Afial Ibérico2019

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AV over IP

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Welcome

- **Course Goal:**
  - To provide the participant with the tools to make an educated decision regarding the design and implementation of an AV over IP system.

- **Participate, Participate, Participate**
  - Remember that there are no wrong questions !

Future proof?

- Sept 2018 PoE++ approved – 100 W
- Oct 2018 Extron announces a line of AV over IP products
- Oct 2018 test of 100G and 400G ethernet, commercial switches available. Conversations start on Tera Byte Ethernet!
- Nov 2018 UK announces 4 centers for AI analysis of medical imaging
- Nov 2018 Sharp announces 70” 8K display
- On going HDMI 2.1, 48 Gbps, 2-3 meters (where are they?)….Spectra HT8481 chip for active cables!

AV over IP

- Agenda
  - Why AV over IP?
  - Digital AV concepts
  - TCP/IP Networking – Ethernet basics
  - AV Compression
  - TCP/IP protocols
  - AV over IP “triangle”
  - Audio Video Bridging (ABV) IEEE 802.1x
  - 1G solutions
  - 10G solutions

Why AV over IP?

- AV started simple, connecting video to monitors and bandwidth was not an issue
- Then, as we wanted more connections, matrix switches appeared (even 128x128!)
- Digital video came along, EDID and HDCP had to be handled and the hardware become more complex
- A consumer connector HDMI was forced upon the pro-AV world
- Now we have 4K/UHD, HDCP 2.2, clock rates to 600 MHz or more, HDMI 2.1 ……
- Oh, and essentially **no standards**, so each solution has a name and does not play well with other solutions.

Why AV over IP

128x128
HDMI Matrix Switcher

Displays

AV Sources

DVI
Display Port
HDMI

Point to point
3 to 15 mts, 100 mts active cables

AV Sources

HDMI

Point to point
4 twisted pair cable up to 100 mts

HDMI

Control Sources
RS232
USB
IR

16x16
HDBaseT Matrix Switcher

Why AV over IP?

- On the IT world meanwhile we have:
  - **Standards** that guarantee product compatibility and interoperability
  - **Networks** that have been operating for years, that are continuously being upgraded in terms of bandwith and performance (10G in the enterprise, 40G/100G fiber, 20G/40G Cat 8 Copper in Data Centers)
  - **Cabling** options that include Category as well as fiber cables that allow enhanced bandwidth and distances
  - The mighty **SWITCH** that can send essentially anything, anywhere (helped by a **ROUTER**) and to many places at the same time (multicast). 10G coming down in price as 4K and 8K arrive.

Why AV over IP?

AV Source
Display Port
HDMI

Control Sources
RS232
USB
IR

"Heavy" Compression
(Lossy)

"Light" Compression
(Visually Lossless)

Switch 1G, 52 ports

Switch 10G, 24 ports

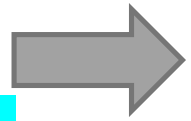
Displays

Why AV over IP?

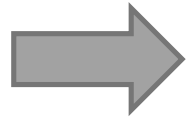
- Flexible and expandable
  - Grow on a port by port basis
  - System size limited only by network bandwidth
  - Support virtual architectural rearrangement
  - Pt to Pt, Pt to Multi-Pt, Multi-Pt to Multi-Pt
- Convenient and cost effective
  - Use existing infrastructure
  - Typically Gb networks, 10G coming down on price
  - Centrally managed
  - Pay as you go
  - Access to content from anywhere

AV over IP

Digitize and compress video



Encode with the necessary structure to transport it over a network (wired or wireless)



Decode and play it back, store it, display it

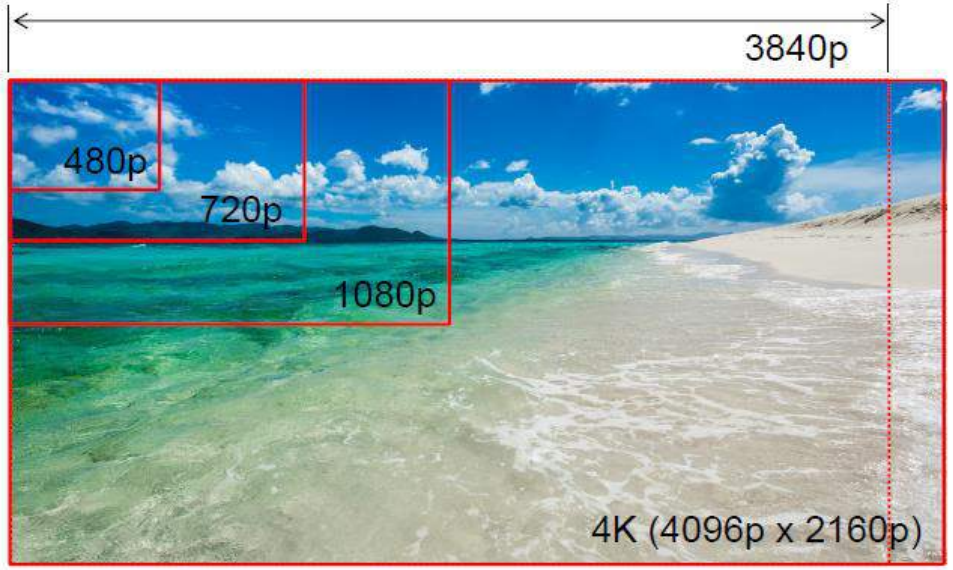
Digital Video Concepts
Chroma Subsampling

Compression Codecs
TCP/IP networking protocols

Compression Codecs

Digital Video Concepts

- **Display Resolution** = # of vertical pixels.
  - HD = 1080, UHD= 2160
  - Horizontal pixels
    - HD= 1920, UHD= 3840 (DCI* = 4096)
  - Total Pixels
    - HD= 2073600, UHD= 8294400



* DCI = Digital Cinema Initiative

Digital Video Concepts

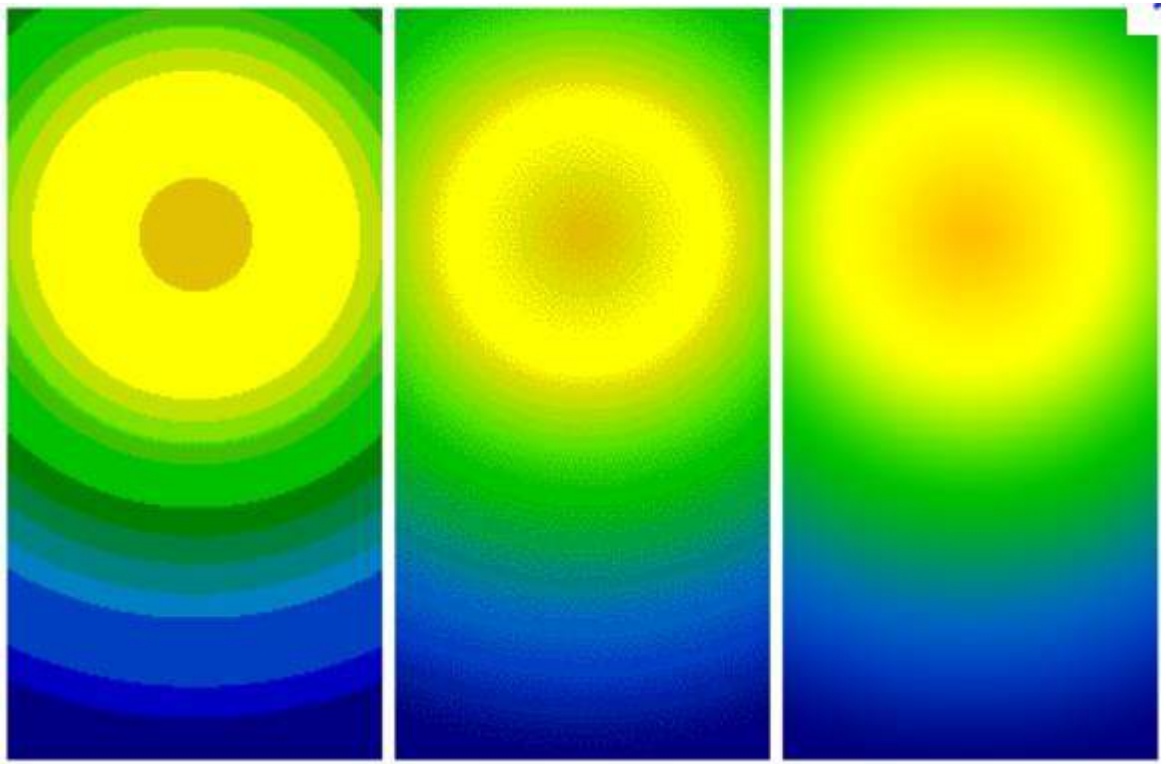
- Color Bit Depth(30, 36, 48 is also called Deep Color)

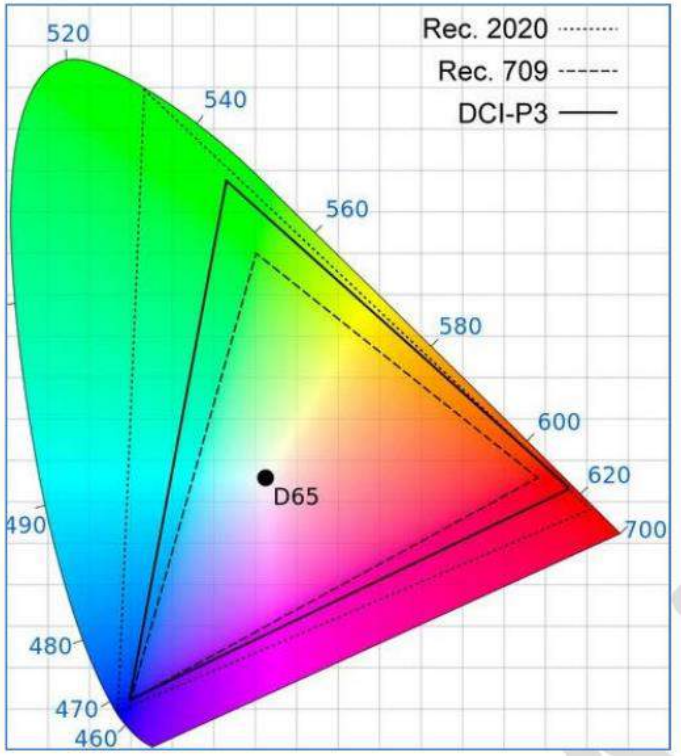
Bit Depth	Bits Per Color	Max Values Per Color	Max Total Colors
24	8-bit	0 - 256	16.78 Million
30	10-bit	0 - 1024	1.1 Billion
36	12-bit	0 - 4096	68.7 Billion
48	16-bit	0 – 65,536	281.5 Trillion

Note – The human eye can see up to 7-10 million colors

Judd, Deane B.; Wyszecki, Günter (1975). Color in Business, Science and Industry. Wiley Series in Pure and Applied Optics (3rd ed.). New York: Wiley-Interscience. p. 388

Digital Video Concepts



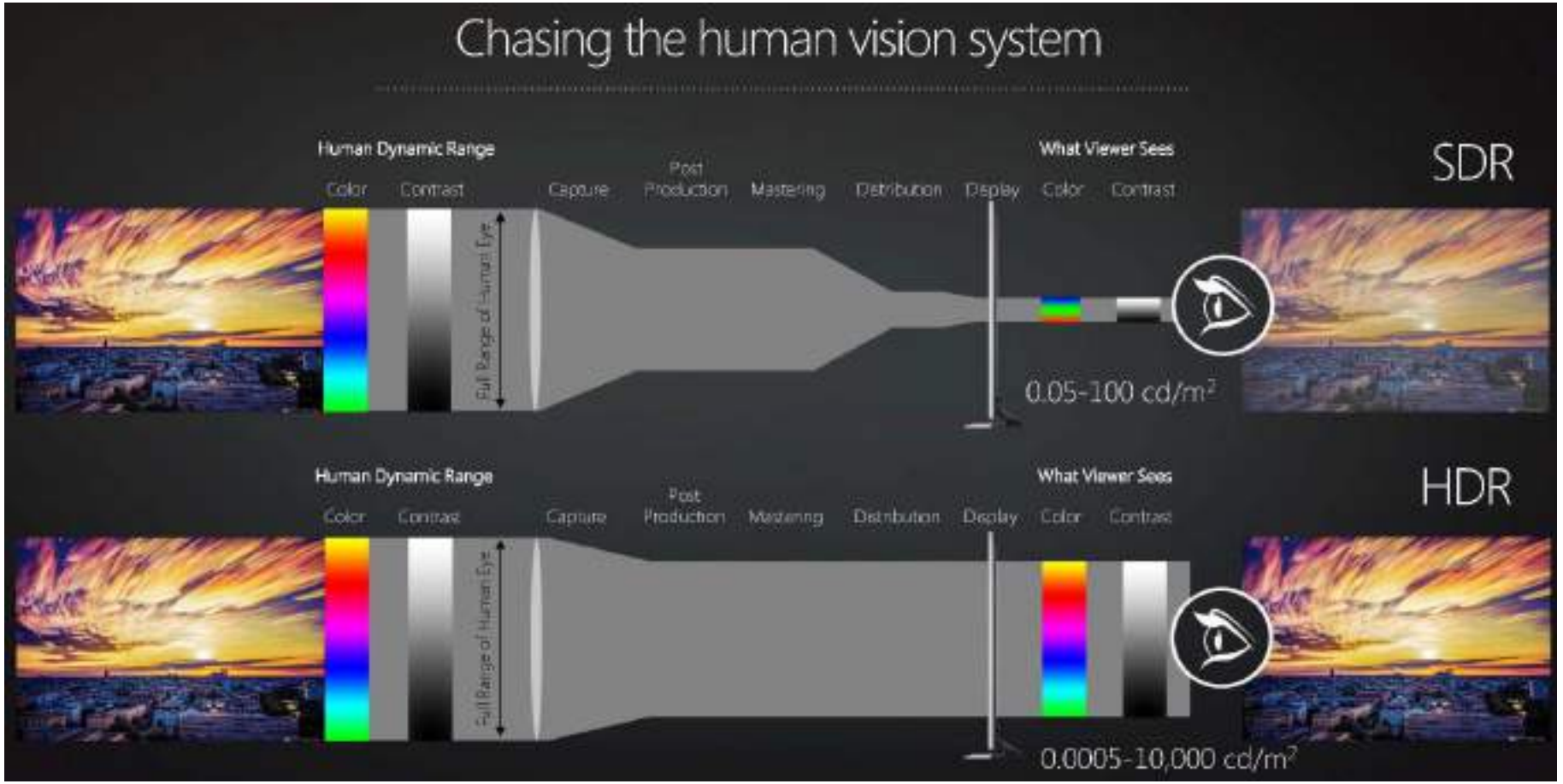


Source http://www.acousticfrontiers.com/uhd-101-v2/

Right: color bit depth 8bits (via Rec.709).
Center: color bit depth 10 bits (via Rec.2020).
Left: color bit depth 12 bits (via Rec.2020).

source: http://forum.hardware.fr/hfr/VideoSon/HiFi-HomeCinema/unique-haute-definition-sujet_141366_1.htm

Digital Video Concepts - HDR



8 bit color

Minimum
10 bit color

Source: http://www.flatpanelshd.com/review.php?subaction=showfull&id=1463743719

Digital AV Concepts- HDR

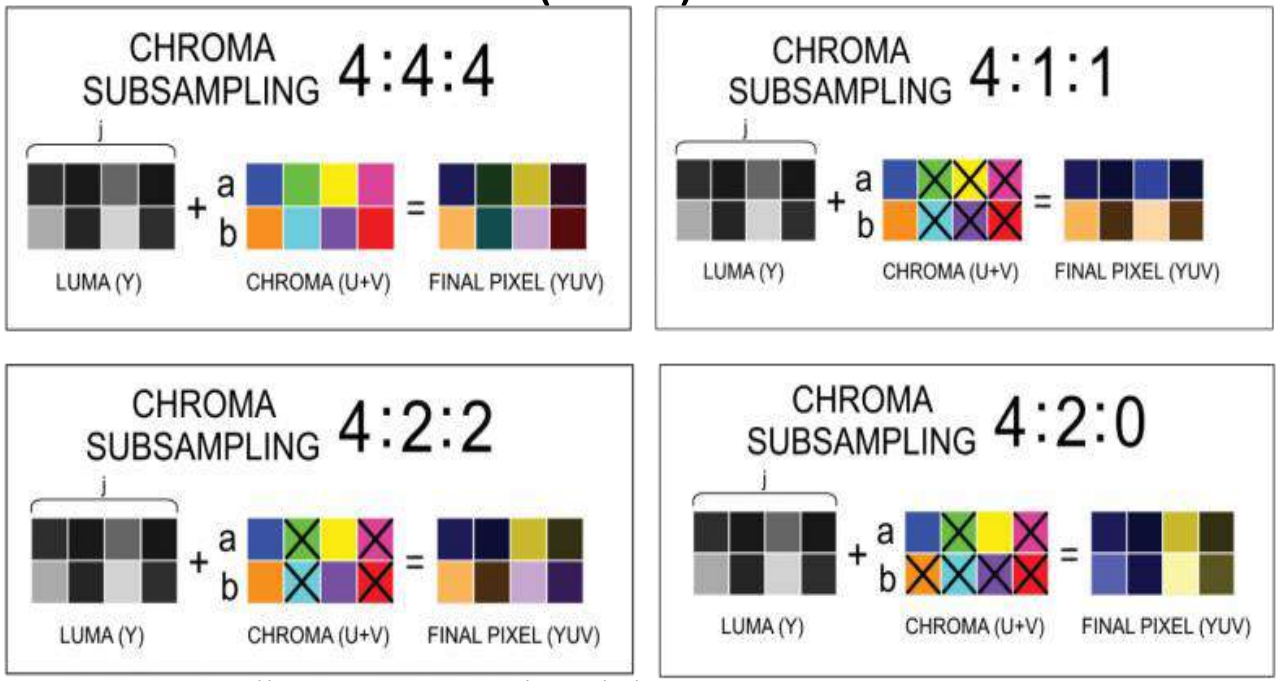
15

Source https://www.gamefaqs.com/boards/691087-playstation-4/74265743

Source: iphone7 Jose Mozota

Digital Video Concepts

- Chroma Subsampling is used to reduce bandwith
- The Colorimetric representation (YCbCr), has a luminosity cahnnel Y and two color difference channels (CbCr)



Source: https://www.videomaker.com/article/f6/15788-the-anatomy-of-chroma-subsampling

