Navigating the Next Disruption to Video Distribution – Video Over Ethernet

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Biamp

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How we got here

Remember 2007?

- Began talk about “Analog Sunset”
- Started to see the first Digital Video Systems

How we got here

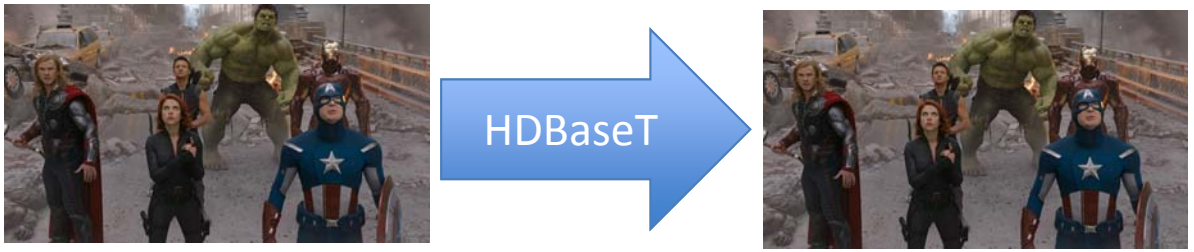
Enter HDBaseT (about 2010)

- Single Cable
- 100 Meter Distance
- Supports Almost Everything HDMI 1.4 Supports

Video Distribution

Balun (HDBaseT) Based Video Matrix Switches

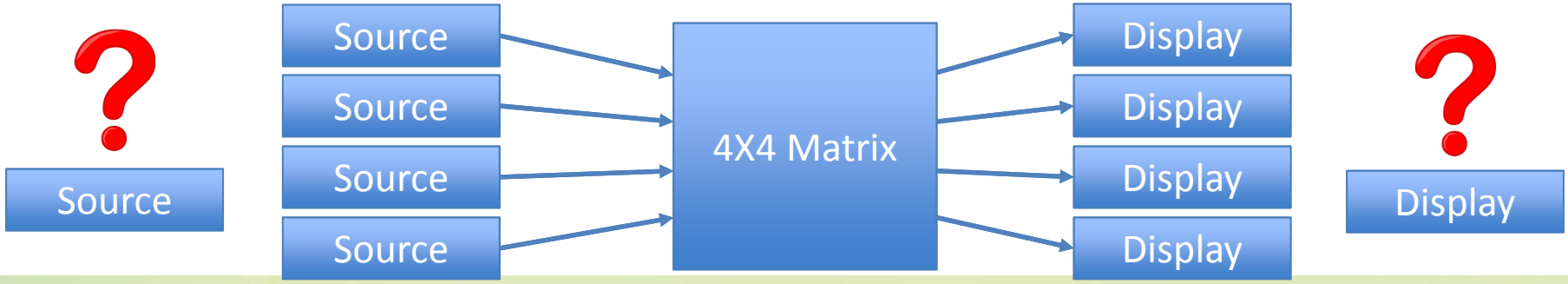
- Centralized Setup
- Low Latency
- Easy Setup



Video Distribution

Balun (HDBaseT) Based Video Matrix Switches

- Expansion difficult
- Difficulty traversing long distances
- Non Linear Cost Structure



Video Distribution

Network Based Video Solutions/Advantages

- Ease of Expansion
- Use of Network Infrastructure
- Linear Cost Structure
- Centralized Management
- Access to content from anywhere
- Capture and Content can be Centralized

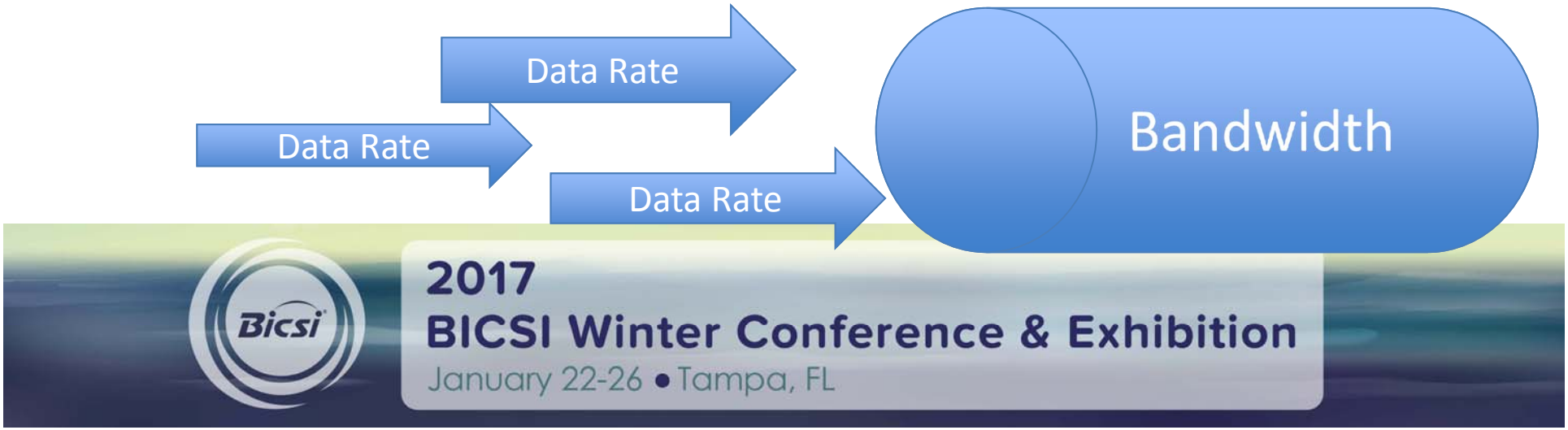
Video Distribution

Network Based Video Solutions Challenges

- Network Capacity (Bandwidth) is Finite
- Network Bandwidth needs to be considered a resource
  - Same way we consider inputs and outputs on matrix today

Bandwidth vs Data Rate

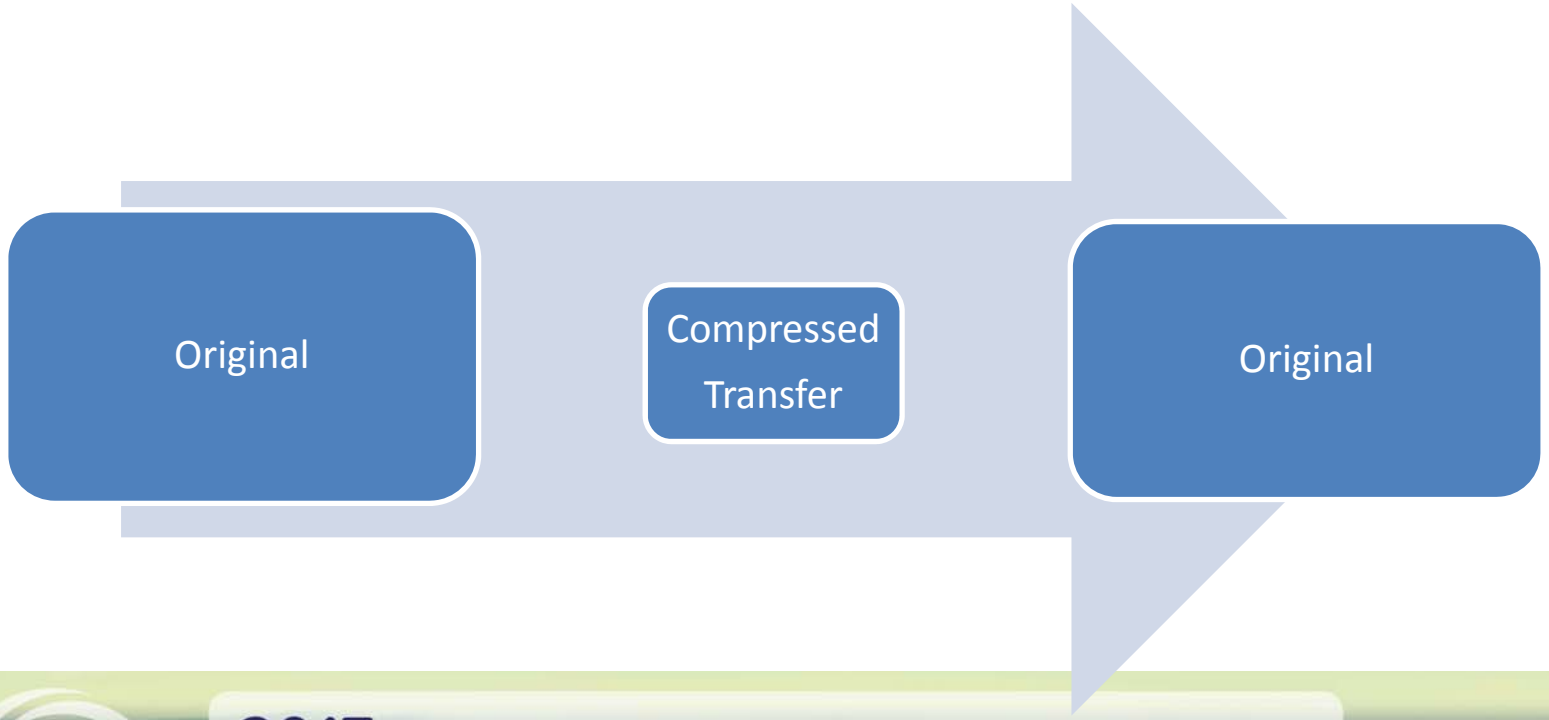
- Bandwidth is generally referred to as the size of the data pipe or network capacity
- Data Rate is the amount of Bandwidth used up by what you are sending between devices



