IMAGINE COMMUNICATIONS

Live Operation of

ST-2110 IP Video Systems

NOVEMBER, 2019

Understand & Use the Standards

SMPTE ST-2110

Video / Audio / ANC separately over IP

- Provides all the advantages of IP-based routing
- Works with standard IP switches / routers

SMPTE 2022-6/7

Multiplexed Signals over IP Networks

- SDI Payload over IP networks

AMWA IS 04

Network Media Open Spec

- Device Registration

SMPTE ST-2059

PTP Timing for Television

- Replaces Black-Burst, LTC, Word Clock, DARS, TriLevel, 10MHz, and 1PPS
- Subject of multiple, successful industry interop events

AMWA IS-05

NMOS Connection Management

- Controllers: *things that make routing happen*
- Devices: *things that make or consume streams*

Imagine Communications and ST-2110

Imagine Communications provides advanced IP, cloud-enabled, software-defined networks and workflow solutions to the Media and Entertainment industry. With decades of experience, Imagine collaborates with partners to design systems with the delivery capabilities they need today, and the flexibility they need for the future. We work with our customers to choose a path that suits them, at a pace that suits them.

Imagine Communications has served as the broadcast routing controller in multiple ST-2110 IP deployments since the ratification of the standard. These projects range from Live Production systems with native ST-2110 edge devices, for professional sports venues, to SDI systems utilizing ST-2110 for point-to-point fiber optimization.

Advantages of ST-2110

- Audio, Video and Data are encapsulated into discrete essences, for dynamic routing.
    - Familiar Audio and Video performance to SDI systems with TDM, or DeMux and Mux
    - Unlocks new ancillary data workflows using discrete ST-2110-40 encapsulation of elements such as closed captioning.

- Video rasters can be anything from a few pixels, to 32k x 32k, in any aspect ratio.
    - Send only the identifying logo "bug" or "lower third" graphics.
    - Or, a large wrap-around graphic for a "ribbon board".

- Packets do not fall victim to the same kinds of impairments as SDI wavelengths when passed through glass, providing increases in both distance and bandwidth.

Video Rasters: SDI versus ST-2110-20

SDI can provide resolutions up to 2160p over 12G links

Resolutions up to 2160p (UHD)

In uncompressed IP, using the ST-2110-20 standard,

Video rasters can be anything from a few pixels, to 32k x 32k, in any aspect ratio.

Resolutions up to 32k x 32k

- Send only the identifying logo "bug" or "lower third" graphics.
- Or, a large wrap-around graphic for a "ribbon board".

Operational Concerns

Live operation of ST-2110 can be as simple as "Destination, Source, Take"

However, the expanded flexibility of ST-2110 requires additional configuration choices for each design.

- How will audio be grouped within multicast streams?

- Where will audio channel shuffling be performed?

- How will ancillary data be grouped within multicast streams?

- With up to 32 HD video streams per fiber strand, how will individual signals be tracked as they are routed through a large non-blocking system?

These are some of the questions Imagine has addressed over the life of ST-2110.

ST-2110 hybrid Live Production systems in 2018

In late 2017, Imagine participated in the design of a cutting-edge Live Production system for a sports arena to host NBA Basketball games. The intent of the design was to provide ST-2110 infrastructure to support change and growth of the system, while retaining the operational feel of an SDI system. Operators for the arena might not receive specialized IP training, and could even be freelance personnel working in SDI systems every other day.

The November 2017 designs for the system defined SDI edge devices with a COTS IP core and Imagine's Selenio Network Processor acting as framesync and gateway of SDI devices. As equipment began to ship to the pre-staging site, in January 2018, other vendors announced they would be capable of providing ST-2110 edge devices. The CCUs and Replay system arrived with ST-2110 interfaces, and their source signals connected directly to the COTS core.

