Validating Broadcast & Media Synchronization Interoperability

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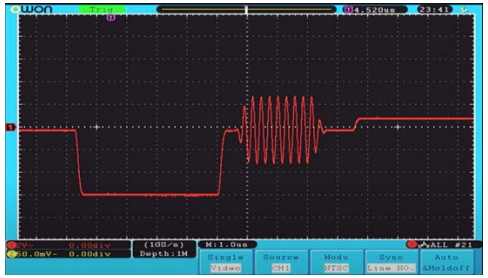
MEINBERG

The Synchronization Experts.

Synchronization Technology for Broadcast

Clap Board

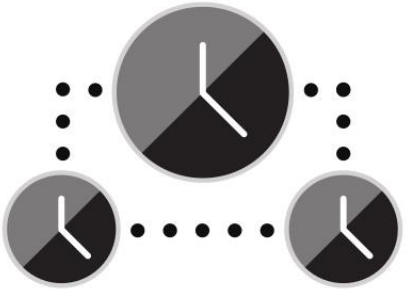
GenLock (BB)



PTP

SMPTE ST 2110

PTP

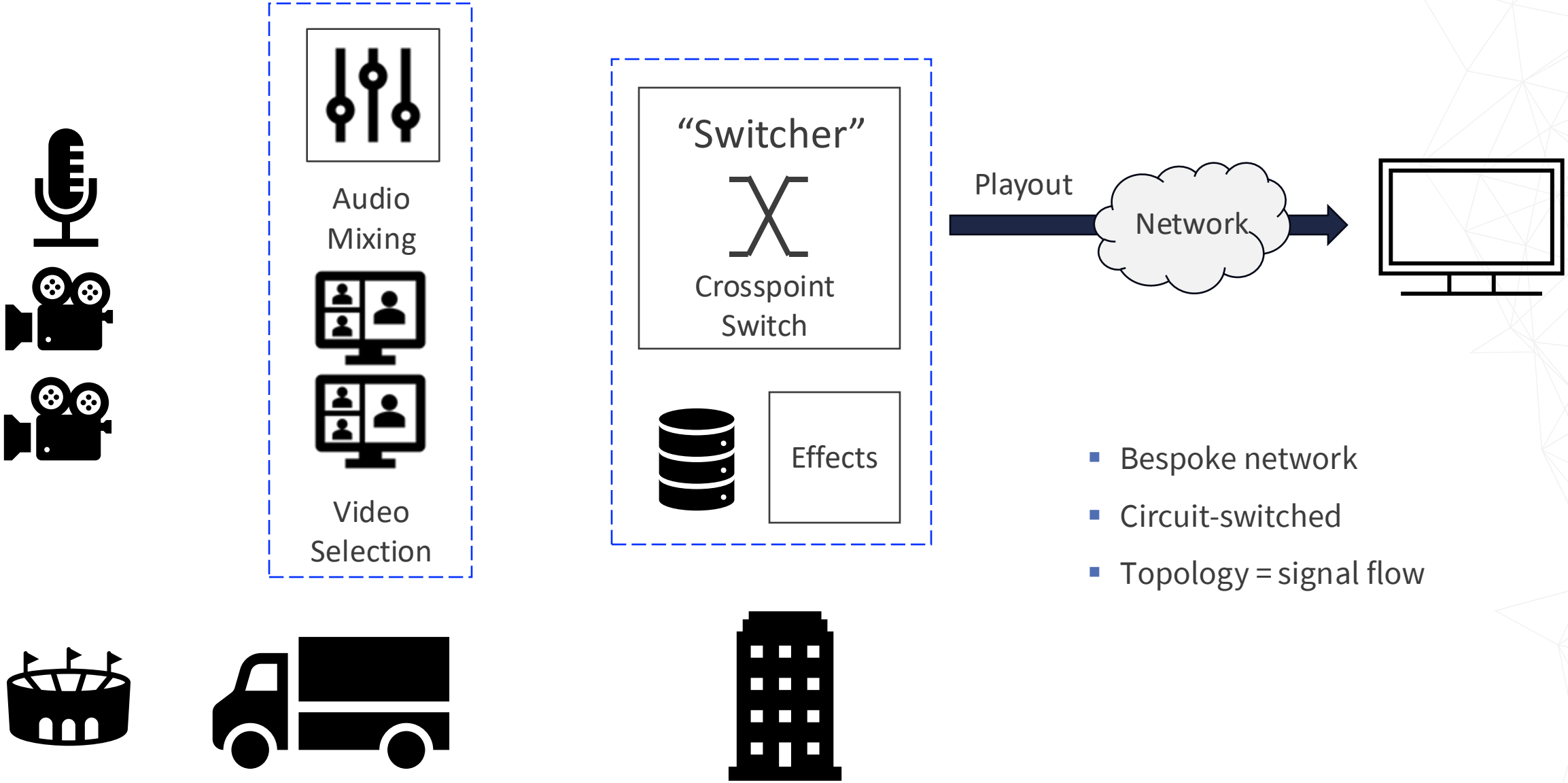


What is SDI? Serial Digital Interface

- Coaxial cable, 75 Ω, BNC connector
- Uncompressed, Unencrypted
- Video (payload & blanking), Audio, & Ancillary Data (closed captions, timecode, sync, metadata)
- Unidirectional (security diode)

Year	Standard	Video Formats	Data Rate
1989	SMPTE 259M	480i, 576i	270 Mbps
2000	SMPTE 344M	480p, 576p	540 Mbps
1998	SMPTE 292M	720p, 1080i	1.485 Gbps
2002	SMPTE 372M	1080p60	2.970 Gbps
2006	SMPTE 424M	1080p60	2.970 Gbps
2015	SMPTE ST 2081	1080p120, 2160p30	6 Gbps
2015	SMPTE ST 2082	2160p60	12 Gbps
2020	SMPTE ST 2083	2160p120, 4320p30	24 Gbps

What Content Production Looks Like – a gross oversimplification



- Bespoke network
- Circuit-switched
- Topology = signal flow

SDI vs. IP

SDI

Advantages

- Familiarity, lots of in-house expertise & experience
- Incremental cost – extensive installed base
- Security – SDI is a security diode (!!!)
- Low risk

Disadvantages

- Inflexible (topology = signal flow)
- Distance limitations of copper cable
- A lot of copper cable
- Footprint = size, weight, power, & heat
- Can’t transport over public internet

IP

Advantages

- Easy transport using telecom & datacom technologies & infrastructure
- Enables remote production
- Total cost – leverages scale (servers, switches, optical modules)
- Faster pace of innovation - new features in software (including AI), many in public cloud (example: AWS)
- Fiber immune to EMI, already in building

Disadvantages

- Expensive to rip out existing infrastructure
- Learning curve for broadcast staff
- Multi-cast routing
- Security