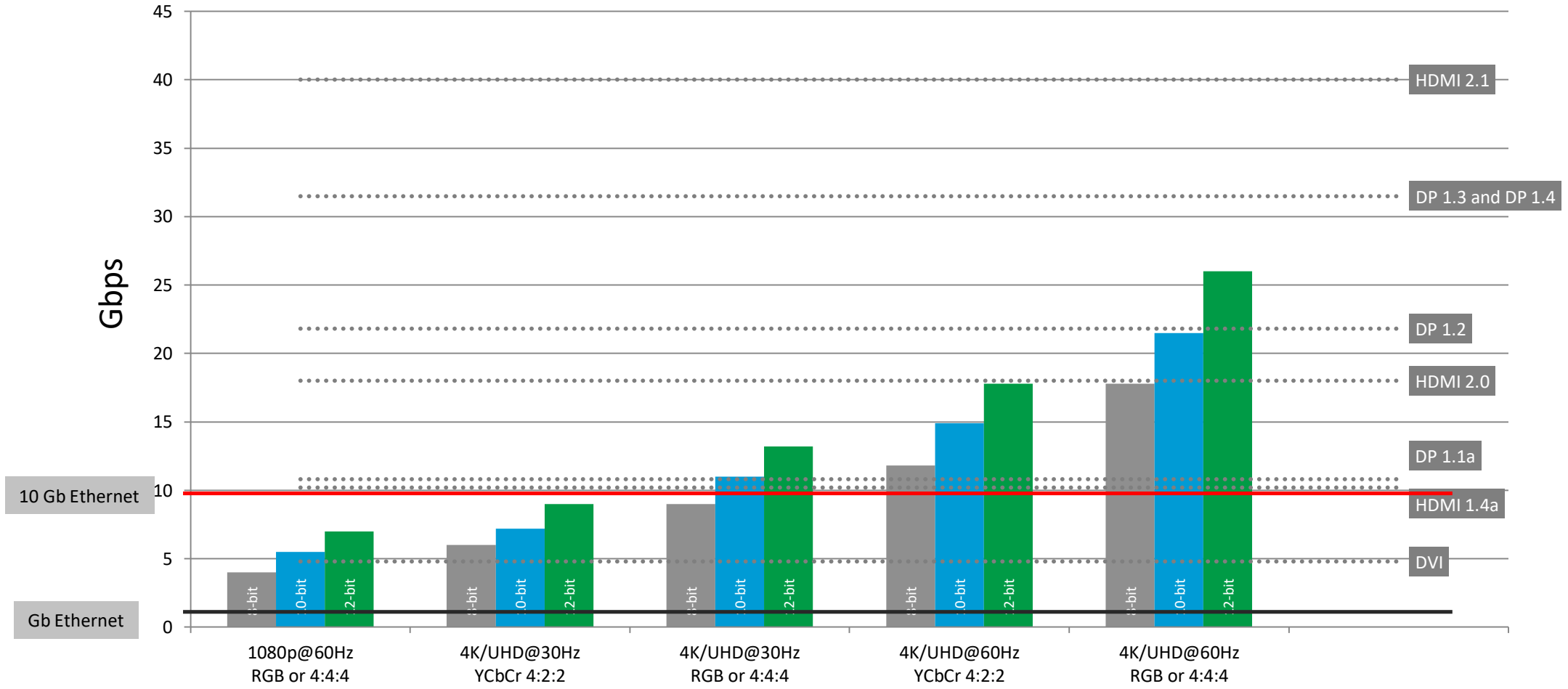
Digital Video Concepts

- Bandwidth calculation
  - resolution – total number of horizontal pixels X total number of lines X
  - frame rate – in North America, typically 24, 30, or 60fps X
  - color bit depth – bit depth plus 2 overhead bits X
  - number of graphics channels – always 3 (RGB or YCbCr) X
  - chroma subsampling – reduces bandwidth by a factor: X
    1. i.e. 4:4:4 – 12 of 12 samples used (no bandwidth reduction)
    2. i.e. 4:2:2 – 8 of 12 samples used (multiply total above by 0.67)
    3. i.e. 4:2:0 – 6 of 12 samples used (multiply total above by 0.50)

4K/UHD, 30fps, 8bit color, 4:4:4 = 3840x2160x30x(8+2)x3x1 = 7.5 Gbps

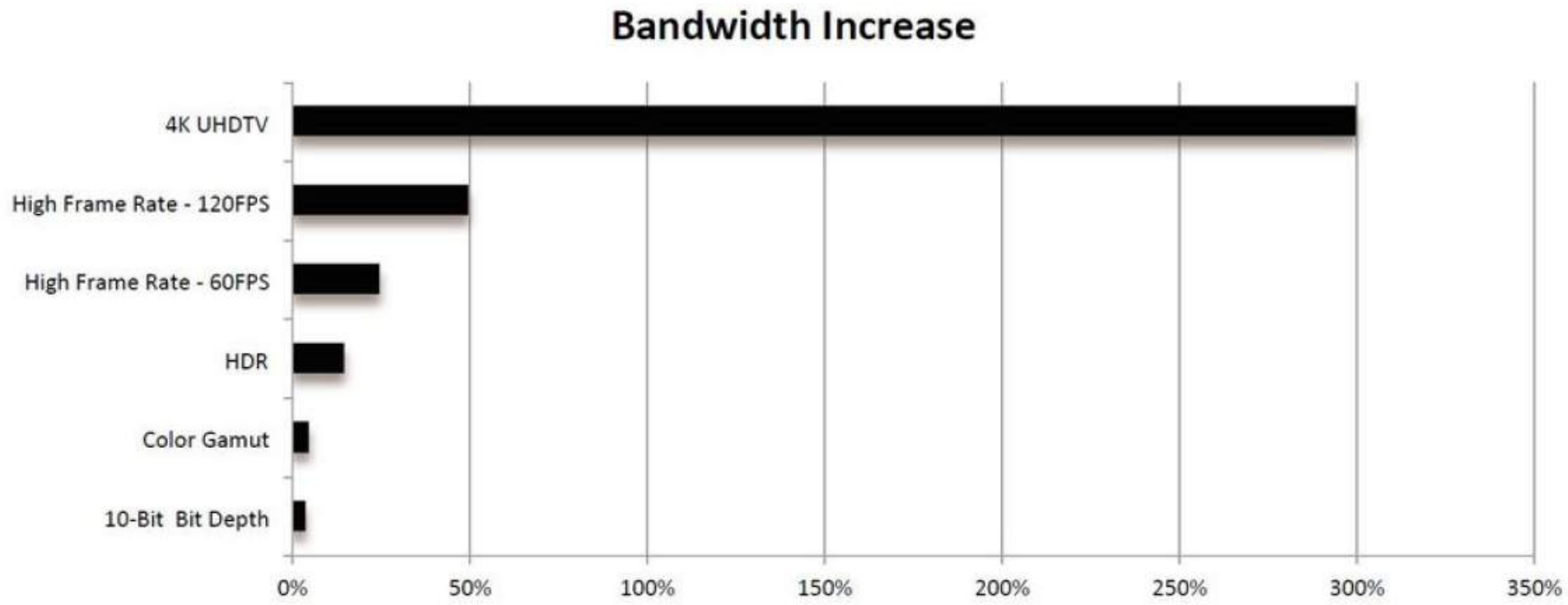
Digital Video Concepts – Bandwidth Challenges

Standard/Bandwidth for HD and 4K/UHD Data Rates

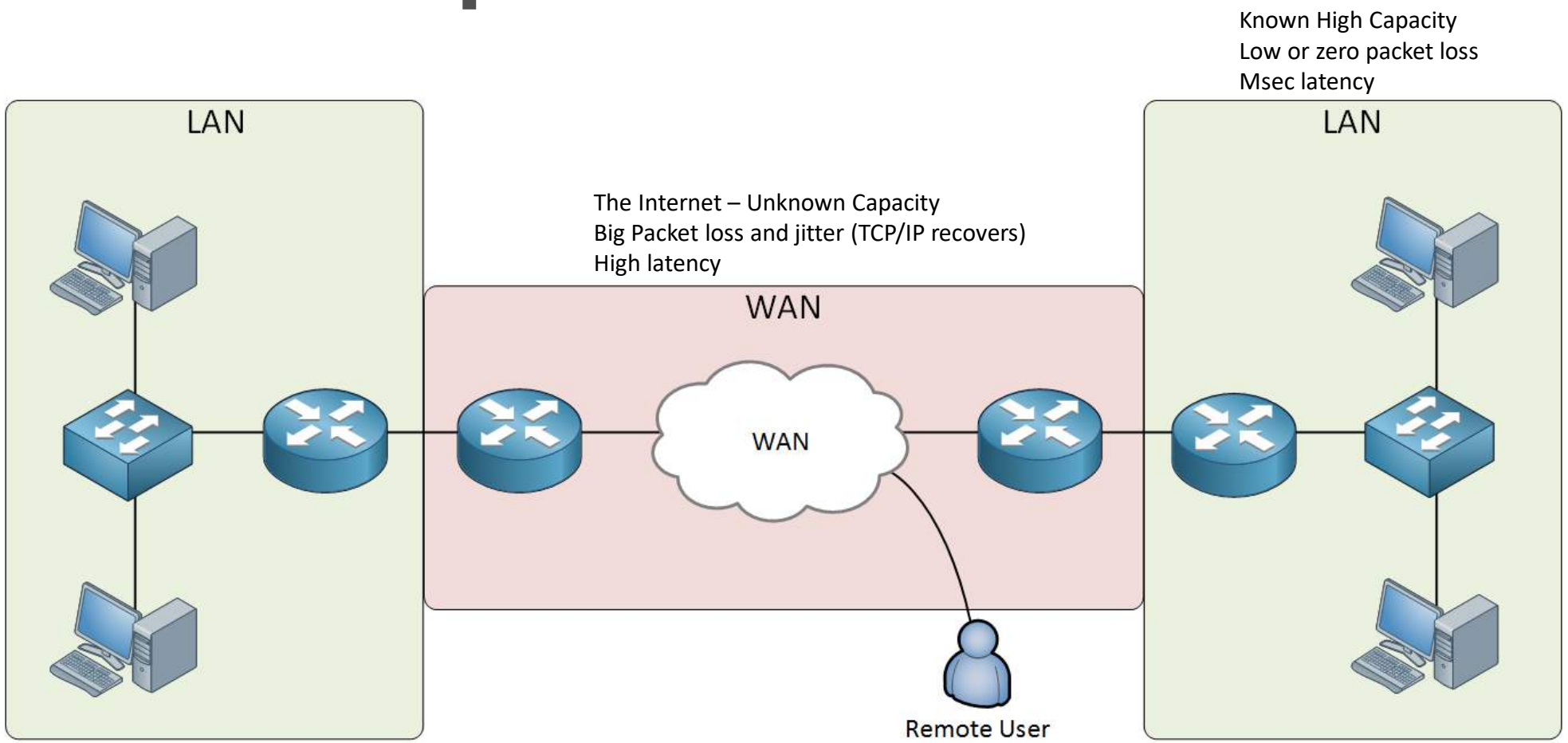


Digital Video Concepts

- Bandwidth demands of 4K, HDR, WCG, HFR



IT Concepts



Source: https://networklessons.com/cisco/ccna-routing-switching-icnd1-100-105/introduction-to-wans-wide-area-network/

IT Concepts

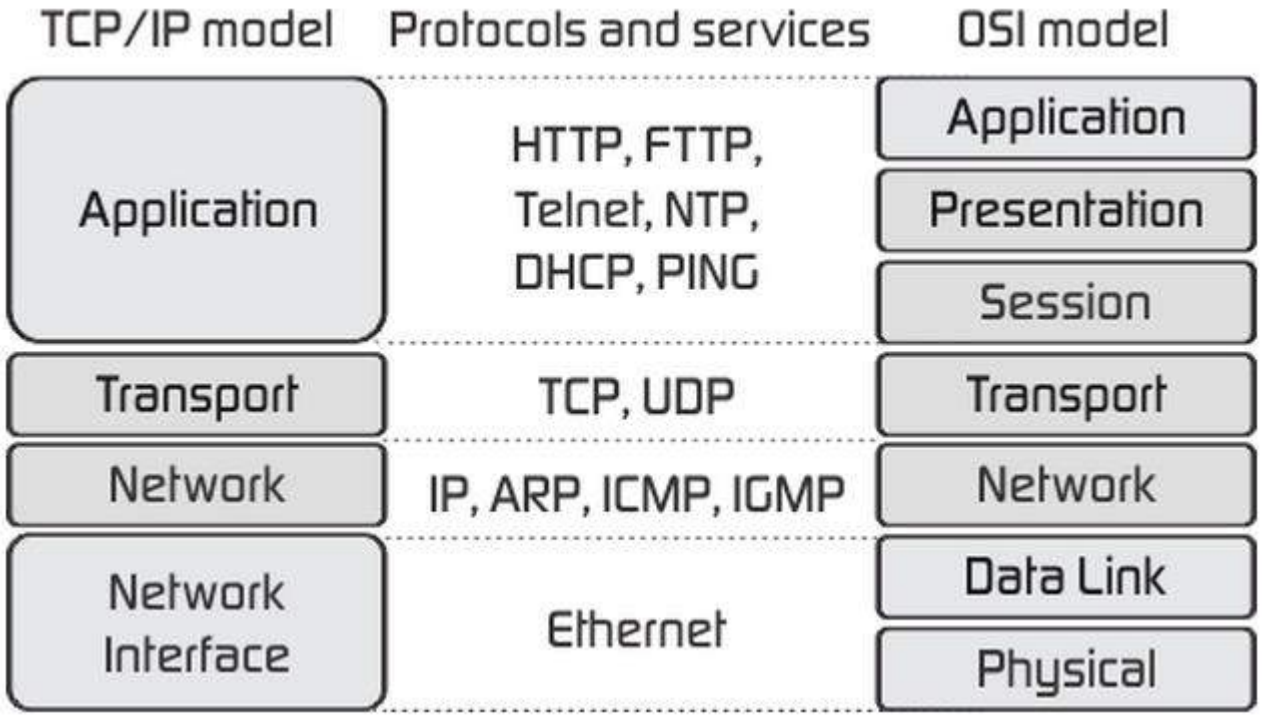
Ethernet wired lan 802.3x

The Evolution of Ethernet Standards to Meet Higher Speeds				
Date	**IEEE Std.**	**Name**	**Data Rate**	**Type of Cabling**
1990	802.3i	10BASE-T	10 Mb/s	Category 3 cabling
1995	802.3u	100BASE-TX	100 Mb/s*	Category 5 cabling
1998	802.3z	1000BASE-SX	1 Gb/s	Multimode fiber
	802.3z	1000BASE-LX/EX		Single mode fiber
1999	802.3ab	1000BASE-T	1 Gb/s*	Category 5e or higher Category
2003	802.3ae	10GBASE-SR	10 Gb/s	Laser-Optimized MMF
	802.3ae	10GBASE-LR/ER		Single mode fiber
2006	802.3an	10GBASE-T	10 Gb/s*	Category 6A cabling
2015	802.3bq	40GBASE-T	40 Gb/s*	Category 8 (Class I & II) Cabling
2010	802.3ba	40GBASE-SR4/LR4	40 Gb/s	Laser-Optimized MMF or SMF
	802.3ba	100GBASE-SR10/LR4/ER4	100 Gb/s	Laser-Optimized MMF or SMF
2015	802.3bm	100GBASE-SR4	100 Gb/s	Laser-Optimized MMF
2016	SG	Under development	400 Gb/s	Laser-Optimized MMF or SMF
Note: *with auto negotiation				

Source: http://www.blog.beldensolutions.com/happy-birthday-ethernet-youve-come-a-long-way/

IT Concepts

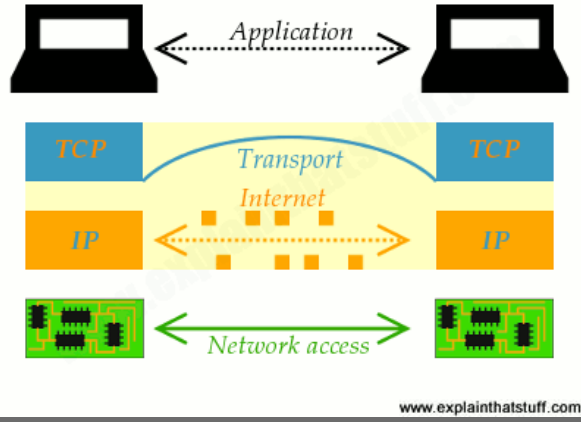
- TCP/IP and OSI networking model



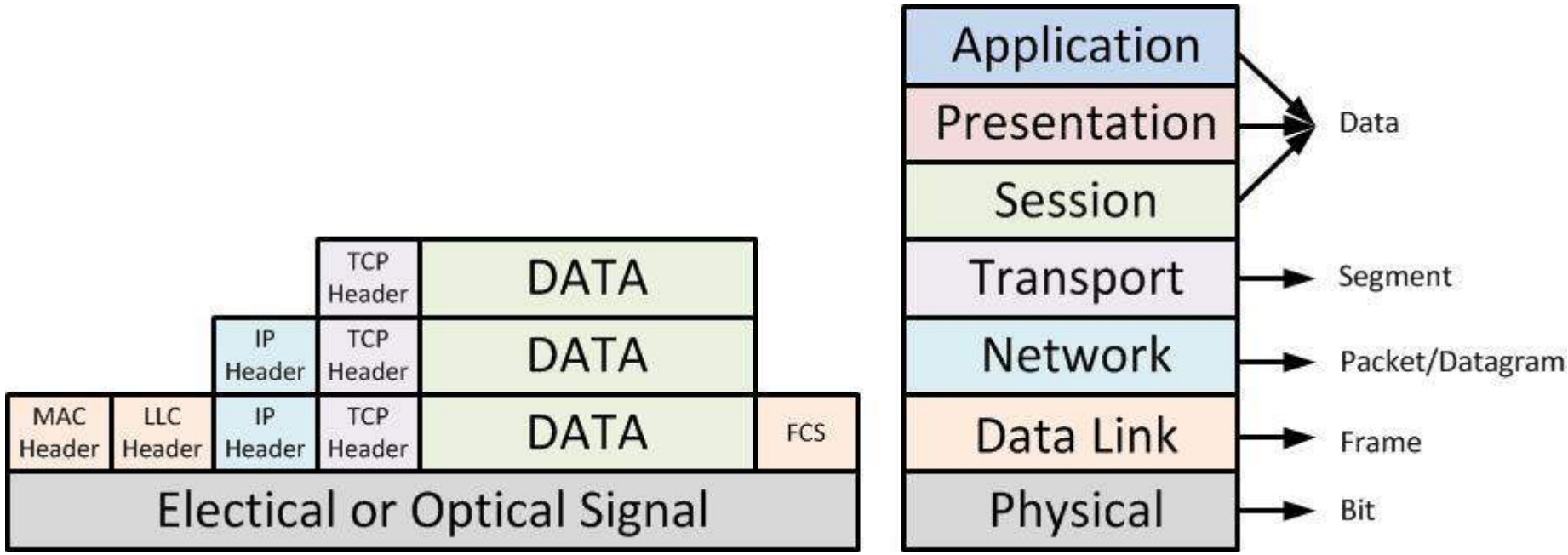
Source: http://fiberbit.com.tw/tcpip-model-vs-osi-model/

