

2017 DICOM Workshop – April 13, 2017
Universitatea de Medicina & Farmacie UMF
Cluj-Napoca, Romania



Video & DICOM: Today & Future

Emmanuel Cordonnier

b<>com Institute of Technology

Director, e-Health

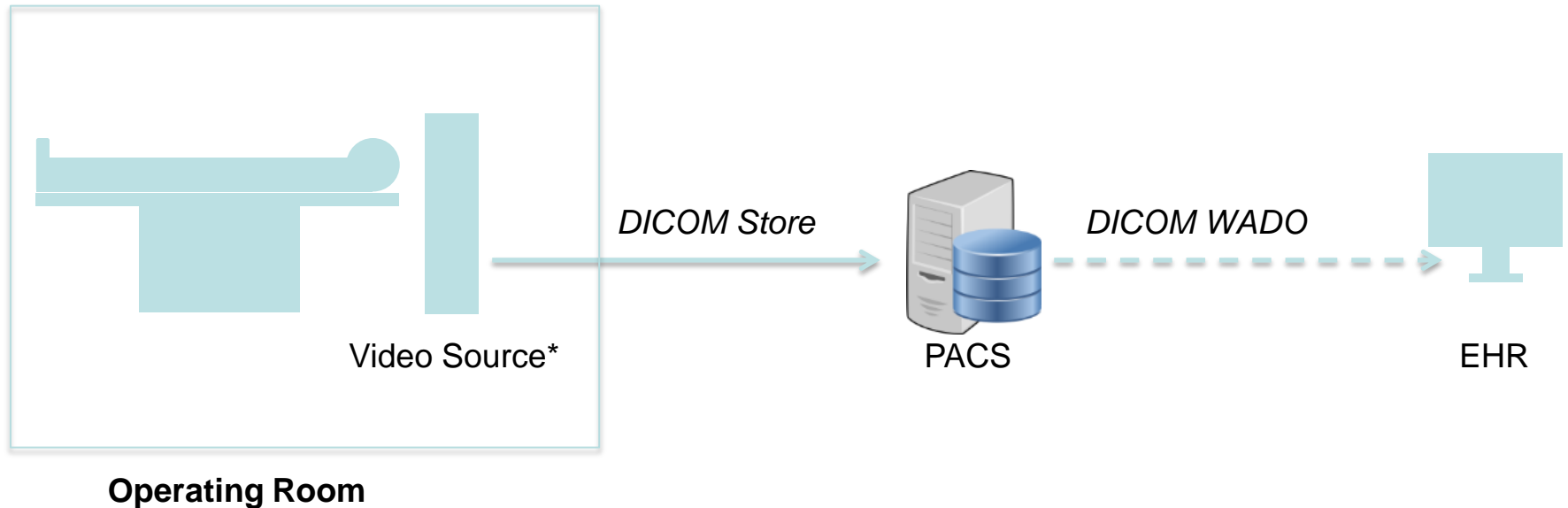
Co-chair DICOM WG13 – Visible Light

Past Co-chair DICOM Standards Committee

b com

DICOM video Today