This direct connection of ST-2110 devices, from a mix of manufacturers, became a good example of a standards-based system in action. The ST-2110 encapsulated streams from each manufacturer interoperated easily. But the pre-staging, and operational testing, of the system proved critical to resolving issues outside the scope of the ST-2110 standard.
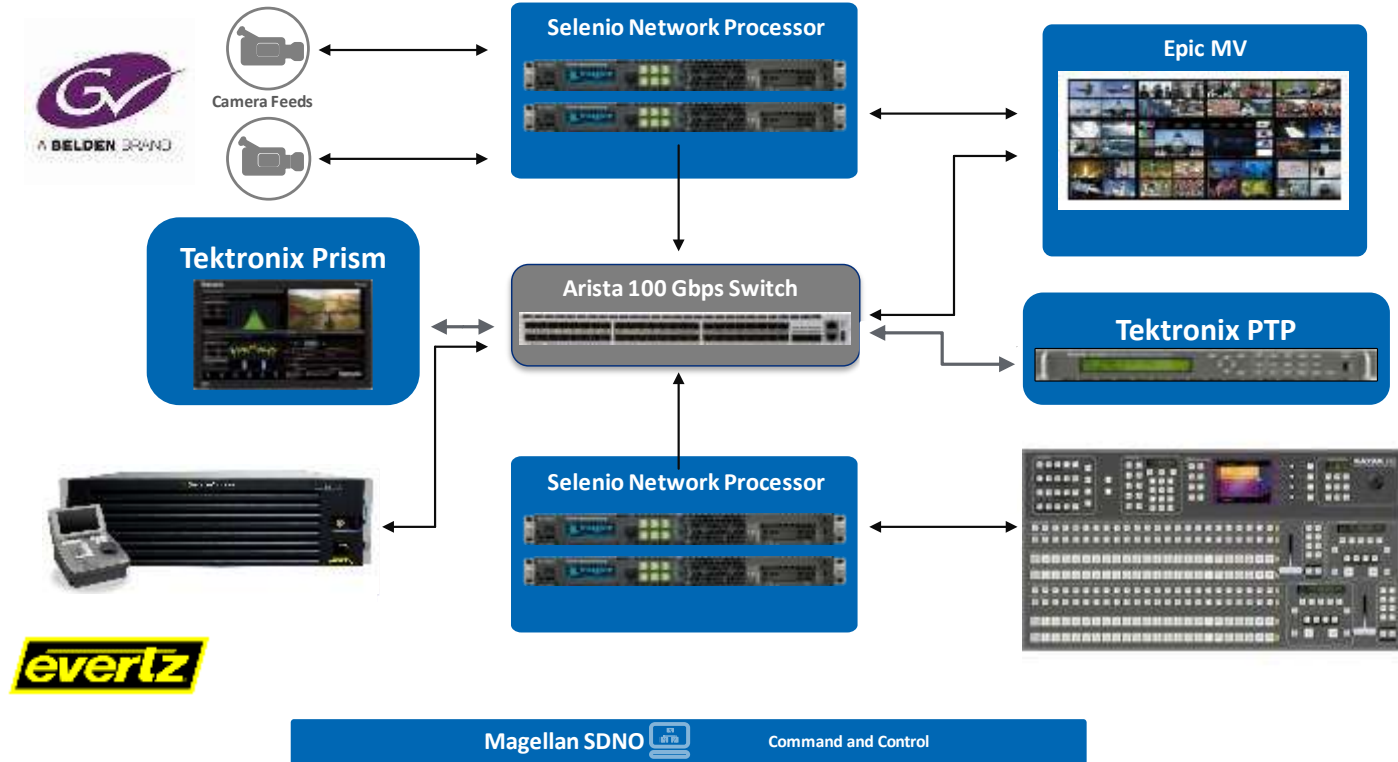
Late 2017 design with SDI edges
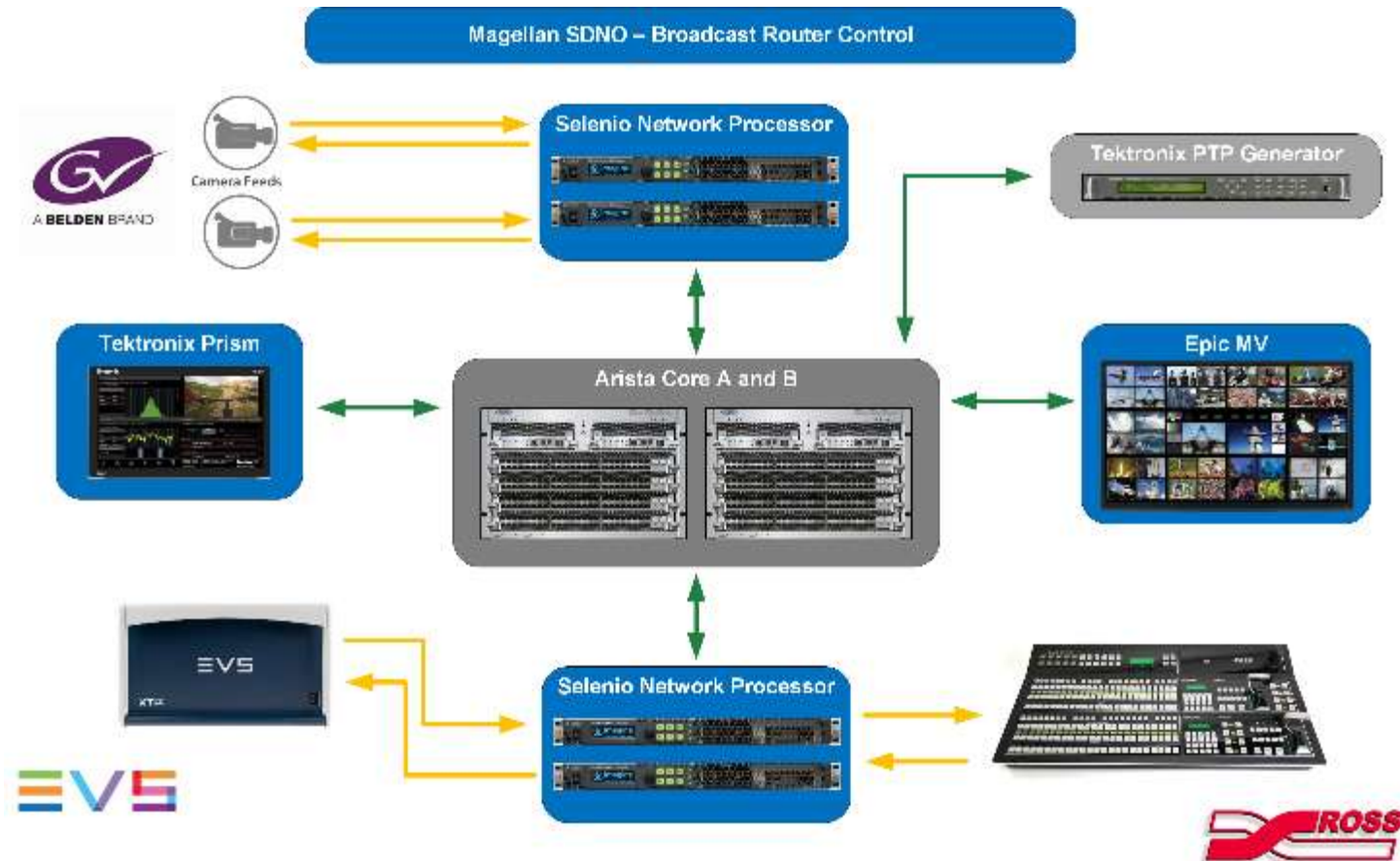
Actual 2018 system with ST-2110 edges
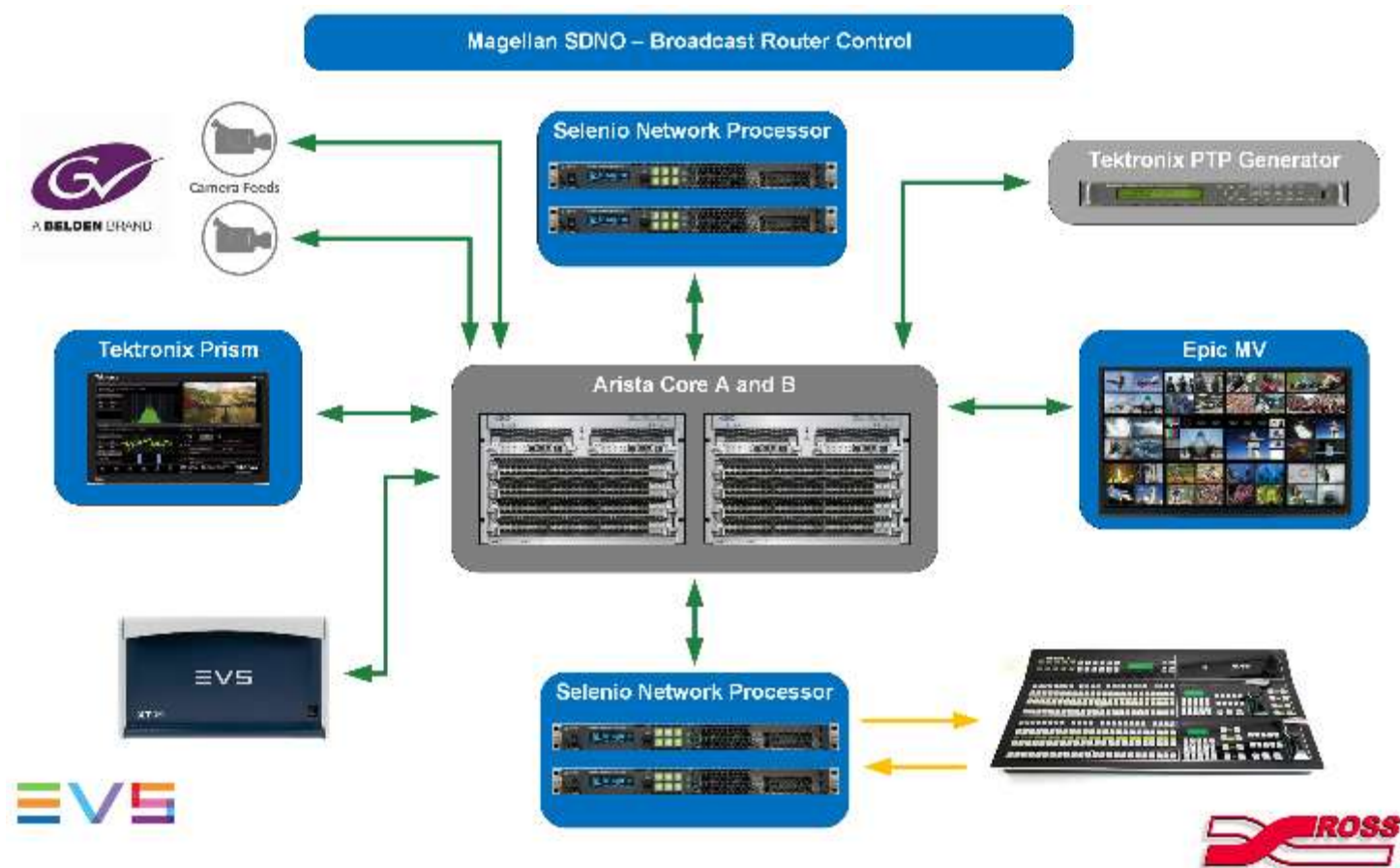
ST-2110 allows for options!