IT Concepts

- TCP/IP networking
  - Best effort delivery – not good enough for AV!
  - In the Data Link layer (layer 2) switches use MAC addresses
  - In the Network layer (Layer 3) routers use IP addresses
  - In the Transport Layer (Layer 4) is where TCP/UDP operate
  - In the Application layer (Layer 7 or 5-7) is where applications reside

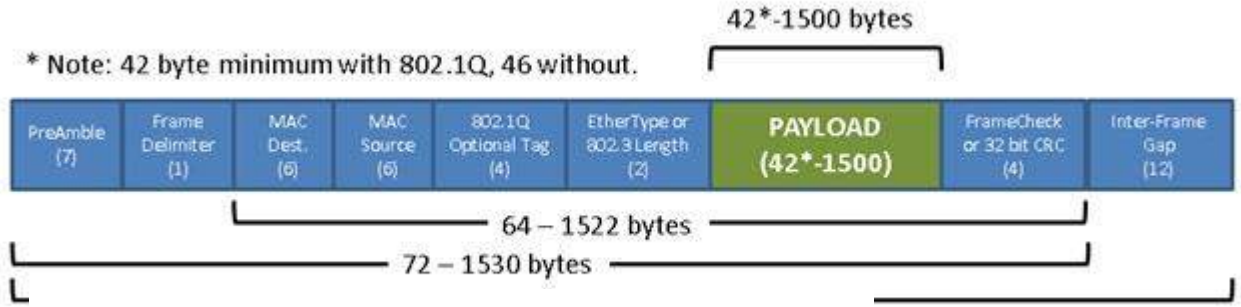


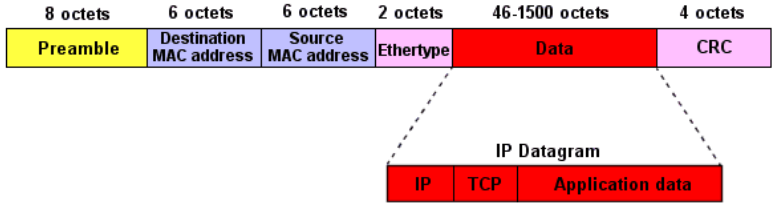
IT concepts



Source: http://packet-network.blogspot.ca/2011/11/data-encapsulation.html

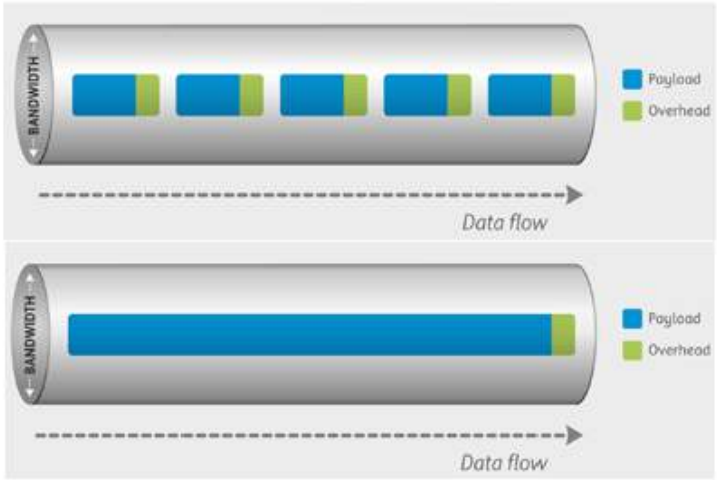
IT Concepts – Frames & Jumbo frames





Source; https://www.pathsolutions.com/run-for-your-lives-attack-of-the-jumbo-frames/

Standard 1500 MTU



Jumbo 9000 MTU

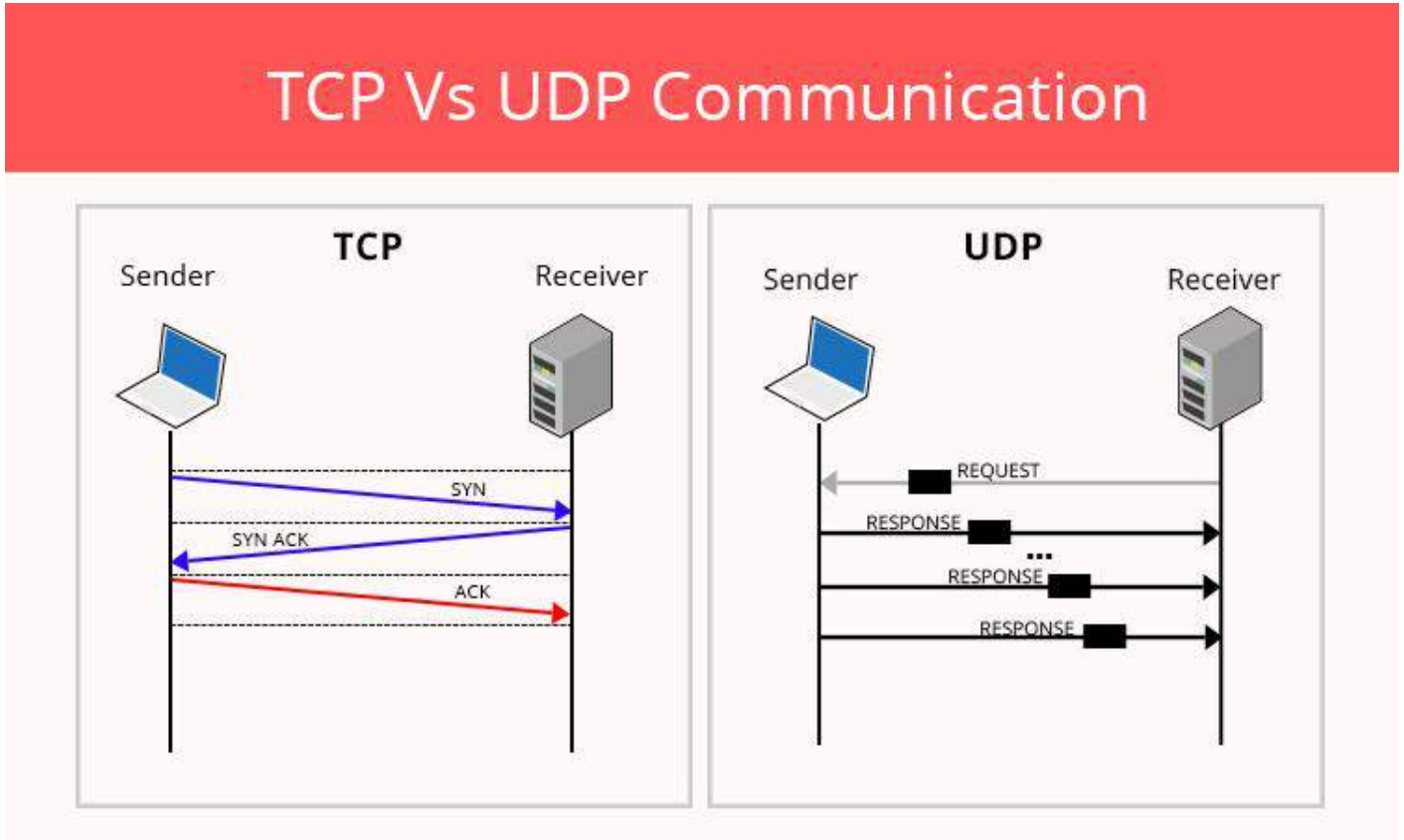
Jumbo frames may cause problems when going through a router, not all routers accept jumbo frames

Source: https://www.routerfreak.com/understanding-ethernet-jumbo-frames/

IT Concepts

- Layer 4 – Transport layer
  - Multiplexing using ports (80:HTTP)
  - Error recovery (reliability)
  - Flow control with windowing
  - Connection establishment and termination
  - Ordered data transfer and segmentation
- Transport Protocols
  - TCP (transmission control protocol), connection oriented and all of the above
  - UDP (user datagram protocol) connectionless and none of the above, except multiplexing. May have trouble through firewalls.

IT concepts



An image = 3.5 Mbps
A frame = 1500 bytes
An image= 2333 frames

Packet loss is not critical

Time synchronization is critical

http://www.oodlestechnologies.com/blogs/Why-UDP-is-preferred-for-Live-Streaming

IT Concepts

TCP Segment Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Sequence Number			
64	Acknowledgment Number			
96	Data Offset	Res	Flags	Window Size
128	Header and Data Checksum		Urgent Pointer	
160...	Options			

UDP Datagram Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Length		Header and Data Checksum	

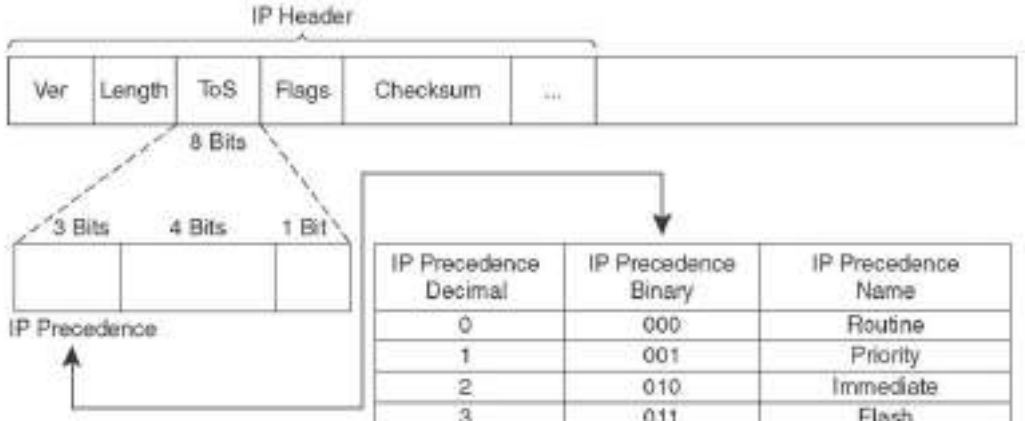
Source http://microchipdeveloper.com/tcpip:tcp-vs-udp

IT Concepts – Vlan

- A **virtual LAN** (**VLAN**) is any broadcast domain that is partitioned and isolated in a computer network at the data link layer (OSI layer 2)
  - Broadcast/Traffic flow control
  - Security
  - Performance/Bandwidth
  - Cost
  - Extend across switches with 802.1Q (trunking)

IT Concepts - QoS

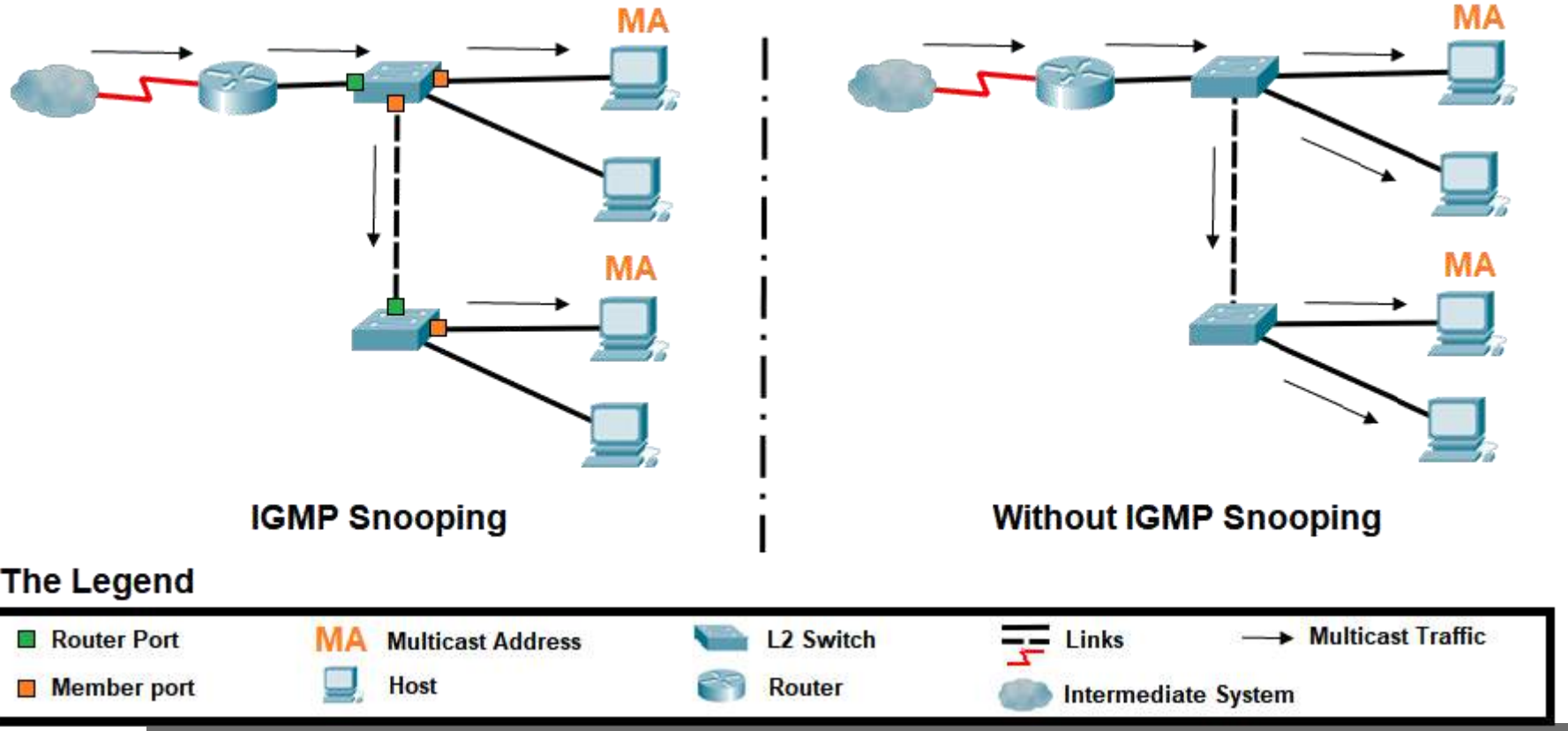
- QoS – Quality of Service
  - DiffServ Classes – IEEE RFC 4594
  - IntServ - RSVP – Resource Reservation Protocol



IP Precedence Decimal	IP Precedence Binary	IP Precedence Name
0	000	Routine
1	001	Priority
2	010	Immediate
3	011	Flash
4	100	Flash-Override
5	101	Critical
6	110	Internetwork Control
7	111	Network Control

IT concepts – IGMP and Snooping

The Internet Group Management Protocol (**IGMP**) is a communications protocol used by hosts and adjacent routers on IPv4 networks to establish multicast group memberships. IGMP Snooping "listens" to the traffic to limit it to the "members"



Source: https://en.wikipedia.org/wiki/IGMP_snooping#/media/File:IGMP_Snooping_Example_-_en.png

IT concepts – IGMP and Snooping

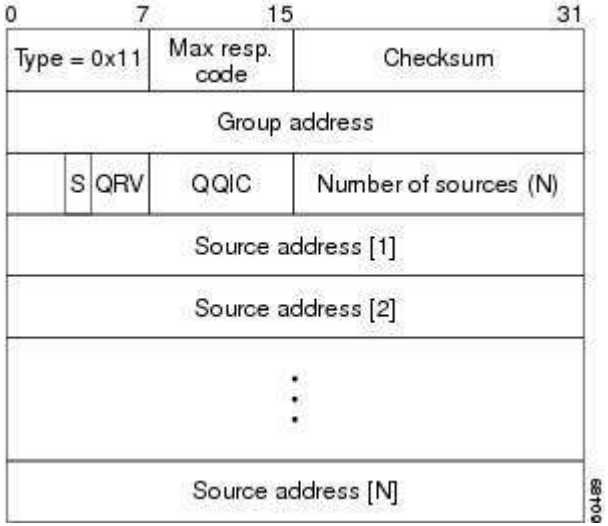


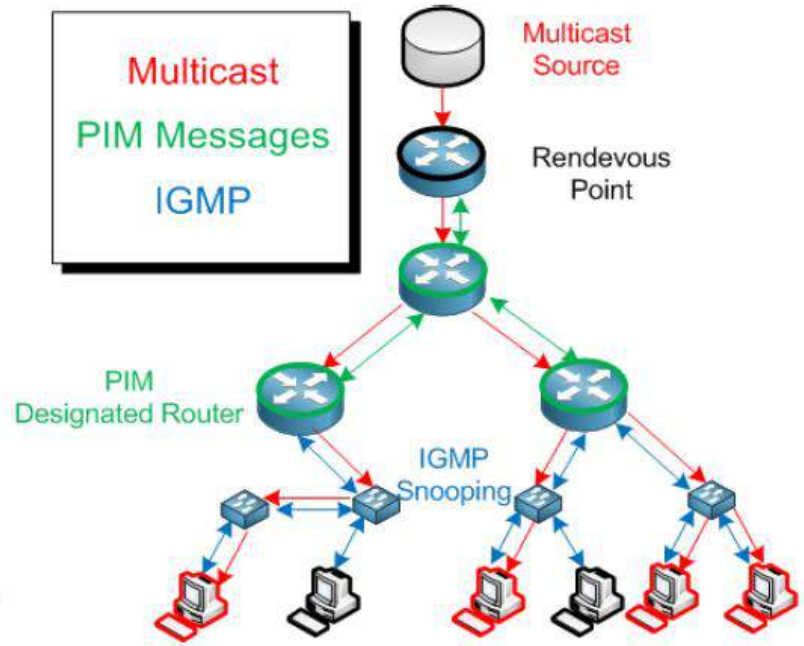
Table 3 IGMPv3 Query Message Field Descriptions

Field	Description
Type = 0x11	IGMP query.
Max resp. code	Maximum response code (in seconds). This field specifies the maximum time allowed before sending a responding report.
Group address	Multicast group address. This address is 0.0.0.0 for general queries.
S	S flag. This flag indicates that processing by routers is being suppressed.
QRV	Querier Robustness Value. This value affects timers and the number of retries.
QQIC	Querier's Query Interval Code (in seconds). This field specifies the Query Interval used by the querier.
Number of sources [N]	Number of sources present in the query. This number is nonzero for a group-and-source query.
Source address [1...N]	Address of the source(s).