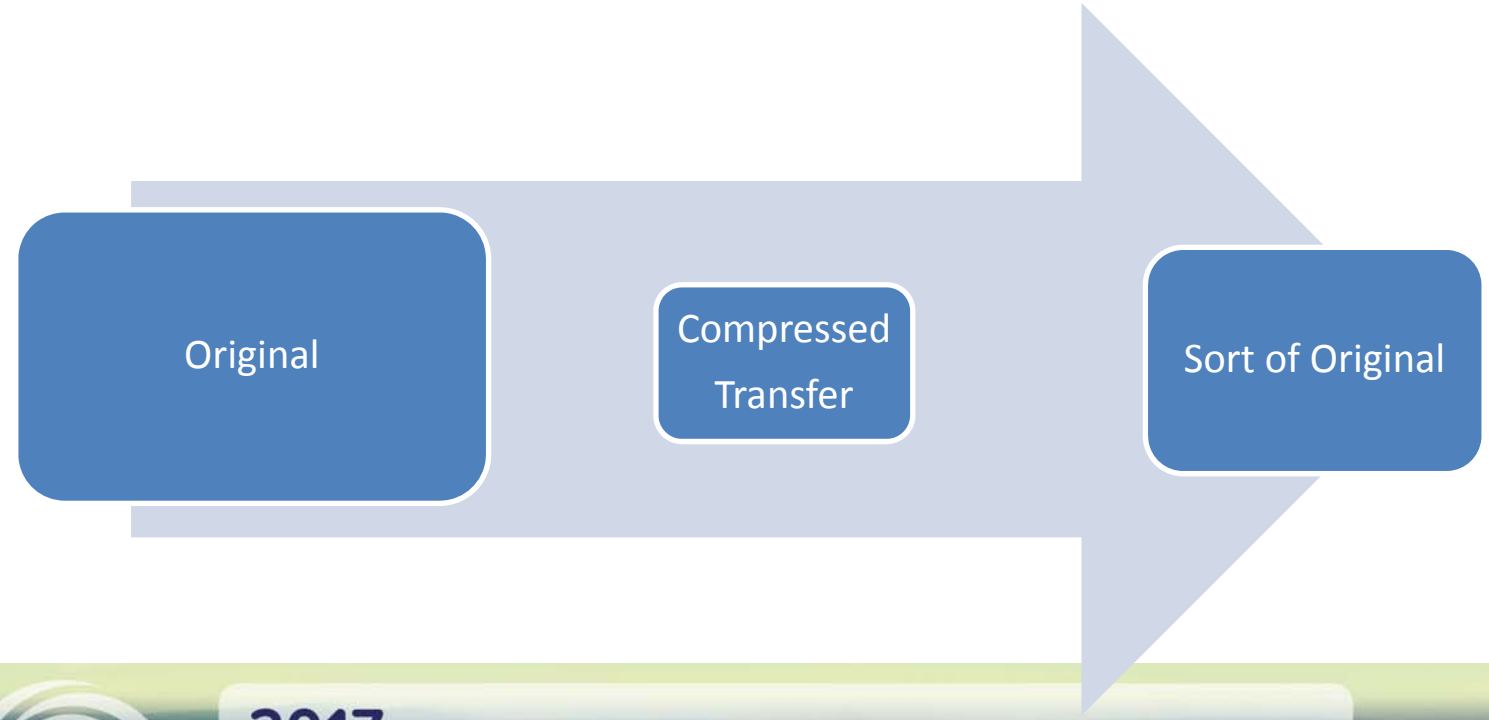
Compression

- Compression involves encoding information using fewer bits than the original representation.
- Can be “lossy” or “lossless”

Lossless Compression



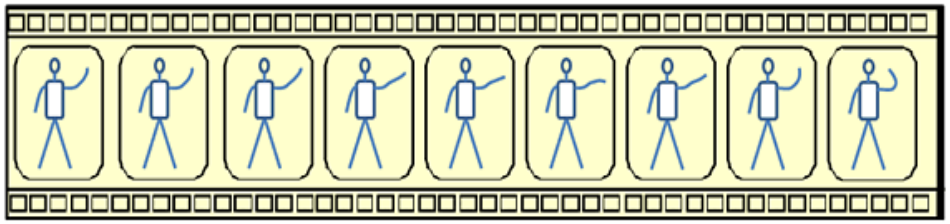
Lossy Compression



Compression Types

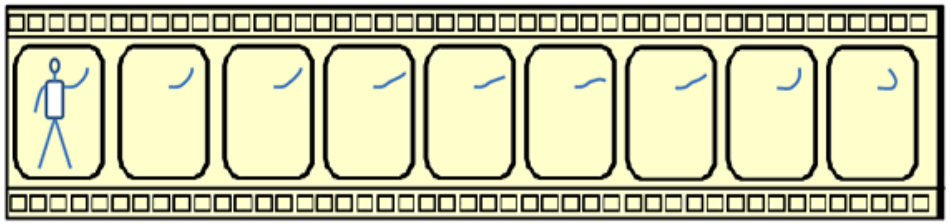
- Spatial Compression
  - Aka intra-fame
  - MJPEG 2000, M-JPEG
- Temporal Compression
  - Aka inter-frame
  - MPEG-4,
    - H.264 and H.265

Compression Types



Intraframe compression

Every frame is encoded individually



Interframe compression

Only the differences between frames are encoded for each group of frames

Compression Debate

- Which Compression is Best?
- It depends
  - Do you know your available bandwidth?
  - How much latency are you willing to tolerate?
  - Cost Structure Encoder vs Decoder?

Compression Types

- MJPEG
  - Supports 12 bit color and VERY high resolutions (64,000 X 64,000)
  - Widely used in Broadcast
- MJPEG-2000
  - About 10x more processor intense than MJPEG
    - Lots of energy used, lots of heat produced
  - Sweet spot – value over 20:1 compression ratios

Compression Types

- MPEG-2 (most widely used temporal compression)
  - Used in early satellite TV broadcasts
  - 8 bit color support
  - Long latency
- MPEG-4 part 10 / H.264
  - Used in Blu-ray discs
  - Capable of up to 14 bit color
  - Capable of resolutions up to UHD
- H.265 (iteration of MPEG-4)
  - Supports very high compression for 4k/UHD content over low bandwidth connections (YouTube)
  - Supports 10 bit color
  - High Latency

Compression Comparison

	M-JPEG, JPEG 2000 (Spatial)	MPEG-4, H.264 (Temporal)
Latency	As low as 33 msec	200 msec or higher

Compression Comparison

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Processing	Symmetric	Asymmetric

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Latency	As low as 33 msec	200 msec or higher
Bandwidth	High	Low
Compression	< 30:1	> 30:1
Processing	Symmetric	Asymmetric
Error Tolerance	High	Low

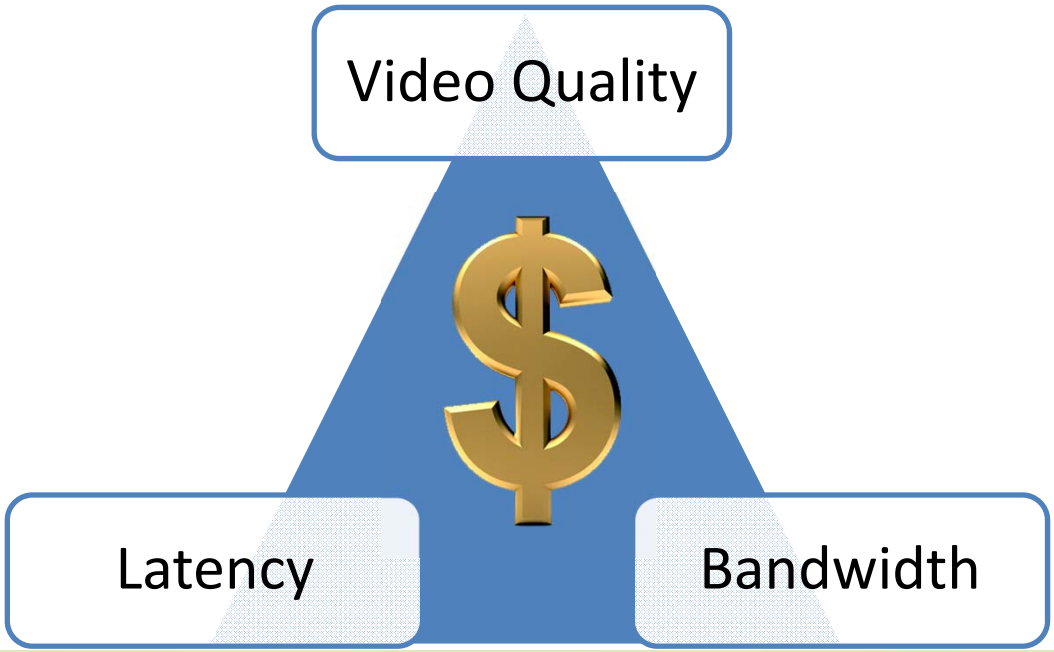
Compression

- All Compression has a cost
  - Processing ($$, power and heat)
  - Time (latency)
  - Data (video quality)
- More Compression = Less Bandwidth Use
- More Compression = More Power, More Cost and often More Latency