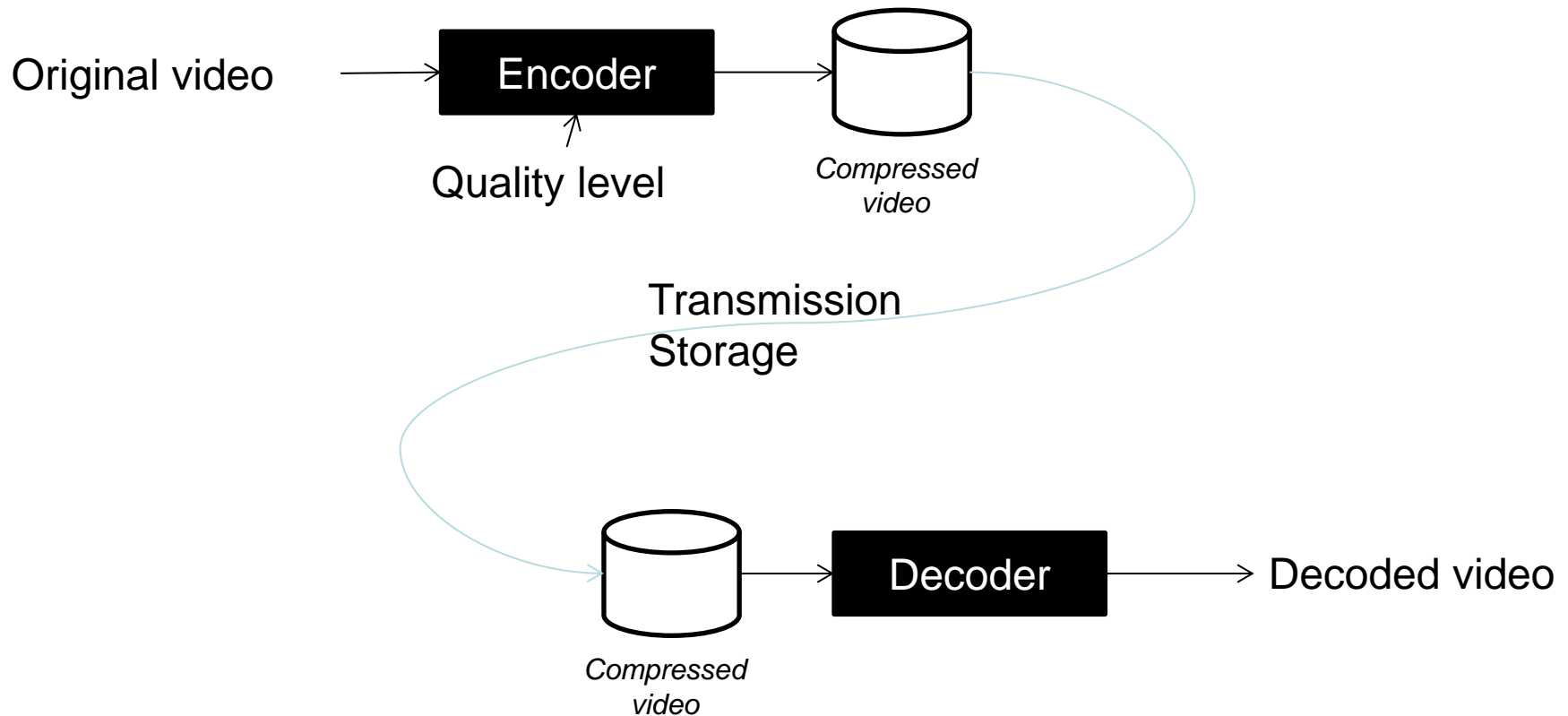
- From Operating Room to EHR through the PACS
- Associating Patient information with the video



*over head camera, endoscope, microscope ...

Video compression principles (1)

Next 10 slides authored by Félix Henri, Orange/b<>com

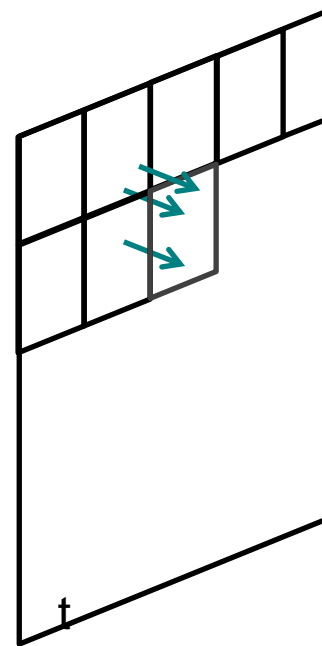
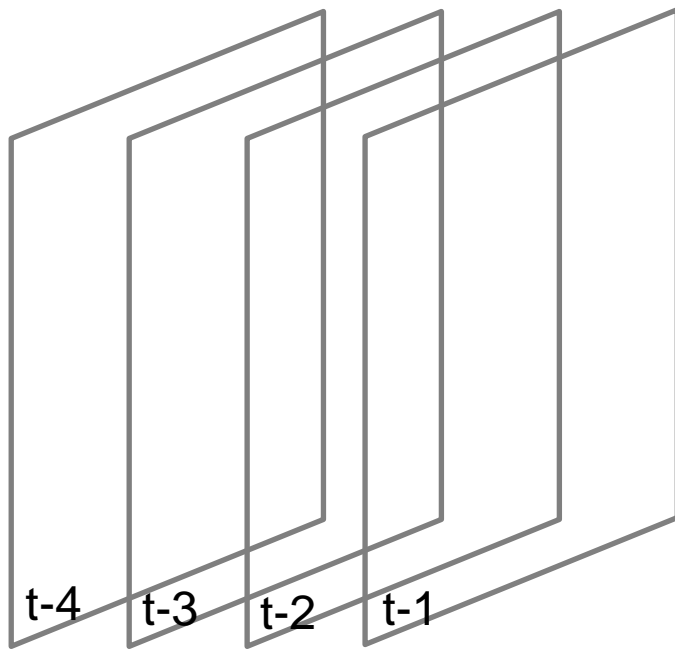


