
sam
Snell
Advanced
Media

SMPTE ST 2110 – The Basics

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Monday 23rd October 2017
Birmingham City University

SMPTE
SINCE 1916

Snell Advanced Media

A Thoroughbred Company with Real Pedigree

- **Long Heritage**
  …since 1970s:
  PAL/NTSC Analog
  Analog to SDI
  Now SDI to IP
- **Over 5 years**
  …developing
  IP strategy &
  systems
- Released
  3rd Gen. IP products
- Delivering IP solutions

SAM

Started ahead..

Staying ahead!

2015: One of five founding members of AIMS

Alliance for IP Media Solutions

...now with over 50 members!

Close working alliances with:

ARISTA CISCO JUNIPER NETWORKS

www.s-a-m.com

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SAM – A Voice in IP Standards

- Member of all relevant Standards organizations
- One of five **Founding** members of **AIMS***
- One of ten **Principal** members of **AMWA***

AIMS Roadmap

Baseline for Interoperability	Enable IP Streaming of Audio	Support Split Video and Audio Routing	Add Video Bandwidth Efficiency to Split Video, Audio and ANC Data Routing	Enable Discovery and Registration of Compliant Streams
SMPTE 2022-6	AES67	VSF TR-04 - SMPTE 2022-6 - AES67 SMPTE 2059	VSF TR-03 - IETC RFC 4175 - AES67 - IETF draft ANC291 SMPTE 2059	AMWA IS-04

AIMS Alliance for IP Media Solutions

SMPTE 2022-6 → AES67 → SMPTE 2110 → IS-04

*To foster the **adoption** of the work of these organizations with regard to IP interoperability*

The Role of AIMS

Technical Recommendations

AMWA · nmi · VSF Video Services Forum

Standards

SMPTE · EBU · AES

Reference Architecture

SMPTE · EBU · VSF Video Services Forum

*AIMS – Alliance for IP Media Solutions

*AMWA – Advanced Media Workflow Association

JT-NM Roadmap of Networked Media Open Interoperability*

LEGEND:

Standard / Specification (Published — Widely available)

Study / Activity or other.

IV. Dematerialized facilities**

EBU R146 — *Cloud Security for Media Companies*

JT-NM Activity — *e.g. Identify Best Practices*

EBU - Investigating models/workflows — *e.g. reports and best-practices*

AMWA Labs Findings — *e.g. AMWA Specs/Best Practices*

Cloud-fit
Open, secure, public/private cloud solutions

Non-media-specific IT
Self-describing, open APIs suitable for virtualization

III. Auto-Provisioning

AMWA IS-06 — *Network Control*

AMWA IS-05 — *Connection management*

AMWA IS-04 — *Discovery & Registration*

Automated resource management for more flexible and sharable infrastructure at scale

II. Elementary flows

VSF TR-03 / ST 2110 — *Transport of uncompressed essence*

SMPTE ST 2059 — *Timing*

AES-67 — *Audio*

SMPTE ST 2022-6

More flexible and efficient workflows
New formats supported like UHD and mezzanine compression

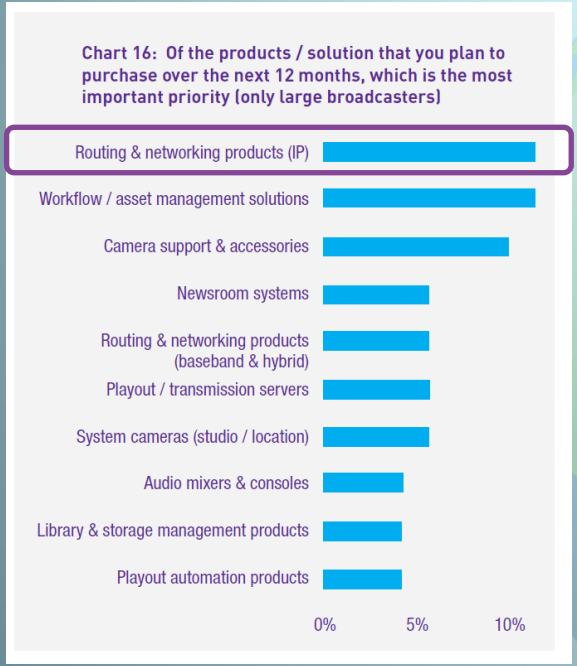
I. SDI over IP

0. Current SDI

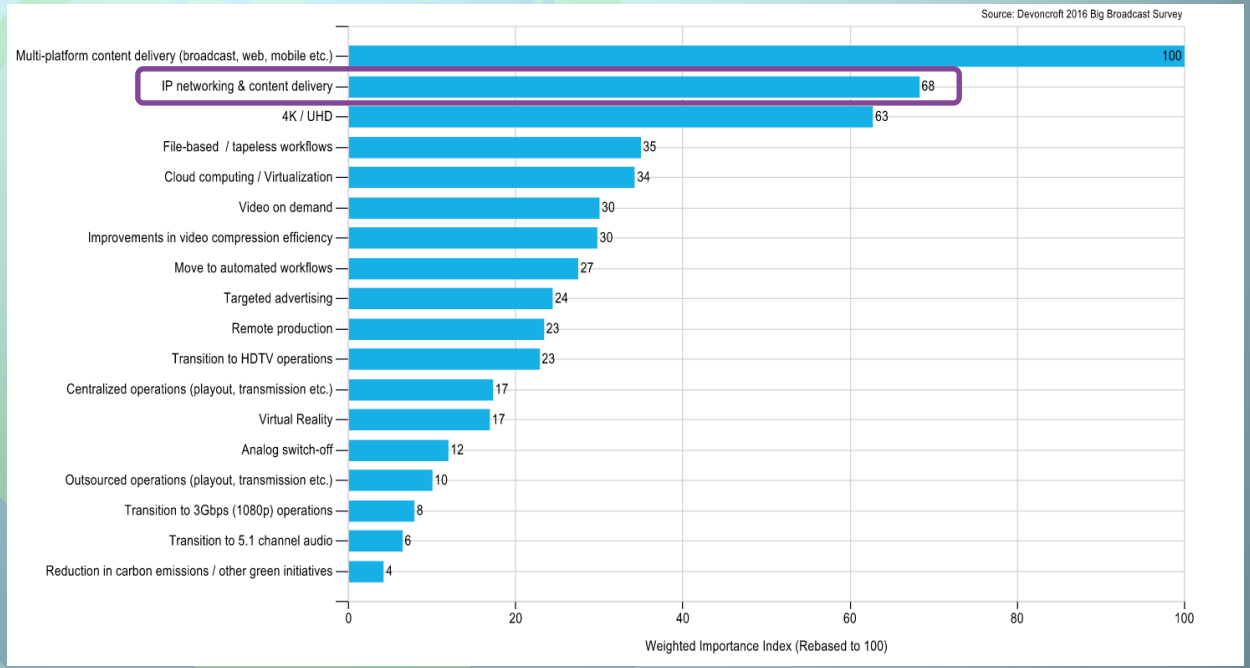
Current and mature technology

**See Dematerialized Facilities FAQ at JT-NM.org for more information. * JT-NM assumption as of August 2017 and will evolve over time. Visit JT-NM.org for the latest update. Feedback to jt-nm-info@videoservicesforum.org

Industry Drivers



* Source – IABM, May 2017 Digest



* Source – Devoncroft "Big Broadcast" Global Market Report 2016

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Why IP Routing?

- **Ubiquity of IP Networks & Infrastructure**
  $10B+ invested each year compared with 10's of millions in baseband SDI
- **Massive IT industry means resources & expertise more readily available**
  Recruiting easier / less specialist training requirements / Younger generation IT literate
- **Universality of IP Infrastructure equipment**
  Better investment case re: Redeployment and change of use
- **Much larger component supplier base**
  Wider choice & better availability
- **Size…IP Router equivalents much smaller!**
  Sirius 840 576^2 = 31U
  Juniper QFX 10008 & **ARISTA** 7508E, 1152 10GbE Ports = 13U
  …that's a massive 5760^2 @ HD SDI Uncompressed

Juniper QFX 10008

ARISTA 7508R

Traditional Broadcast & Media routing

Connectivity

Copper

Video

Audio

Multi-way 'D' type for Analog & AES Digital. BNC for MADI

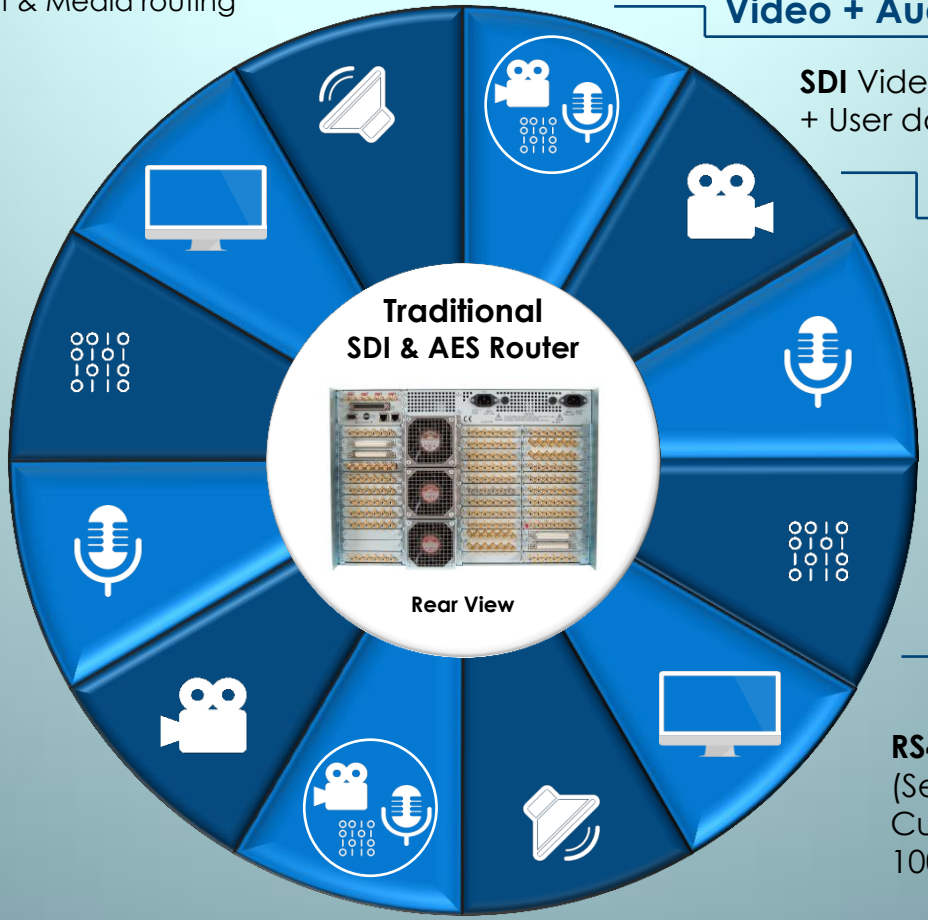
Fiber (SM/MM)