Compression

- Excessive Compression introduces visible artifacts
  - Blocking – visible structures from block based algorithms
  - Blurring – loss of high frequency detail like smoothing of textures
  - Ringing – present on steep edges in an image
  - Mosquito Noise – time variant edge busyness (prediction errors)
  - Posterization & Solarization – color artifacts introduced by bit depth adjustments

Network Video Design



Compression (Natural Video)

- Compression Ratio
  - Used to quantify the reduction in data-representation size produced by a data compression algorithm
- 10:1 Compression Ratio
  - Applied to a 1Gbps stream would produce a 100Mbps stream
- 2:1 Video can be “mathematically lossless”
- 6:1 Video considered “visually lossless”

Deciding What Video To Distribute

Consumer Marketing

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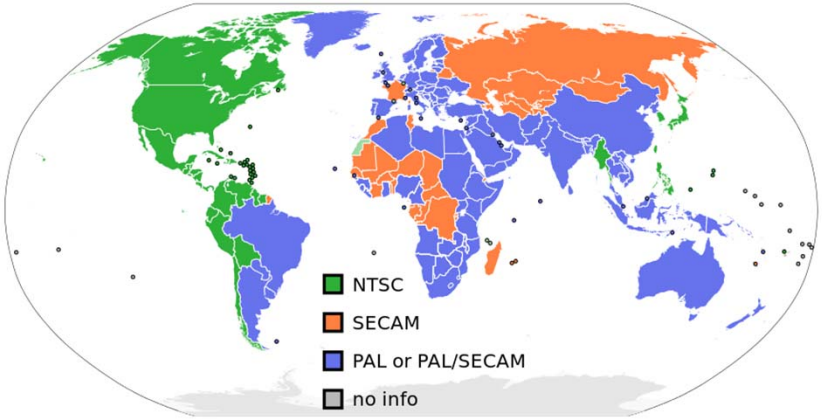
Refresh Rates

Content Refresh Rates

- 24 Hz (Movies)
- 60 Hz (NTSC)
- 50 Hz (PAL, SECAM)



Display Refresh Rates

- 60 Hz
- 120 Hz
- 240 Hz
- 480 Hz

Refresh Rates

Key Takeaways

- There is no widely available content with refresh greater than 60Hz
- Higher refresh support in displays have nothing to do with transport

Content Refresh Rates

- 24 Hz (Movies)
- 60 Hz (NTSC)
- 50 Hz (PAL, SECAM)

Display Refresh Rates

- 60 Hz
- 120 Hz
- 240 Hz
- 480 Hz

Video Resolution

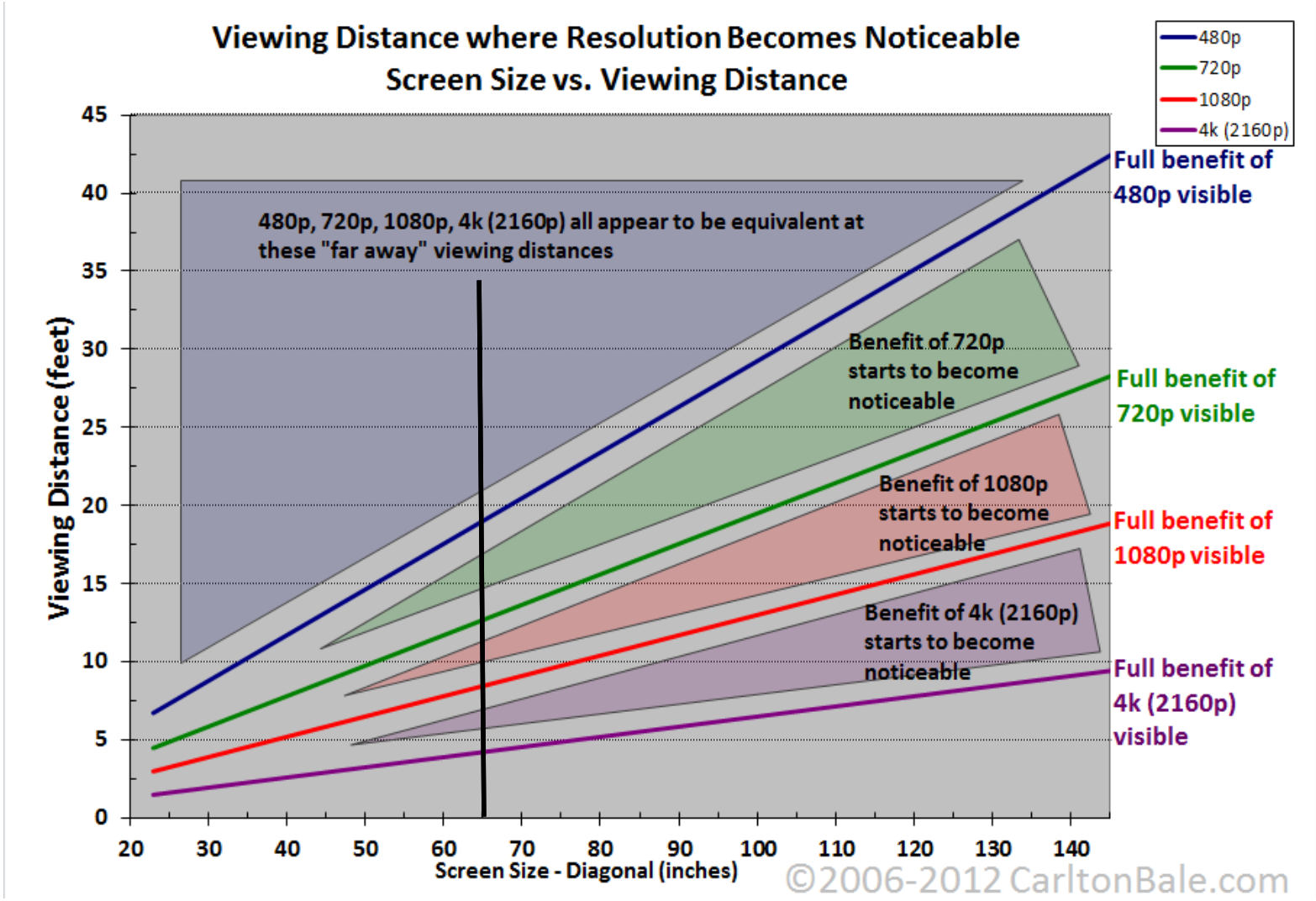
Resolution Marketing Evolution

Name	Vertical X Horizontal	
480i	640 X 480	interlaced (240 lines)
480p	640 X 480	progressive (480 lines)
720p	1280 X 720	progressive
1080p	1920 X 1080	progressive
4K	3840 X 2160	progressive

Resolution vs Viewing Distance

Recommendations vary by industry

- Consumer
- InfoComm (more credible, has well documented math to support it)


Viewing Distance where Resolution Becomes Noticeable
Screen Size vs. Viewing Distance
480p
720p
1080p
4k (2160p)
Viewing Distance (feet)
Screen Size - Diagonal (inches)
480p, 720p, 1080p, 4k (2160p) all appear to be equivalent at these "far away" viewing distances
Benefit of 720p starts to become noticeable
Benefit of 1080p starts to become noticeable
Benefit of 4k (2160p) starts to become noticeable
Full benefit of 480p visible
Full benefit of 720p visible
Full benefit of 1080p visible
Full benefit of 4k (2160p) visible
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Resolution vs Viewing Distance

Infocomm International Standard *"Display Image Size for 2D Content in Audiovisual Systems"*

Analytical Decision Making

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance} * \#\text{Vertical Pixels}}{3438}$$

Basic Decision Making

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance}}{200 * \%\text{Element}}$$

Basic Decision Making Example

5% Element Height and 70” Diag. Flat Screen

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance}}{200 * \%\text{Element}}$$

$$38” = \frac{\text{Maximum Viewing Distance}}{200 * 5\%}$$

Maximum Viewing Distance = 32 feet (380”)

Basic Decision Making Example

5% Element Height and 5’ Height Proj. Screen

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance}}{200 * \%\text{Element}}$$

$$60” = \frac{\text{Maximum Viewing Distance}}{200 * 5\%}$$

Maximum Viewing Distance = 46 feet (600”)