Source: http://dtdccie.blogspot.ca/2015/01/igmp.html

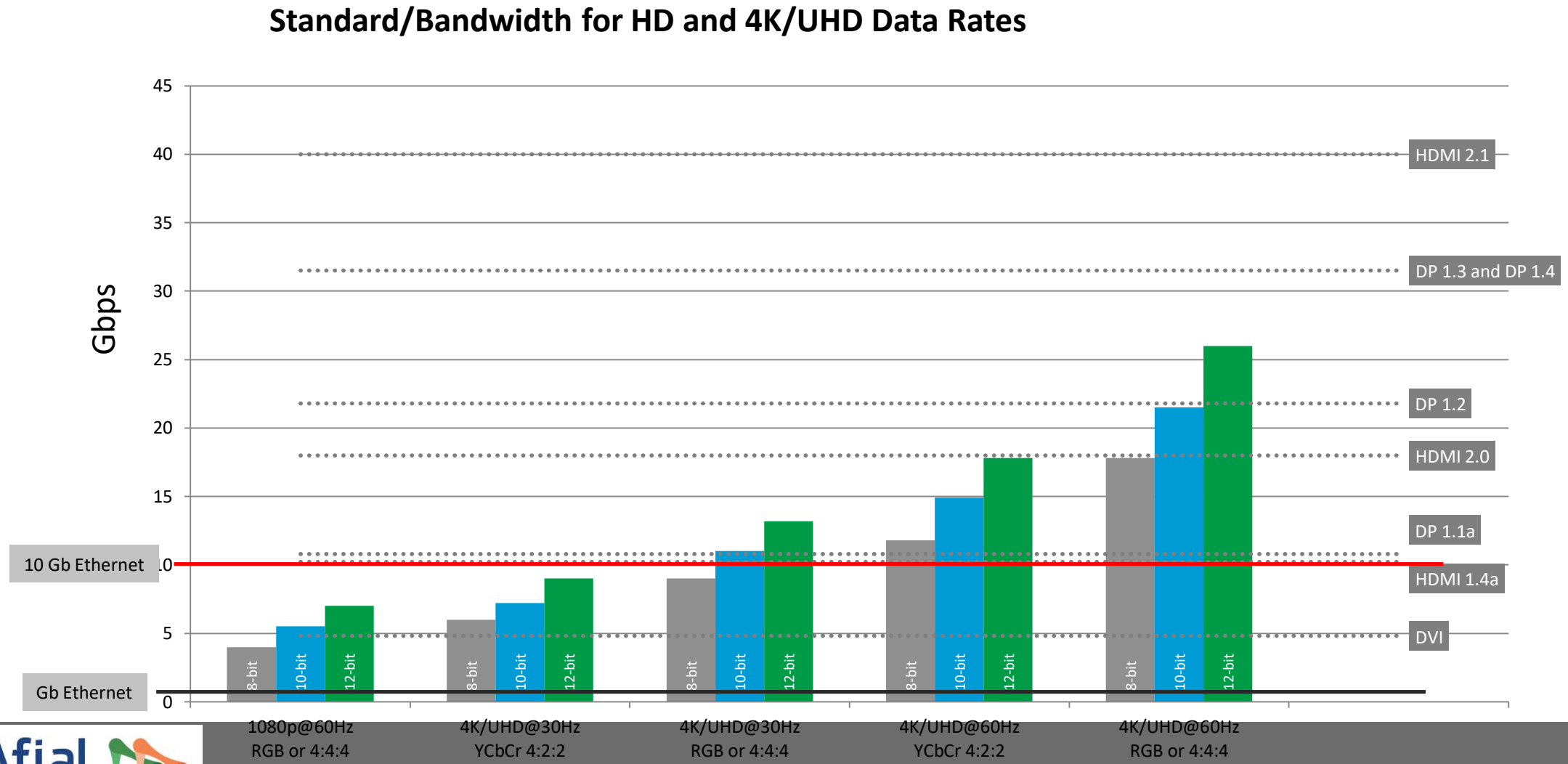
IT concepts – PIM

- Protocol-Independent Multicast



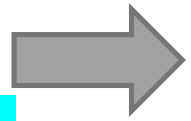
Source: http://dtdccie.blogspot.ca/2015/01/igmp.html

Digital Video Concepts – Bandwidth Challenges

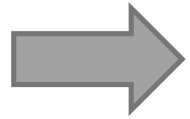


AV over IP

Digitize and compress video



Encode with the necessary structure to transport it over a network (wired or wireless)



Decode and play it back, store it, display it

Digital Video Concepts
Chroma Subsampling

Compression Codecs
TCP/IP networking protocols

Compression Codecs

Compression

- "lossless" compression means no information is lost and the final file is identical to the original. Reduces bits by identifying and eliminating statistical redundancy. Hoffman and Run length algorithms.
- "lossy" or “Visually lossless” compression sacrifices some data from the file to achieve much higher compression rates. Lossy compression schemes use complicated algorithms that toss out image detail that is not discernible to the human eye. The decompressed file is extremely similar in character to the original, yet is not identical.

What you lose is not recoverable

Compression

Source: http://bangtanb775.blogspot.ca/2016/07/lossy-and-lossless-compression.html

Compression

Source: https://optimus.keycdn.com/support/lossy-vs-lossless/

Compression

- *Spatial* (or *intraframe*) compression takes place on each individual frame of the video, compressing the pixel information as though it were a still image.
- *Temporal* (or *interframe*) compression happens over a series of frames and takes advantage of areas of the image that remain unchanged from frame to frame, throwing out data for repeated pixels.
  - Temporal compression relies on the placement of *key frames* interspersed throughout the frames sequence. The key frames are used as masters against which the following frames (called delta frames) are compared. It is recommended that a key frame be placed once every second; therefore, if you have a frame rate of 15 fps, set your key frame rate once every 15 frames.

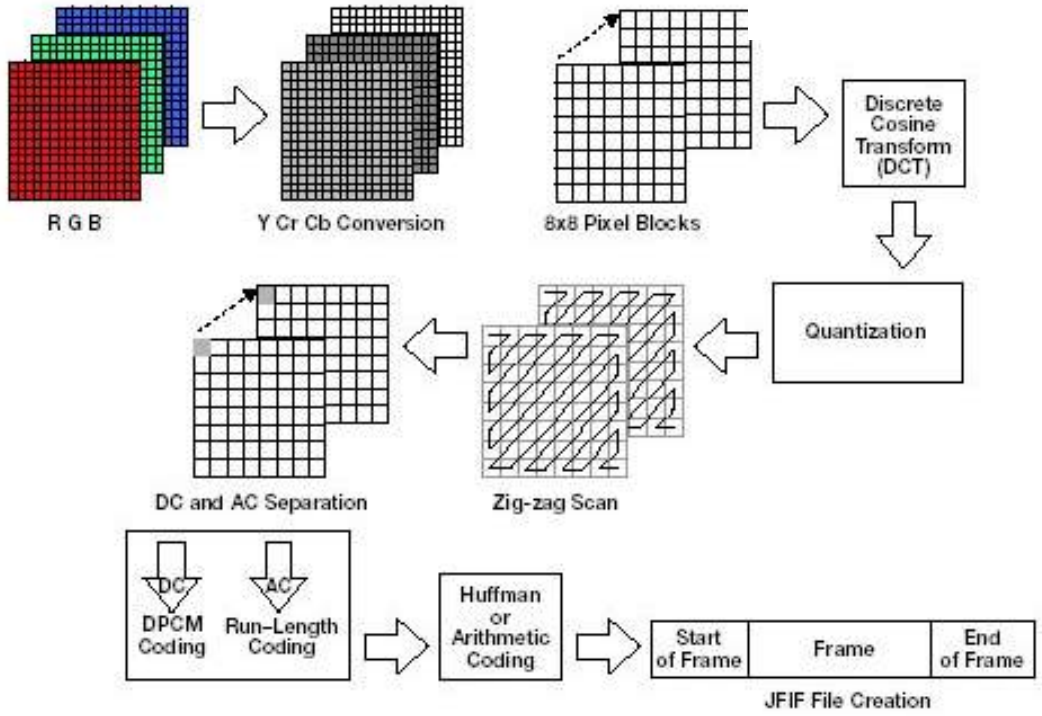
Compression

http://telestreamblog.telestream.net/2015/02/video-compression/

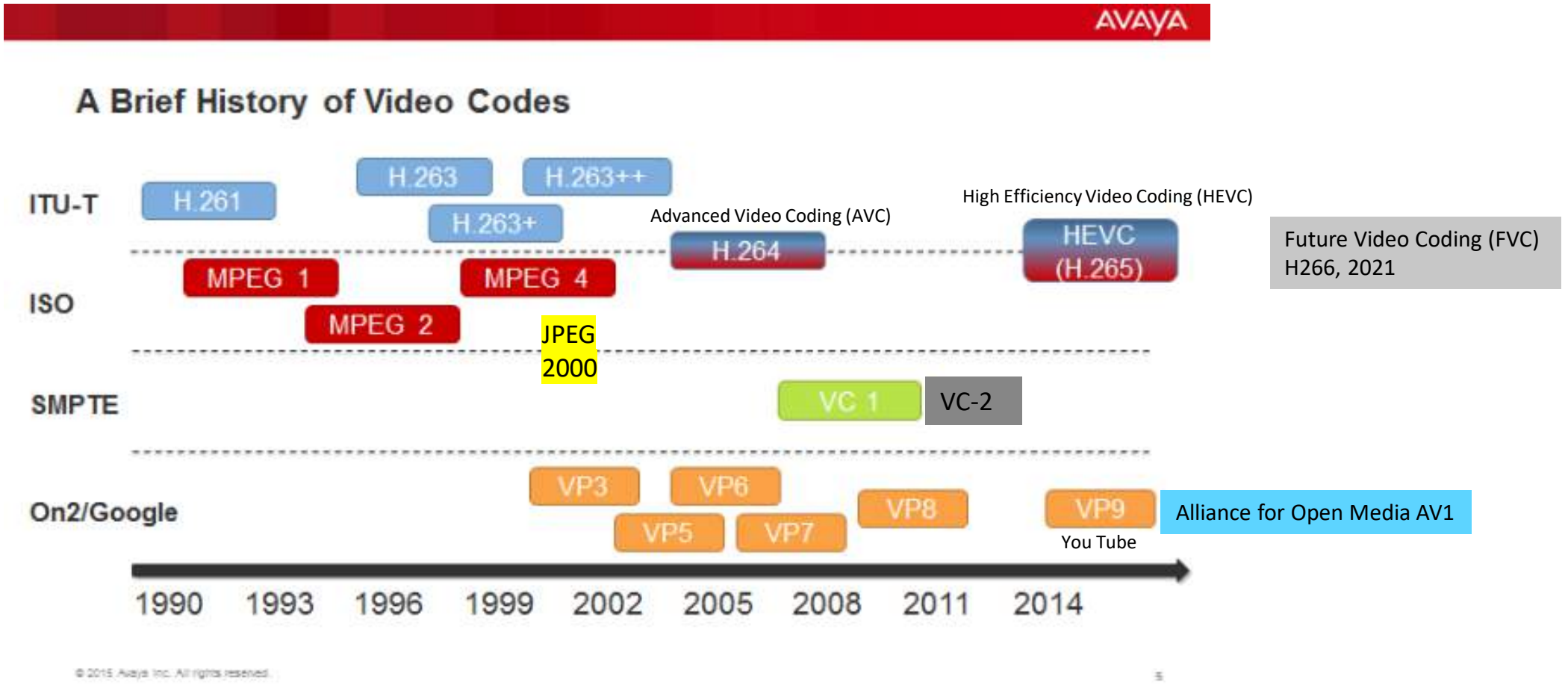
Compression

Example DCT integral and matrix

$$B(k_1,k_2) = \sum_{i=0}^{N_1-1} \sum_{j=0}^{N_2-1} 4\cdot A(i,j)\cdot \cos\left[\frac{\pi\cdot k_1}{2\cdot N_1}\cdot(2\cdot i+1)\right]\cdot \cos\left[\frac{\pi\cdot k_2}{2\cdot N_2}\cdot(2\cdot j+1)\right]$$



Compression Codecs



Compression

- Typical Compression ratios and bandwidth

Compression Category	Example System	Example Data Rate Ranges	Example Compression Ratios
"lossless?" (visually lossless)	SDVoE DSC	0.3 – 10 Gbps	1:1 1.3:1, 2:1. 3:1
Visually Lossless *Subjective to judgment of viewer*	JPEG2000 MJPEG, DIRAC Pro	30 – 800 Mbps	15:1 to 300:1
Lossy *Aggressive to achieve low data rate*	MPEG-2, H.264, HEVC	1 – 40 Mbps	300:1 to 3000:1

Compression Codecs

Codec	Type	Bandwidth	Image quality*	Latency	Technique	Standard
MPEG-2	Lossy	low	low	High	DCT - Inter	Y - royalty
H264/H265	Lossy	low	low	High	Hybrid STPM	Y - royalty
JPEG2000	VL to Lossy	Low to medium	medium	High to Medium	DWT - Intra	Y - royalty
VC2	VL	medium	medium	Medium	DCT - Inter	Y - free
VP9	Lossy	low	low	High	Inter	Y - free
Blue River	VL	high	high	Low	Spatial, line by line	N
DSC	VL	high	high	Low	DPCM+ICH	Y - free

* As judged by actual viewers

Compression – MPEG

- MPEG features
  - Interframe compression
  - Uses DCT (Discrete Cosine Tranform)
  - All evolutions, MPEG-1, MPEG-2 and MPEG-4, backwards compatible.
  - Widely used and inexpensive.
  - Lossy compression
  - High latency

Compression – JPEG2000

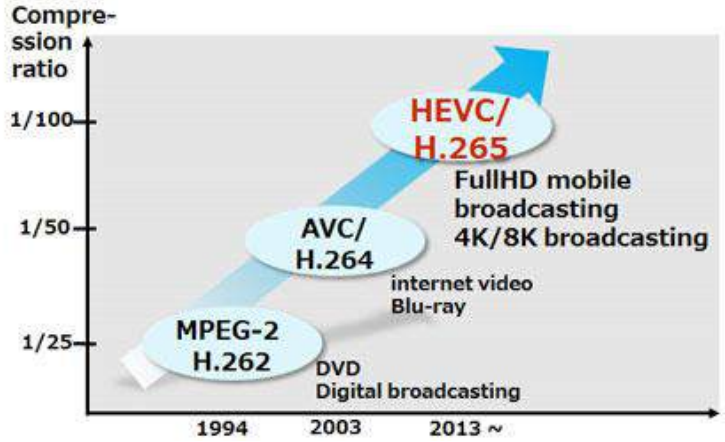
- JPEG 2000 features
  - Lossy to visually lossless compression (specify size of file)
  - Intraframe compression
  - All frames are “key” frames
  - Coded with DWT, Discrete Wavelength Transform
  - No blocking artifacts at high compression ratios
  - Digital Cinema Standard
  - JPEG2000 video streams can travel with IP headers (may need Jumbo frames)
  - High-quality video compression, low latency

Source: http://www.utdallas.edu/~aria/mcl/post/

Compression - H264/H265

	Category	H.264	H.265
General	Names	MPEG 4 Part 10 AVC (Introduced in 2004)	MPEG-H, HEVC, Part 2 (Approved in Jan 2013)
	Industry adoption	Dominant and accepted video codec for Terrestrial, Cable, Satellite and IPTV broadcast. (ATSC/DVB/ISDB) Widely used across Blu-Ray, security systems, videoconferencing , mobile video, media players, video chat etc.	Implementation demonstration across NAB, IBC and other events starting 2012 from companies e.g. ATEME, Broadcom, Thomson , Harmonic (Cisco), Ericsson, Qualcomm etc.. Increased R&D across Encoder/Decoder /CE vendors for software and hardware based solutions
	Key Improvement	• 40-50% bit rate reduction compared to MPEG -2 • Led the growth of HD content delivery for Broadcast and Online	• 40-50% the bit rate reduction at the same visual quality compared to H.264 • Potential to realize UHD, 2K, 4K for Broadcast and Online (OTT)
	Progression	Successor to MPEG-2 Part	Successor to MPEG 4 AVC, H.264
TECHNICAL	Compression Model	Hybrid spatial-temporal prediction model • Flexible partition of Macro Block (MB) , sub MB for motion estimation • Intra Prediction (extrapolate already decoded neighboring pixels for prediction) • Introduced multi-view extension • 9 directional modes for intra prediction • Macro Blocks structure with maximum size of 16x16 • Entropy coding is CABAC and CAVLC	Enhanced Hybrid spatial-temporal prediction model • Flexible partitioning, introduces Coding Tree Units (Coding, Prediction and Transform Units -CU, PU, TU) • 35 directional modes for intra prediction • Superior parallel processing architecture, enhancements in multi-view coding extension • CTU supporting larger block structure (64x64) with more variable sub partition structures • Entropy coding is only CABAC
	Specification	Support Up to 4K (4,096×2,304) Supports up to 59.94 fps 21 profiles ; 17 levels	Up to 8K UHDTV (8192×4320) Supports up to 300 fps 3 approved profiles, draft for additional 5 ; 13 levels
	Drawbacks	Unrealistic for UHD content delivery due to high bit rate requirements. Frame rate support restricted to 59.94	Computationally expensive (~ 300 % +) due to larger prediction units and expensive Motion Estimation (Intra prediction with more nodes, asymmetric partitions in Inter Prediction).

