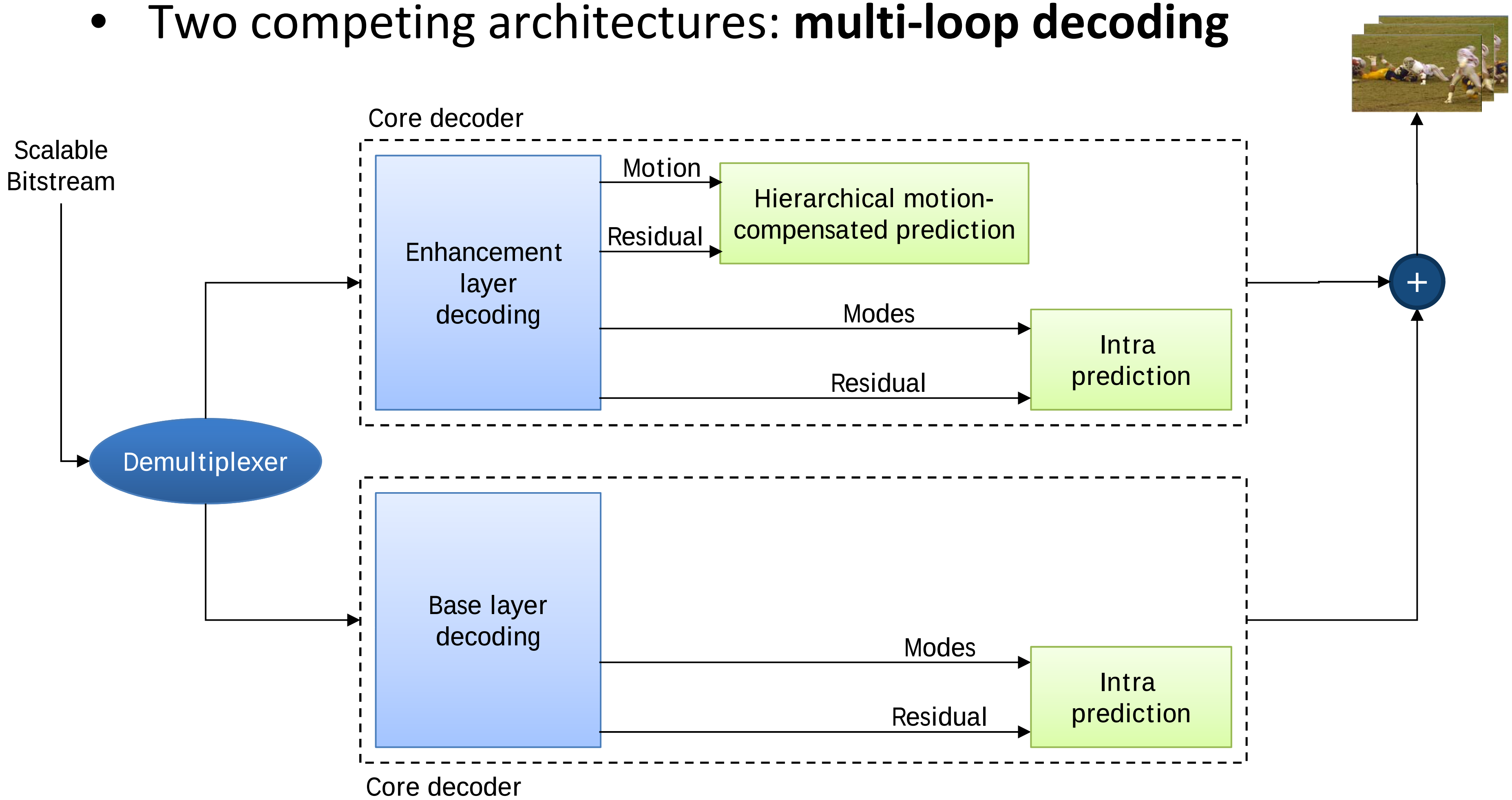
- **Scalable video coding**
  - scalable extension of H.264/AVC (SVC)
    - finalized in 2007
    - limited usage in industry so far



