New Standards That Will Make a Difference: HDR & All-IP

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HDR is Not About Brighter Display!

- **SDR**: Video generally ≤ 1.25x; Cinema generally ≤ 2.7x
- **HDR**: May be up to 100x

Source: Report ITU-R BT.2390
“HDR” is Really 3 Advanced Image Technologies

- High Dynamic Range
- Wide Color Gamut
- 10-bit Sampling

What is being called “HDR” is really the combination of HDR, WCG and higher sample precision technologies.
Color Volume

Outer triangle: UHDTV primaries
Rec. ITU-R BT.2020

Inner triangle: HDTV primaries
Rec. ITU-R BT.709

CIE 1931 XY+ HDR Z
Color Volume Mapping

• “HDR” displays have different color volumes
• Use color volume mapping to map into the target display color volume
  • Both tone mapping (intensity) and gamut mapping (color)
  • 3D color volume mapping
**HDR Systems: “Static”**

- **PQ10** = SMPTE ST 2084 PQ HDR transfer function (also in Rec. ITU-R BT.2100) + UHD WCG (in BT.2020 → BT.2100) + 10-bit sample depth

- **HDR10** = PQ10 + reference display metadata (static)
  - Metadata = SMPTE ST 2086 HDR *static* metadata* + MaxCLL + MaxFALL
  - Specified by Blu-ray® Disc Association, DECE, CTA, UHD Alliance for pre-produced content
  - *ST 2086:2014 – Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images*
    - Specifies mastering display primaries, white point, and min/max luminance
    - Used in HEVC: Mastering Display Color Volume & Content Light Level SEI messages

- **HLG10** = HLG HDR transfer function (in BT.2100) + UHD WCG + 10-bit sample depth
  - No metadata
Dynamic metadata systems = PQ10 + frame-by-frame “Display Adaptation” metadata

**SMPTE ST 2094-x suite** – Content-Dependent Metadata for Color Volume Transformation of High Luminance and Wide Color Gamut Images

- Specifies dynamic metadata used in the color volume transformation of source content mastered with HDR and/or WCG imagery, when such content is rendered for presentation on a display having a smaller color volume.

- The most important elements for **live** production are:
  - Deep shadow => Min
  - Mid-tone (facial and interior) => Mid
  - Highlight regions => Max

- Computed on a frame-by-frame basis
HDR Systems: “Dynamic” (2)

- **Dolby Vision**
  - Defined in **SMPTE ST 2094-10**
  - Descriptive metadata

- **Samsung HDR10+**
  - Defined in **SMPTE ST 2094-40**
  - Descriptive metadata

- **Philips/Technicolor SL-HDR1**
  - **Prescriptive metadata**: carries the dynamic color volume transform metadata created during the down-conversion to SDR process
    - Required to recover the original HDR color volume
HDR Signaling & Metadata Carriage

Baseband SDI & SDI-in-IP (SMPTE ST 2022-6)
- Signaling carried in SMPTE ST 352 Payload ID
  - HD-SDI (ST 372), 3G-SDI (ST 425-1)
  - 6G-SDI (ST 2081), 12G-SDI (ST 2082)
- Metadata carried per
  - SMPTE ST 2108-1 HDR/WCG Metadata Packing and Signaling in the Vertical Ancillary Data Space
  - SMPTE ST 2108-2 Vertical Ancillary Data Mapping of KLV Formatted HDR/WCG Metadata

Pro Media over IP (SMPTE ST 2110)
- ST 2108 metadata carried in SMPTE ST 2110-40 Transport of SMPTE ST 291-1 Ancillary data

CTA/HDMI Forum (CTA 861-G)
- Minimum HDMI 2.0b

Compressed
- For 4K: HEVC Main10 Profile
- Signaling carried as VUI messages
- HLG has a compatibility mode where the HLG TF is signaled in an SEI
- Metadata as AVC|HEVC SEI messages
  - Unfortunately, the mapping is not identical
  - Each HDR scheme uses a different defining document, different provider code, different internal structure
  - No coordination but there does not appear to be any conflicts
Mixing SDR into HDR Flows: SDR-to-HDR Upconversion

- Early HDR Live TV will have a limited amount of HDR content
  - SDR content likely to be mixed with HDR content during an HDR broadcast
- SDR needs to be converted for correct visualization on HDR displays
- While one cannot “create” HDR from SDR, as the SDR content has no HDR information, one can “balance” SDR hue saturation and luma values, so that it looks correct on a HDR TV, running in HDR mode
  - **Real-Time Intelligent Inverse Tone Mapping**
Tone Mapping Matters

HDR  SDR  SDR  HDR

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Tone Mapping Matters
So What About 1080p HDR?