Source: Quora



Source: https://www.nec.com/en/global/rd/research/cl/hevc/index.html

Compression – SMPTE 2042 VC-2

- Supports RGB and 4:4:4, 4:2:2 and 4:2:2 YCbCr
- Uses Discrete Wavelet Transform
- Allows efficient compression or low latency
- Developed and used by the BCC (DIRAC)
- Open Source, no license fees
- SMPTE (society of motion picture and television engineers) standard

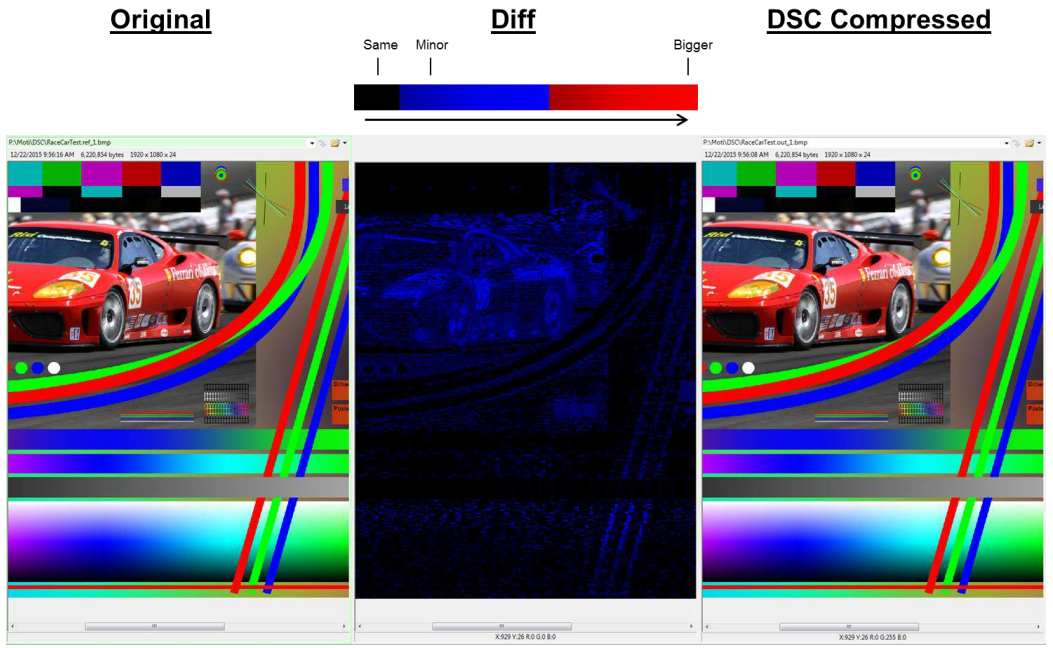
Compression – AV1 (V9)

Compression – Aptovision Blue River

- Spatial compression
- Line by line compression
- Reduces the video payload by discarding some H and V blanking regions data, before applying the codec
- Similar to mosaic compression
- Very low latency
- 1.4 : 1 compression ratio brings 4K/60/4:4:4 below 10G
- No jumbo frames

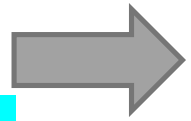
Compression - DSC

- VESA DSC (Display Stream Compression) – not yet used for Av over IP
  - Visually lossless to as low as 8 bits/pixel
  - The DSC encoding algorithm is based on delta pulse code modulation (DPCM) with an Indexed Color History (ICH)
  - Fixed rate codec
  - Compression ratio of 2:1 to 3:1
  - Industry standard
  - License free
  - Deployed in Display Port 1.4
  - Used by HDBaseT
  - Will be in HDMI 2.1

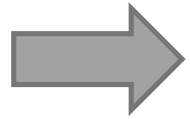


AV over IP

Digitize and compress video



Encode with the necessary structure to transport it over a network (wired or wireless)



Decode and play it back, store it, display it

Digital Video Concepts
Chroma Subsampling

Compression Codecs
TCP/IP networking protocols

Compression Codecs

IT Concepts – Switches for AV

- Full layer 2 and 3
- Fully non-blocking
- IGMP Version 2 snooping
- IGMP Queries
- IGMP FASTLEAVE for 4K seamless switching
- Drop unregistered Multicast traffic

IT Concepts – Switches for AV

- H264/265/266/VC-2 require a 1Gig Ethernet Switch supporting IGMP and PoE
- JPEG2000 requires a 1Gig Ethernet Switch supporting IGMP, Jumbo Frames and PoE
- Aptovision Blue River/ VESA DCS require a 10Gig Ethernet Switch (they support IGMP & Jumbo Frames but not PoE (fiber!))
- For large numbers of source and sink equipment, beyond the port count of a single 1G Ethernet Switch, you need to stack Switches. Use a 1G switch with a 10G fiber stack port

AV over IP – Transport Protocols

- RTP – Real Time Transport Protocol
  - RTCP - Real Time Control Protocol
  - RTSP – Real Time Streaming Protocol
  - RTMP – Real Time Messaging Protocol
- SMPTE (Society of Motion Picture and Television Engineers) 2022.x
- TSN – Time sensitive Networking; AVB – Audio Video Bridging 802.1BA, AS, Qat Qav/IEEE 1722(AVTP)

AV over IP – Transport Protocols

- RTP – specifies a way to manage real-time transmissions of multimedia over a network
- Uses RTCP as a control protocol
- Typically runs on UDP

Figure 1: RTP in the IP Packet

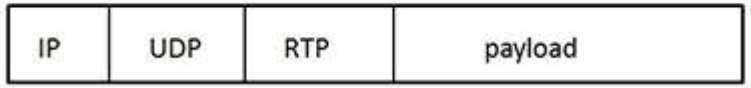
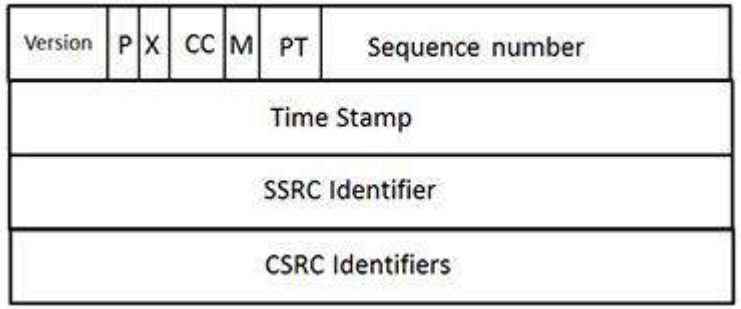


Figure 2: RTP Header



Source: AV Network

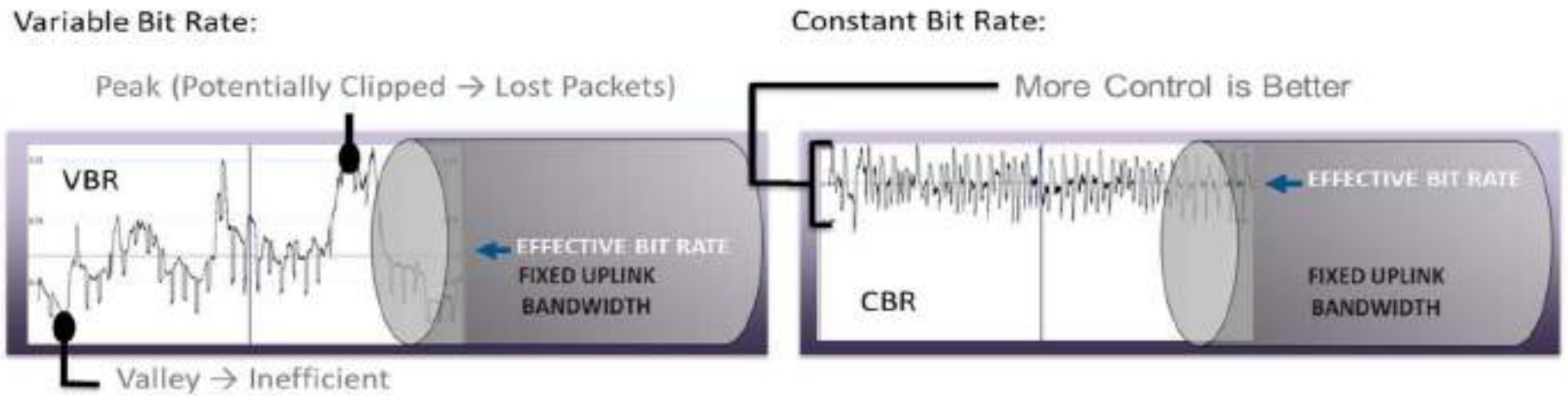
AV over IP - Transport Protocols

- SMPTE 2022 – Standard that describes how to send digital video over an IP network, using RTP (over UDP)
  - ST 2022-1:2007 - Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks
  - ST 2022-2:2007 - Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks
  - ST 2022-3:2010 - Unidirectional Transport of Variable Bit Rate MPEG-2 Transport Streams on IP Networks
  - ST 2022-4:2011 - Unidirectional Transport of Non-Piecewise Constant Variable Bit Rate MPEG-2 Streams on IP Networks
  - ST 2022-5:2013 - Forward Error Correction for Transport of High Bit Rate Media Signals over IP Networks (HBRMT)
  - ST 2022-6:2012 - Transport of High Bit Rate Media Signals over IP Networks (HBRMT), it provides a wrapper that encapsulates baseband video so that it can be carried in IP frames
  - ST 2022-7:2013 - Seamless Protection Switching of SMPTE ST 2022 IP Datagrams
- SMPTE 2110 – Standard for live digital video production based on IP.

AV over IP – Transport Protocols

- Streaming- content streamed or sent to a CDN(content Delivery network) and then streamed
  - HLS – HTTP Live Streaming (most popular)
  - HDS – HTTP Dynamic Streaming (based on Adobe Flash)
  - MPEG-DASH – Dynamic Adaptive Streaming over HTTP (the future?)
  - Streaming Techniques
    - ABR – Adaptive Bit Rate Streaming
    - DSS - Dynamic Rate Shaping
    - MBR – MultiBit Rate Streaming

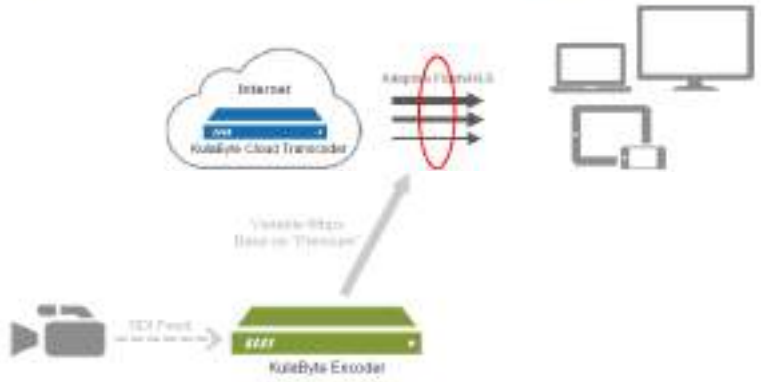
AV over IP - Streaming



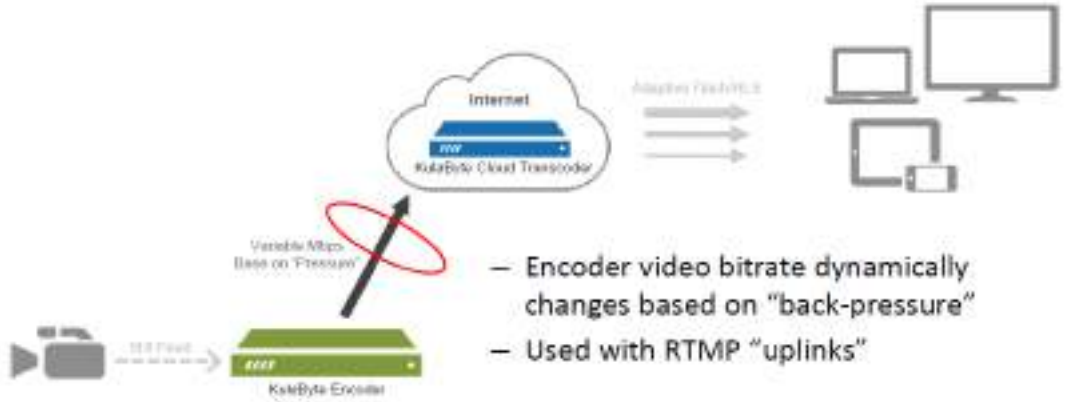
CBR is the best for QoS

AV over IP - Streaming

Adaptive Bit Rate Streaming (ABR)

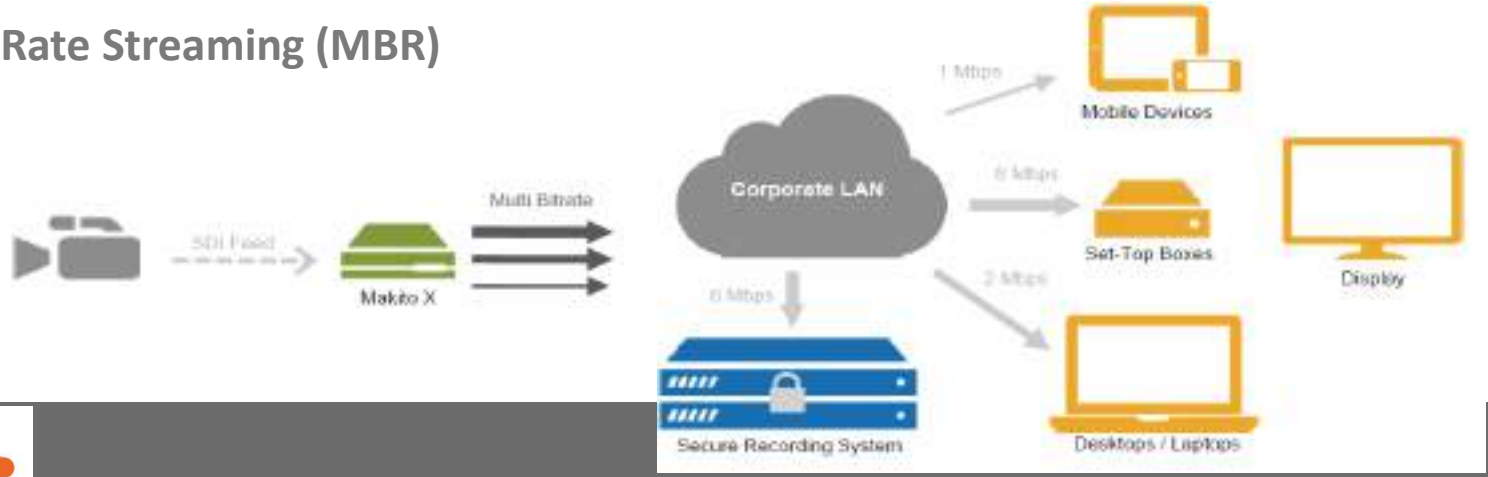


Dynamic Stream Shaping (DSS)

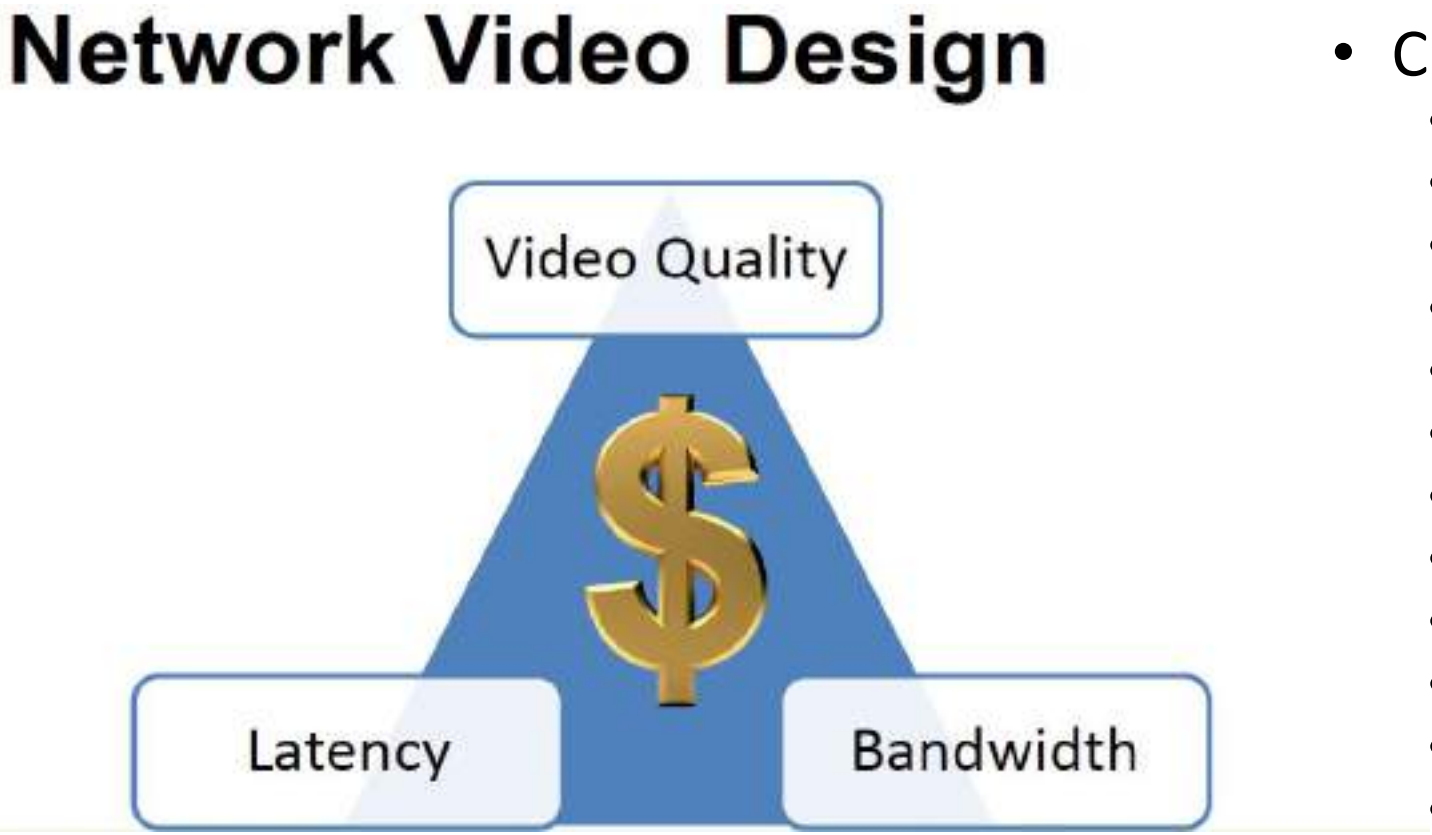


- Encoder video bitrate dynamically changes based on "back-pressure"
- Used with RTMP "uplinks"

Multi Bit Rate Streaming (MBR)

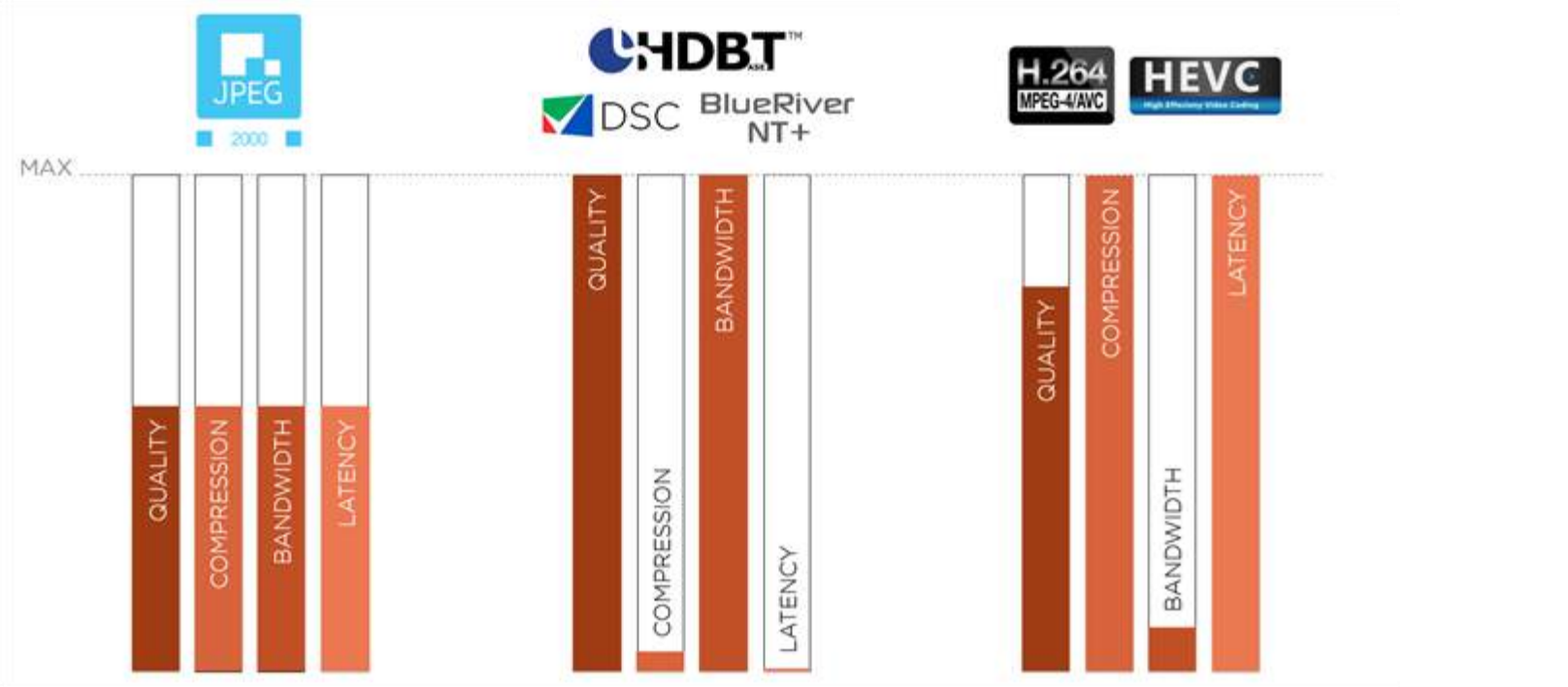


AV over IP “Triangle”