  - scalable extension of HEVC
    - Call for Proposals launched in JCT-VC

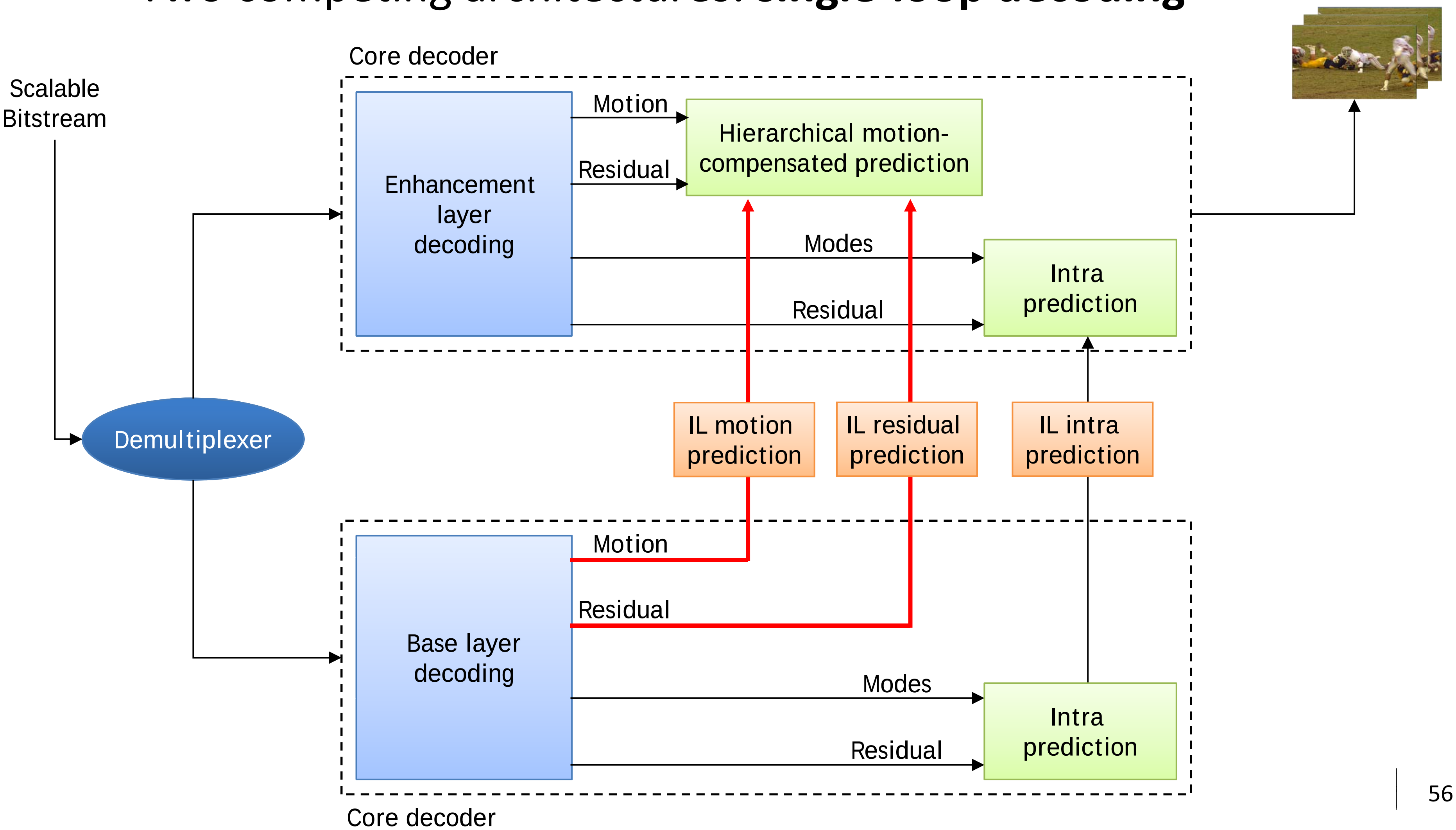
Video adaptation

- Two competing architectures: **multi-loop decoding**



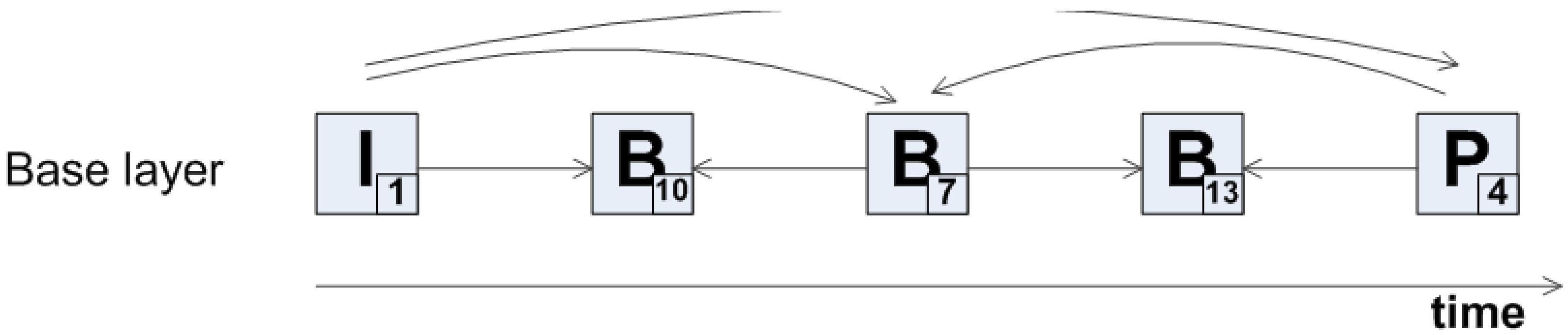
Video adaptation

