AIMS
Alliance for IP Media Solutions

IPMX
IP MEDIA EXPERIENCE

Overview on essential Ingredients

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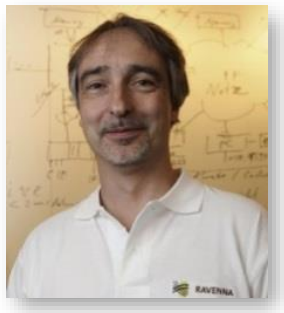

Andreas Hildebrand, RAVENNA Technology Evangelist

- more than 25 years in the professional audio / broadcasting industry
- graduate diploma in computer science
- R&D, project & product management experience
- member of AES67 TG and ST2110 DG

ALC NetworX GmbH, Munich / Germany

- established 2008
- R&D center
- developing & promoting RAVENNA
- Partnerships with > 40 manufacturers

RAVENNA

- IP media networking technology
- designed to meet requirements of professional audio / broadcasting applications
- open technology approach, license-free
- fully AES67/ST2110-compliant (*built-in*)

What is IPMX?

Internet Protocol Media Experience

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IPMX – Proposed Roadmap (Draft)

Audio over IP	Standardized Transport of Audio, Video, & ANC Elements	ProAV Standards & Specifications	
AES67 **Audio Over IP**	**SMPTE ST 2110-10** **Timing & Definitions** **SMPTE ST 2110-20** **Uncompressed Video** **SMPTE ST 2110-21** **Packet Pacing** **SMPTE ST 2110-30** **AES67 Audio** **SMPTE ST 2110-31** **AES3 Audio Transport** **SMPTE ST 2110-40** **Ancillary Data**	***SMPTE ST 2110-22*** ***CBR Compression in ST 2110*** ***ISO/IEC 21122*** ***JPEG XS Codec*** ***NMOS IS-04 & IS-05*** ***Discovery, registration & connection management*** ***EDID / DisplayID / HPD Support**** **(Required)**	**HDCP*** ***Copy protection*** **General Purpose I/O*** **IR Remotes, GPIO, USB, RS232 over IP** **NMOS IS-08*** **Audio channel mapping** **IPv6*** **Network addressing** ***Security**** **Authentication, Encryption** **(Optional)**

AES67 → **SMPTE ST 2110** → **IPMX**

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Relevant Standards

- **AES67**
  - defines high-performance AoIP interoperability
- **SMPTE ST 2110**
  - defines elementary essence data transport on managed IP networks
- **SMPTE ST 2059**
  - defines PTP profile for SMPTE ST 2110
- **AMWA NMOS**
  - defines upper layer operational & management functionalities (device discovery & connection management)

AES67

What was the original goal?

- “Provide a method to connect disparate Audio-over-IP systems to achieve workaround-free networked audio interoperability”

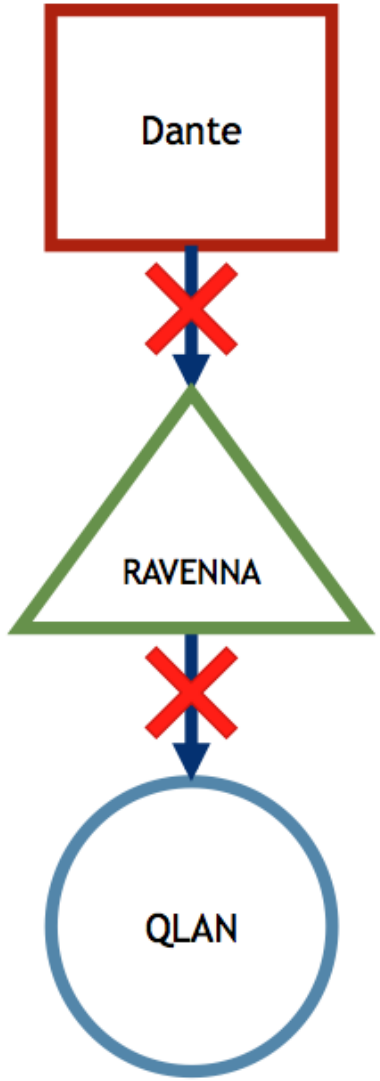
AES67

What is AES67?