Practical Application

1280 X 720

8 Point Font
10 Point Font
12 Point Font
14 Point Font
16 Point Font
18 Point Font
20 Point Font
24 Point Font
28 Point Font
36 Point Font
40 Point Font
44 Point Font
54 Point Font

1920 X 1080

8 Point Font
10 Point Font
12 Point Font
14 Point Font
16 Point Font
18 Point Font
20 Point Font
24 Point Font
28 Point Font
36 Point Font
40 Point Font
44 Point Font
54 Point Font

3840 X 2160

8 Point Font
10 Point Font
12 Point Font
14 Point Font
16 Point Font
18 Point Font
20 Point Font
24 Point Font
28 Point Font
36 Point Font
40 Point Font
44 Point Font
54 Point Font

Analytical Decision Making Example

Analytical Decision Making 20’ Conference Room

$$\text{Minimum Image Height} = \frac{\text{Maximum Viewing Distance} * \#\text{Vertical Pixels}}{3438}$$

$$\text{Minimum Image Height} = \frac{240 * 720}{3438} = 50\text{”} \ (4\text{’}2\text{”}, 1.27\text{m})$$

$$\text{Minimum Image Height} = \frac{240 * 2160}{3438} = 151\text{”} \ (12\text{’}7\text{”}, 3.8\text{m})$$

Resolution

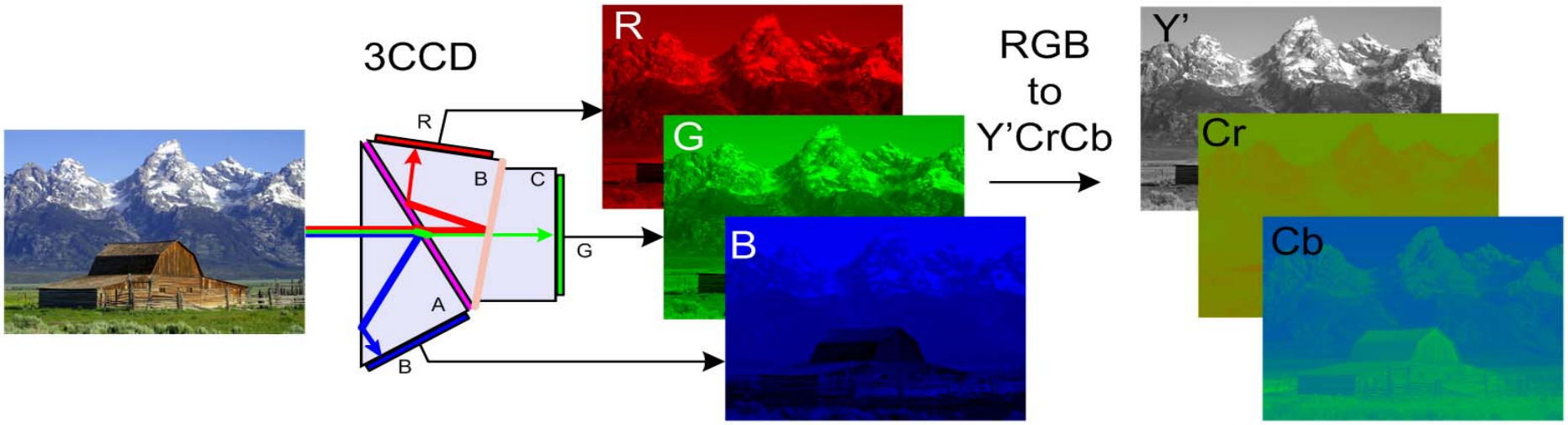
Key Takeaways

- When watching motion video higher resolution won't matter
- When view computer graphics higher resolution is harmful to room function and "health/comfort" of the viewer

Regardless, customers will demand this capacity

4K doesn't necessary mean…better!

Color Space



Chroma Sub Sampling

Chroma Sub Sampling

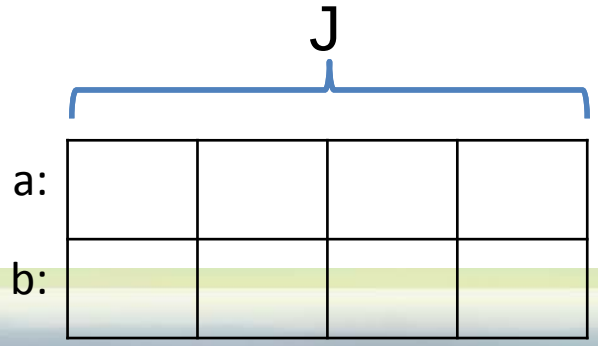
- Y, Cb, Cr

Chroma Sub Sampling

- Playing with human perception
- Human vision can resolve fine detail spatial differences in luminance to a greater extent than similar detail in chrominance
- Displaying all of the brightness (Luma) information but only some of the color (Chroma) saves us bandwidth but keeps quality very high

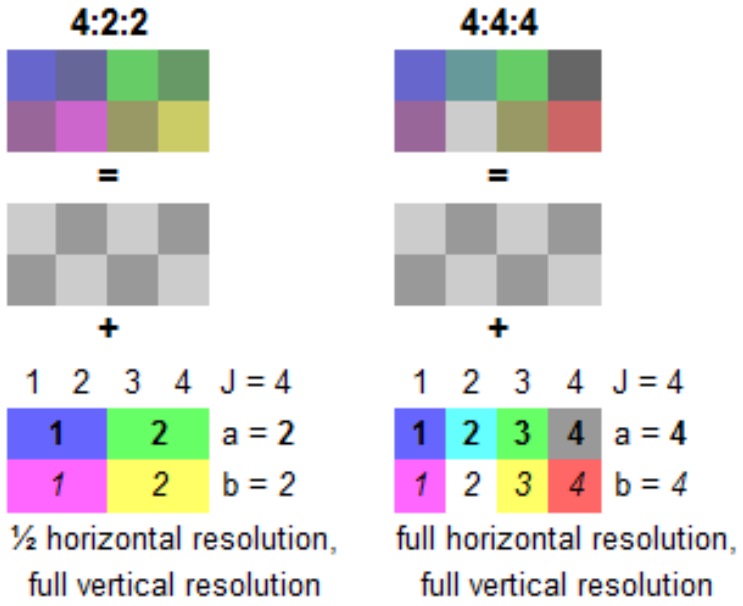
Chroma Sub Sampling

- 4:4:4, 4:2:2, 4:2:0
- J:a:b
  - J = Reference Block Size (Width, # of Columns)
    - The Height or # of Rows is fixed
  - a = Number of pixels in 1st row that get a sample
  - b = Number of pixels in the 2nd row that get a sample