- Two competing architectures: **single-loop decoding**



Scalable HEVC – Quality layering

- Scalable extension of HEVC
  - first solution: pixel-domain prediction by reordering reference pictures



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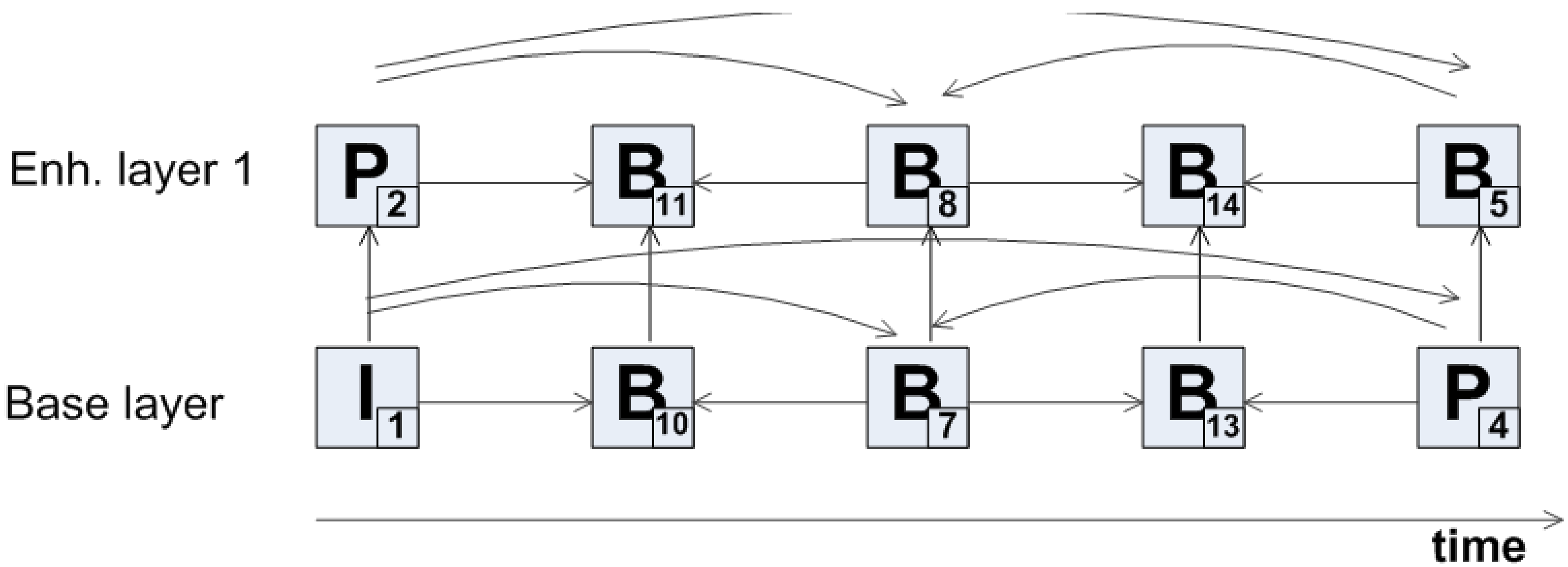