- **Universal principles**
 1. **Flexible subdivision in blocks**
 2. **For each block**
 1. Inter-image or intra image prediction
 2. Construction of a residue
 3. Transform
 4. Quantification
 5. Entropic encoding

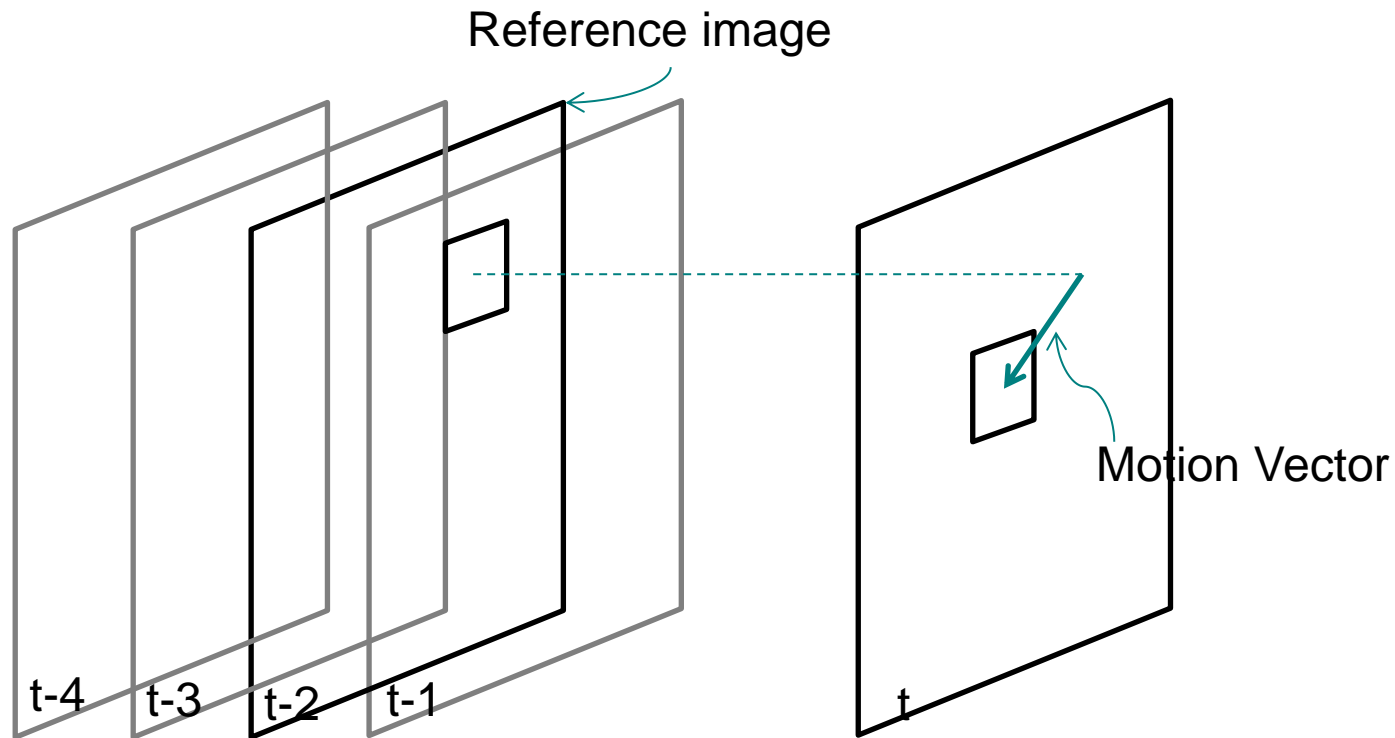
- **Flexible subdivision in blocks**



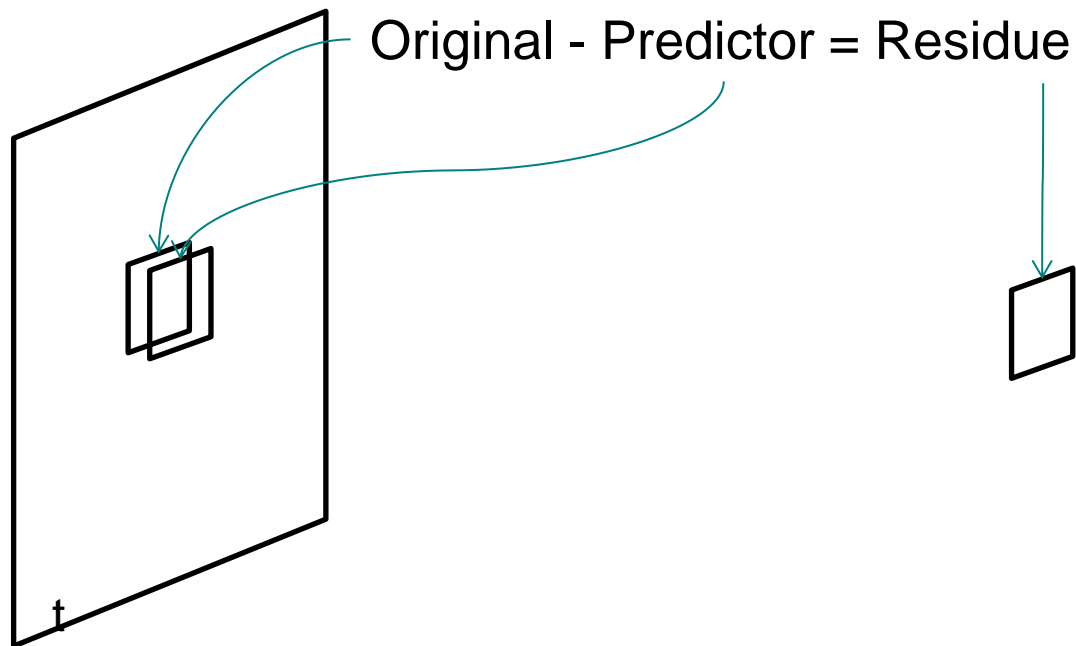
1. Intra image prediction



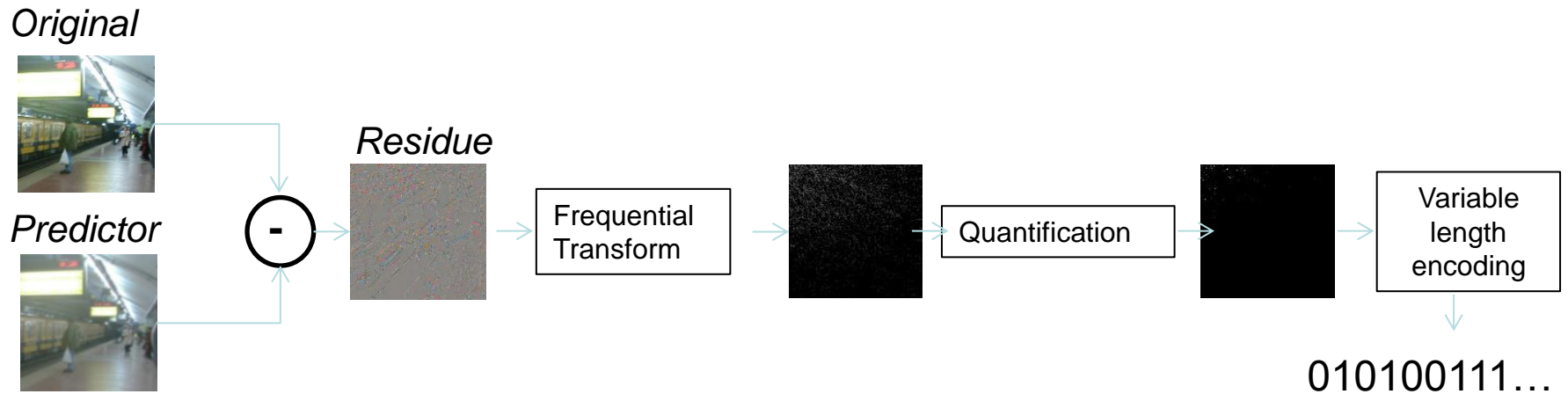
1. Inter image prediction



2. Construction of a residue

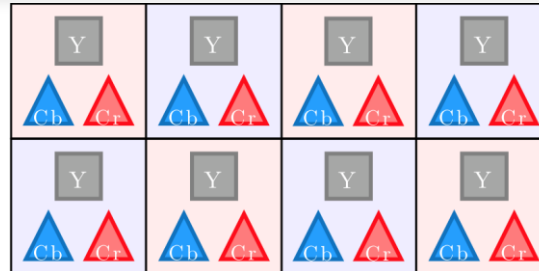


- 3. Transform
- 4. Quantification
- 5. Entropic encoding

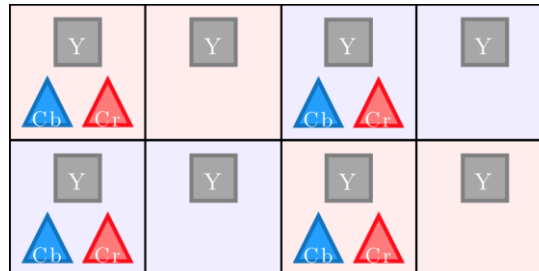


Video color coding schemes

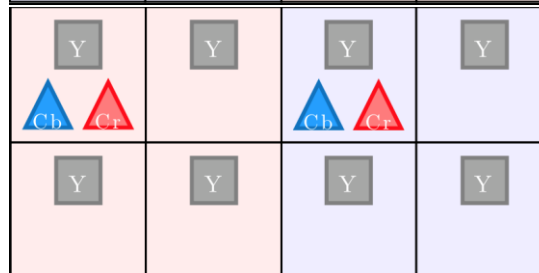
- 4:4:4



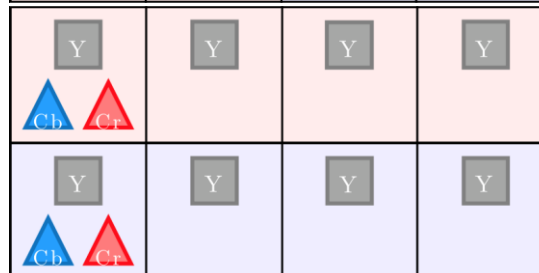
- 4:2:2



- 4:2:0



- 4:1:1



- **Video compression standards**
 - **50% improvement every 10 years**