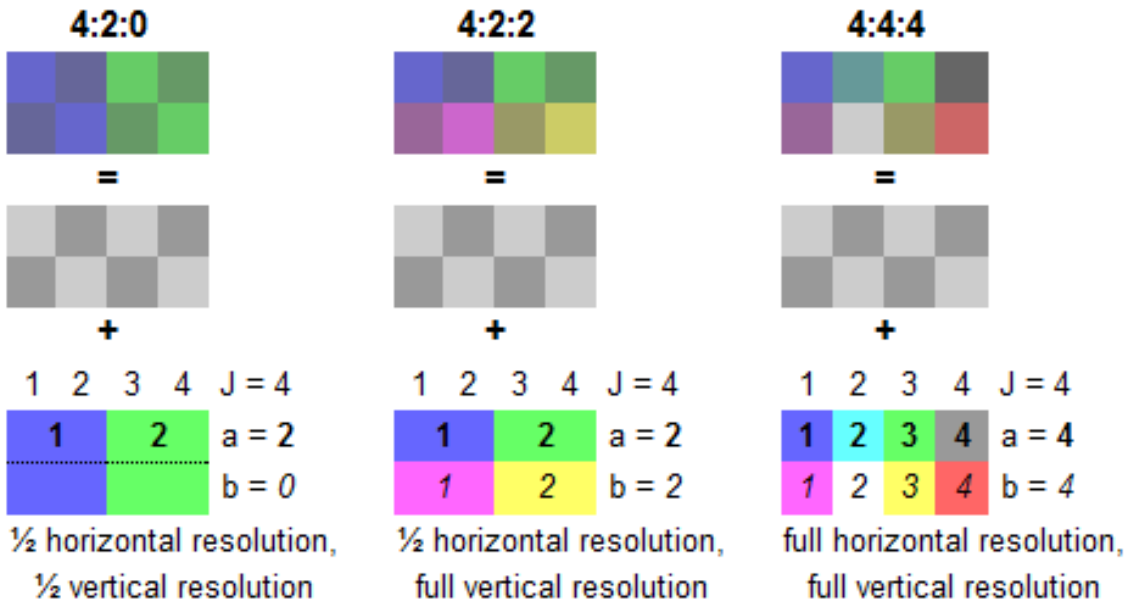


Chroma Sub Sampling

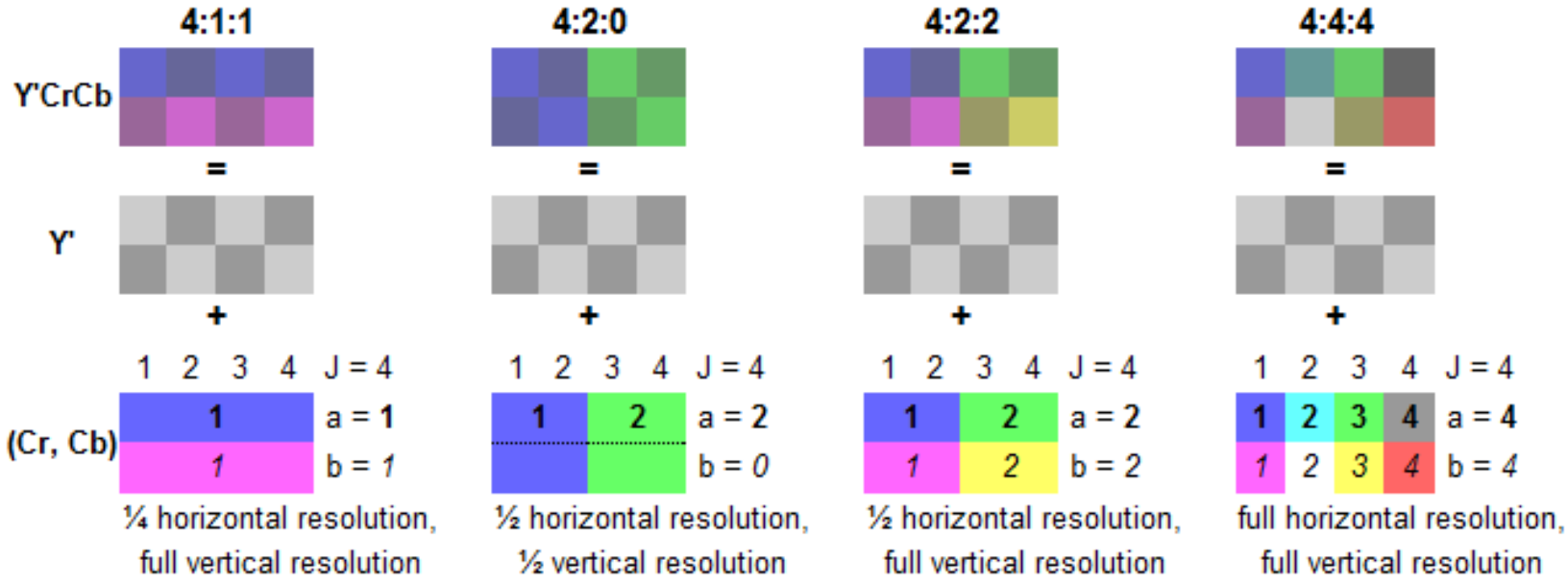
Chroma Sub Sampling



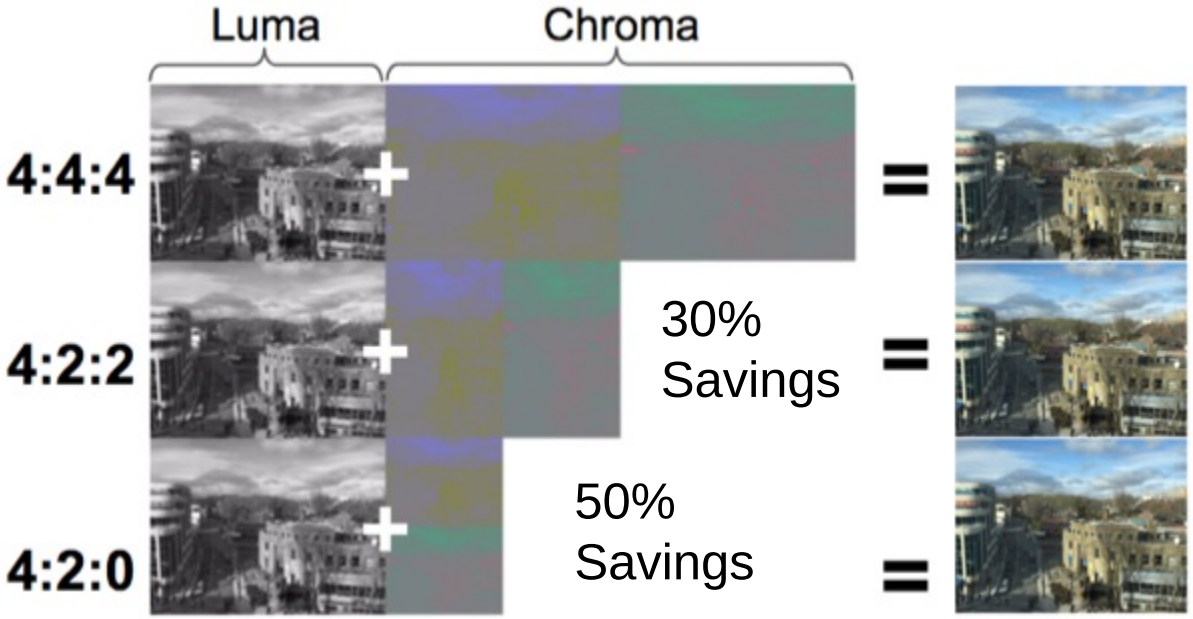
Chroma Sub Sampling



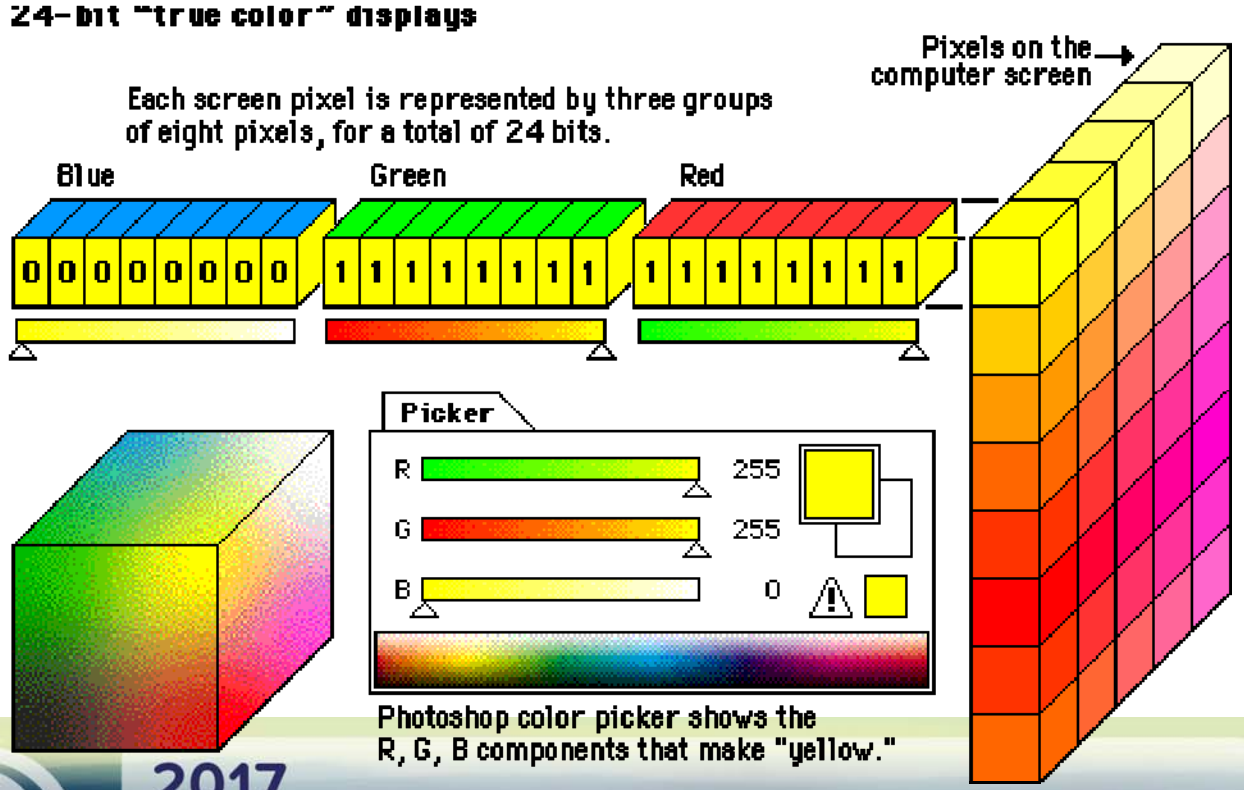
Chroma Sub Sampling



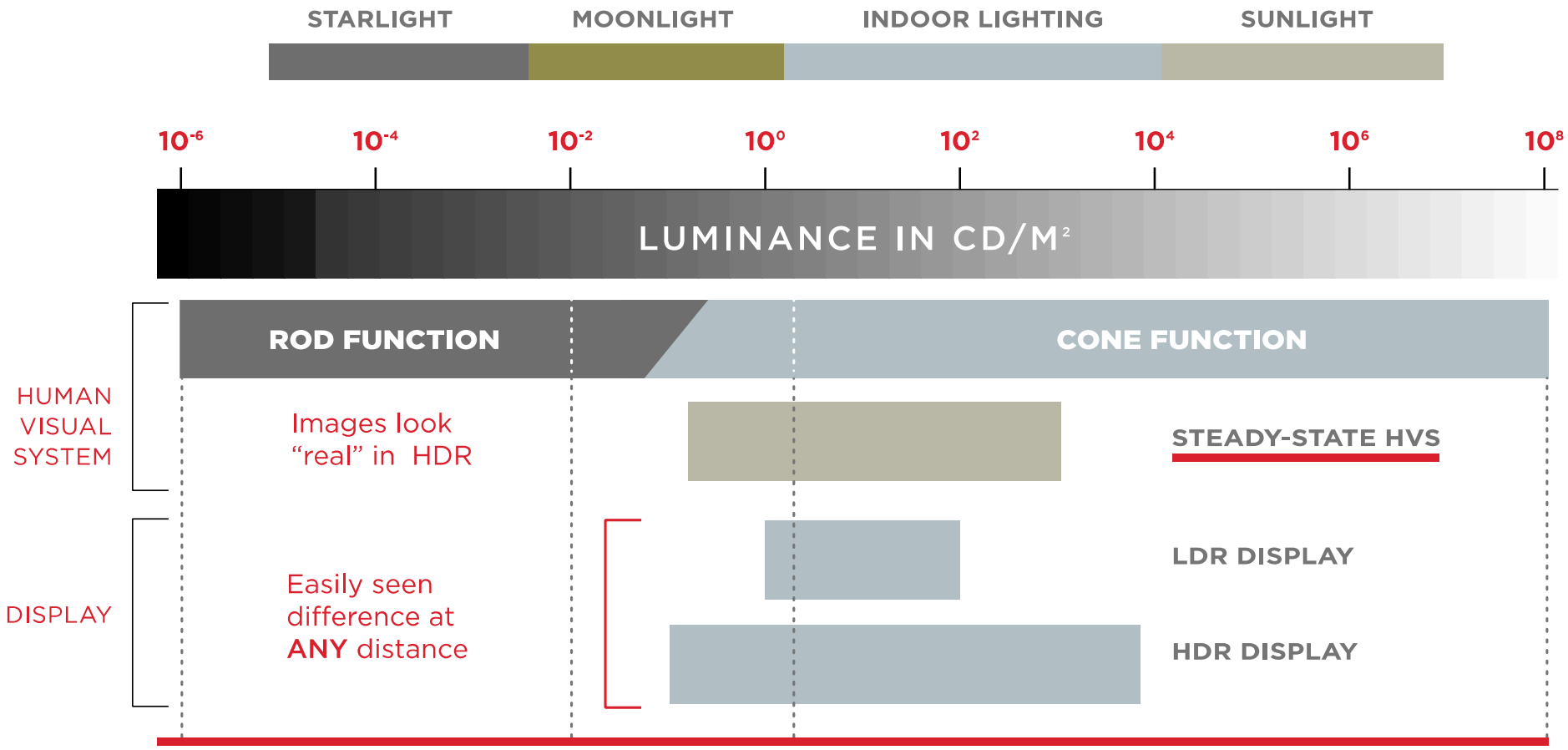
Chroma Sub Sampling – Bandwidth Sampling



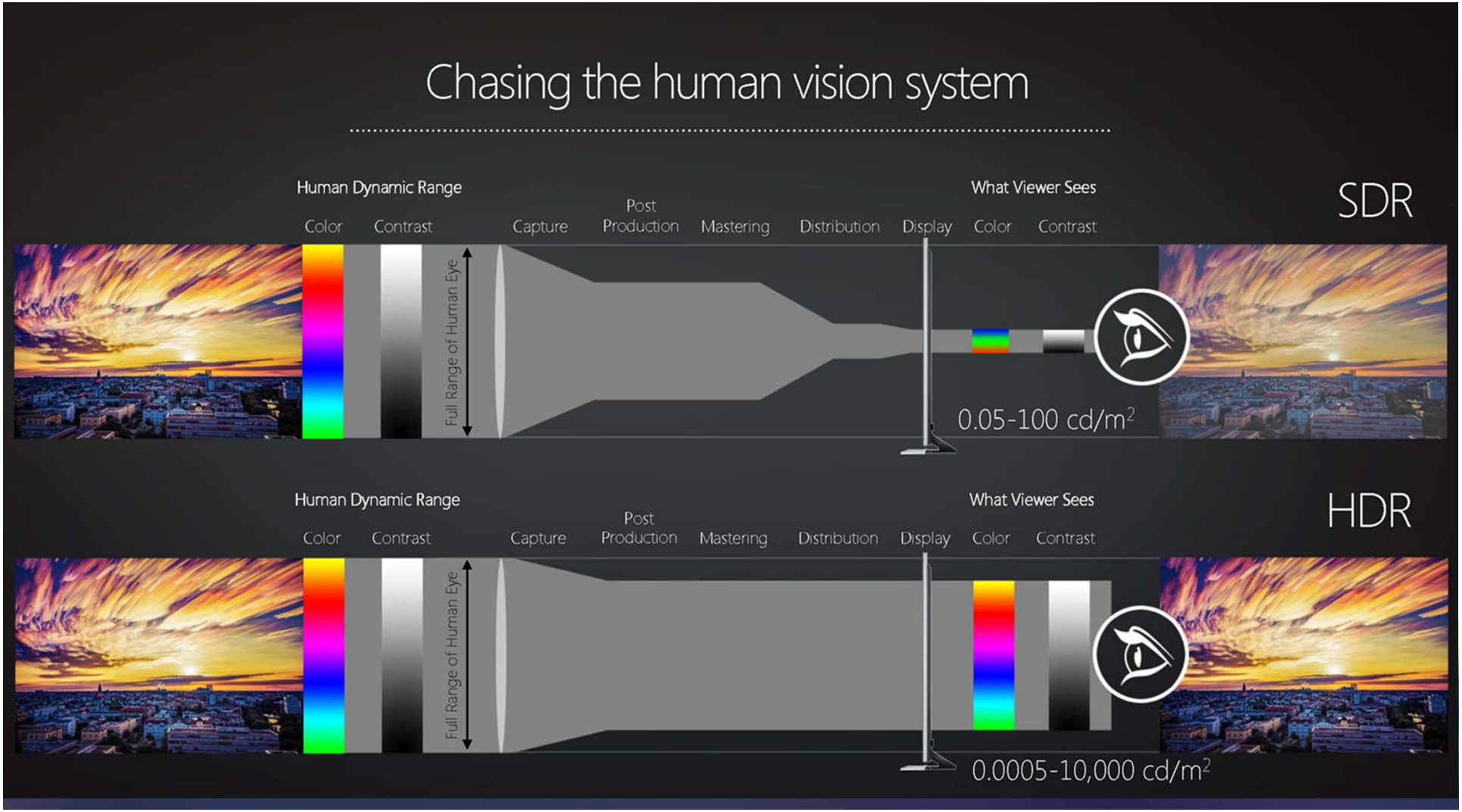
Color or Pixel Depth



Dynamic Range



Chasing the human vision system



Video Design