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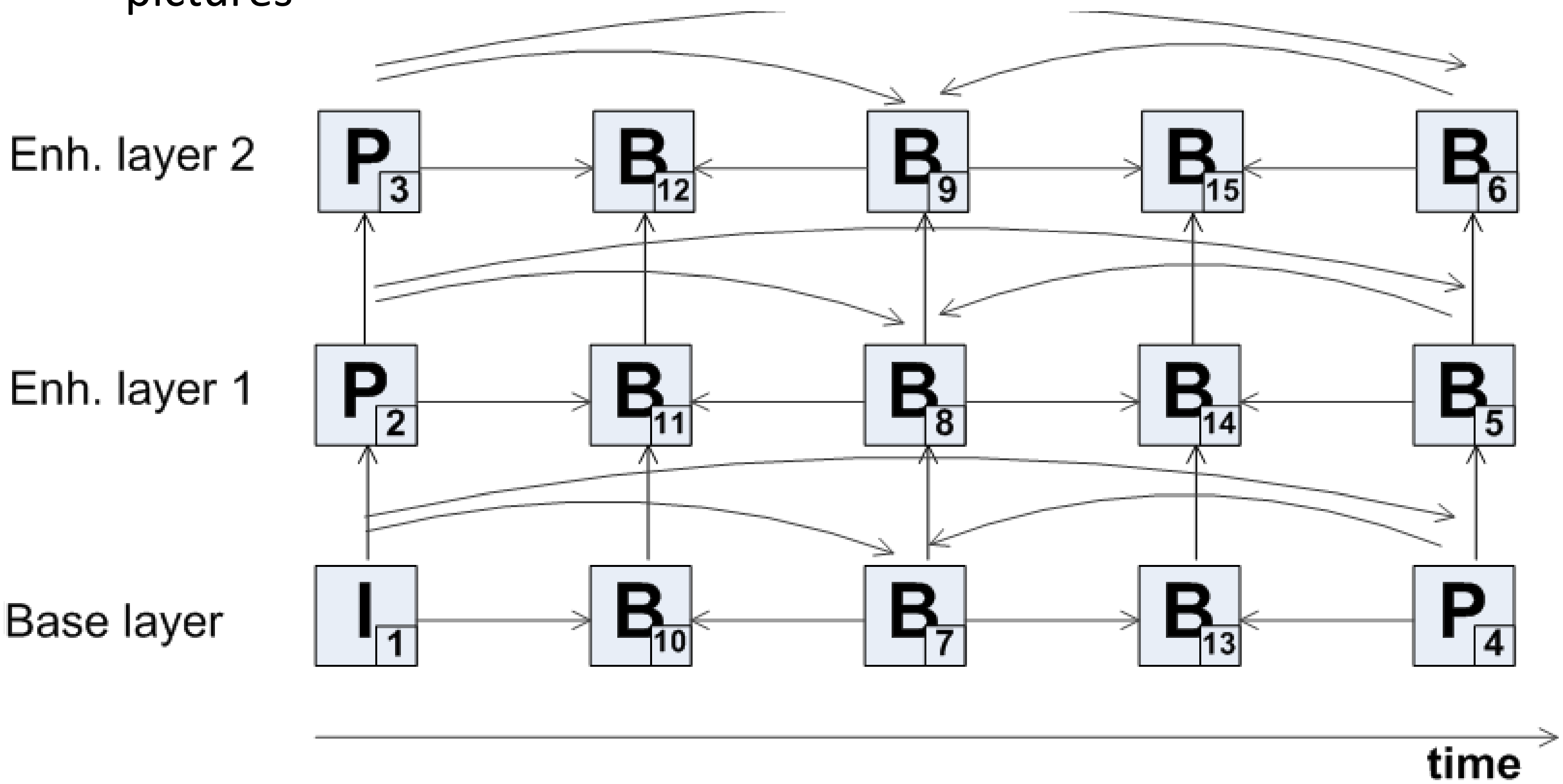
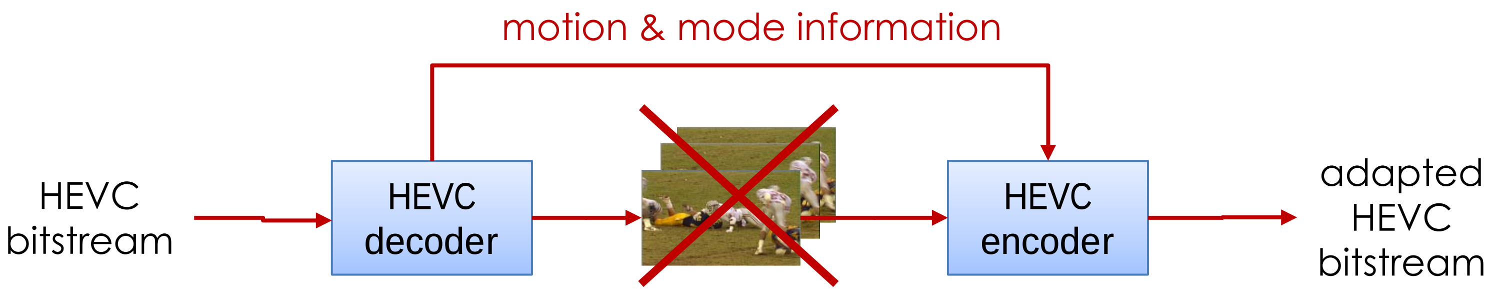