You Can’t Teach an Old Dog New Tricks

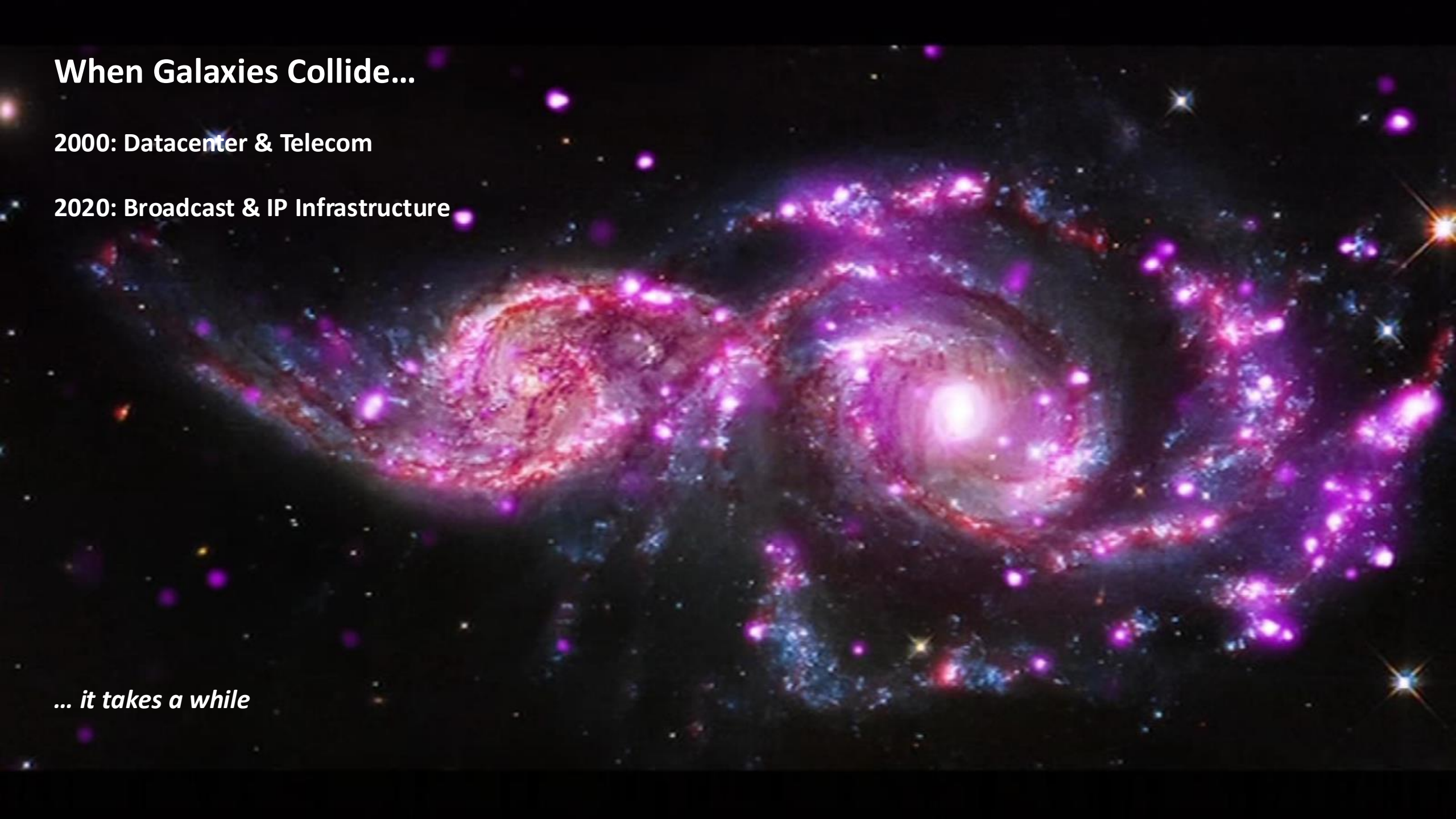
Broadcast
SMPTE

Network
IP

When Galaxies Collide…

2000: Datacenter & Telecom

2020: Broadcast & IP Infrastructure



… it takes a while

SDI to IP Transition

Why is it Taking so Long !!!

- Existing infrastructure is paid for
- Expertise is still being developed
- IP & ST-2110 are new (!)
  bugs being discovered & worked out