SFP*

3G/HD/SD-SDI

Dual Transmitters (2x Tx)
Dual Receiver (2x Rx)
Transceiver (Tx/Rx)

AES MADI 100Mb/s (Tx/Rx)



Video + Audio + Data

SDI Video + Embedded Audio (x16)
+ User data (270Mb/s, 1.5/3Gb/s)

Video

SDI Video
(270Mb/s, 1.5/3Gb/s)

Audio

AES Digital Audio
(3Mb/s – 48kHz sampling)
Balanced - Differential
Unbalanced - Single Ended

Data

RS485 Serial - Older systems!
(Separate or integrated)
Currently more likely separate
100MbE or GbE IP Switch

www.s-a-m.com

SFP* – '**S**mall **F**orm-factor **P**luggable'

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IP World of Broadcast & Media routing

Connectivity

Copper

Up to **10**GbE*

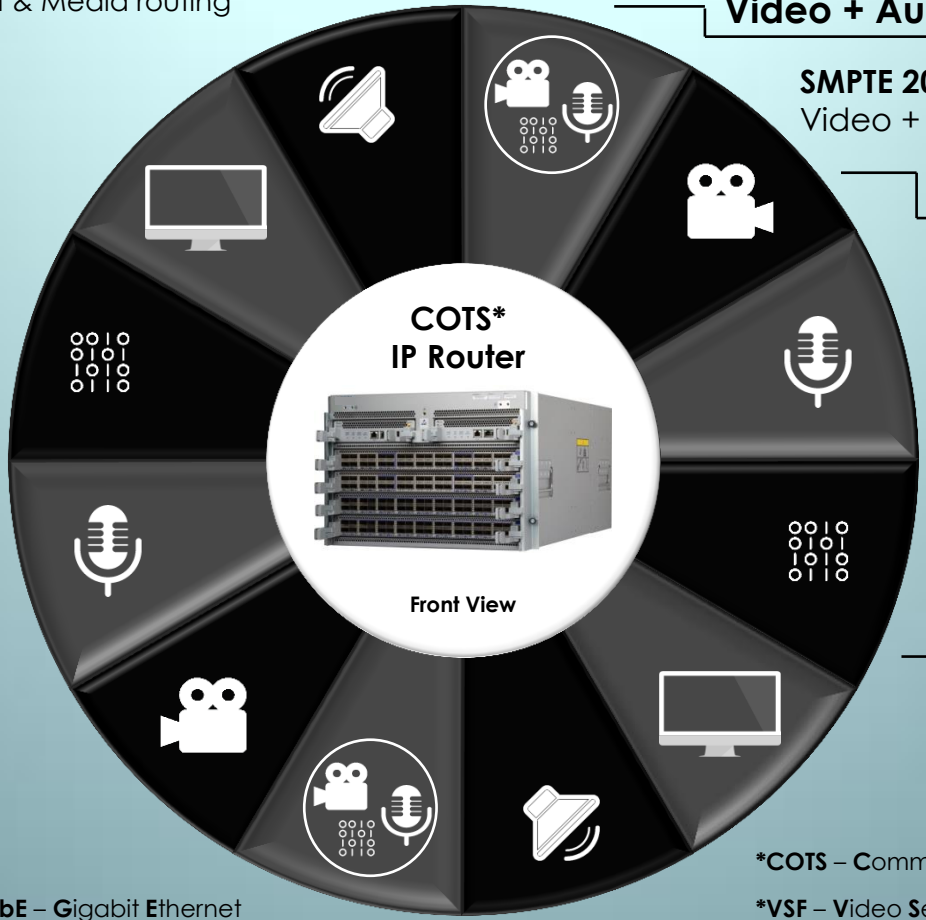
Fiber

SFP*

10GbE **SFP+**

25GbE **SFP28**

QSFP+
QSFP28



Video + Audio + Data

SMPTE 2022-6/-7 IP wrapper for SDI
Video + Embedded Audio + Data

Video

VSF* TR-04 SDI but video only
VSF TR-03 Video to **RTP**
Payload format (2110-20)
Map VANC separately

Audio

AES67 Digital Audio
High-performance
IP streaming for Production
Supported in (2110-30)

Data

TCP-IP Ancillary
Data (2110-40)

*GbE – Gigabit Ethernet

*SFP – Small Form-factor Pluggable

*COTS – Commercial Off The Shelf

*VSF – Video Services Forum

IETF – Internet Engineering Task Force

www.s-a-m.com

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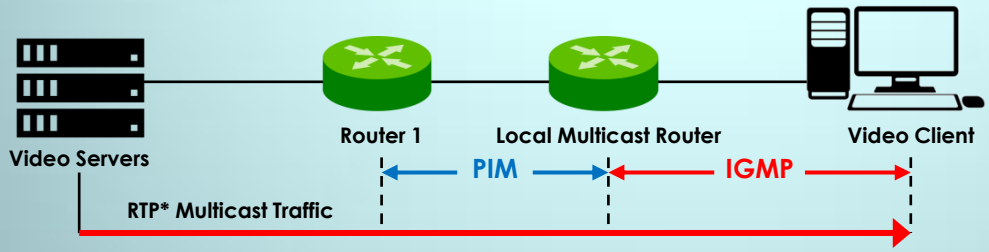
A little about COTS* IP Video Routers

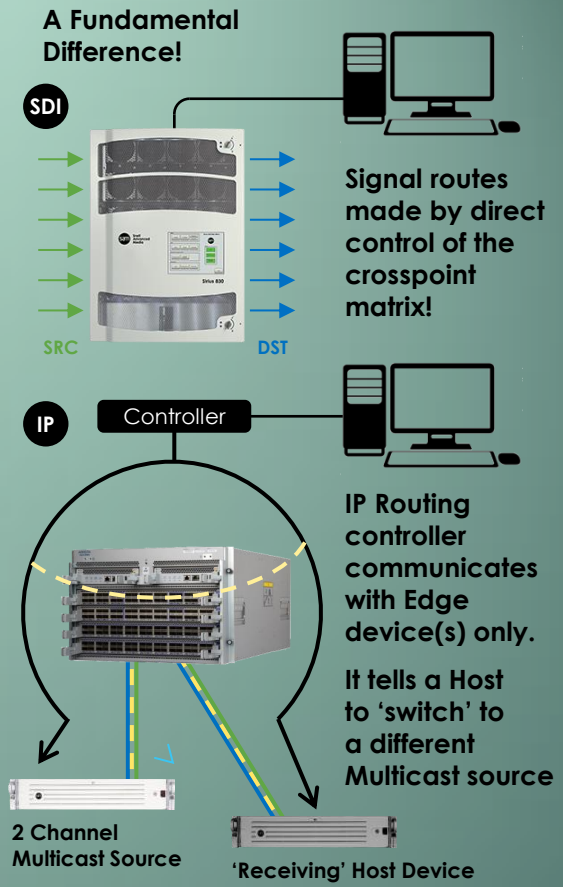


- **Very large bandwidth** Up to 115 Tbits/s, Up to 51 Bpkts/s
- **Non-Blocking**

  Router internal bandwidth can handle all the port bandwidths at the same time & at full capacity
- **IGMP**v3 **I**nternet **G**roup **M**anagement **P**rotocol

  Communications protocol used by clients & adjacent routers on IPv4 networks to establish multicast group memberships
- **PIM-SSM** **P**rotocol **I**ndependent **M**ulticast - **S**ource **S**pecific **M**ulticast

  Between routers & subnets. Essentially allows a client to receive multicast traffic directly from the source



*RTP – Real-Time Protocol

*COTS – Commercial Off The Shelf

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A
B
C
D
E
F

The Basics – the building blocks

Design considerations for an IP infrastructure

- **Standards** – Which ones ? Do we care ?
- **IP Conversion (to/from SDI)** – Amount ? Formats ?
- **IP Conversion (to/from MADI)** - Amount ? Formats ? Processing ?
- **Native IP Devices** – Amount ? Format ? Control ?
- **Signal Processing** – Video ? Audio ? Transportation ?
- **Multi-viewers** – Amount ? Formats ? Layouts ? Tally ? Control ?
- **Connectivity** – 1.5, 3 or 12Gbps ? 10, 25, 40, 50 or 100Gbps ?
- **Network Design** – Singular switch ? Spine/Leaf ? Modular ? L2 or L3 ?
- **Control & Monitoring System** – Topology ? Performance ? Licensing ? SNMP ?
- **Timing** – Legacy BB/TL ? PTP ? Ordinary ? Boundary ?
- **System redundancy** – All or Core Components ?