Operating an ST-2110 system in 2018

Several considerations must be made to provide the "Destination, Source, Take" live production performance of an IP system, similar to the expectations of an SDI system. Audio provides an interesting example:

- The discrete essences of ST-2110-30 allow for mono-per-multicast IP routing
  - Many ST-2110 edge devices cannot receive or transmit audio multicast with this level of granularity.
  - The project team must compromise on a channel-per-stream configuration which minimizes the need for grooming and offers the flexibility of a fully demuxed mono system.

- A four-channel-per-stream configuration was adopted through the ST-2110 media network
  - Non-compliant channel-per-multicast could be routed, IP-to-IP, through the Imagine Selenio Network Processor for grooming as needed.

Audio Channels within ST-2110-30

The ST-2110-30 standard allows audio channels to be grouped in multicast as needed

Audio Ch. 1

Mono Channel per Multicast

Audio Ch. 1
Audio Ch. 2
Audio Ch. 3
Audio Ch. 4

Four Channels per Multicast

Audio Ch. 1
Audio Ch. 2
Audio Ch. 3
Audio Ch. 4
Audio Ch. 5
Audio Ch. 6
Audio Ch. 7
Audio Ch. 8

Eight Channels per Multicast

Choose the best configuration for your system and workflows

imagine

ST-2110-40 Ancillary Data

A similar design exercise would be required for handling of data multicast carrying "ancillary" information:

- All information which may have been part of the ancillary data within SDI can become multiple discrete multicast streams in the ST-2110-40 standard.

- Closed Captioning may be delivered to the ST-2110 media network via 1G direct link to a Closed Captioning encoder.

- The Broadcast Router Control system, such as Imagine's SDNO, can link the ST-2110-40 multicast to audio and video streams and route everything as a group.

The limitations of the edge devices to receive and interpret ST-2110-40 within multicast streams must be defined, to properly plan for any grooming needs.

Ancillary Data within ST-2110-40

The ST-2110-40 standard allows ancillary data to be split across multicast as needed

Closed Captioning

Timecode

AFD

VITC

SCTE

…???

All Ancillary Data in one Multicast

Separate Closed Captioning to allow for breakaway routing of languages by multicast

Closed Captioning

Single Data type per Multicast

Fiber Optimization using ST-2110 in a distributed campus

While several Live Event venues and Broadcasters dove into ST-2110 head-first, other video professionals recognized the strength of IP technology for fiber optimization over long distances

- One college in the U.S. elected to place the Selenio Network Processor at several event venues across their campus, aggregating high definition SDI signals from Coax connections into bi-directional 10km single mode fiber links.

- The legacy SDI router remains the central crosspoint of the system, and the ST-2110 rotes are static links between gateway devices. The operations team only need understand the IP infrastructure if they are involved with creation of a new workflow or troubleshooting at the IP level.