Scalable extensions of HEVC

- More advanced prediction schemes are being tested
  - inter-layer motion prediction
  - inter-layer residual prediction
  - inter-layer intra prediction

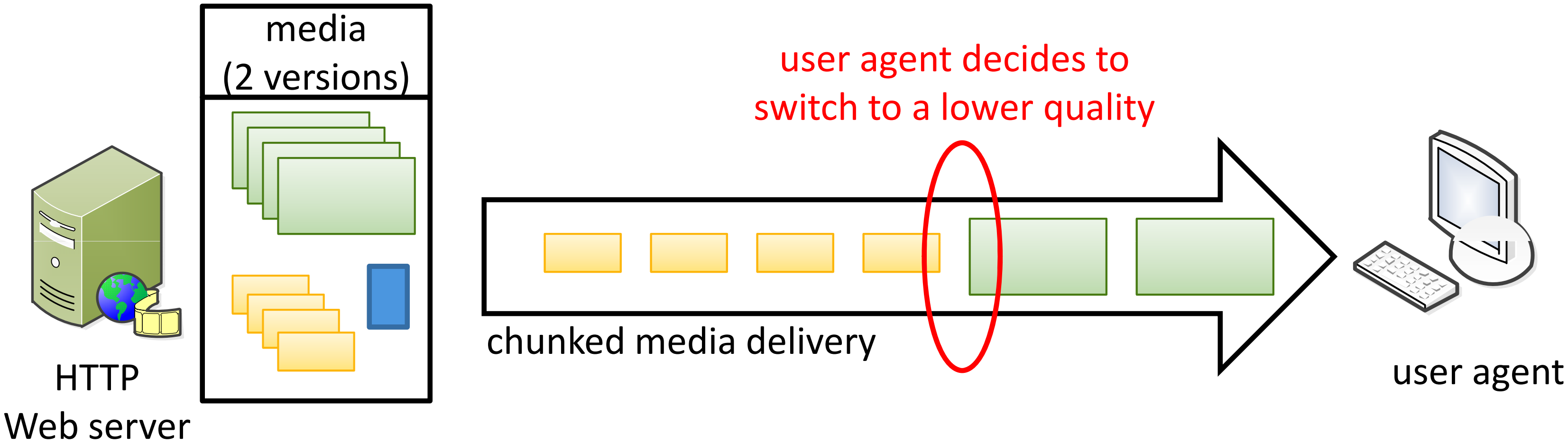
Video adaptation

- **Transcoding**
  - MPEG-2 and H.264/AVC transcoding have been explored in the last decade
  - new problems arise with the planned introduction of HEVC
    - increased complexity of HEVC
    - high-resolution material
    - migration of existing video



Video adaptation

- **Adaptive streaming over HTTP**
  - divide video/audio in chunks
  - switch between alternate-quality chunks
  - patent by Move Networks (‘streamlets’)
  - HTTP streaming → no firewall issues