The Basics – the building blocks

Design considerations for an IP infrastructure

- **Standards** – Which ones ? Do we care ?
- **IP Conversion (to/from SDI)** – Amount ? **Formats** ?
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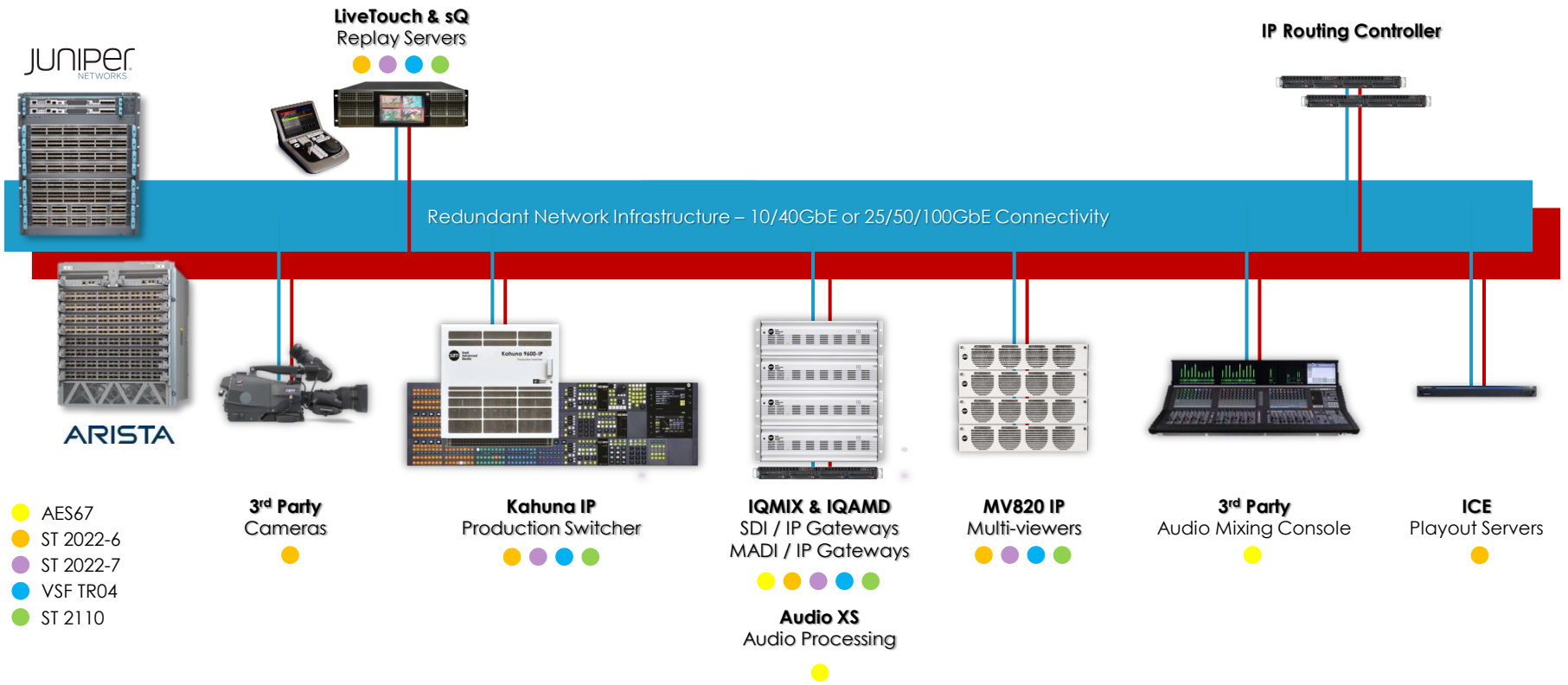
Why? – Required to build an IP system !



The Basics – the building blocks

Existing standards

SMPTE ST 2022-2 (Compressed Transport Streams)

SMPTE ST 2022-5 (Forward Error Correction)

SMPTE ST 2022-6 (High Bit Rate Media Transport)

SMPTE ST 2022-7 (Seamless Protection Switching)

Well aligned to support legacy SDI infrastructure in an IP domain

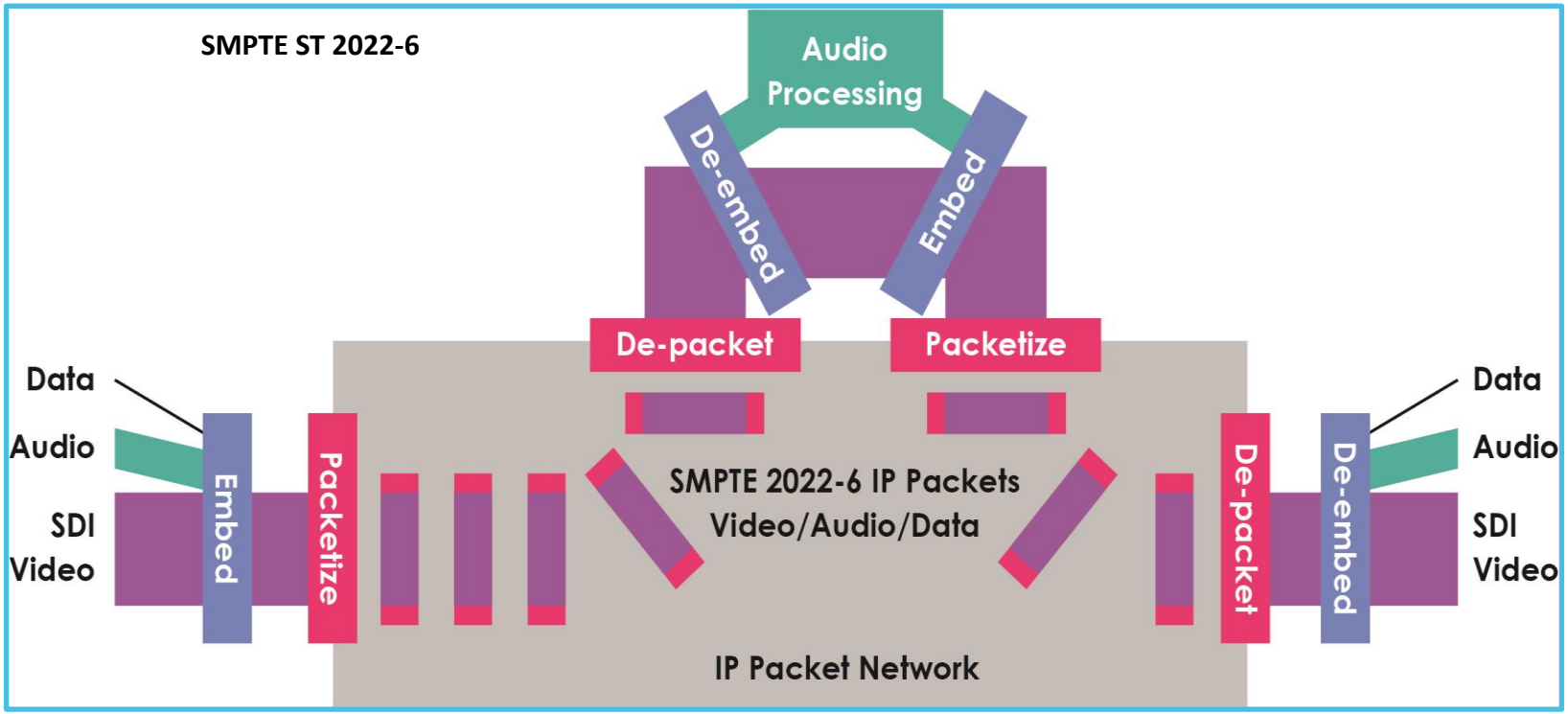
SMPTE ST 2059-1 (Generation of PTP Signals, Epoch)

SMPTE ST 2059-2 (SMPTE Profile for IEEE1588 PTP)

SMPTE ST 2042 (VC2 compression)

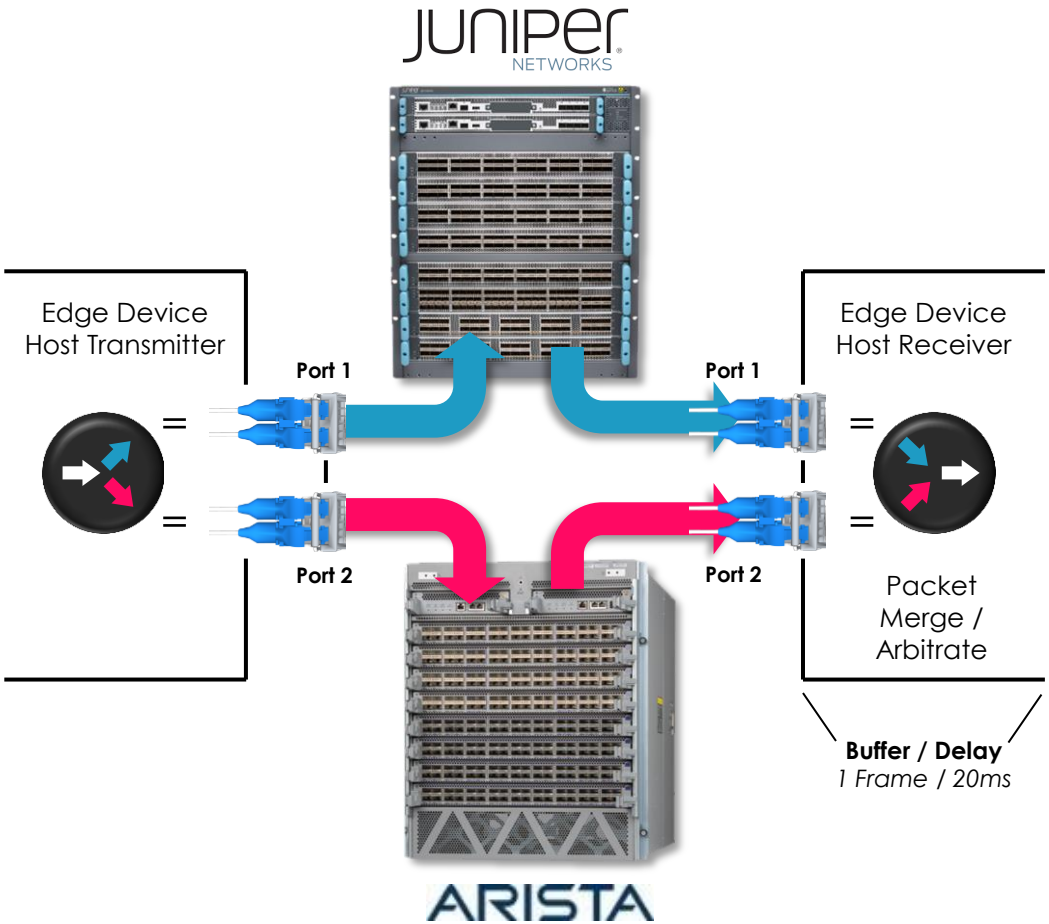
Defined with the future in mind, an all IP future!