- Where SDI was limited to a signal uncompressed HD signal per fiber, ST-2110 packetization allows for up to 32 uncompressed HD signals to pass over a single fiber.
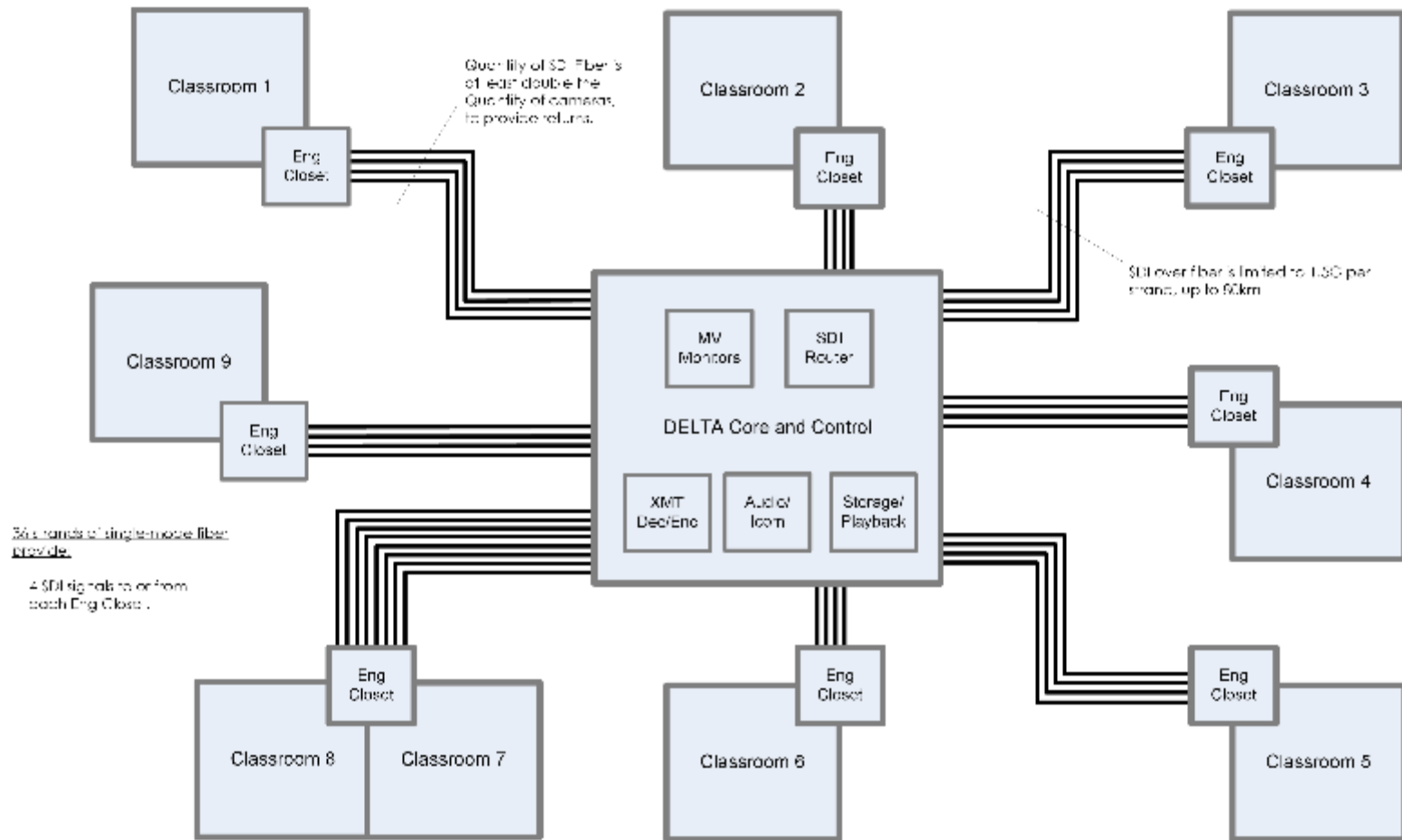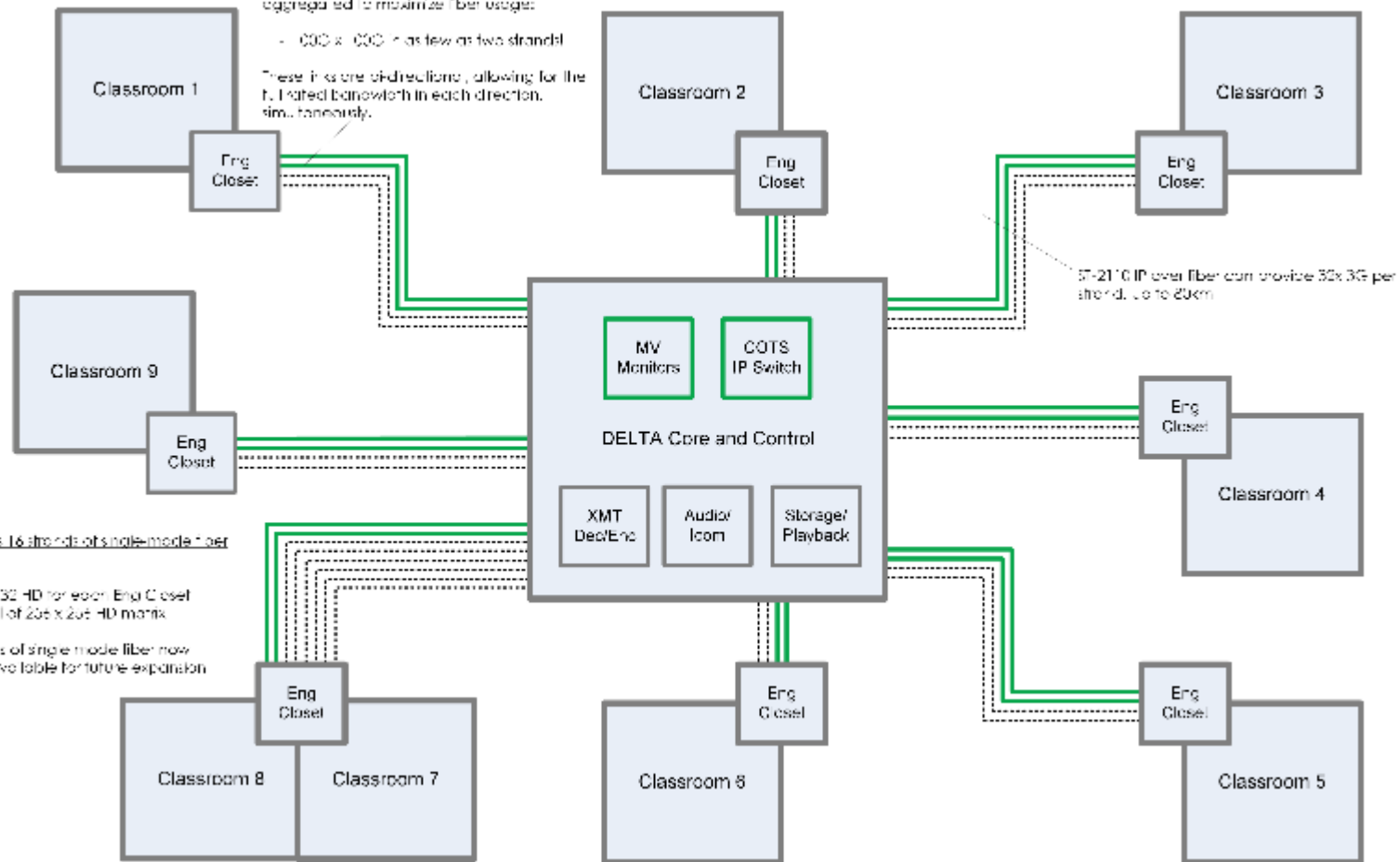
SDI to IP... IP to IP... IP to SDI
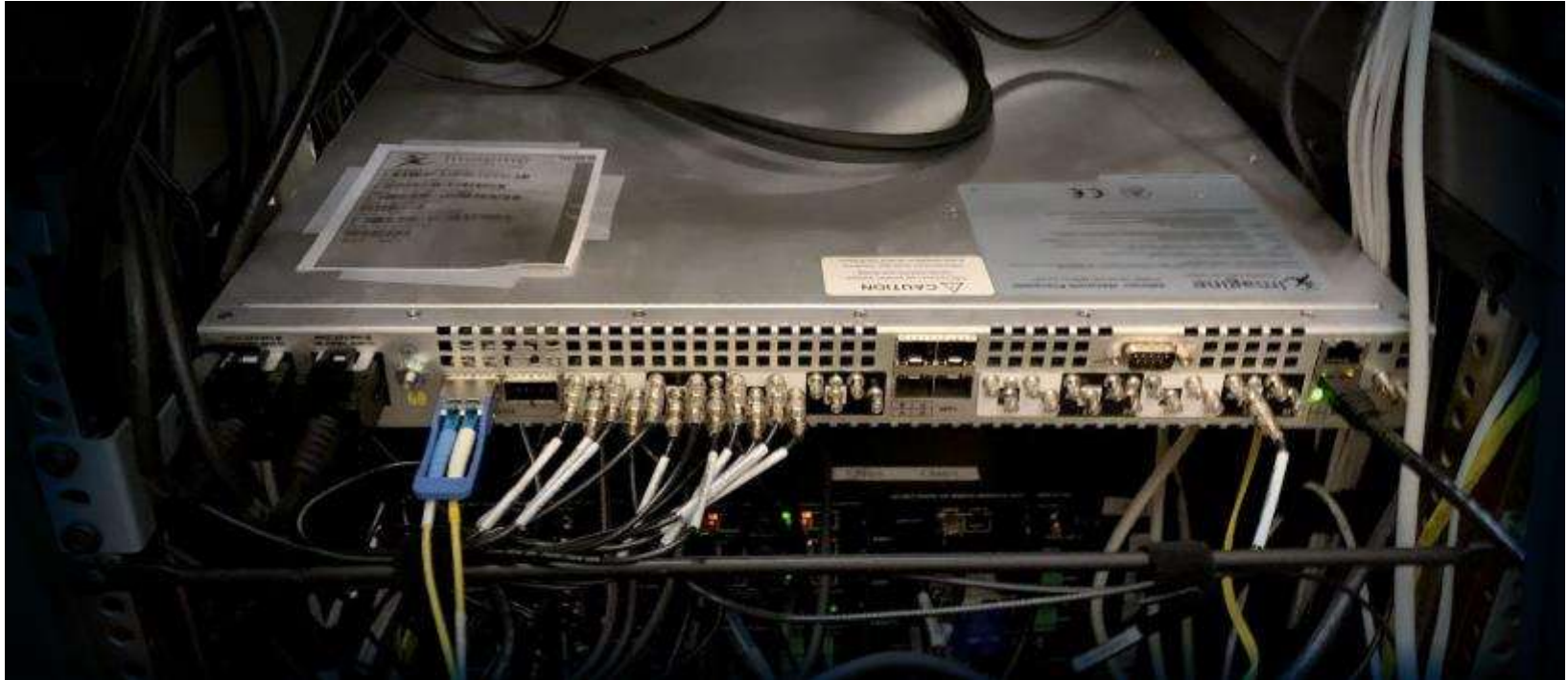
Seamless operation in a hitless packet merge system