	1993	2003	2013	2022
Standard	MPEG-2	H.264 (MPEG-4)	H.265 (HEVC)	?
HD in	12Mb/s	6Mb/s	3Mb/s	1.5Mb/s?



Video compression standards (2)

• Video Codecs War

	Name	Owner	Licencing	Compression	Adoption
Official standards	AVC H.264 MPEG-4 part 10	ISO / ITU-T	FRAND, cheap, bounded	100%	Universal
	HEVC H.265 MPEG-H	ISO / ITU-T	FRAND + uncertainties	50%	Big, growing
Private initiatives	Theora	Open source community	Free	300%	Small
	VP9	Google	Free	75%	Medium
	Perseus / V-NOVA	V-NOVA	Proprietary	Claim 30%	Tiny
	Alliance for Open Media	Microsoft, Google, Amazon, Netflix, Mozilla, Intel et Cisco	Claimed free	?	Non existent

- **Supporting video formats produced by sources**
- **Providing a video format that is supported by PCs**
- **Maintaining the quality of image along the chain...**
- **while staying compatible with the PACS capacity**
- **Not altering the shape of anatomical objects**
- **Conveying metadata information along with video**
 - Patient demographics
 - Study information
 - Equipment information
 - Image information (duplicated from the video content)
- **Not exceeding 4GBytes per message/file**

- **Add audio information in CINE MODULE (PS 3.3)**
 - Multiplexed Audio Channels Description Code Sequence
- **Add stereo information in MF MODULE (PS 3.3)**
 - Stereo Pairs Present in Multi-Frame and Group MF modules
- **Create new Transfer Syntaxes (PS 3.5, PS 3.6)**
- **Create new SOP Classes (PS 3.6)**
- **Create new Interchange Profiles (PS 3.11)**
 - DVD (sup. 42)
 - BD (sup. 153)
- **Create new Physical Media (PS 3.12)**
 - BD (sup. 153)
- **Add new Mapping Resources (PS 3.16)**
 - Audio Channel sources