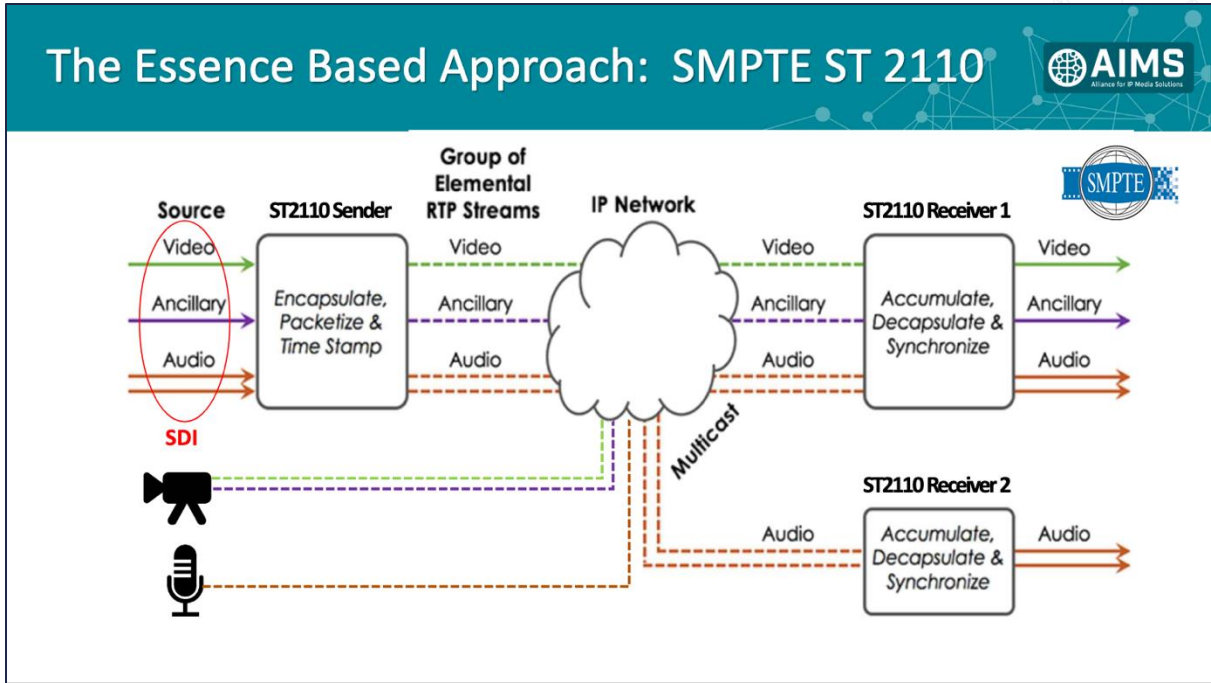
What can we do to help?

- Prove ST-2110 interoperability

What is ST-2110?

SMPTE standard that describes how to send digital media over an IP network

- ST 2110-10: System architecture
  - Audio, Video, Ancillary data are 3 separate Essences (Multicast Streams)
  - RTP (Real-Time Transport Protocol)
  - SDP (Session Description Protocol)
  - PTP (Precision Time Protocol = IEEE 1588) as per SMPTE 2059-2 profile
- ST 2110-20 Uncompressed Active Video
- ST 2110-30 Uncompressed PCM Audio, based on AES67
- ST 2110-40 Ancillary (ANC) Data
  closed captions, subtitles, scoreboards, cover art, …
- First published 27 Nov 2017,
  based on Video Services Forum TR-03 & TR-04, Nov. 2015



Why ST-2110 Needs Time Sync

Video Source Synchronization

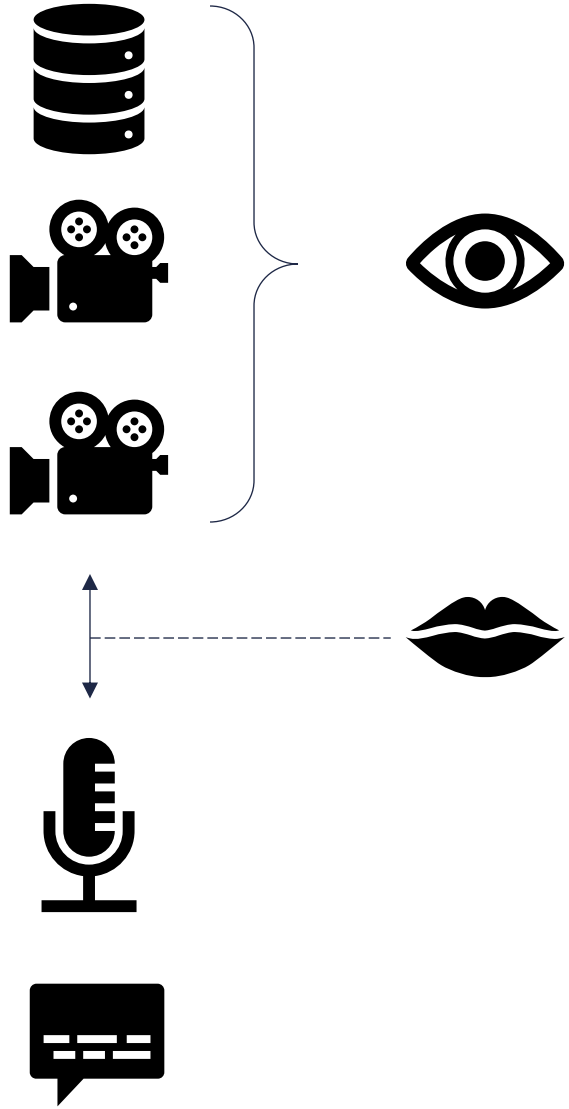
- Smooth video transitions among multiple cameras, playback devices, and other video sources
- Solves black frame / drop sync (Δ phase, Δ frequency)
- Prevent jitter and artifacts