- All of the aspects of a video signal impact it's data rate.
- Impact varies and what aspects are important and depend on your application.

Network Impact

How does Resolution Effect Data Rate?

- 4k (3840x2160) quadruples data rate relative to 1080p (1920x1080)
- No practical application for rooms larger than huddle space

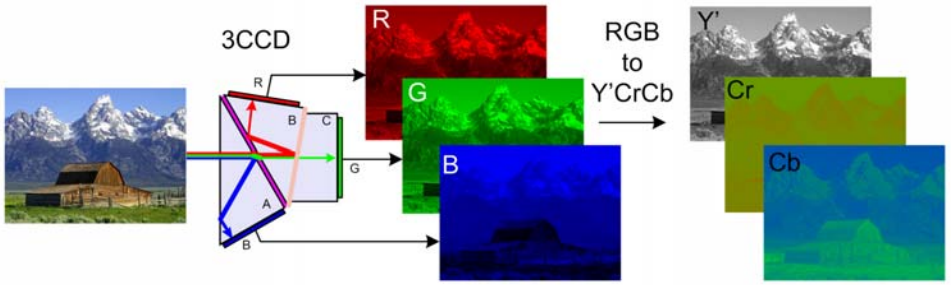
1920 x 1080, 60Hz, 4:2:2, 8bit = 1.99Gbps

3840 x 2160, 60Hz, 4:2:2, 8bit = 7.96Gbps***

Network Impact

How does Color Space Effect Data Rate?