Sup. #	Year	Title
42	2003	MPEG2 Transfer Syntax
47	2003	Visible Light Video SOP Classes
137	2008	MPEG2 MP@HL Transfer Syntax
149	2009	MPEG-4 AVC/H.264 Transfer Syntax
153	2009	Blu-ray Disc Media Application Profiles
180	2015	MPEG-4 AVC/H.264 Transfer Syntax
195	2016	HEVC 4:2:0 Transfer Syntax
202	2018?	<i>Real Time Video</i>

CP. #	Year	Title
457	2004	Add YBR_420 for Ultrasound MPEG
536	2004	Correct VL Image Photometric Interpretation for MPEG
575	2004	Clarify use of Multiplexed Audio for MPEG
769	2008	MONOCHROME2 missing in part of MPEG2 definition
1256	2011	Add defined term for MPEG4
1267	2011	Video streams are independent and may not span instances
1304	2013	Various corrections related to MPEG-4 AVC/H.264 Transfer Syntax
1349	ballot	Link from still picture to video
1488	2015	Clarify RT Image Exposure Attributes in case of MPEG Encoding
1518	work	Add default media type for video for web services

#	SOP Class (1.2.840.10008.5.1.4.1.1.+#)
77.1.1.1	Video Endoscopic Image Storage
77.1.2.1	Video Microscopic Image Storage
77.1.4.1	Video Photographic Image Storage
7.1	Multi-frame Single Bit Secondary Capture Image Storage
7.2	Multi-frame Grayscale Byte Secondary Capture Image Storage
7.3	Multi-frame Grayscale Word Secondary Capture Image Storage
7.4	Multi-frame True Color Secondary Capture Image Storage
12.1	X-Ray Angiographic Image Storage
12.2	X-Ray Radiofluoroscopic Image Storage
3.1	Ultrasound Multi-frame Image Storage
481.1	RT Image Storage
77.1.5.1	Ophthalmic Photography 8 Bit Image Storage
77.1.5.2	Ophthalmic Photography 16 Bit Image Storage
77.1.5.5	Wide Field Ophthalmic Photography Stereographic Projection Image St.
77.1.5.6	Wide Field Ophthalmic Photography 3D Coordinates Image Storage

#	Transfer Syntax (1.2.840.10008.1.2.4.+#)
100	MPEG2 Main Profile @ Main Level
101	MPEG2 Main Profile @ High Level
102	MPEG-4 AVC/H.264 High Profile / Level 4.1
103	MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1
104	MPEG-4 AVC/H.264 High Profile / Level 4.2 For 2D Video
105	MPEG-4 AVC/H.264 High Profile / Level 4.2 For 3D Video
106	MPEG-4 AVC/H.264 Stereo High Profile / Level 4.2
107	HEVC/H.265 Main Profile / Level 5.1
108	HEVC/H.265 Main 10 Profile / Level 5.1

DICOM Video Formats



TS#	Code	Bandwidth	Color	Resolution	F.Rate	Transport
100	MPEG2 MP@ML	4-8Mb/s	Y_420 8b B&W	480x720 576x720	30 25	MPEG-2 TS
101	MPEG2 MP@HL	15-40Mb/s	Y_420 8b B&W	1080ix1920 720px1920	30 60	MPEG-2 TS MP4 cont.
102	H.264 HP 4.1	62.5Mb/s	Y_420 8b B&W	1080ix1920 720px1920	30 60	MPEG-2 TS MP4 cont.
103	H.264 BD 4.1	40Mb/s	Y_420 8b B&W	1080ix1920 720px1920	30 60	MPEG-2 TS MP4 cont.
104	H.264 4.2 2D	62.5Mb/s	Y_420 8b B&W	1080px1920	60	MPEG-2 TS MP4 cont.
105	H.264 4.2 3D	62.5Mb/s	Y_420 8b B&W	1080ix1920 720px1920	30 60	MPEG-2 TS MP4 cont.
106	H.264 Stereo	62.5Mb/s	Y_420 8b B&W	1080ix1920 720px1920	30 60	MPEG-2 TS MP4 cont.
107	H.265 Stereo	160Mb/s	Y_420 8b B&W	2160px4096	60	MPEG-2 TS MP4 cont.
108	H.265 Stereo	165Mb/s	Y_420 10b B&W	2160px4096	60	MPEG-2 TS MP4 cont.