SMPTE ST 2022-6 (Multiplexed streams)



SMPTE ST 2022-7 (Redundancy)

- **SMPTE ST 2022-7** Seamless protection of ST 2022 IP Datagrams
- Originally for **SMPTE ST 2022-6** streams. Good for **ST 2110 RTP** Video, Audio & Metadata streams
- Requires copy of Multicast Source
- Two identical network interfaces
- Two IP Routers or two IP Router cards
- Packets received / joined at Host
- Packet-by-packet merging / arbitration
- Works for individual packet or full stream loss



The Basics – the building blocks

Standards – approved and ready for deployment today!

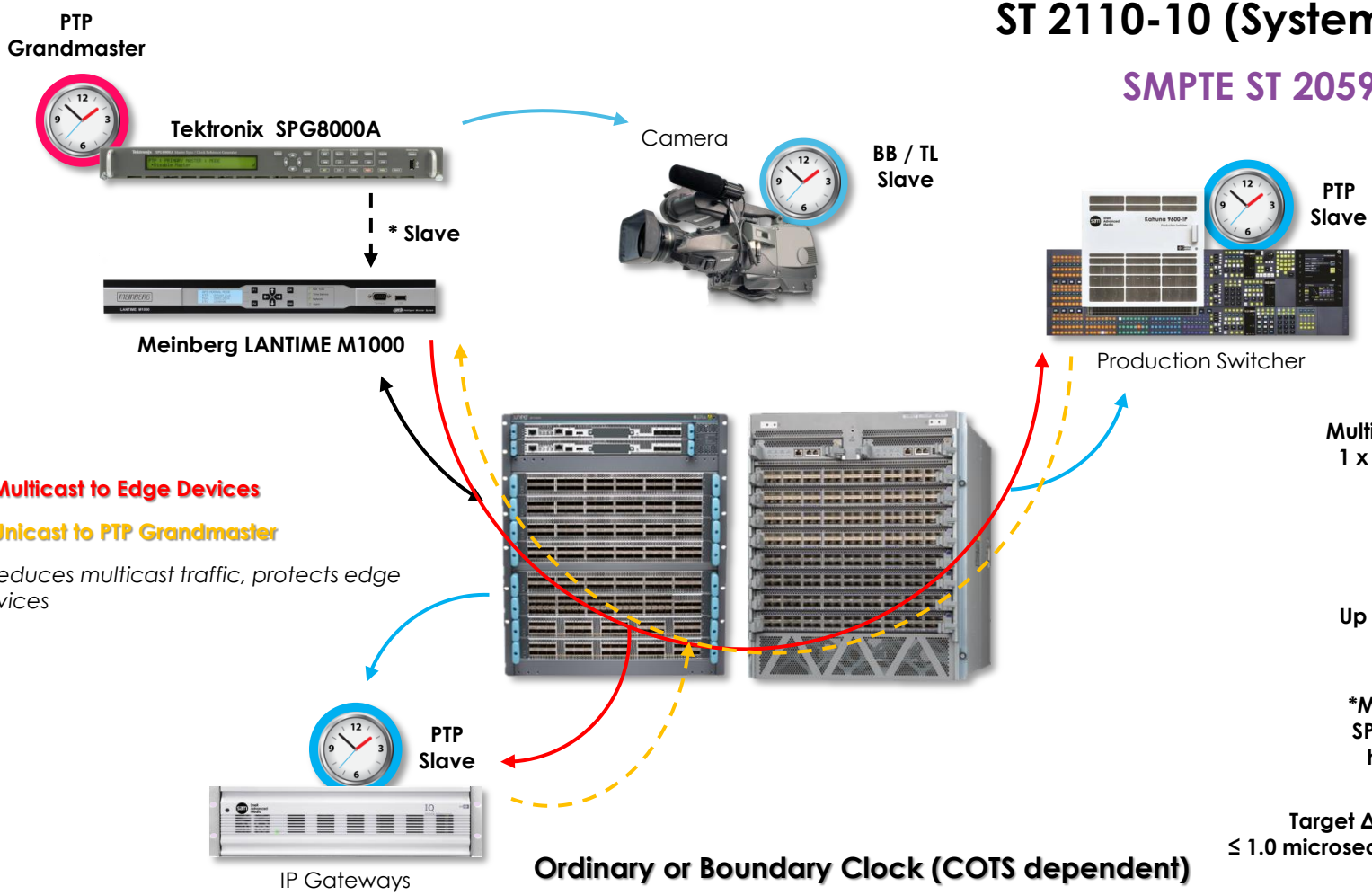
SMPTE ST 2110 – 10 (System – RTP, SMPTE ST 2059, SDP)

Engineering criteria that defines an extensible system of RTP-based essence streams referenced to a common reference clock, in a manner which specifies their timing relationships. This standard specifies the system timing model and the requirements common to of all of the essence streams

- RTP (Real-time Transport Protocol – RFC 3550) ➔ proven technology for transporting time-critical data over UDP packets (RFC 768)
- SMPTE ST 2059 ➔ based on IEEE 1588 standard, greater technology maturity
- PTP utilised in many other mission critical applications ➔ high frequency trading, energy infrastructure and robotics to name a few
- SDP (Session Description Protocol – RFC 4566) ➔ metadata exposed by the senders, tells the receiver what it needs to know – distributed by the control system (not covered in ST 2110-10)

ST 2110-10 (System Timing)

SMPTE ST 2059-1 and -2



1. Multicast to Edge Devices

2. Unicast to PTP Grandmaster

** Reduces multicast traffic, protects edge devices*

Ordinary or Boundary Clock (COTS dependent)

Multi-format SDI references
1 x PTP (RJ45), 1 x PTP(SFP)
Free-run or Genlock
GPS option

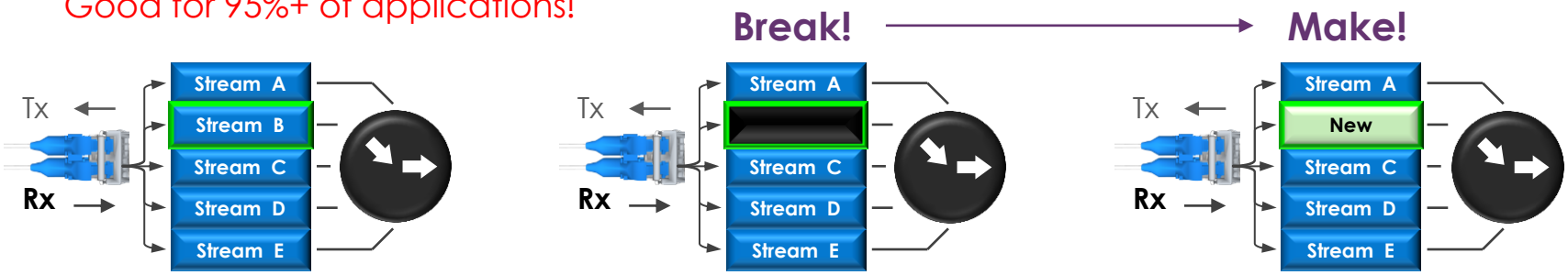
Modular (No SDI)
Up to 4 PTP ports/modules
Free-run or Genlock
GPS option

***M1000 can be slaved to SPG8000A to circumvent high client count issues**

Target ΔT between all devices:
≤ 1.0 microsecond (Lock time < 5s)

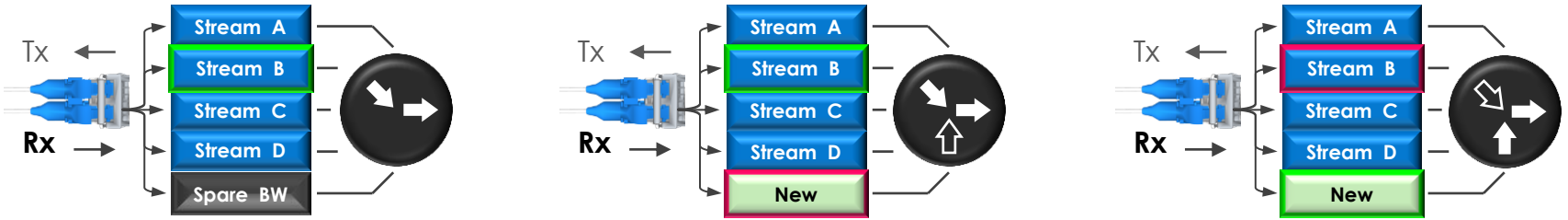
Break-before-Make Clean, Very fast & Visibly undetectable (One frame repeat)

Good for 95%+ of applications!