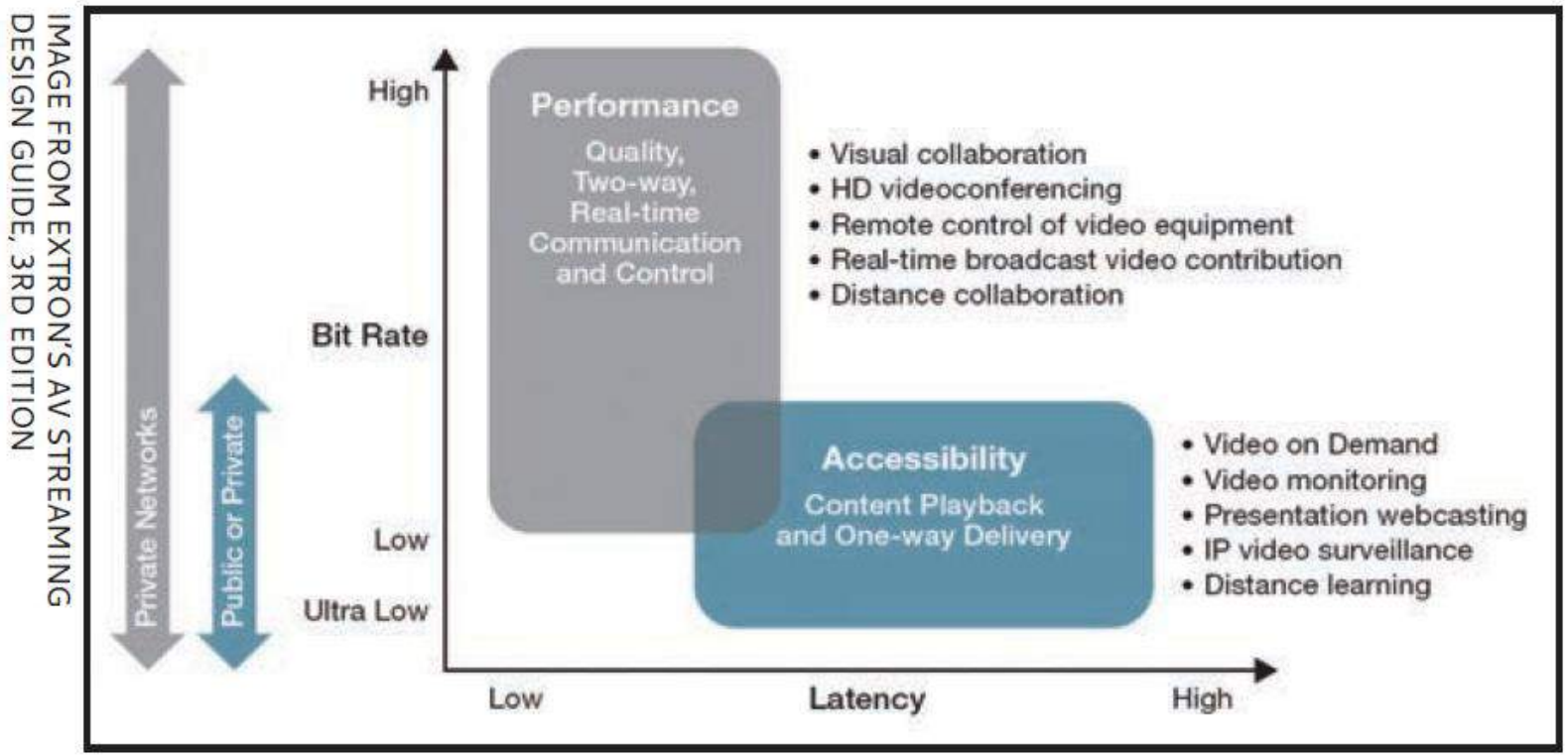
- Challenges of AV over IP
  - Compression
  - HDMI 1.4, 2.0, 2.1
  - HDCP handling
  - 1G or 10G
  - Managed Switch
  - Port Density
  - Time Sync
  - Discovery and control
  - Reliability
  - Transport
  - Interoperability
  - PoE

AV over IP - Compromises



Source: http://www.hiddenwires.co.uk/features/article/the-essentials-of-av-over-ip

AV over IP



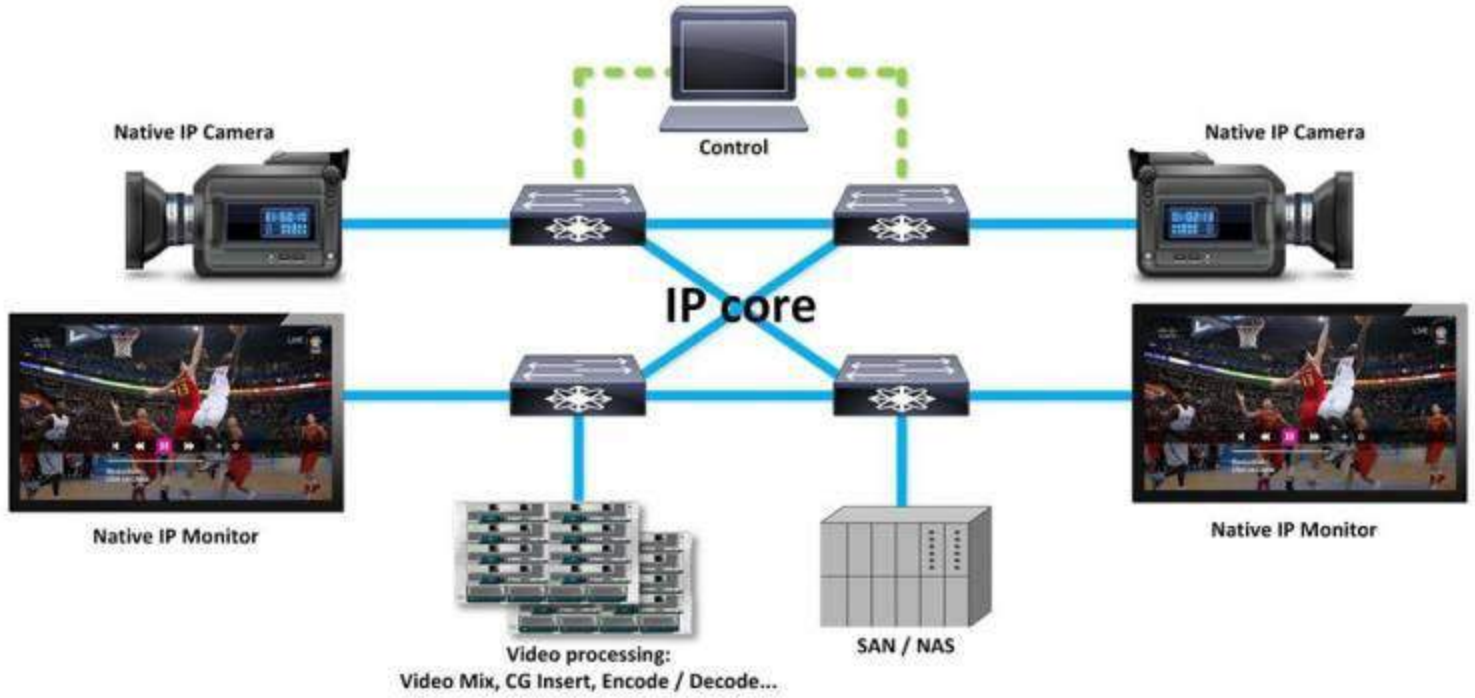
AV over IP - Latency

Contributions to delay in a low-latency, 1080p30 video streaming system

Processing Stage	Buffering	Latency (1080p30)
Capture Post-Processing (e.g., Bayer filter, chroma resampling)	A few lines (e.g. 8)	< 0.50ms
Video Compression (e.g. Motion-JPEG, MPEG-1/2/4 or H.264 with single-pass bitrate regulation)	8 lines for conversion from raster scan A few thousand pixels on the encoder pipeline	0.25ms << 0.10ms
Network Processing (e.g. RTP/UDP/IP encapsulation)	A few Kbytes	< 0.01ms
Decoder Stream Buffer	From a number of frames (e.g. more than 30) to sub-frame (e.g. 1/2 frame)	from 16ms to 1sec
Video Decompression (JPEG, MPEG-1/2/4, or H.264)	8 lines for conversion from raster scan A few thousand of pixels on the decoder pipeline	0.25ms << 0.10ms
Display Pre-Processing (e.g. Scaling, Chroma Resampling)	A few lines (e.g. 8)	< 0.50ms

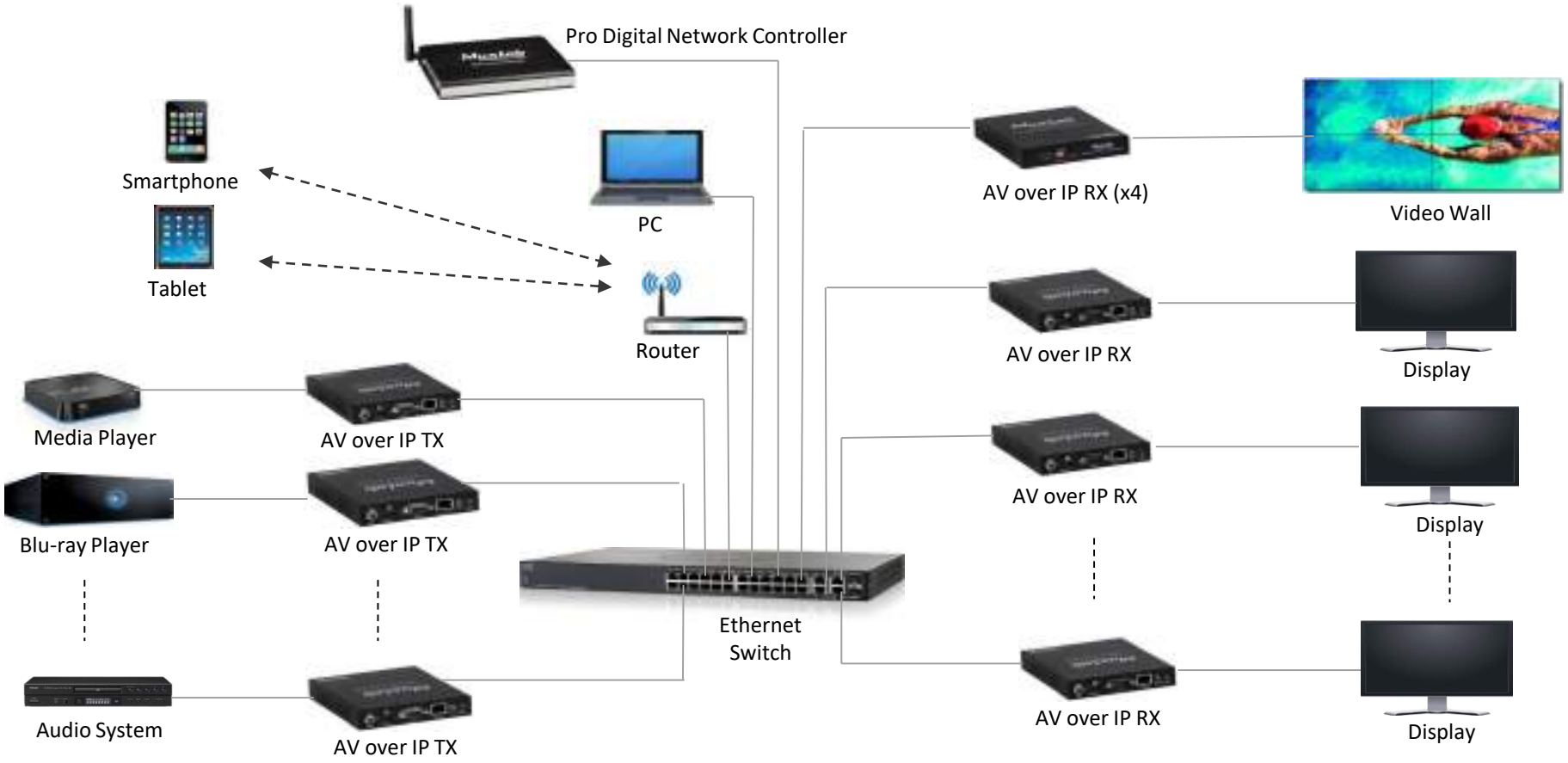
Source: www.design-reuse.com/articles/33005/understanding-latency-in-video-compression-systems.html

AV over IP - Production

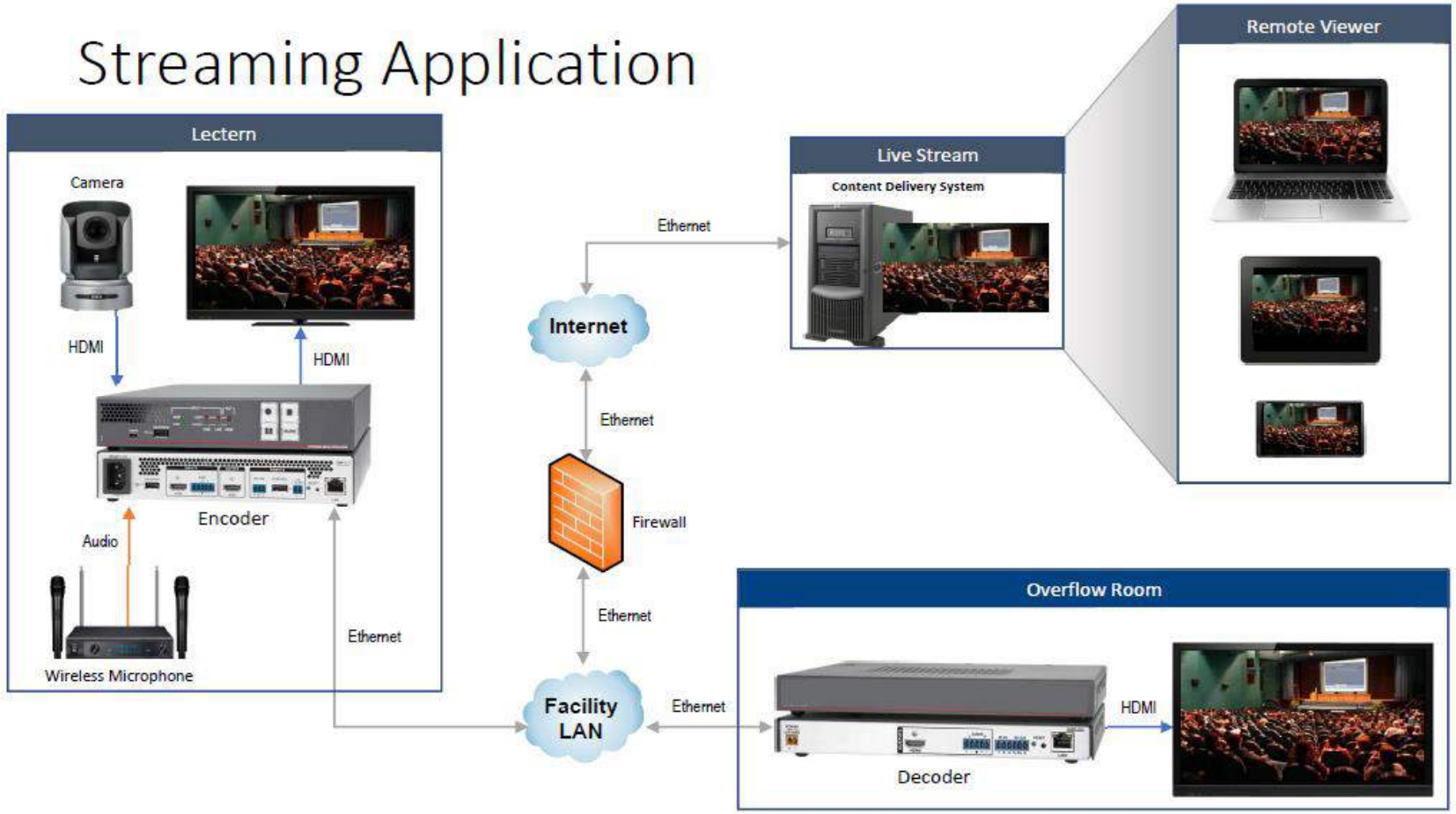


Source https://www.thebroadcastbridge.com/content/entry/325/routing-live-uncompressed-production-video-on-ip-networks

AV over IP – multi source/multi display



AV over IP - Streaming



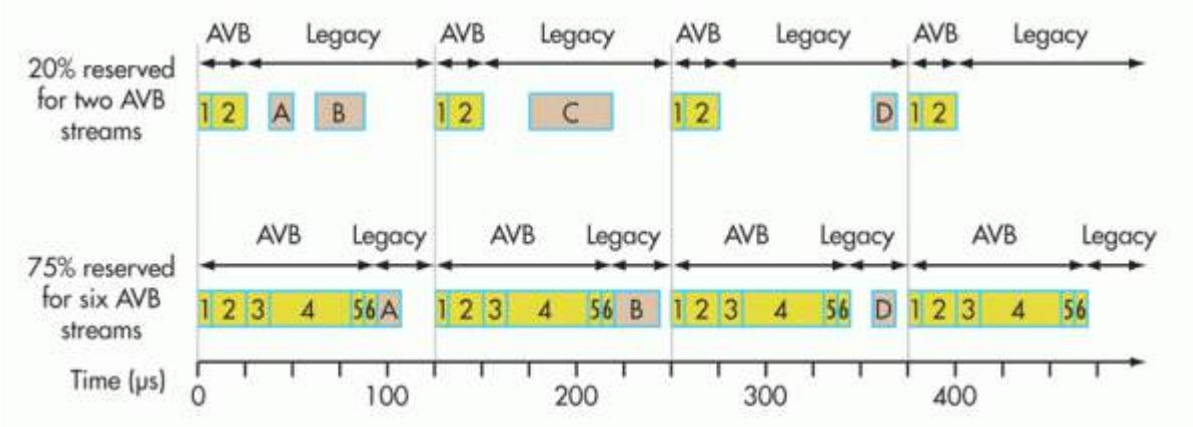
AV over IP

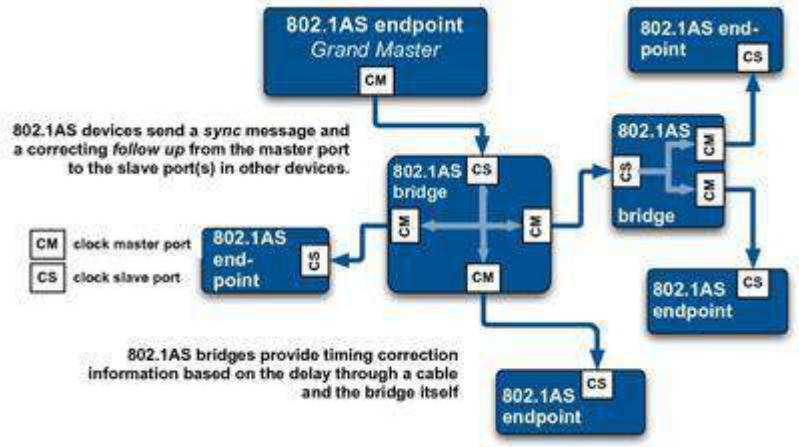
- Solutions
  - AVB (ethernet standard)
  - 1G
  - 10G