Audio-Video Synchronization

- Lip-sync issues (Δ timestamp)
- Prevents audio dropout during switching
- Prevents audio drifting
- Prevents pops and crackling artifacts

Ancillary Data (ANC) = Metadata

- Closed Caption and Subtitles in sync with the video
- Color Matching when cameras are switched



Timing Requirements – Where are the Specs?

SMPTE ST 2059-2:2021

- References: IEEE 1588-2008, IETF RFC 2236 IGMPv2, IETF RFC 2710 MLD, IETF RFC 3376 IGMPv3, IETF RFC 3810 MLDv2
- Grandmaster, Leader-Follower, BMCA
- Defaults & Allowed Ranges
  - Priority1/2: 128, 0 to 255
  - Domain: 127, 0 to 127
  - Announce Interval: 0, -3 to +1
  - Announce Receipt Timeout: 3, 2 to 10
  - Log Sync Interval: -3, -1 to -1
- Frequency Accuracy ±5 ppm

https://pub.smpte.org/pub/st2059-2/st2059-2-2021.pdf

JT-NM Reference Architecture v1.0
Timing Framework starts on page 17

- Multi-Channel Audio Imaging Synchronization
  10 µs
- Slave Synchronization
  1 µs within 5 seconds of connection to the network
- Multiple Camera Synchronization
  within ±2 µs

> This is provided so that in live capture, a switch or fade between cameras pointed at the same object is undetectable. The ±2 µs timing is based on the length of the SMPTE RP 168 switch point for 720p59.94, which is the shortest SMPTE RP 168 switching area (4.37 µs). This requirement may be overly stringent, but without additional information it is difficult to relax this constraint. Many applications require considerably less stringent tolerance.

https://static.jt-nm.org/RA-1.0/JT-NMReferenceArchitecturev1.0%20150904%20FINAL.pdf