- RGB doesn't support Chroma Sub Sampling
- YCbCr 4:4:4 Data Rate = RGB Data Rate



Network Impact

How does Chroma Sub Sampling Effect Data Rate?

- YCbCr 4:4:4 Data Rate = RGB Data Rate
- 4:2:2 uses 33% less Data than 4:4:4
- 4:2:2 is basically all video today, including Blu-ray

1920 x 1080, 60Hz, 4:4:4, 8bit = 2.99Gbps

1920 x 1080, 60Hz, 4:2:2, 8bit = 1.99Gbps

Network Impact

How does HDR Effect Data Rate?

- HDR = 10bit Color
- 10bit uses 25% more Data than 8bit
- Real Impact with existing content at any distance

1920 x 1080, 60Hz, 4:2:2, 10bit = 2.49Gbps

1920 x 1080, 60Hz, 4:2:2, 8bit = 1.99Gbps

Today’s Changes to the Network

Today's Network Changes

- AVB = Audio Video Bridging
- TSN = Time Sensitive Networking
- Deterministic Networking
- IEEE 802.

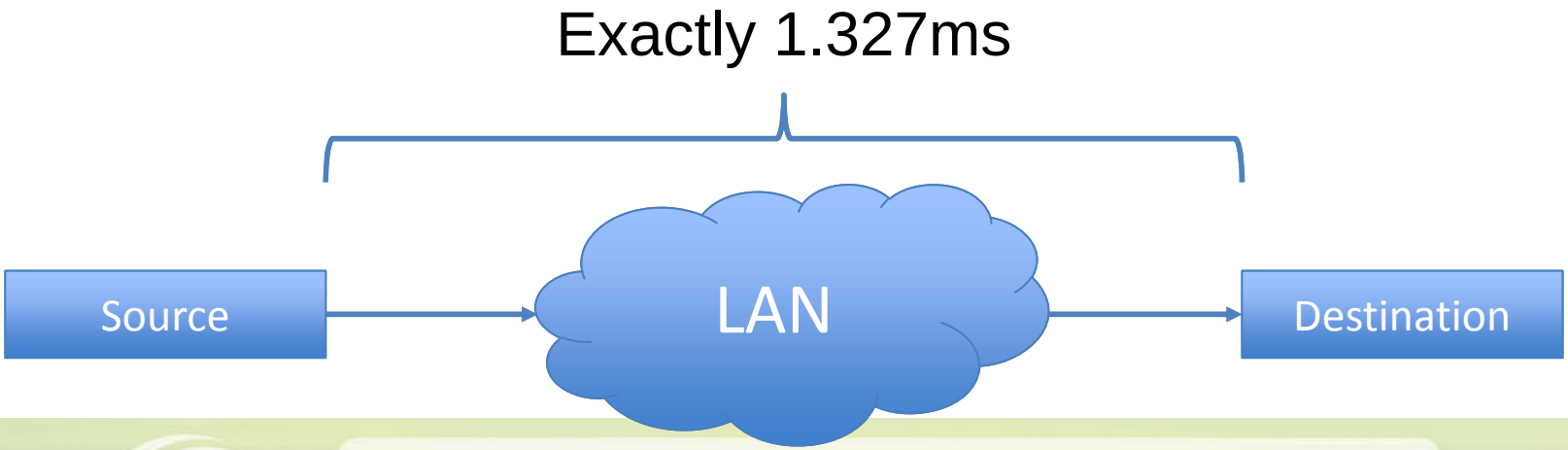
Today's Network Changes

IEEE's AVB Ethernet Additions

- IEEE 802.1AS
  - Generalized Precision Time Protocol (gPTP)
- IEEE 802.Qat
  - Stream Reservation Protocol (SRP) / Multiple Stream Reservation Protocol (MSRP)
- IEEE 802.Qav
  - Forwarding and Queuing for Time-Sensitive Streams (FQTSS)
- IEEE 802.1BA
  - An umbrella standard for the three above

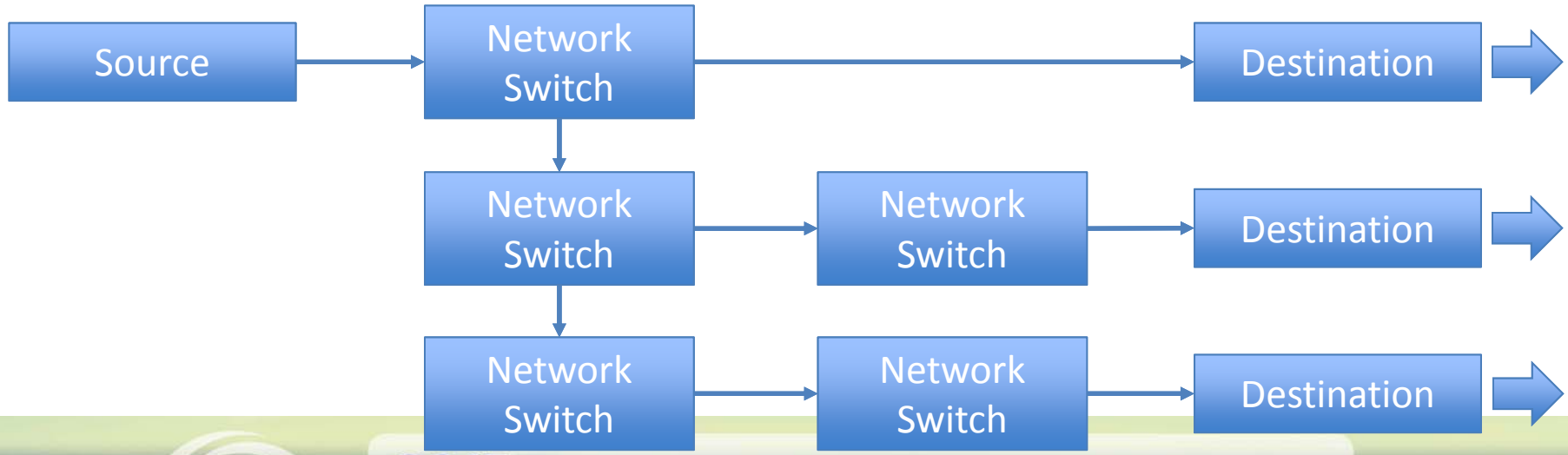
Deterministic Networking

- Bounded Latency



Deterministic Networking

- Bounded Latency
- Precise Timing / Synchronization



Deterministic Networking

- Bounded Latency
- Precise Timing / Synchronization
- Automatic Setup
  - VLAN
  - QoS
  - Traffic Shaping
  - Bandwidth Management and Guaranteed capacity

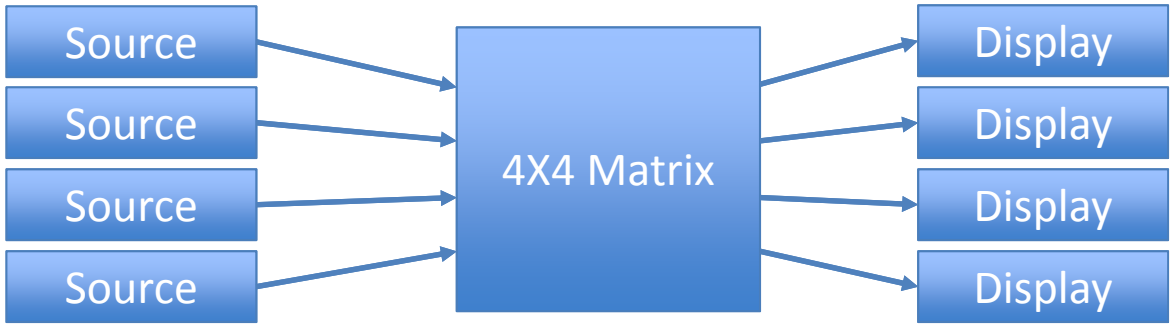
AVB – Available Switches

- MOTU
- Netgear
- Extreme Networks
- Cisco

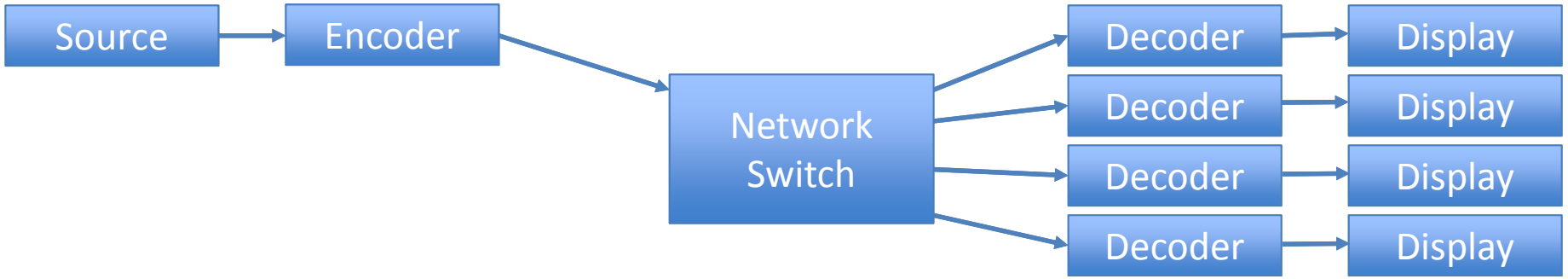
“V” in AVB

- Today…this is possible:
  - Route, combine or separate audio and video signals at will
  - Process them separately **and** still guarantee lip-sync
  - Doing this all over AVB guarantying network transit time and performance
  - AVB also removes the need for complex manual network setup.