For 24/7/365 systems, or those for which seamless operation is critical for events, ST-2110 can be implemented in an ST-2022-7 model. The ST-2022-7 model can provide redundancy to the link level, meaning there are dual paths for both transmit and receive of all data. Receivers simultaneously listen to both the A and B, or Red and Blue, paths to ensure reception of needed packets.

In the event of a failure to the A network, packets could remain available via the B network, ensuring hitless continuation of the signal path. This is not a "failover" recovery, but instead a "never fail" recovery.

Receivers dynamically cherry-pick the best packets from either network, A or B, and each network is "hot" at all times.

Rather than allowing audio and video impairments to exit the video system, signal flow continues while the operations staff is notified of errors on the failed network via the network monitoring system.

2022 / 2110 Redundancy Architecture

What if a Switch Fails?
What if the Optics Fail?
*What if a Cable Fails?*

SMPTE ST 2022-7 Works Really Well

- Send **Two Copies**
- On **Two Interfaces**
- To **Two Switches**
- Join and Receive from both
- Packet-by-packet merge
- Used for SMPTE ST 2022-6 video & AES67 audio
- **Also used for all parts of SMPTE ST 2110**
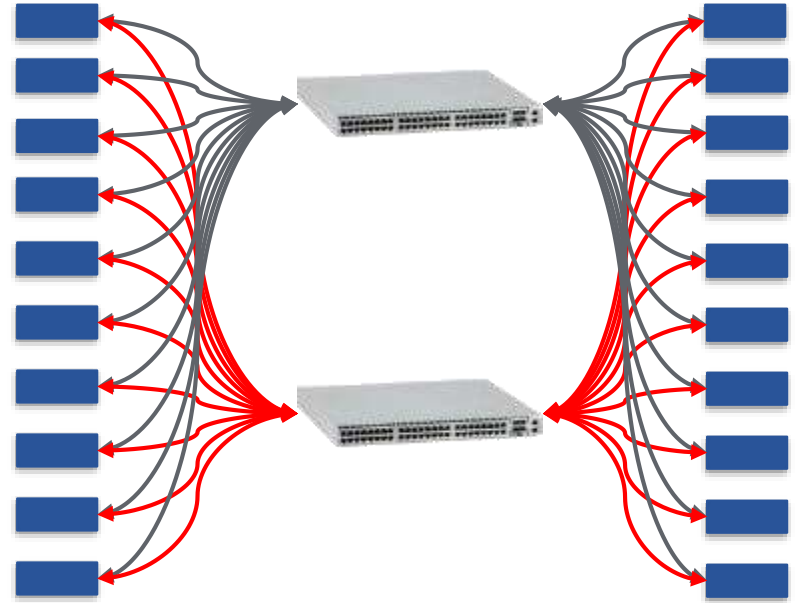
Seamless Switching – SMPTE-2022 / 2110

- IP De-encapsulators or Compressed Decoder modules will buffer both incoming streams

- Buffering on the Receiver will handle the difference in latency of the primary and backup stream

- Additional resiliency can be added such as forward error correction, packet re-ordering

- Duplicate packets are discarded to create one single transport stream

    - If both streams have lost the same packets and it exceeds the capability of the error correction hitless switching is not possible.
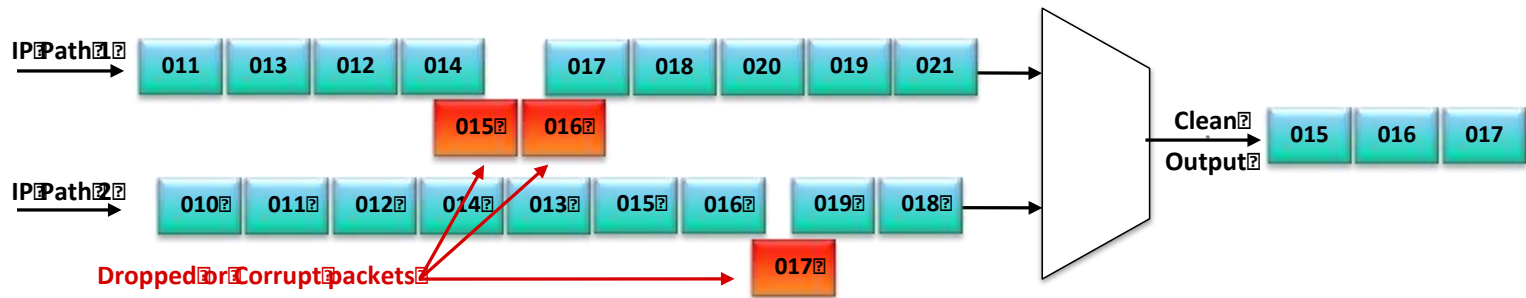
Troubleshooting, or; Where is my Patch Bay?

When commissioning a new IP device, it is recommended that the device be configured and proven within an isolated sandbox before introduction to the larger ST-2110 network.

For our basketball arena in 2018, this was achieved by directly connecting devices to a Tektronix Prism waveform monitor. But how do you identify and troubleshoot individual streams after commissioning?

Using COTS 100G QSFP transceivers within an ST-2110 IP system, up to 32 uncompressed HD video streams can be shared over a single strand of fiber.

Engineers or operators need the ability to track individual signals as they are routed through a large non-blocking system, just as trustworthy router tables were referred to in baseband crosspoints.

Yes, Imagine's SDNO can route groupings of audio/video/data with a "Destination, Source, Take", but what if each discrete essence is being provided by a separate device and only one device is failing?