Make-before-Break 'Clean' (Switches on frame boundary)

Bandwidth burden for switch duration



Preferred mode set for each Destination

ST 2110-10 (Session Description Protocol)

Flow Metadata

```
v=0
o=- 243362948900865 0 IN IP4 192.168.20.112
s=Snell IQMIX
t=0 0
a=ts-refclk:ptp=IEEE1588-2008:ec-46-70-ff-fe-00-bf-60:0
a=mediaclk:direct=0
a=clock-domain:PTPv2 0
m=audio 50000 RTP/AVP 97
i=RAVENNA Audio-strm0/0,RAVENNA Audio-strm0/1
c=IN IP4 239.31.112.1/31
a=source-filter: incl IN IP4 239.31.112.1 192.168.20.112
a=rtpmap:97 L24/48000/2
a=framecount:48
a=ptime:1
a=recvonly
a=sync-time:0
```

Should include the following metadata:

- Sender description
- Video and/or audio essence
- Raster size (in pixels)
- Frame-rate (video)
- Channel count (audio)
- Sampling structure (audio/video)
- Bit depth (audio/video)
- Colourimetry
- Source IP address and port
- RTP payload ID (audio/video)
- PTP grandmaster source and domain

The Basics – the building blocks

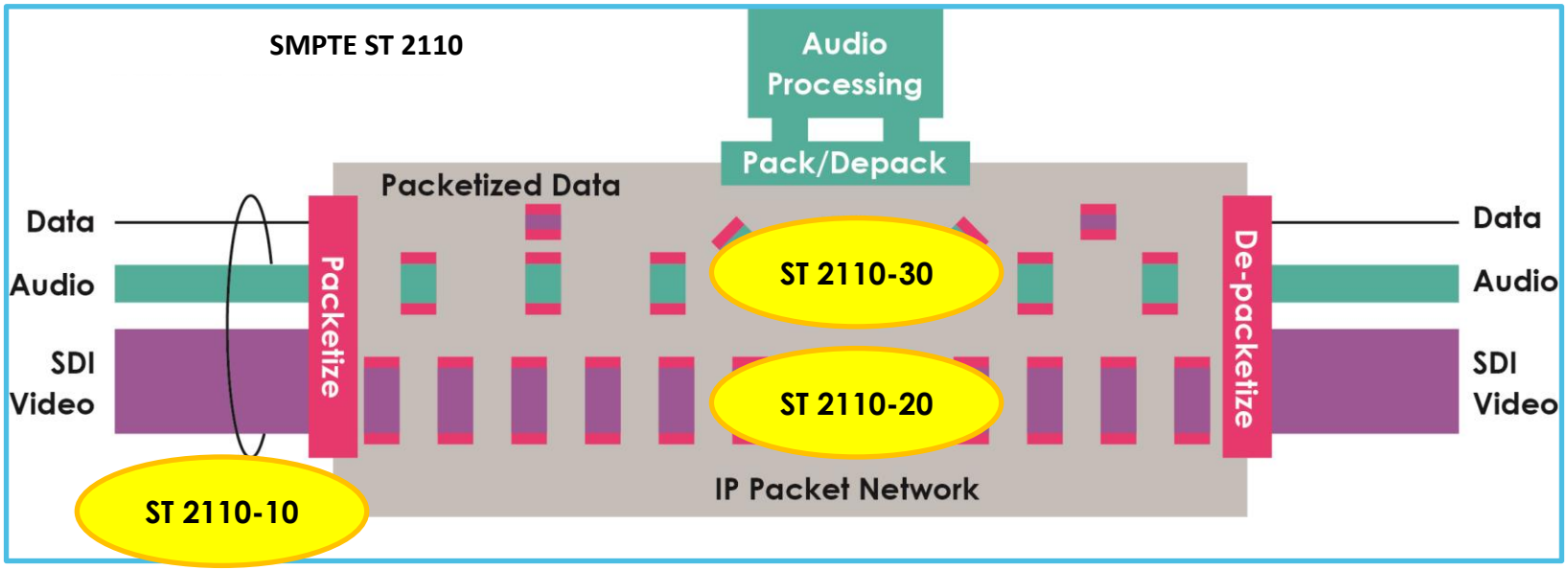
Standards – approved and ready for deployment today!

SMPTE ST 2110 – 20 (Uncompressed Video – RFC 4175)

Specifies the real-time, RTP-based transport of uncompressed active video essence over IP networks. An SDP-based signalling method is defined for image technical metadata necessary to receive and interpret the stream

- Raster size independent ➔ up to 32K x 32K pixels
- Agnostic
  - Colour sampling ➔ 4:1:1 to 4:4:4+
  - Bit depth ➔ 8 to 16-Bit+
  - Frame-rate ➔ 23.98 to 120 fps+
- Support for HDR ➔ PQ & HLG
- Significant bandwidth efficiency ➔ 1080p50 @ ST 2022-6 = 3,074Gbps vs 1080p50 @ ST 2110-20 = 2,143Gbps

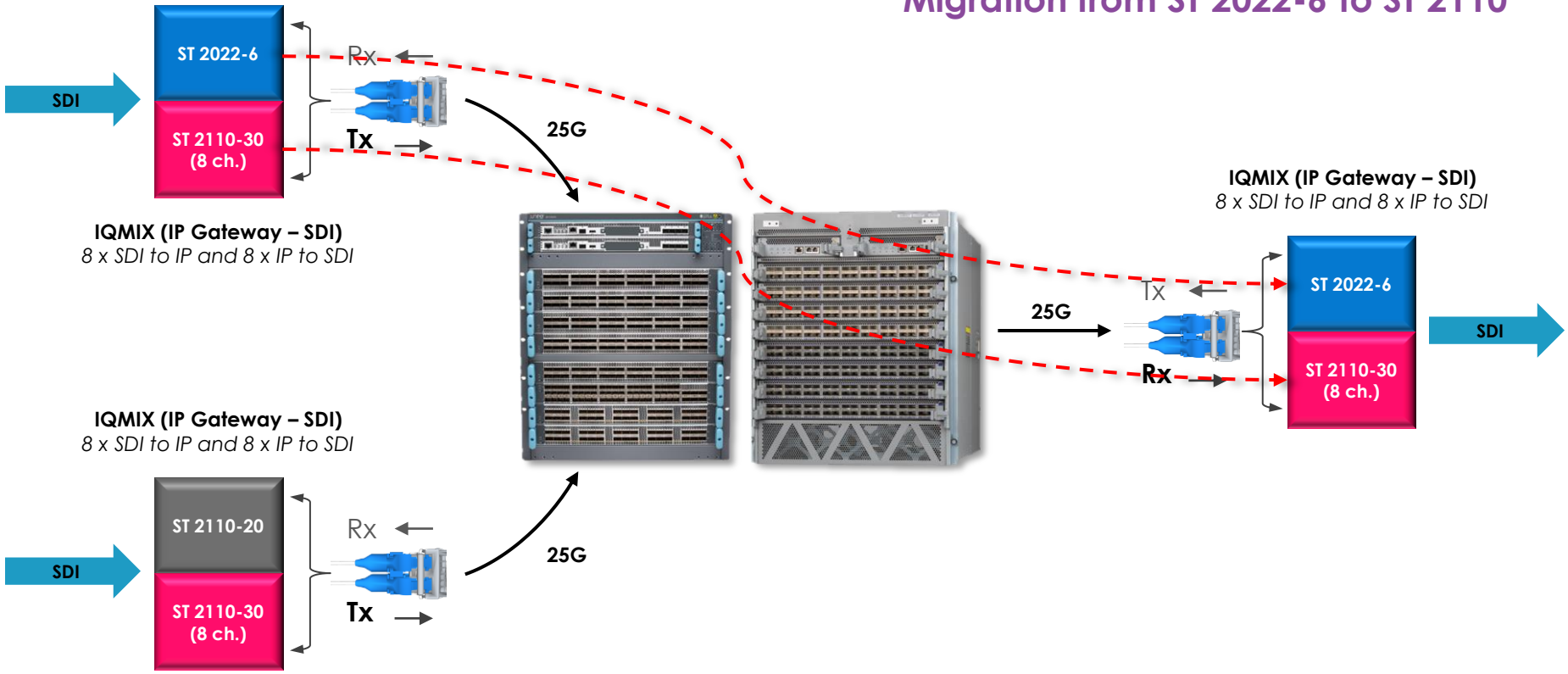
SMPTE ST 2110 (Essence streams)



ST 2110-20 & 30 (Uncompressed Audio & Video)

Migration from ST 2022-6 to ST 2110

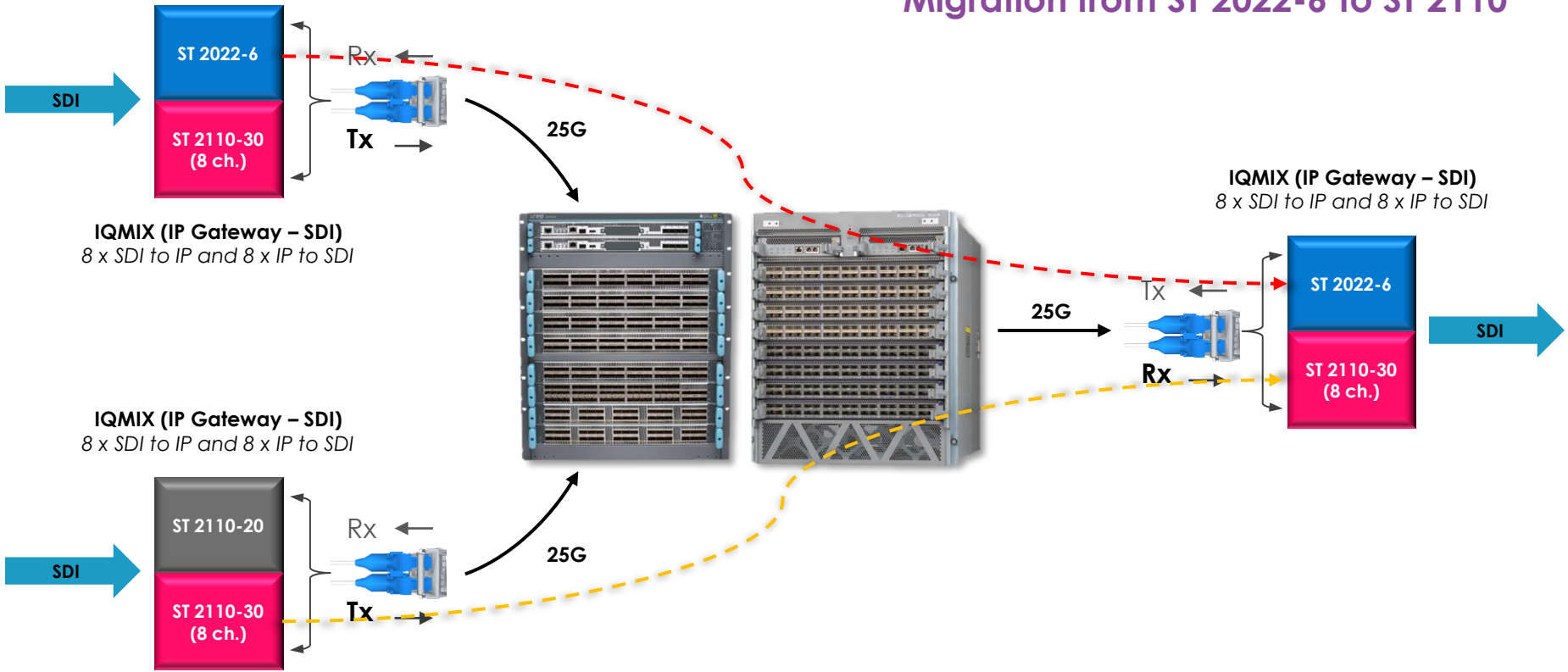
SDI generated ST 2110-30 audio stream configured as 8 ch. @ 1ms