• If bandwidth constraints prevent a broadcaster from offering all of the new technologies, then focus on the “best bang for the bit”
  • 1080p50/60 HDR

• Take advantage of all modern displays’ ability to up-convert 1080p to 4K (2160p)
  • Of course, display must support HDR to render HDR
Why IP for Contribution, Live Production, & Playout?

1. To enhance the **flexibility** & **agility** of the video plant
2. Compatible with network interfaces on **commodity** Ethernet switches and **commodity** servers
3. **Flexible** association of streams into desired groups of media
4. **Network-based** registration and discovery of devices, streams, and media capabilities
5. **Denser** than SDI and inherently bi-directional
6. **Agnostic** to specific video format (resolution, bit depth, frame rate, etc.)

*The “on-ramp” to the software-oriented, virtualized video production plant*
Simplifies and Reduces Cabling

Example:
4K Ultra-HD OB Truck

Equivalent amount of **3G-SDI cabling** required

Photos courtesy of NAB18 IP Showcase
SMPTE ST 2110-x Suite of Standards

- **ST 2110-0** Roadmap for the document suite
- **ST 2110-10** “System Timing & Definitions”
- **ST 2110-20** “Uncompressed Active Video”
  - Based on RFC 4175
- **ST 2110-30** “PCM Digital Audio”
  - AES67
- **ST 2110-40** “SMPTE ST 291-1 Ancillary Data”
  - Captions, subtitles, time codes, active format description, dynamic range, etc.
  - Co-developed with IETF as new RFC 8331 RTP Payload for SMPTE ST 291-1
- **ST 2110-21** “Traffic Shaping & Delivery Timing for Video”
- **ST 2110-31** “AES3 Transparent Transport”
  - Includes compressed audio
- **ST 2110-22** “Constant Bit-Rate Compressed Video”
- **RP 2110-23** “Single Video Essence Transport over Multiple ST 2110-20 Streams”
- **ST 2110-41** “Fast Metadata”
- **ST 2110-42** “Formatting of ST 2110 Sender SDP Object for Transport using ST 2110-41 Fast Metadata”
Related to SMPTE ST 2110

• SMPTE ST 2022-8 “Professional Media over Managed IP Networks: Timing of ST 2022-6 streams in ST 2110-10 Systems”
  • To be sent to Draft Publication ballot

• SMPTE ST 2022-7 Seamless Protection Switching revision
  • To add “ultra-low-skew” class and genericize to “All-IP” (includes ST 2110 RTP payloads)
  • To be sent to ST audit
Leverage IP Standards vs. Reinventing the Protocol Stack

Video
ST 2110-20

Audio
ST 2110-30

ANC Data
ST 2110-40

RFC 3550  RTP  Real-time Transport Protocol
RFC 768  UDP  User Datagram Protocol
RFC 791  IP  Internet Protocol
IEEE 802.3  Ethernet
x Gbps fiber, copper

SMPTE
IETF
IEEE
Comparison of Real-Time Media over IP-based Transport Protocols

- **SMPTE ST 2022-6**
  - "SDI over IP"
  - RTP encapsulation
  - Easy conversion to/from SDI
  - Good for mixed SDI/IP system and interfacility where timing can't be tightly managed

- **SMPTE ST 2110-x**
  - Essence-based encapsulation
  - RTP encapsulation
  - PTP for timing
  - Good for IP-native systems, intra-facility
Transformation Requires More Than Just Media over IP Transport

• IT transformation promises flexibility; IP transport protocols alone do not deliver flexibility

• Static configuration of IP flows is cumbersome as it is, but ...
• Dynamic configuration of IP flows is what is desired

• IP-based architecture introduces problems such as lack of determinism and security concerns, which need to be addressed

• We need “smarter” networks & media processing
  • Software Defined Networking (SDN) abstracts the setup of low-level network functions
  • Do the same for media processing
  • Separates control plane (defining connections) from data plane (traffic carriage)
  • Standard interfaces can be used to interact with the control plane
AMWA NMOS

• Solves major shortcomings with today’s SDI-based systems
  • **Discovery & Registration**: Find out about other endpoints on network & what flows are available, list on a shared registry, provide uniform way to query the registry
  • **Connection management**: Form a connection with another endpoint, identify flows and associate them with a timestamp

• Developed & tested through **Network Media Incubator** events

• Provides “Universal Plug ‘n Play” for media
  • No manual entry of IP addresses and port numbers!

• Implementation Specifications
  • IS-04 NMOS Discovery and Registration
  • IS-05 Connection Management
  • IS-06 Network Control

Follows **JT-NM Architecture Model**
So ... Is Pro Media for IP Real?

Live use cases & interop of real-time professional media over IP
IBC16, NAB17, IBC17, SMPTE ATC 17, NAB18, SET Expo 18, IBC18

@ IBC 2018:
Over 50 vendors!