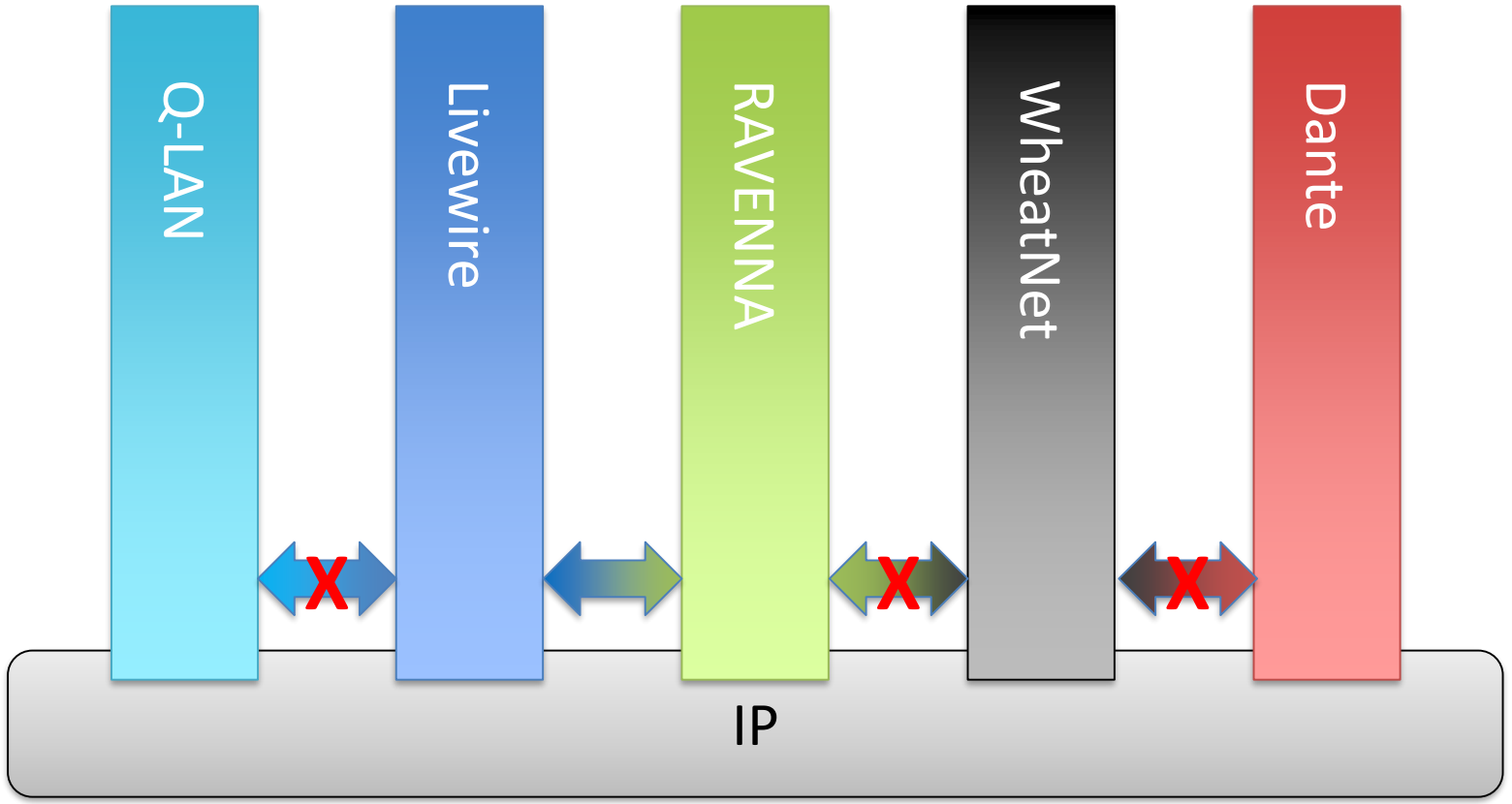
- Interoperability Standard for high performance Audio-over-IP networks
- Based on existing protocols and trusted IT standards
  - This ensures compatibility with existing network infrastructure
  - Allows coexistence with other IT data
  - High adoption rate by all major solution providers

Problem Statement

- Audio-over-IP (aka Networked Audio) provides simpler and better connection between audio equipment
- Coupled with many advantages, one clear challenge presented itself: **Compatibility**
- While each Audio-over-IP solution offered in-system connectivity, there was no standard to provide inter-system connectivity



AES67



AES67

AES67

AES67 technology components

Discovery	Not specified
Connection Management	SIP (unicast), IGMP (multicast)
Session Description	SDP (RFC4566, RFC7273)
Encoding	L16/L24, 1..8 ch, 48 samples
QoS	Differentiated Services (DiffServ w/ 3 CoS)
Transport	RTP / UDP / IP, unicast & multicast
Media Clock	48 kHz
Synchronisation	IEEE 1588-2008 (PTPv2)

AES67

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AES67 - Status

2013 – initial publication

- 3 years of work
- 100+ participants (manufacturers, consultants, system integrators, end users)

2015 – first revision

- Corrigendum & clarifications
- Backward compatibility (no new requirements)

2018 – second revision

- Further clarifications
- Backward compatibility (no new requirements)
- PICS added

AES67

Current status

- Task Group is working on further topics (multicast addressing, SDP, homologation w/ ST 2110 etc.)