DICOM video embedded audio formats

Audio	Video	Transport	Bit rate	channels	kHz
LPCM	MPEG4 all HEVC all	MPEG-2 TS	4.6 Mb/s	2	48.96
AC3	MPEG4 all HEVC all	MPEG2-TS	640kb/s	2 or 5.1	48
AAC	MPEG4 all HEVC all	MPEG-2 TS MP4 cont.	640kb/s	2 or 5.1	48
MP3	MPEG2 all MPEG4 all HEVC all	MPEG-2 TS MP4 cont.	320kb/s	2 + nx2	32, 44.1 or 48
MPEG-1 Layer II	MPEG4 all HEVC all	MPEG-2 TS MP4 cont.	384kb/s	2	32, 44.1 or 48

Main modules in DICOM video instances



IODs Modules	US MF	SC MF SB	SC MF GB	SC MF GW	SC MF TC	XA	RF	RT IM	Vid VL EN	Vid VL MC	Vid VL PH	Oph 8 Bit	Oph 16 Bit	WF Oph St	WF Oph 3DC
Patient	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Clinical Trial Subject	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
General Study	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Patient Study	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Clinical Trial Study	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
General Series	M	M	M	M	M	M	M		M	M	M	M	M	M	M
Clinical Trial Series	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Frame of Reference	U		C	C	C			U						M	M
Synchronization	U		U	U	U	U	U					M	M	M	M
General Equipment	M	U	U	U	U	M	M	M	M	M	M	M	M	M	M
General Image	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Image Pixel	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Cine	M	C	C	C	C	C	C	C	M	M	M	C	C	C	C
Multi-frame	M	M	M	M	M	C	C	C	M	M	M	M	M	M	M
Device	U	U	U	U	U	U	U	U	U	U	U	U	U		
Specimen	U	U	U	U	U	U	U		C	C	C				
VOI LUT	U		C	C		U	U	U							
Common Instance Reference	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
SOP Common	M*	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Frame Extraction	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

M: Mandatory, C: Conditional, U: User Option

Video Conformance Statement / Sources



Vendor	Model	SOP Classes	Format
Karl Storz	AIDA	Video Endoscopic	MPEG2 MP@ML/HL, MPEG4 HP 4.1
Karl Storz	OR1 HD Connect NEO	Video Endoscopic	MPEG2 MP@ML
Varian	System Server	RT Image	MPEG2 MP@ML
Zeiss	Calisto	Video Photographic	MPEG2 MP@ML
etiam	DICOM Izer (converter)	Video Endo/Micro/Photo MF Sb/GB/GW/TC SC	MPEG2 MP@ML/HL MPEG4 HP BD/4.1

Video Conformance Statement / Servers



Vendor	Model	SOP Classes	Format
Agfa	Enterprise Imaging	Video Endo/Micro/Photo MF Sb/GB/GW/TC SC	MPEG2 MP@ML/HL, MPEG4 HP BD/4.1
Carestream	Vue PACS	Video Endo/Micro/Photo MF Sb/GB/GW/TC SC	MPEG2 MP@ML/HL, MPEG4 HP BD/4.1
Fujifilm	Synapse VNA	Video Endo/Micro/Photo MF Sb/GB/GW/TC SC	MPEG2 MP@ML
GE	Centricity	Video Endo/Micro/Photo MF Sb/GB/GW/TC SC	MPEG2 MP@ML
Karl Storz	AIDA	Video Endoscopic / Microscopic / Photog.	MPEG2 MP@ML
Karl Storz	OR1 NEO	Video Endoscopic	MPEG2 MP@ML
Siemens	Syngo	Video Endo/Micro/Photo MF Sb/GB/GW/TC SC	MPEG2 MP@ML/HL, MPEG4 HP BD/4.1