AV over IP – AVB (TSN)

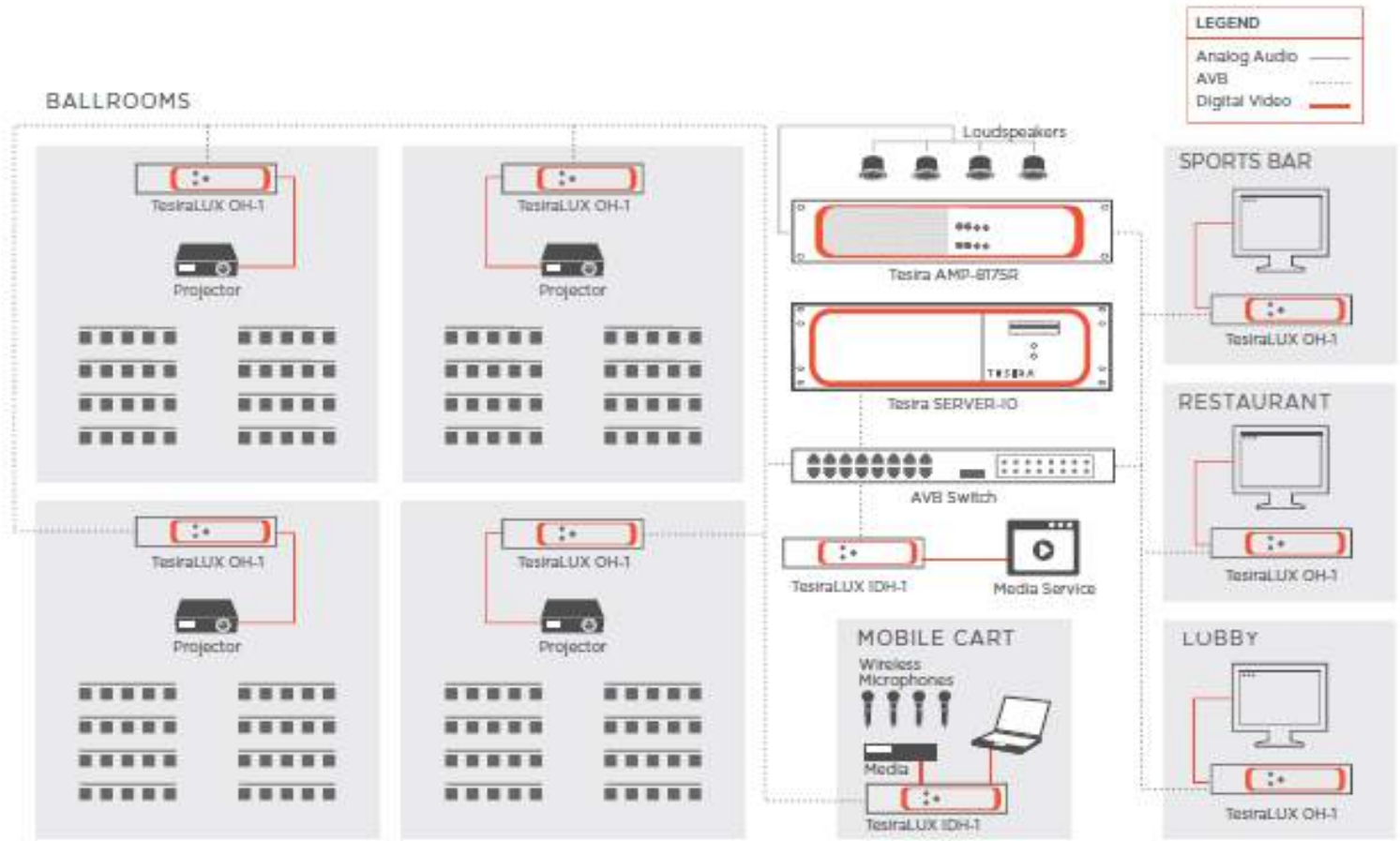
- IEEE 802.1 BA
  - AS – Generalized Precision Time Protocol (gPTP), IEEE 1588
  - Qat – Stream Reservation Protocol (SRP)/Multiple Stream (MSRP)
  - Qav – Forwarding and Queuing for time-sensitive streams (FQTS)
- Payload uses IEEE 1722 (Audio Video Transport Protocol)
- Layer 2 (not routable, thus limited to the LAN)
- 7 hops
- 2 ms latency
- Up to 75% bandwidth reservation!
- Switches and equipment have to be AVB enabled/compatible

AV over IP – AVB (TSN)





AV over IP – AVB (TSN) Biamp Tesira



Hospitality

Av over IP Solutions – 1G

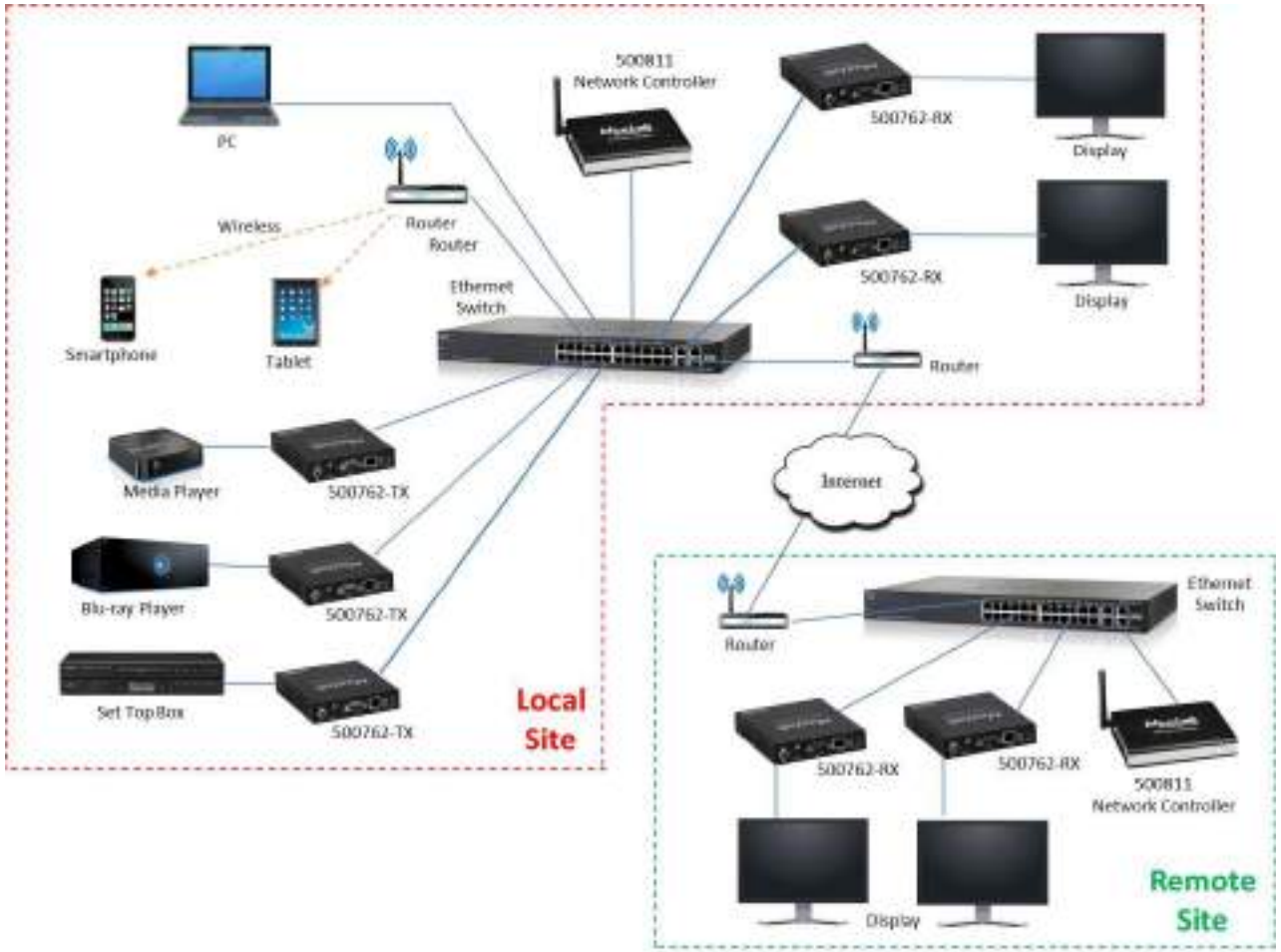
HDMI Ext	HDMI VW/Ext	HDMI Ext		HDMI VW/Ext
1080p/60	1080p/30	4K/60	4K/30	4K/60
Motion JPG	H.264 (757), H.264/H.265 (762)		JPG 2000	AptoVision
1 Frame/80Mbps	500ms/15Mbps	100ms/15Mbps	1 Frame/500Mbps	0 Latency/<10Gbps
Visually Lossless				
IR & PoE	RS232, IR & PoE		Audio, RS232, IR & PoE	Audio, RS232 & IR

1G

10G

1G Solutions

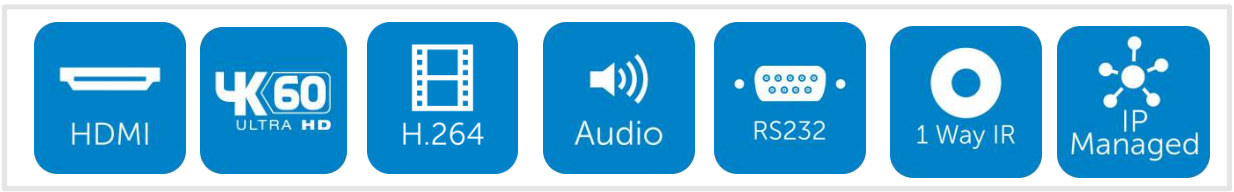
HDMI over IP H.264/265 PoE Extender Kit



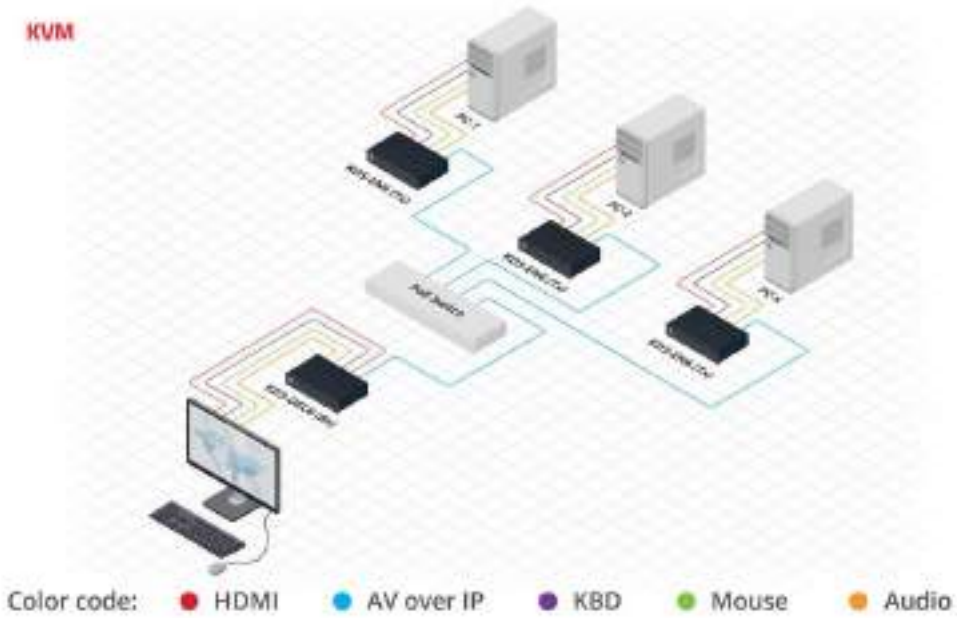
1G Solutions

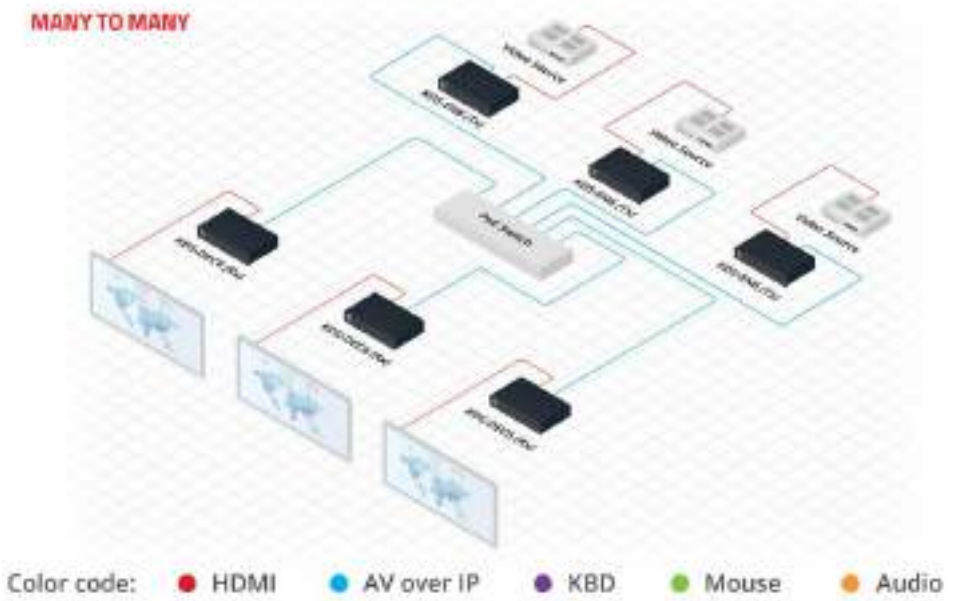
HDMI over IP H.264/265 PoE Extender Kit

- RX: Supports up to 4K @ 60Hz (4:4:4) and up-scales 1080p @ 60Hz to 4K @ 60Hz
- TX: Supports up to 1080p @ 60Hz (up-scaled to 4K/60 by RX)
- Extends local AV transmission up to 330ft (100m) over Cat5e/6
- H.264/265 video codec, excellent for LAN, WiFi & Internet transmission
- Supports Multicast (for LAN), and RTSP / RTMP / HLS / FLV / TS (for LAN & Internet)
- RX: USB 3.0 port for storing and playback of local content from external USB drive
- RX: Supports SPDIF (TosLink) Audio Out
- TX: Supports 2CH audio insert, RX: Supports 2CH audio extract.
- RS232 and Directional IR for remote control of end-devices