Further Work in AES Task Groups

AES70 – Open Control Architecture

- Initially published in 2017
- AES70-2018 – improvements + additions (i.e. CM3, web sockets / UDP support, Task mechanism etc.)
- Current work: further improvements, AES70 for AES67 Connection Management, NMOS convergence

X238 – Requirements for Media Network Directories and Directory Services

- setting forth technical recommendations for media network directories and directory-related services
- Covering: Registration, query, and administration protocols; security mechanisms; directory data model; query language and related semantics; scalability strategies

X242 – Streaming audio metadata over IP

- Defining a transport mechanism for real-time audio meta data associated with an AES67 audio stream
- Synchronization, RTP payload format (but agnostic to actual payload data), association & alignment w/ AES67 streams
- Seeking alignment / coordination w/ SMPTE ST 2110-41 (“Transport of Extensible Fast Metadata”)

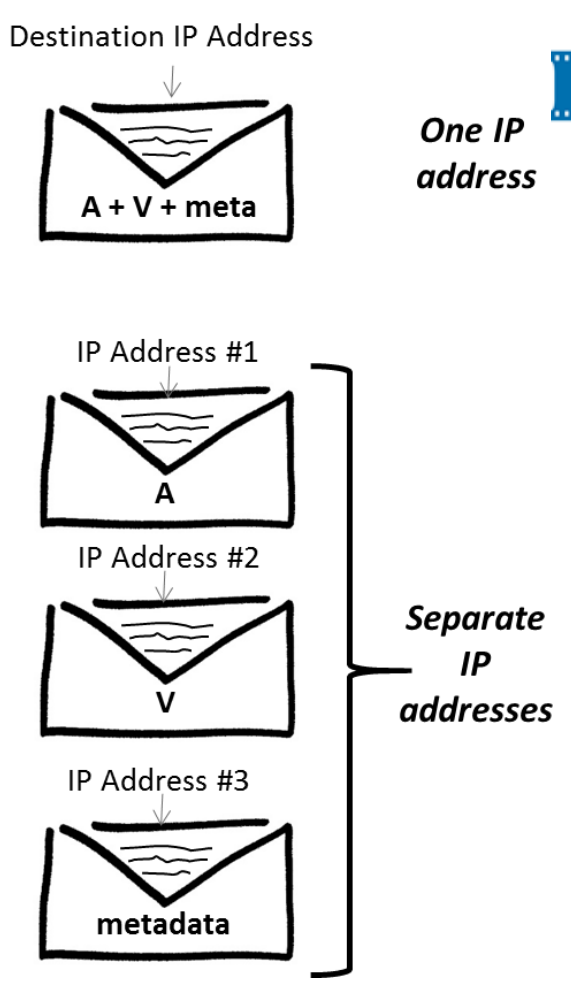
SMPTE ST 2110 – Professional Media over Managed IP Networks

The SMPTE ST 2110 standards suite specifies

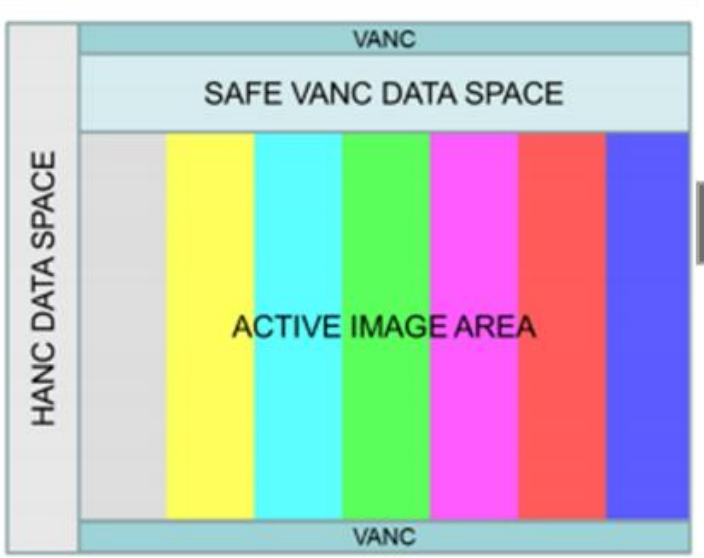
- the transport, synchronization and description of
  - separate elementary essence streams (video, audio, ancillary data)
    - over managed IP networks (at any speed, from 1GbE to 100 GbE and beyond)
      - for real-time production, playout and other professional media applications.