SDI generated ST 2110-30 audio stream configured as 8 ch. @ 1ms

ST 2110-20 & 30 (Uncompressed Audio & Video)

Migration from ST 2022-6 to ST 2110



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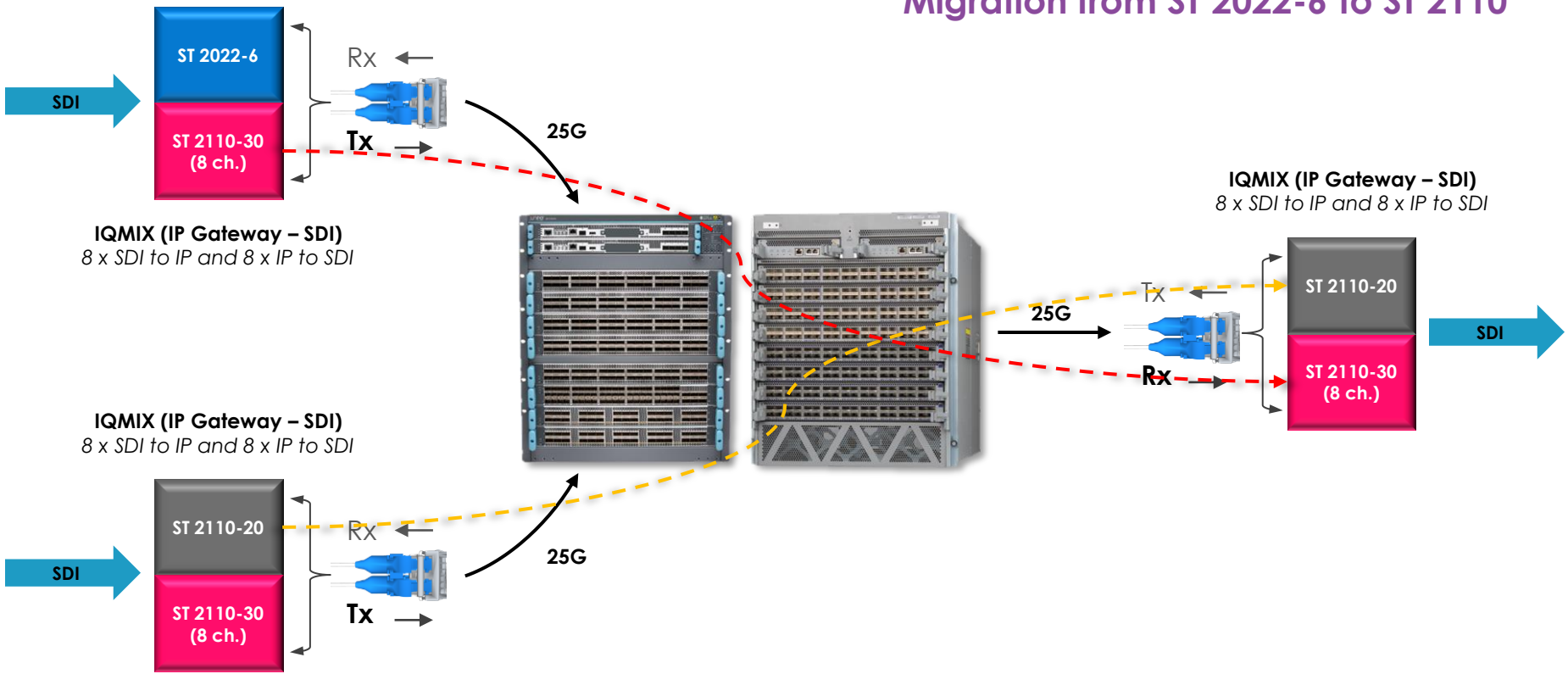

ST 2110-20 & 30 (Uncompressed Audio & Video)

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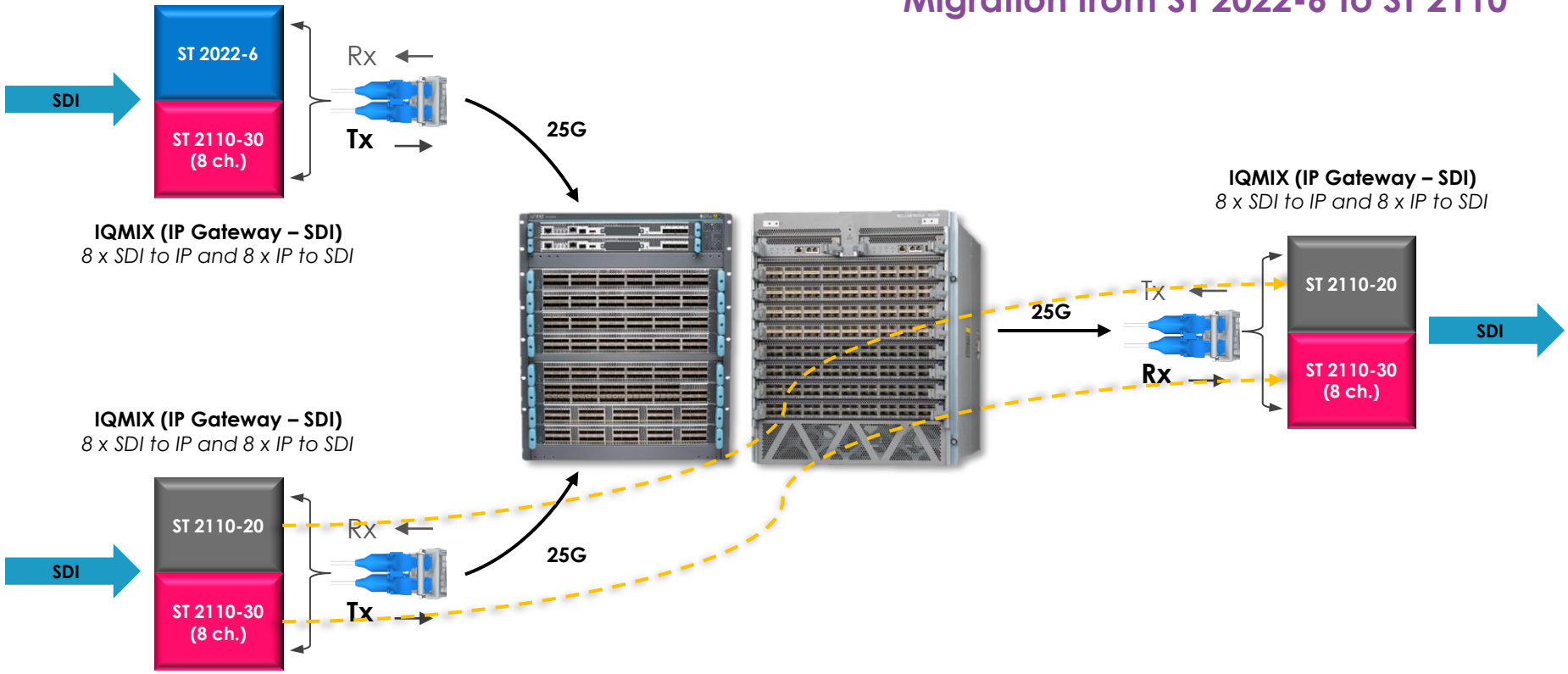


SDI generated ST 2110-30 audio stream configured as 8 ch. @ 1ms

The Basics – the building blocks

Standards – approved and ready for deployment today!

SMPTE ST 2110 – 30 (Uncompressed Audio – AES67)