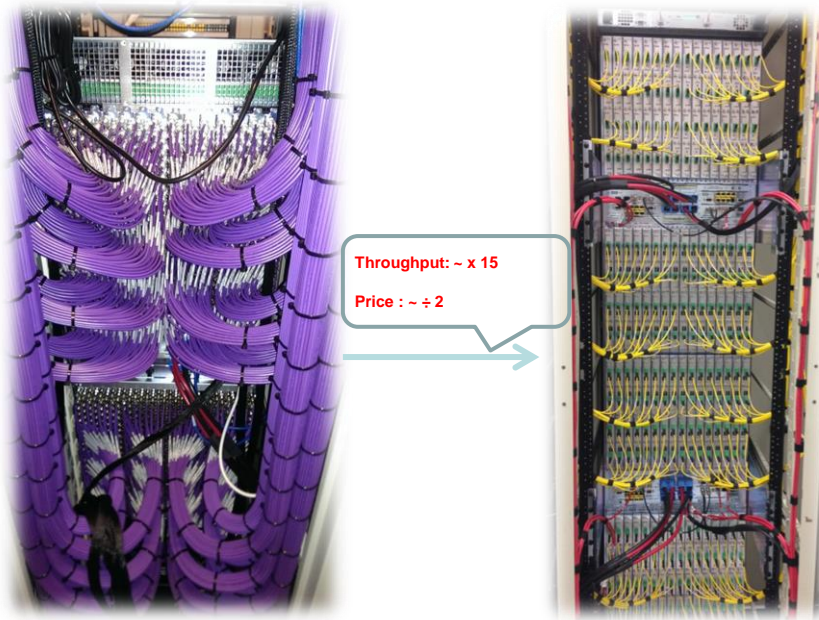
- **Pixel ratio different than 1:1 (error in display)**
- **Inconsistency DICOM header vs. video header**
 - the viewer will ignore DICOM header information
- **Too big file or message**
 - split the video in multiple files (do not decode/encode)
 - each part has to be playable independently
 - they reference earlier parts via Reference Image Seq.
- **PACS does not support the video format**
 - save still (key) images in high definition
 - convert in the supported format

DICOM video Future

Professional AV world (R)evolution

From 1998 to 2012:

Migration of pro AV transport from coax infrastructure to networking technologies: Ethernet (IP), first for long haul, then for intra-studio applications (ProMPEG, VSF, SMPTE, IETF, ISO).



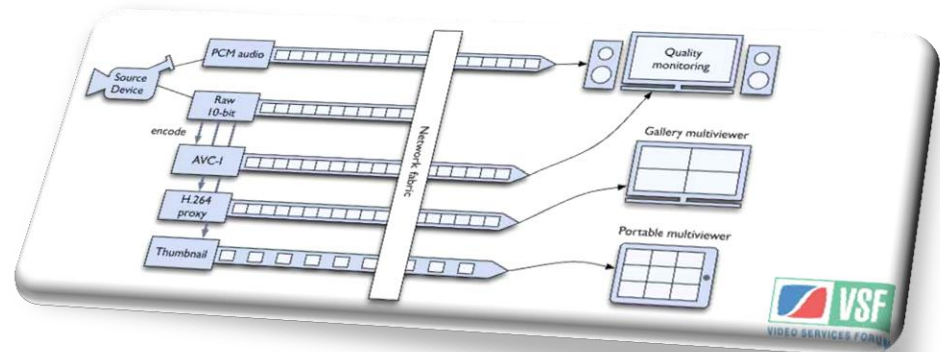
Throughput: ~ x 15
Price : ~ ÷ 2



2013-2017:

« There is more to be done with IP than merely replacing a cable with another »

- ✓ Using SDN technologies for open control of networking gear along the path of AV streams.
- ✓ Re-visiting the essence exchange and transport model.



Focus of the *Joint Task Force for New Media* (EBU/VSF/SMPTE) VSF-TR03 & TR04 Tech. Recommendations published 11/12/15. First interop session performed in February, 2016.

Candidate for “TR03” standards: SMPTE 2110-xx

Upcoming :

- Define profiles for compressed video streams
- New data types, including non-AV metadata

- **Surgery is more and more based on video**
- **IP based video is now pretty mature**
- **Several solutions exist but still proprietary**
- **Interoperable standard is required to**
 - enable communication inside and outside OR
 - convey metadata along with the video
 - enable to create value by combining multiple videos
- **Such a standard has to respect constraints**
 - good image quality while compatible with infrastructure
 - very low latency achievable when required (inside OR)
- **New Work Item approved by DSC Dec., 2016**

- **Emmanuel Cordonnier**
 - emmanuel.cordonnier@b-com.com
 - www.b-com.com
 - IRT b<>com
1219 Avenue des Champs Blancs
35510 CESSON-SEVIGNE
FRANCE

Thank you for your attention!