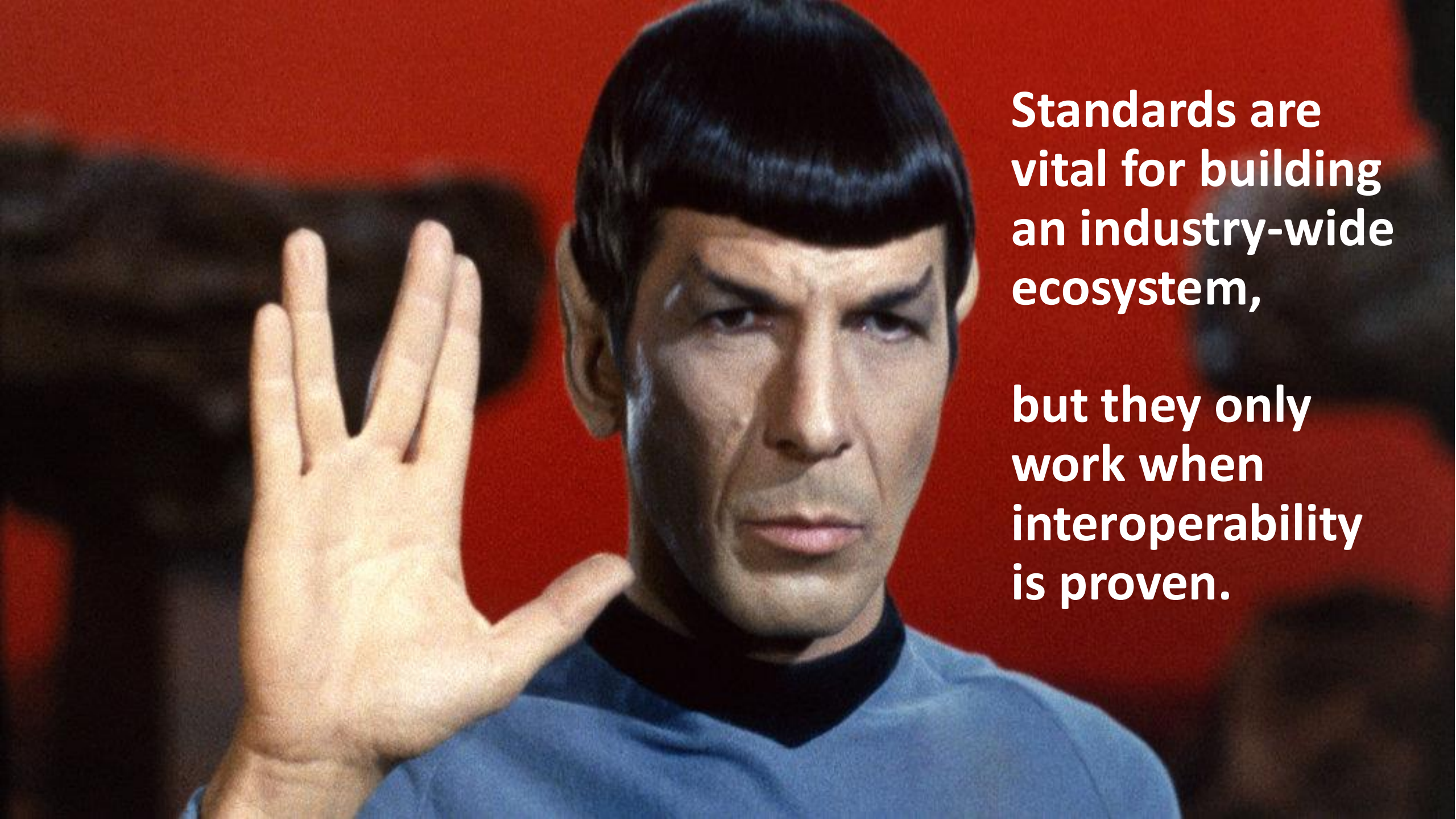
ST-2110 Interoperability Challenges

What PTP modes does the device support?

- Transparent Clock mode & Boundary Clock mode
- Leader & Follower mode (downstream devices are followers)
- Multicast (typically) & Unicast (rare)
- 2022-6 Wrapping for Transport
- 2022-7 Redundancy

Challenges:

- How long does it take for a device to lock to PTP?
- Is the device compatible with all PTP versions (v1 for Dante, v2 current, v2.1 future)?
- What happens during source switching? Does the receiver drop video frame (sync)? lose audio?
- What happens when PTP is lost? Drifting, video blinking, audio loss?


Standards are vital for building an industry-wide ecosystem,
but they only work when interoperability is proven.

ST-2110 Interop Validation Plan

- Establish a **Reference Test Environment** to include
  - Video Sources (standard resolutions)
  - Audio Sources with multi-channel support
  - Network Switches (with PTP support)
  - SDI and HDMI Displays
  - Speakers and Audio Meters
  - SFPs and Fiber cables
- Establish a **List of Tests** which the devices will go through
- Have **Monitoring and Diagnostic Tools** to confirm test outcomes
- **Invite Device Vendors** to participate
- **Share the Results** with the vendors so they may address any problems and comply with the standards
- Document a **List of Approved Devices** that conform to these tests and standards

“Misty” ST-2110 Interoperability Test System

MSTE (Meinberg Studio Test Environment)

1. Laptop streaming synchronization source, outputting in HDMI
2. HDMI to SDI Converter
3. SDI to IP Encoders
4. 2 Switches
5. 2 PTP Grandmasters
6. IP to SDI Decoders
7. Dual SDI Monitor
8. Speaker
9. 2 HDMI Displays (SDI monitors include SDI-HDMI converter)
10. Control PC
11. Control-Plane Switch
12. 2 HDMI Displays to show device UIs & PTP TrackHound

What's In "Misty?"