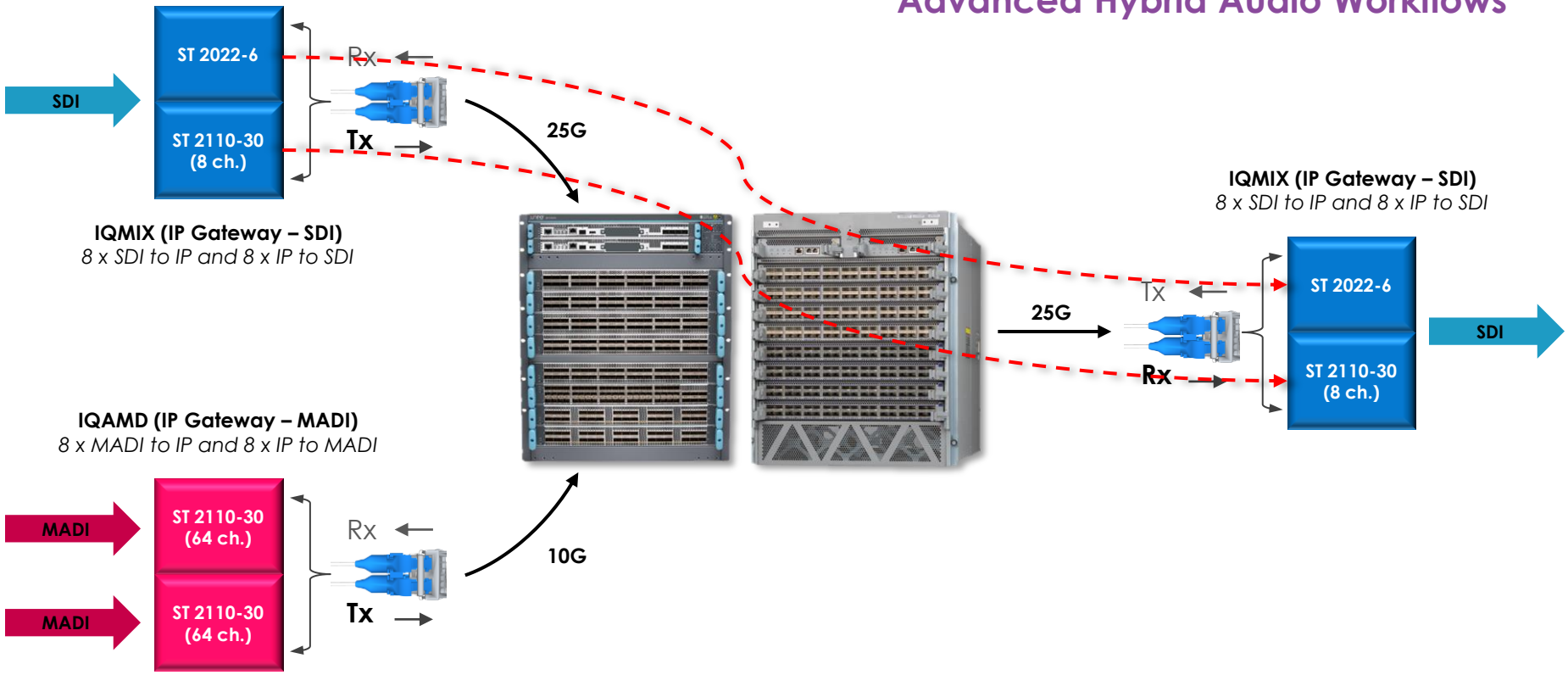
Specifies the real-time, RTP-based transport of PCM digital audio streams over IP networks by reference to AES67. An SDP-based signalling method is defined for metadata necessary to receive and interpret the stream

- Uncompressed Linear PCM Audio only
- Relatively flexible
  - 48kHz sampling
  - 16 and 24-Bit depth
  - Variable packet timing ➔ 125us to 1ms
  - Channel count based on packet timing ➔ 8 channels @ 1ms vs 64 channels @ 125us
- Low bandwidth consumption ➔ 8 channels x 24 bits x 48,000 samples x 1.5 (RTP) = 9.7Mbits/sec

ST 2110-20 & 30 (Uncompressed Audio & Video)

Advanced Hybrid Audio Workflows

SDI generated ST 2110-30 audio stream configured as 8 ch. @ 1ms

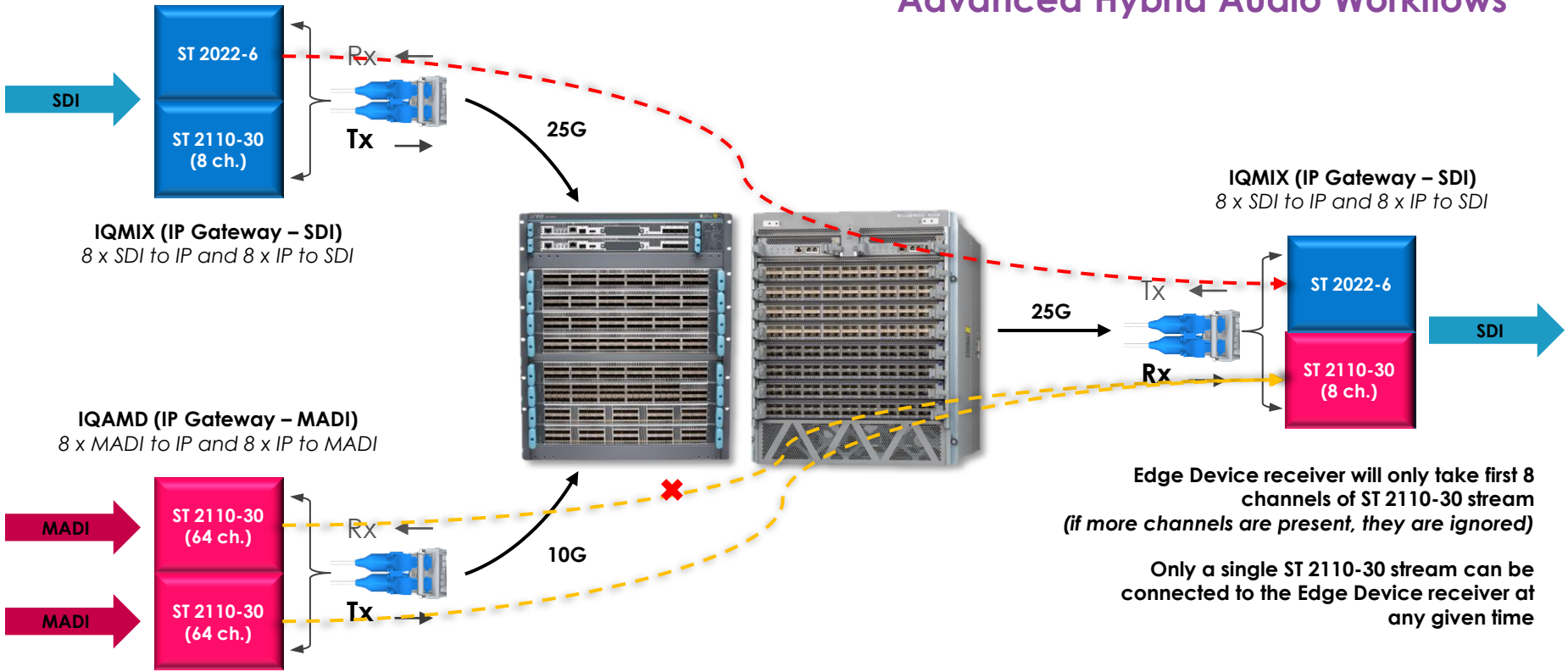


MADI generated ST 2110-30 audio stream configured as 64 ch. @ 125us

ST 2110-20 & 30 (Uncompressed Audio & Video)

Advanced Hybrid Audio Workflows

SDI generated ST 2110-30 audio stream
configured as 8 ch. @ 1ms



Edge Device receiver will only take first 8 channels of ST 2110-30 stream
(if more channels are present, they are ignored)

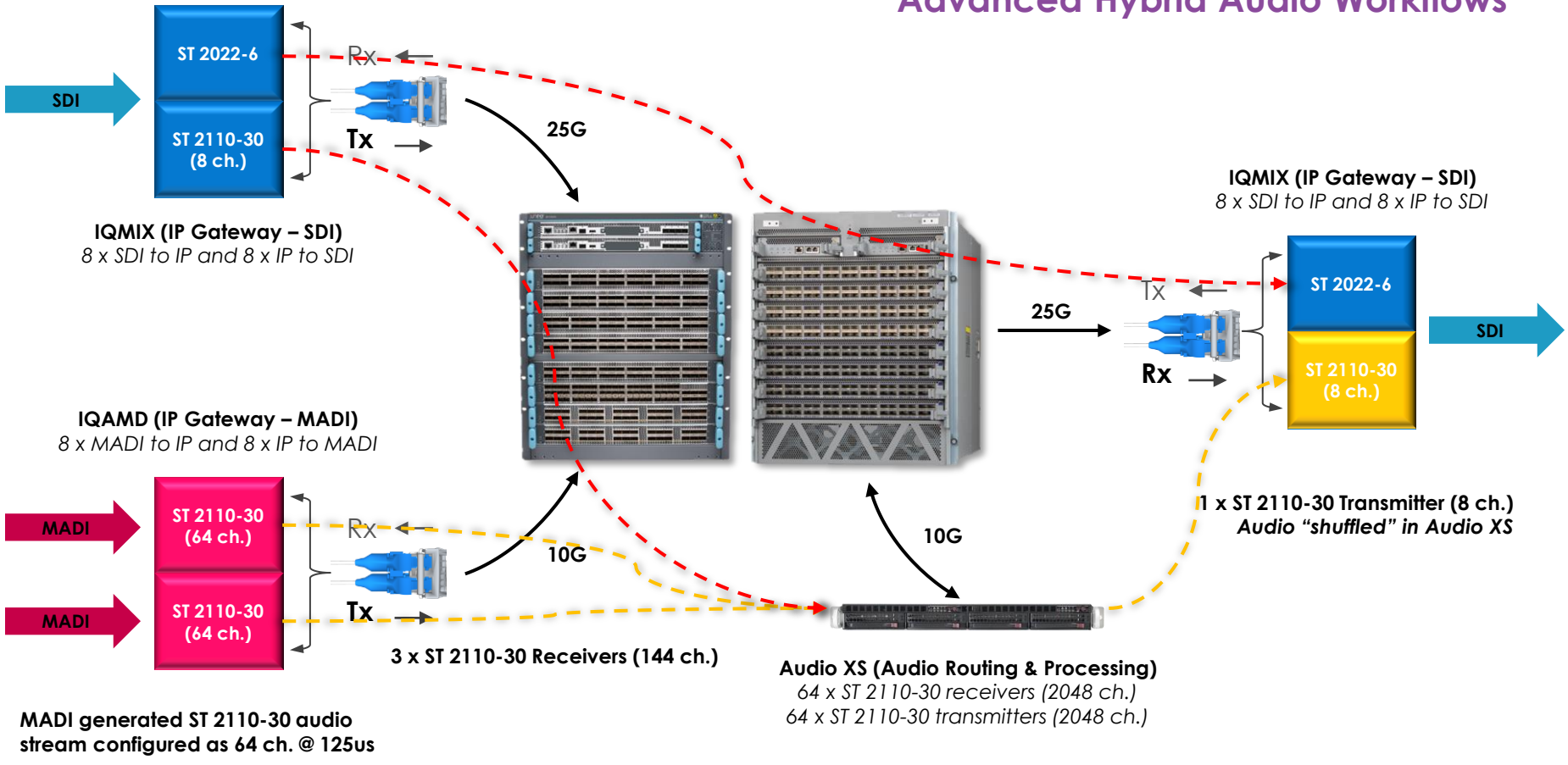
Only a single ST 2110-30 stream can be connected to the Edge Device receiver at any given time

MADI generated ST 2110-30 audio stream
configured as 64 ch. @ 125us

ST 2110-20 & 30 (Uncompressed Audio & Video)

Advanced Hybrid Audio Workflows

SDI generated ST 2110-30 audio stream configured as 8 ch. @ 1ms



MADI generated ST 2110-30 audio stream configured as 64 ch. @ 125us

The Basics – the building blocks

Standards in final ballot draft / in progress – coming soon !