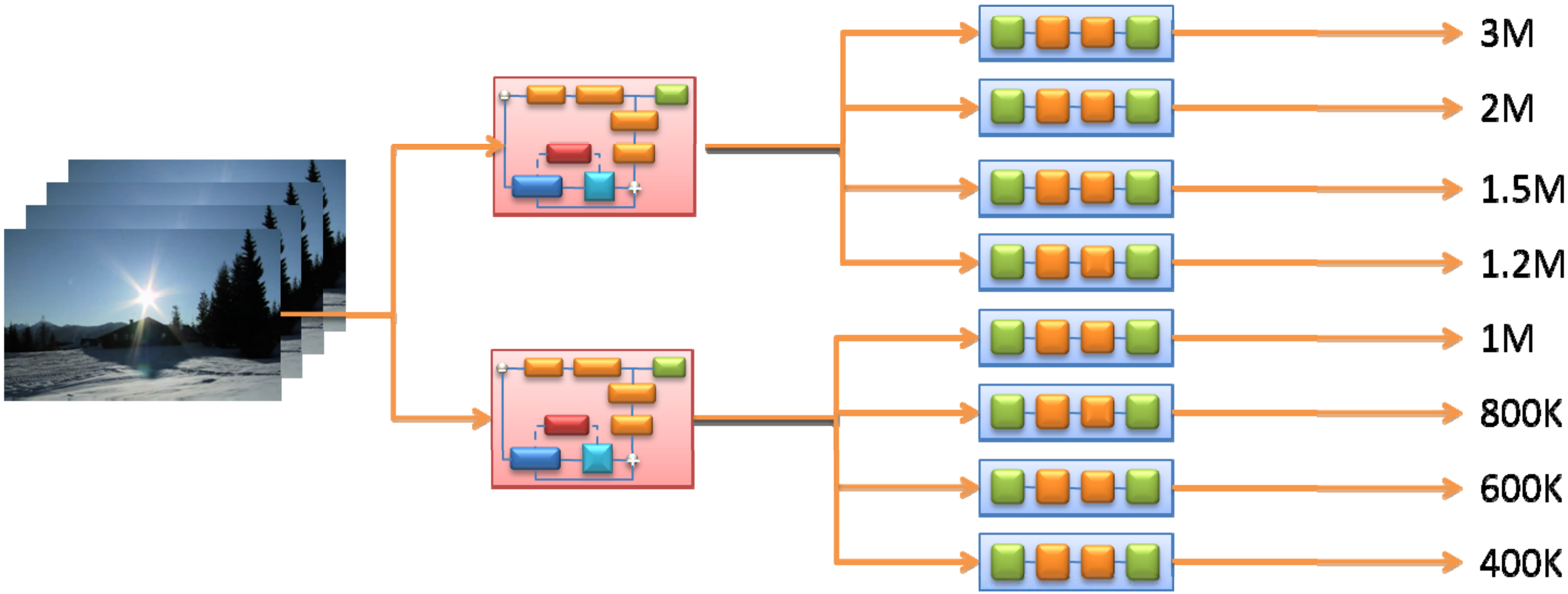
Video adaptation

- **Adaptive streaming over HTTP**
  - several technologies available

Proprietary			Standardized	
Apple HTTP Live Streaming (HLS)	**Adobe HTTP Dynamic Streaming**	**Microsoft Smooth Streaming**	**3GPP Adaptive HTTP Streaming (AHS)**	**MPEG DASH**
HTTP progressive download	HTTP & RTMP	IIS extension	HTTP delivery of media	MPEG-2 TS & MPEG-4 file format
QuickTime, iPhone	Flash	SilverLight, Windows Phone 7	packaging of segments	based on 3GPP AHS

Video adaptation

- **Adaptive streaming over HTTP**
  - generating multiple video packets (with minimal complexity)
    - e.g., trade-off between encoding and transcoding



Overview

- Introduction
- High-Efficiency Video Coding (HEVC)
- 3D video
- Video adaptation
- Concluding remarks

Concluding remarks

- New challenges imposed by future displays and applications
  - (significantly) higher resolutions
  - multiple views
  - mobile video
- … explains the need for new video coding techniques and standards

- Some challenges will be tackled in HEVC… and some by MPEG 3D
- Several options for video adaptation
  - scalability & transcoding need update for new standards

Concluding remarks

- Video coding research in Multimedia Lab
  - HEVC
    - coding efficiency (JCT-VC contributions)
    - applications
  - (MPEG) 3D
    - coding schemes (for stereo and autostereo)
    - multi-view extension of HEVC
    - 2D-3D conversion
  - adaptation
    - scalable extension of HEVC
    - transcoding
    - (adaptive) streaming technology