Input

- Program material: Neil Peart drum solo
- Program source: laptop PC output in HDMI
- HDMI to SDI converter

Red & Blue Networks

- 2 ST-2110 encoders (SDI to IP)
- 2 data-plane switches + 1 control-plane switch
- 2 PTP Grandmasters
- 2 ST-2110 decoders (IP to SDI)

Output

- 2 SDI studio monitors
- 2 SDI to HDMI converters & 2 HDMI displays
- 2 speakers

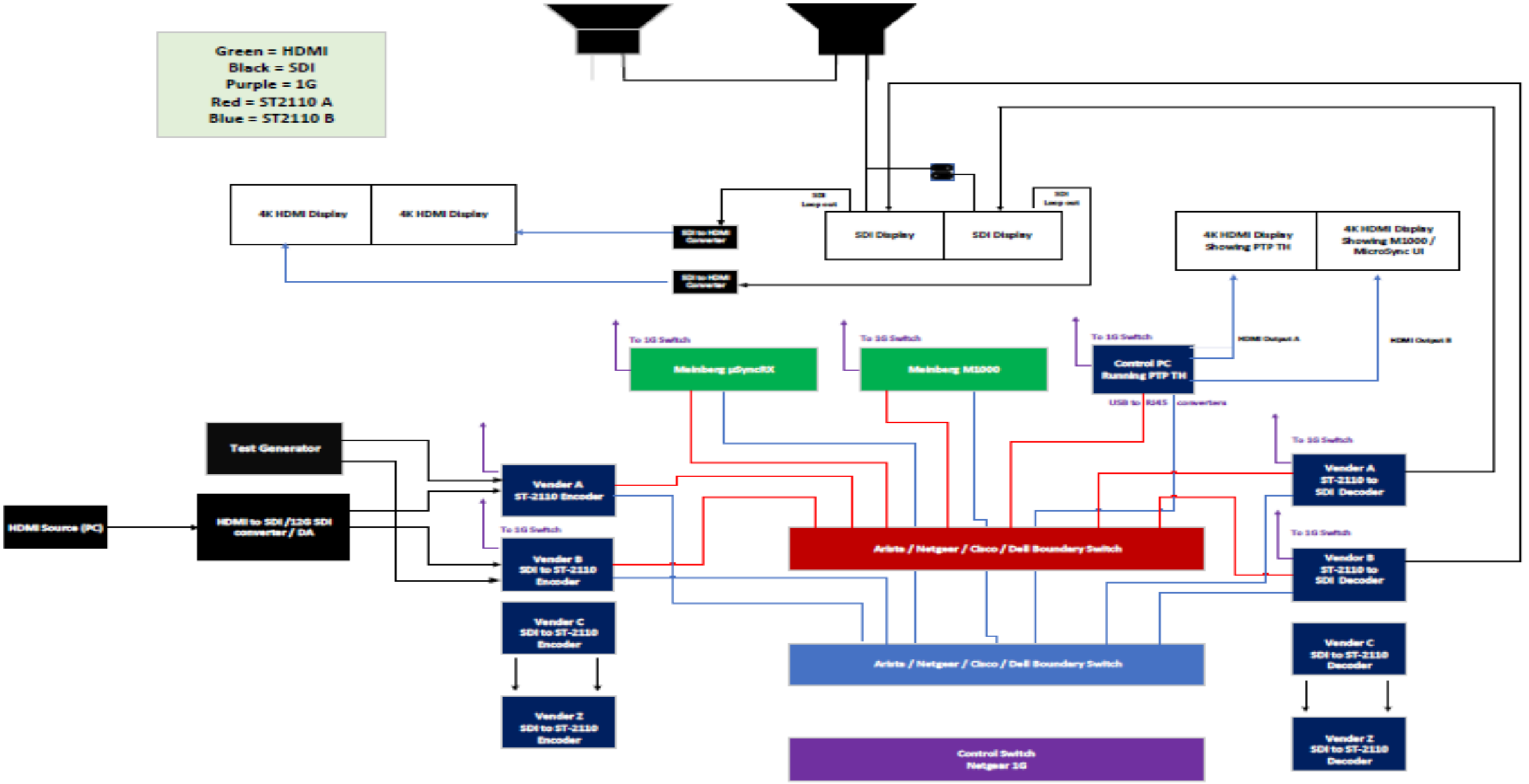
Diagnostic Tools

- Control plane switch
- Control PC running PTP TrackHound just like as in ISPCS
- 2 HDMI displays

Which devices are being tested?