Recovery and Diagnosis

Similar to the operation of an SDI system with breakaway and shuffling of TDM audio, ST-2110 allows for breakaway and shuffling of audio video data multicast streams.

If a closed captioning device fails:

- The broadcast router control system can perform a breakaway route to place an alternate closed captioning multicast stream in the signal path.

- The closed captioning stream with errors can then be routed to a scope for further investigation.

Using modern HTML5 interfaces, the entire process of correcting and trouble-shooting a signal path can be performed from a desktop computer, with no need to run to a patch bay and QC station within the equipment racks.

Automatic Virtual Workflow Visual Generation
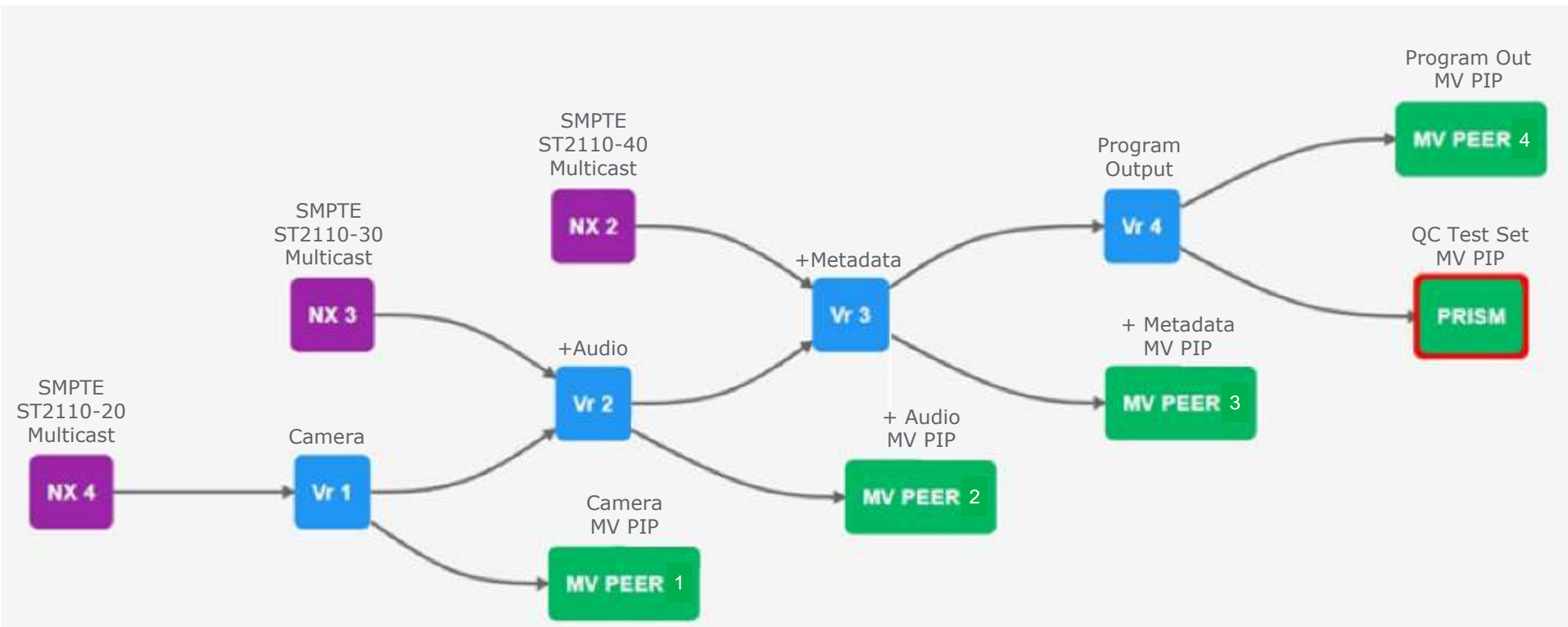
- Virtual Patch Points can be created, routed, and mapped to the Multiviewer

How do I know what is on the wire?

System Design Engineers have struggled with methods of detailing IP systems in drawings. With SDI, we could draw the physical connection, and describe the signal in one line of text, such as "Camera One Output".

With ST-2110, even the connection to a single camera now contains multiple streams of "inputs and outputs". In many cases, the multicast streams riding within a single physical link will dynamically change, to suit each "show" or "event". In this case, the broadcast router control system becomes the only true keeper of all signal routing, and must be relied upon to know what is happening at the edges.

Imagine is taking the information learned from use cases across the globe to help engineers and operators not only trust their IP system, but leverage the advantages of IP to improve and even simplify workflows.

Live Production in Uncompressed ST-2110 IP:

Real Today

- Multi-vendor, COTS-based, ST-2110 systems have been in audience-facing operation since August of 2018
  - UHD+HDR systems utilizing single-raster ST-2110-20 video streams
  - Low-latency live production systems for sports venues
  - Distributed campus systems leveraging packet technology for fiber optimization

- Each of these systems is utilizing a unique mix of products from diverse manufacturers
  - Standards-based systems allow for "best of breed" designs