Video Distribution – Traditionally (non-network)



Video Distribution –
Natural Evolution (Network based)



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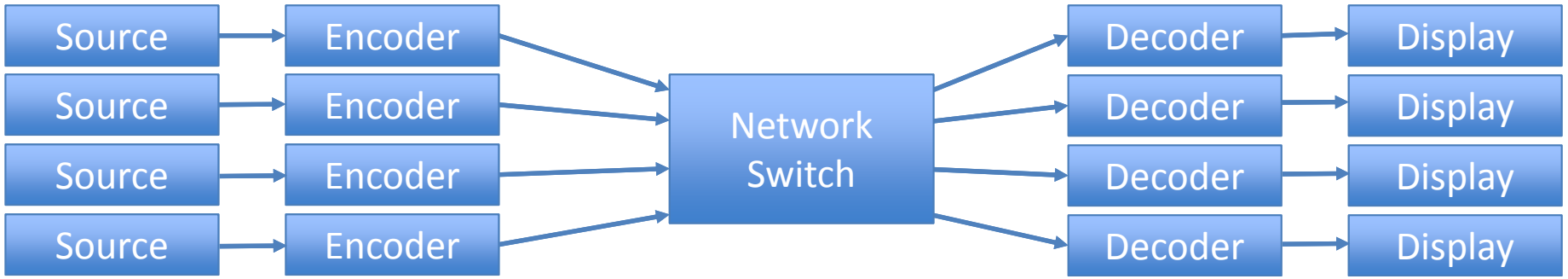


HDMI 2.0a

- HDMI forum's official Statement:

  The specification has been updated to enable transmission of HDR formats, which provide enhanced picture quality by simultaneously enabling greater detail for both the dark and bright parts of an image. The HDR-related updates include references to CEA-861.3, CEA's recently published update of HDR Static Metadata Extensions. - *HDMI Forum, Inc.*

- Starting to see support now, many displays late 2016

HDMI 2.0a

- YCbCr 4:2:0 Chroma sub sampling support
- 14.4Gbps data rate (additions in red)

	8bit	10bit
4K@24	RGB 4:4:4	RGB 4:4:4
4K@25		
4K@30		
4K@50	RGB 4:4:4 4:2:0	4:2:2 4:2:0
4K@60		

HDCP

High-bandwidth Digital Content Protection

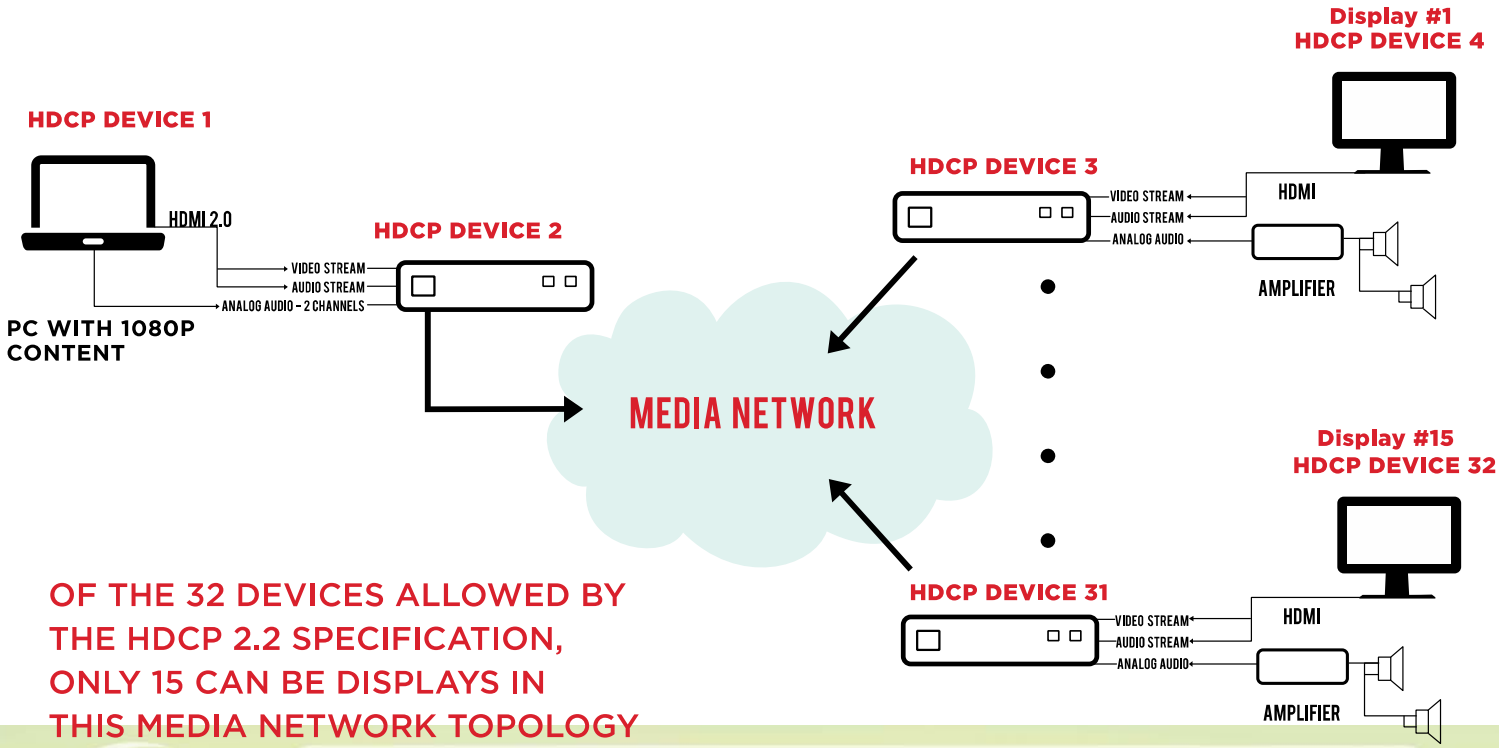
- HDCP 1.4
  - Widely deployed legacy version
  - Point to Point solution
  - No Network Support; Wired only connections (HDMI, DVI, DisplayPort)
  - Today, HDCP isn't deployed correctly in most products

HDCP 2.2

High-bandwidth Digital Content Protection

- HDCP 2.2
  - 2.x required for UHD type 1 (High Value Content)
  - Not required for HDR or WCG content (supported with HDMI 2.0a)
  - Required for any Network based distribution
    - TCP/IP, USB, WiFi
    - HDMI, DVI, DisplayPort Support
  - 32 Device Count Limit

HDCP 2.2



OF THE 32 DEVICES ALLOWED BY THE HDCP 2.2 SPECIFICATION, ONLY 15 CAN BE DISPLAYS IN THIS MEDIA NETWORK TOPOLOGY

HDCP 2.2 Pro

High-bandwidth Digital Content Protection

- HDCP 2.2 Pro
  - Issued on May 13, 2016
  - Unlimited Number of Devices Supported
  - White-Listed Site Support

HDCP 2.2 Pro

Preliminary Site White List

- Education facilities (Classrooms, lecture theatres)
- Office buildings
- Share trading floors
- Hospitals & Medical training facilities
- Transport venues (Airports, railway stations etc.)
- Hospitality (Bars, Casinos, Convention centers, Hotel & conference centers)
- Manufacturing facilities
- Houses of Worship
- Broadcast production facilities
- Military installations
- Government / Municipal sites (parliaments, local government, town halls)
- Courts & Justice facilities (Court rooms, detention centers)
- Sporting facilities (Stadiums, arenas, coaching facilities)
- Large Retail outlets, (e.g. Best Buy or Walmart wall of monitors),
- Shopping Malls
- Airports, airlines
- Cruise ships
- Single family dwelling (Bill Gates house)

HDCP 2.2 Pro

Not All Sunshine and Rainbows

- Current HDCP Pro Draft:
  - Requires New and Specific Hardware
  - Must not be re-deployed
  - Requires “Licensed Installers” to report hardware location at time of sale
  - Hardware must receive regular updates (quarterly)

HDCP

	HDCP 1.x	HDCP 2.2	HDCP 2.2 Professional
Network capable	No	Yes	Yes
Max levels	7	4	unrestricted
Max devices	128	32	unrestricted
Leave/join tolerant	No	No	Yes
UHD type 1 support	No	Yes	Yes
White list sites only	No	No	Yes

Questions

Thank You

Michael D. Frank, CTS

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