SMPTE ST 2110 – 21 (Performance of transmitters – packet pacing, bursts, gaps)

SMPTE ST 2110 – 40 (Ancillary Data – VANC based on IETF ANC 291)

SMPTE ST 2110 – 31 (Compressed Audio – non-PCM/AES3, Guardband aware, stereo)

SMPTE ST 2110 – 50 (Support for legacy SMPTE ST 2022-6 infrastructure)

… hot discussion at the moment, ST 2110-2x (Compressed Video)

The Basics – the building blocks

The SMPTE ST 2110 suite of standards!

SMPTE ST 2110 – 10 (System – RTP, SMPTE ST 2059, SDP)

SMPTE ST 2110 – 20 (Uncompressed Video – RFC 4175)

SMPTE ST 2110 – 21 (Performance of transmitters – packet pacing, bursts, gaps)

SMPTE ST 2110 – 30 (Uncompressed Audio – AES67)

SMPTE ST 2110 – 31 (Compressed Audio – AES3)

SMPTE ST 2110 – 40 (Ancillary Data - IETF ANC 291)

SMPTE ST 2110 – 50 (SMPTE ST 2022-6 Essence)

- Approved (September 2017)
- Final draft ballot (Target : late 2017 / early 2018)
- In progress (Target : 2018)

The Basics – the building blocks

<u>But</u>, don't get confused - technical recommendations or standards ?

NMOS IS-04 - (Device Discovery and Registration) Specification by AMWA

NMOS IS-05 - (Connection Management) Specification by AMWA

NMOS IS-06 - (Network Control) Specification by AMWA

VSF TR04 - (2022-6 & AES67) Technical recommendation by Video Services Forum

VSF TR03 - (RFC4175 & AES67) Technical recommendation by Video Services Forum

SMPTE RDD 34 - (Sony LLVC compression) Registered Disclosure Document

SMPTE RDD 35 - (IntoPIX Tico compression) Registered Disclosure Document

SMPTE RDD 37 - (Evertz ASPEN) Registered Disclosure Document

In summary – why are we doing this again ?

Flexibility ➔ upgradeability and future expansion

Format **agnostic** ➔ 1080p, UHD, HDR, HFR and beyond

Cost saving and **efficiency** ➔ less cabling, quicker installation, easier to maintain

Agility – Building a platform for the enabling of virtualised services

Highest **reliability** – can be no less than what has come before (SDI served us well)

No limitation on a single vendor ➔ highest level of **interoperability**, breeds best in class products

… **lastly**, these are exciting times for the broadcast industry, a chance to leverage technological change. Change is happening – its an opportunity, don't dwell on the past, embrace the future – SMPTE ST 2110 greatly aids this evolution in the broadcast industry and its here today!

IBC 2017

Multi-vendor interoperability with over 50+ vendors
Focused on live production, contribution and playout workflows
Real-world customer deployments presented

Real-world Deployment

SMPTE ST 2110

SMPTE
SINCE 1916

Snell Advanced Media

2,000+ Signal Flows @ ST 2110-20 and ST 2110-30
Critical path redundancy – ST 2022-7
Award winning, industry first, great example - SMPTE ST 2110 delivered !

UHD-2 Overview

Introduction to Timeline TV

Established in 2006

Market leading provider of broadcast technology and services – across the globe. Broadcast Anywhere!

Portfolio includes:

- Outside Broadcasts (all 4K capable)
- Post-production facilities in Soho, Ealing Studios, BT Sport and MediaCityUK
- RF and Satellite
- Managed services
- System integration

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Introduction to Timeline TV

Trusted supplier to the biggest brands in both UK and International television markets – including : BBC, ITV, Channel 4 and BT Sport

Broadcast centres built and managed for clients such as BT Sport, Manchester City FC TV and Racing UK

Technical and creative facilities for a diverse range of programmes, such as live music and award shows, political conferences, global sporting competitions, light entertainment and current affairs

Key events covered for clients – Wimbledon, Americas Cup, UEFA Europa League, Dubai World Cup, Artic Live for BBC and Henley Royal Regatta

The challenge

Current OB fleet includes a mid-sized UHD baseband truck which was purpose built back in 2015 (UHD-1). UHD-1 contains: SAM Sirius S840 Router, Kahuna 4ME Production Switcher, Sony HDC-4300 cameras, EVS UHD replay servers and a Calrec Artemis audio console

During 2016, Timeline identified a gap in the market for a larger OB truck to provide UHD coverage of live events where a greater number of camera and replay devices were required ➔ as well as to cover additional audio requirements!

Key driver ➔ to provide the same client experience of a large modern HD truck but in UHD

After visiting many broadcast suppliers at IBC 2016, IP technology was identified as the only viable way by Timeline to achieve their technical and commercial requirements for "UHD-2"

Based on these findings, Timeline commissioned their second UHD OB Truck to be built in early 2017 (UHD-2) – with a target on air date of early May 2017

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Project requirements

Timeline's core technical requirements for "UHD-2":

- Support for up to 32 x UHD cameras
- Connectivity for 12 x UHD replay servers and 2 x UHD archive servers
- Core IP Infrastructure – COTS based with 25, 50 and 100G connectivity
- Signal agnostic IP fabric - uncompressed UHD 2160p video with support for multiple resolutions (i.e. 3G 1080p, HD 1080i, etc.)
- Industry standards based approach throughout – SMPTE ST 2110 (RFC 4175 & AES67) and SMPTE ST 2022-6 today
- Support for newer technologies such as high dynamic range (HDR) and high frame rate (HFR)
- Expectation – overall reduction in cabling and equipment (i.e. weight and accessibility)

Objectives and concept

Expandability and flexibility to cope with all production scenarios

Support for complex and enhanced audio workflows

Decentralisation of equipment ➔ cost effective for large events that currently only scale by using more than one OB vehicle

Produce simultaneous UHD 2160p HDR & SDR, 3G 1080p HDR & SDR and HD1080i content

Cutting edge technology ➔ agile, not locked into a single vendor or specific IP format (i.e. intoPIX TICO, VC2, etc.)

Most importantly, enables Timeline to offer new services, attract new clients and be more competitive

IP Delivered

Core technology installed in “UHD-2” (Triple Expander):

- SAM Kahuna IP Production Switchers – HDR 6ME and SDR 6ME
- SAM IQMIX (SDI) and IQAMD (MADI) IP Gateways – embed/de-embed on all I/O
- SAM Audio XS Audio Routing and Processing System
- SAM MV-820 IP Multi-viewers
- SAM Orbit IP Routing and Monitoring System
- Arista 7504R Modular COTS network switch with up to four 100G line-cards (up to 14.4Tbps)
- Tektronix SPG8000A and Meinberg LANTIME M1000 PTP/TL/BB Solution
- Sony HDC-4300 UHD / HDR Cameras
- EVS XT4K UHD Replay Servers
- Sony PWS-4400 UHD Archive Servers
- Calrec Apollo Audio Console – 56 faders
- Axon Cerebrum Control System

Flexible tailboard providing both SDI and IP (100G) connectivity – TX with Dolby Atmos

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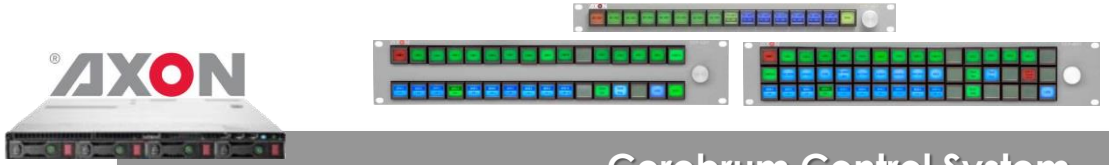


Cerebrum Control System

SWP-08
(Routing)

RollCall
(MV Layout Recall)

TSL-5
(Tally)

- ✓ SAM is providing IP routing layer
- ✓ SAM is responsible for overall IP system performance
- ✓ SAM is providing 3rd party edge device drivers where required – i.e. Sony Cameras, EVS, etc.

SAM Orbit IP Routing and Monitoring System

Configuration and Edge Device Control

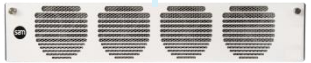
3rd Party Edge Device

SAM Edge Device
(IQMIX & IQAMD)

IP Switching
(Arista)

SAM Edge Device
(Audio XS)

SAM Edge Device
(Kahuna IP)



SAM Edge Device
(MV-820 IP)

Summary

An OB vehicle of this size and complexity is a huge investment

Adopting a future proof standard increases operational lifespan

Provides significant client benefits:

- Full production capability on large scale OB events in uncompressed UHD
- Ultimate flexibility ➔ Efficiently add multiple adhoc production areas
- Any source or destination is de-embeddable / embeddable ➔ reduced processing requirements
- Viewing anywhere ➔ Scalable distributed IP multi-viewer architecture
- Faster set up ➔ Less external cabling ➔ Labour saving

Connectivity to almost any IP, SDI format ➔ challenging in an SDI world

Unparalleled level of system wide redundancy

Commissioned and on-air as of 29th April 2017. However no rest, continual innovation with IP technology ➔ IP Remote production and Flypack solutions to follow…

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Timeline TV
Timeline
FULL CTRL


Broadcast Anywhere
Timeline TV


OS 63:RADIO CAM
VISION 8300
FULL CTRL
A: D
B: A
D: B

Q & A

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