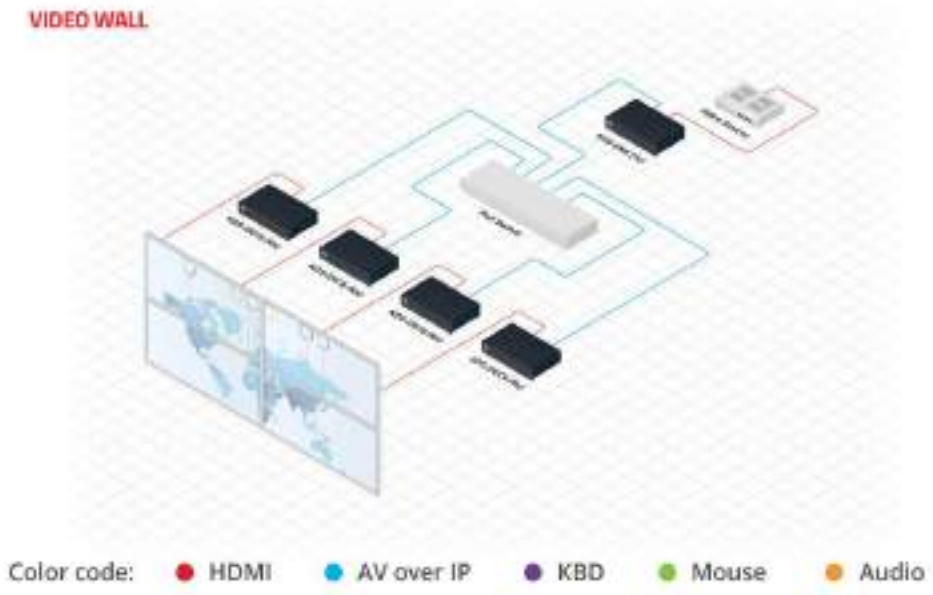


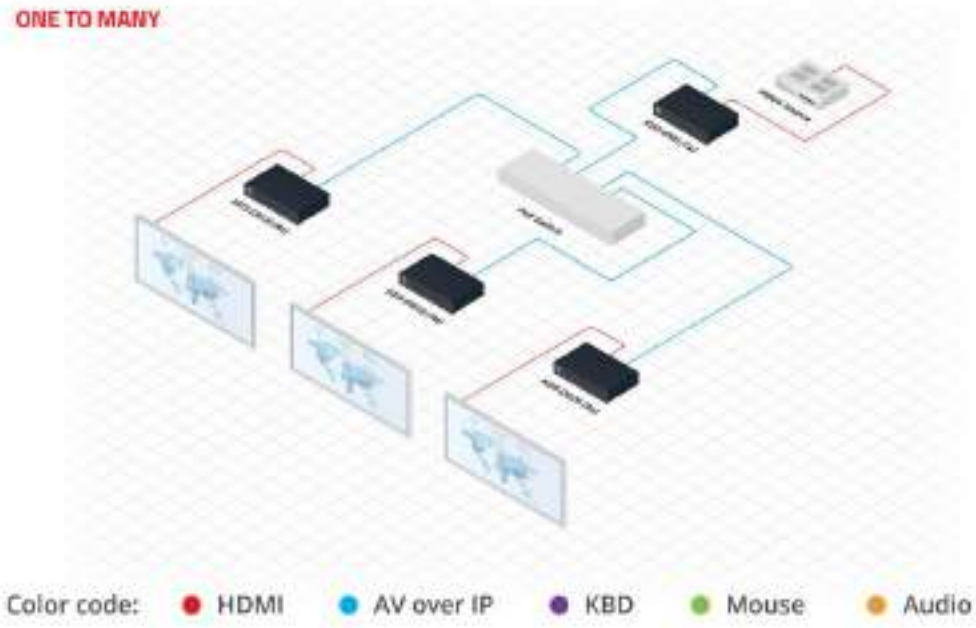
1G Solutions





1G Solutions - Kramer

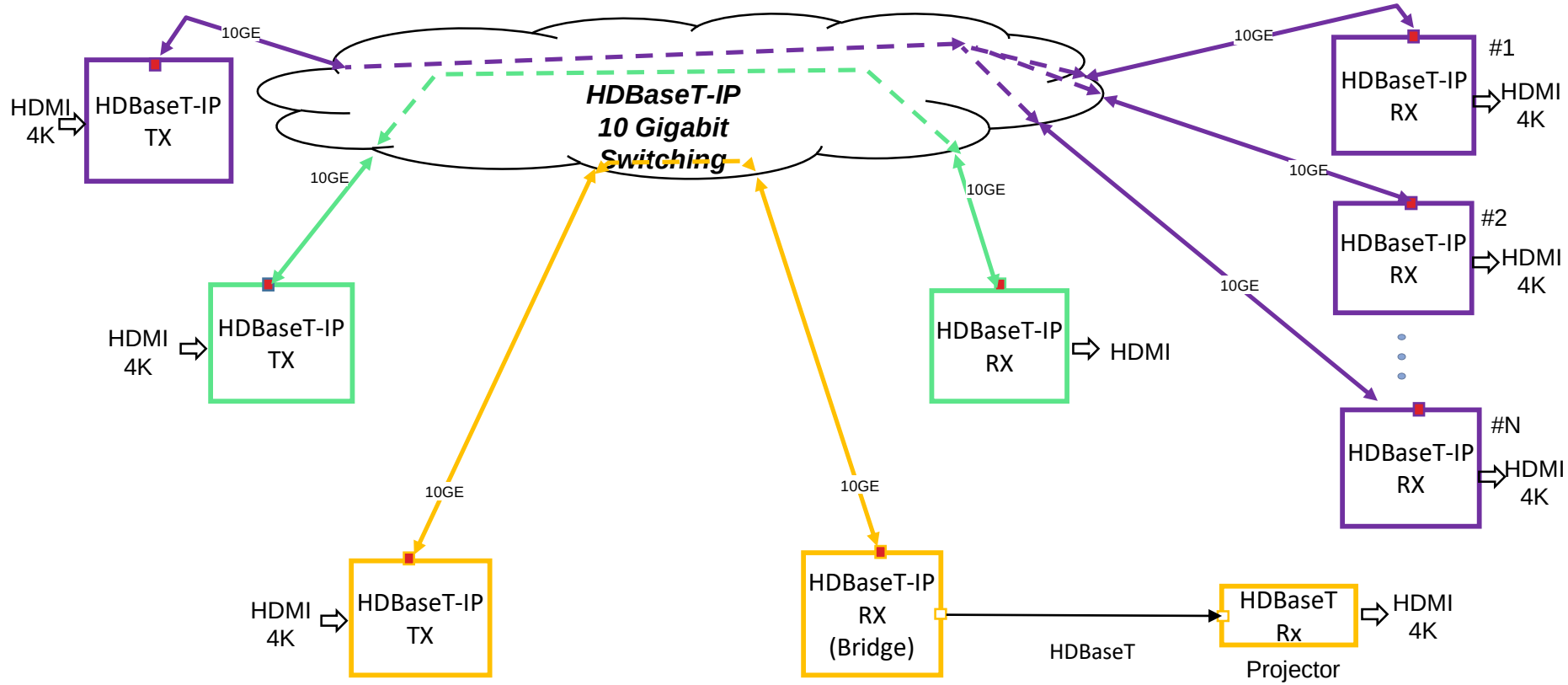




1G Solutions

INPUTS
•1 Ethernet (LAN/PoE) on an RJ–45 connector, 1 IR (Rx)
OUTPUTS
•1 HDMI, 2 left and right unbalanced stereo audio, 1 RS–232, 2 USB (type A) ports, 1 IR (tx), 1 Ethernet on an RJ–45 connector (daisy–chain LAN)
NETWORK
•10M/100M/1000M
SWITCH
1G multicast, IMGP snooping non–blocking, Layer 2
STREAMING
•Unicast and multicast through RTSP (Real Time Streaming Protocol)
IR
•Wide–band 20kHz~60kHz bidirectional IR transmission
MANAGEMENT
•API, Kramer Control, Kramer AV services (powered by Kramer Network)
VIDEO ENCODING/DECODING
•Compression standard JPEG 2000
HDCP
•HDCP 2.2
BIT RATES
•4K peak: 850Mbps, 4K average: 350Mbps, 1080p average: 250Mbps
RESOLUTION
•4096x2160@60Hz, 3840x2160@60Hz, 1920×1200@60Hz, 1920×1080@60Hz and others
AUDIO ENCODING/DECODING
•Compression standard (analog in/out): AAC–LC
CHANNELS (HDMI EMBEDDED AUDIO)
•PCM 2, 5.1, 7.1 Channel, Dolby Digital 5.1 Channel, Dolby Digital Plus, Dolby Digital True–HD, DTS 5.1 Channel, DTS–ES, DTS–HD High Resolution, DTS–HD Master Audio

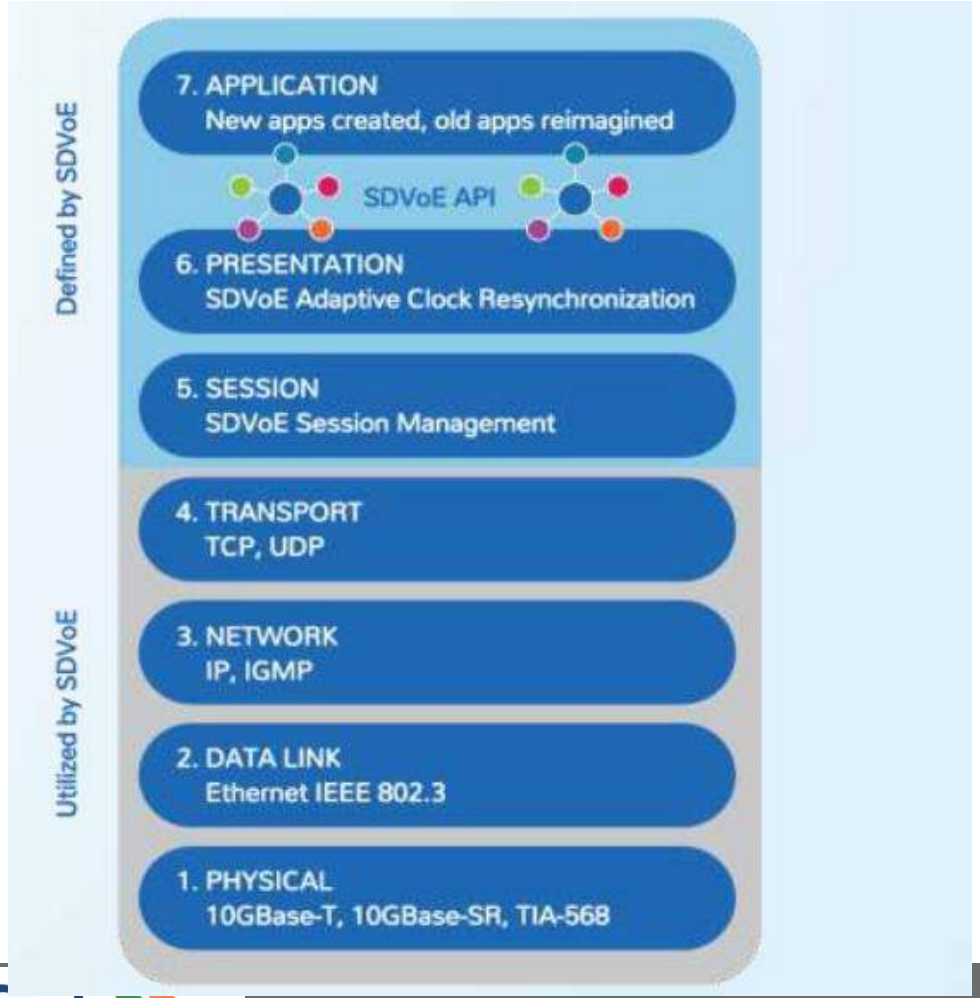
10G Solutions – HDBaseT over IP



P2P
Multicast
P2P + HDBaseT Extension (Hybrid)

Tx boxes will have DSC encoder, Rx boxes will have DSC decoder chips

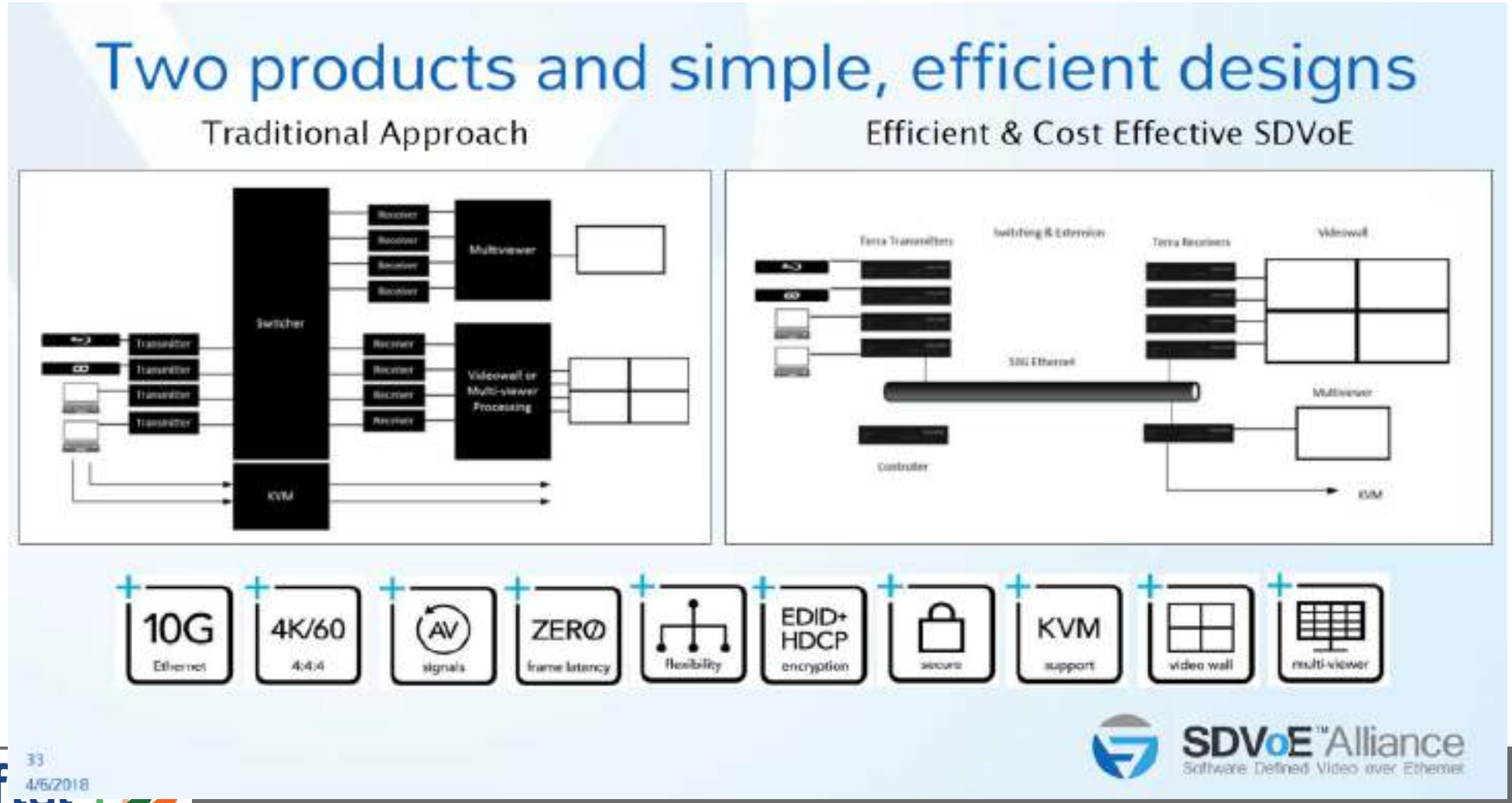
10G Solutions - SDVoE



10G Solutions - SDVoE

- Why now 10G?
  - Bandwidth
    - Ethernet caught up to video
  - Cost
    - 10G down to $100/port
  - Technology
    - Adaptive Clock Re-synchronization
      - Proprietary protocol
      - “similar” to IEEE 1588, not as precise.

10G Solutions - SDVoE



10G Solutions - SDVoE

adding

moving

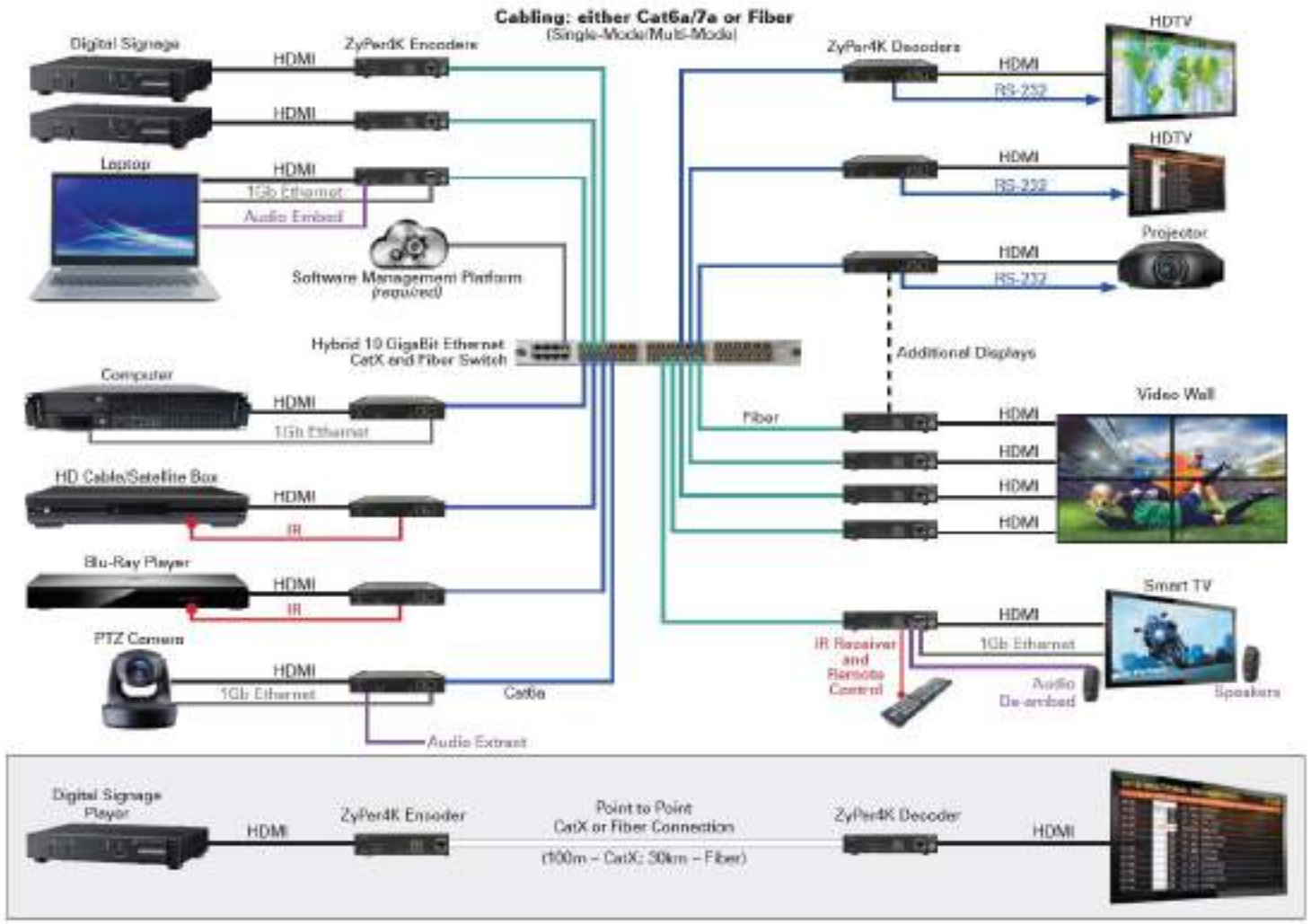
New features

10G Solutions – SDVoE

AV over IP 4K/60 Uncompressed Extender Application

- HDMI (TX & RX) and DisplayPort 1.2a (TX) up to 4K @ 60Hz
- Uncompressed up to 4K/60 (4:2:0) (zero latency)
- Light compression up to 4K/60 (4:4:4) (<1 frame latency)
- Supports Video Wall, Virtual Matrix Switch and Virtual Splitter
- 2CH audio insert (TX) & 2CH audio extract (RX)
- RS232 & 2-way IR for remote control of end-devices
- Supports HDR

10G Solutions – SDVoE



AV over IP – which system do you choose?

- Educate yourself
- Cut through the “noise”
- What do the user needs?

It is all about the application

- And remember : Talk to the IT people!

AV over IP - References

- Chroma Subsampling : https://en.wikipedia.org/wiki/Chroma_subsampling
- HDR: https://en.wikipedia.org/wiki/High-dynamic-range_imaging
- Color Space: https://en.wikipedia.org/wiki/Color_space
- TCP/IP: https://searchnetworking.techtarget.com/definition/TCP-IP
- TCP/IP protocols : http://www.comptechdoc.org/independent/networking/protocol/protnet.html
- Vlan : https://www.alliedtelesis.com/sites/default/files/overview_vlans.pdf
- IGMP : http://www.networksorcery.com/enp/protocol/igmp.htm
- JPEG2000 : https://jpeg.org/jpeg2000/
- H264 : https://www.vcodex.com/an-overview-of-h264-advanced-video-coding/
- H265 book (2014) : https://doc.lagout.org/science/0_Computer%20Science/2_Algorithms/High%20Efficiency%20Video%20Coding%20%28HEVC%29_%20Algorithms%20and%20Architectures%20%5BSze%2C%20Budagavi%20%26%20Sullivan%202014-08-24%5D.pdf
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AV over IP - References

- VC-2 : https://en.wikipedia.org/wiki/Dirac_(video_compression_format)
- AV1 : https://aomedia.org/av1-bitstream-and-decoding-process-specification/
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