- Encoders
- Decoders
- Switches
- PTP GMs

”Misty” ST-2110 Interoperability Test System



“Misty” ST-2110 Interop Test Results

Details

- One vendor found dropping audio packets when switching between sources
- One vendor found to drop frame Sync (black video frame) when switching between sources
- One vendor found to support SDI Level A, but not Level B (Direct 3G signal mapping verses dual-link 1.5G mapping)
- One vendor dropped audio completely when PTP was turned off & didn’t come back until the source was redetected
- Another vendor dropped audio for 20 seconds when PTP was turned off then came back
- Another vendor’s audio drifted when PTP was turned off (expected behavior)
- One vendor dropped video and audio when Red switch PTP was turned off (not 2022-7 redundant compliant).
- One vendor declared itself as a “Boundary Clock” despite being set as a follower
- Couple of vendors do not report Delay Request Interval messages to PTP track hound

Summary:

- Most devices work well in steady state
- We found a lot of problems with ST 2022-7 protection switching

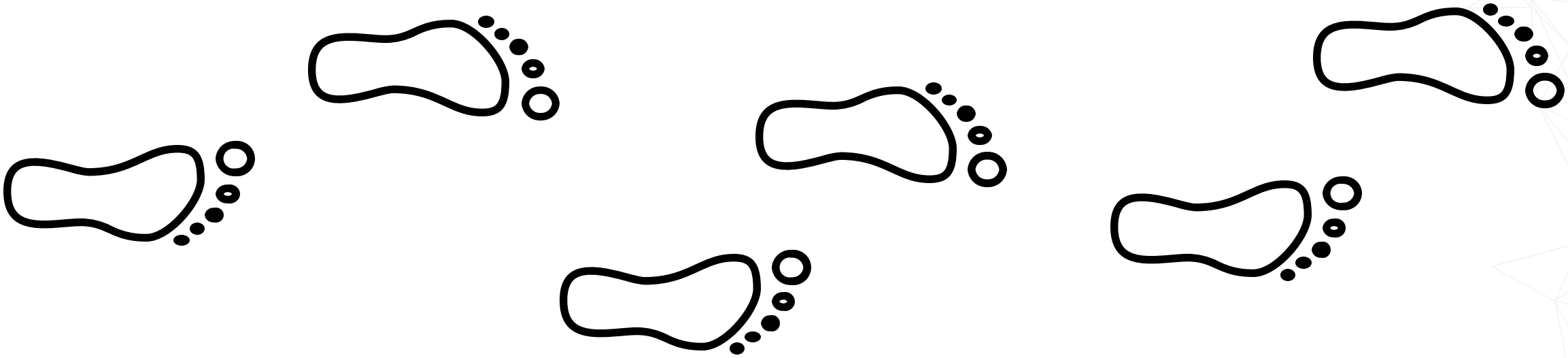
Next Steps

ST-2110 Interop Testing

- Continued collaboration with device vendors
- Publish list of validated devices

IPMX Development

- IPMX is equivalent to ST-2110 but for ProAV industry
- Based on ST-2110, AES67, AMWA NMOS, & VSF TR-20
- Adds HDCP, RTCP required, PTP optional
- 32 companies involved

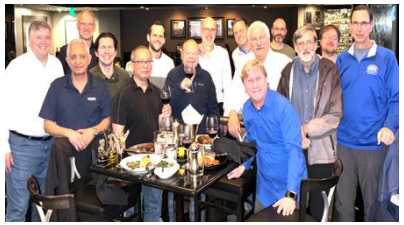


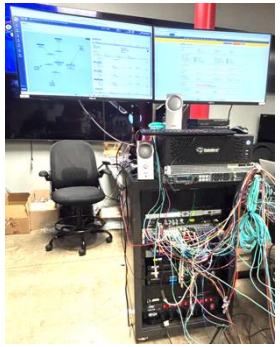
IPMX Events

March 2023
@ NFL
Los Angeles, CA

January 2024
@ Matrox
Munich, Germany

March 2025
@ Evertz
Burbank, CA





“Badging”
Fall 2025
@ TBD

Thank You!

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