Two Fundamental Approaches to IP Transport

- **Bundled** (Audio, Video, Metadata together)
  - Audio/Video/Metadata/Sync travel ***coherently***
  - Requires extra work to “unpack” separate essences
- **Essence-based** (Audio, Video, Metadata separate)
  - Ideal for ***Studio/Production*** workflows
  - Individual essence kept in sync using PTP timing



The Bundled Approach: SMPTE ST 2022-6



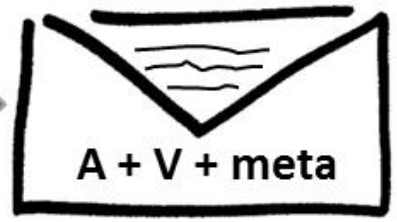
SDI Raster

IP Packetization of SDI Raster

Method: **SMPTE ST 2022-6**

- Audio (from HANC)
- Video (from active area)
- Metadata (from VANC)
- Sync/Timing (from frame)

One Destination IP Address



Published beginning in 2012

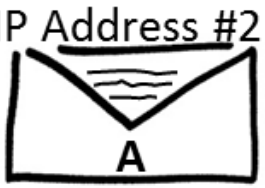
The Essence-based Approach: SMPTE ST 2110

Active Video

IP Packetization of Active Video
Method: **SMPTE ST 2110-20**

Audio

IP Packetization of Audio Channels
Method: **SMPTE ST 2110-30**



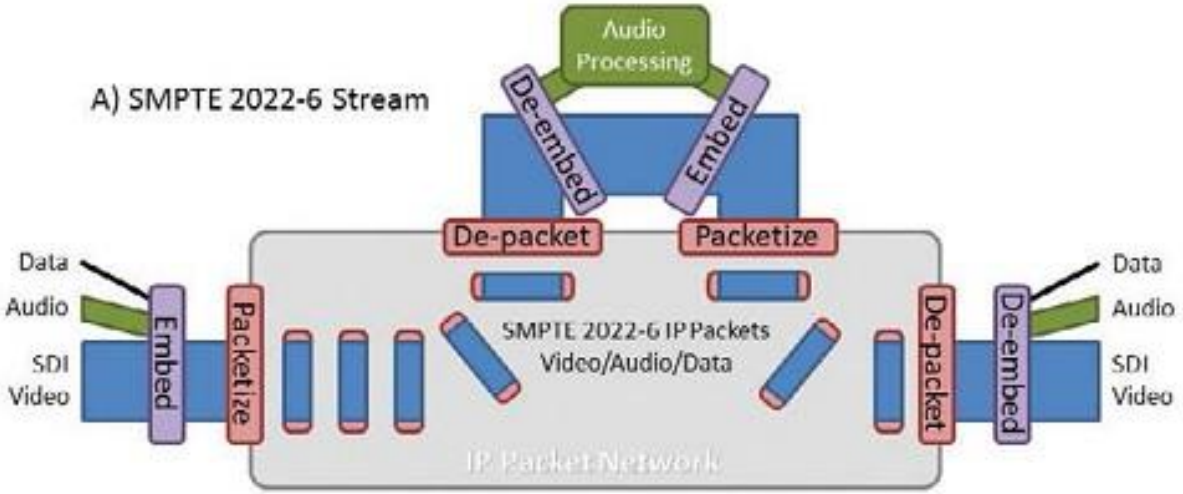
Metadata

IP Packetization of ANC Data
Method: **SMPTE ST 2110-40**

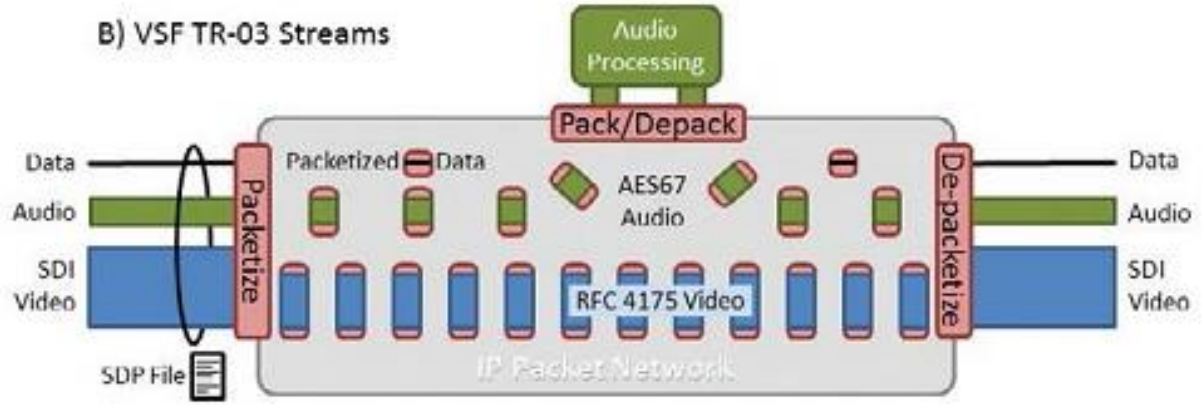
Published in 2017

Bundled vs. Essence-based Approach

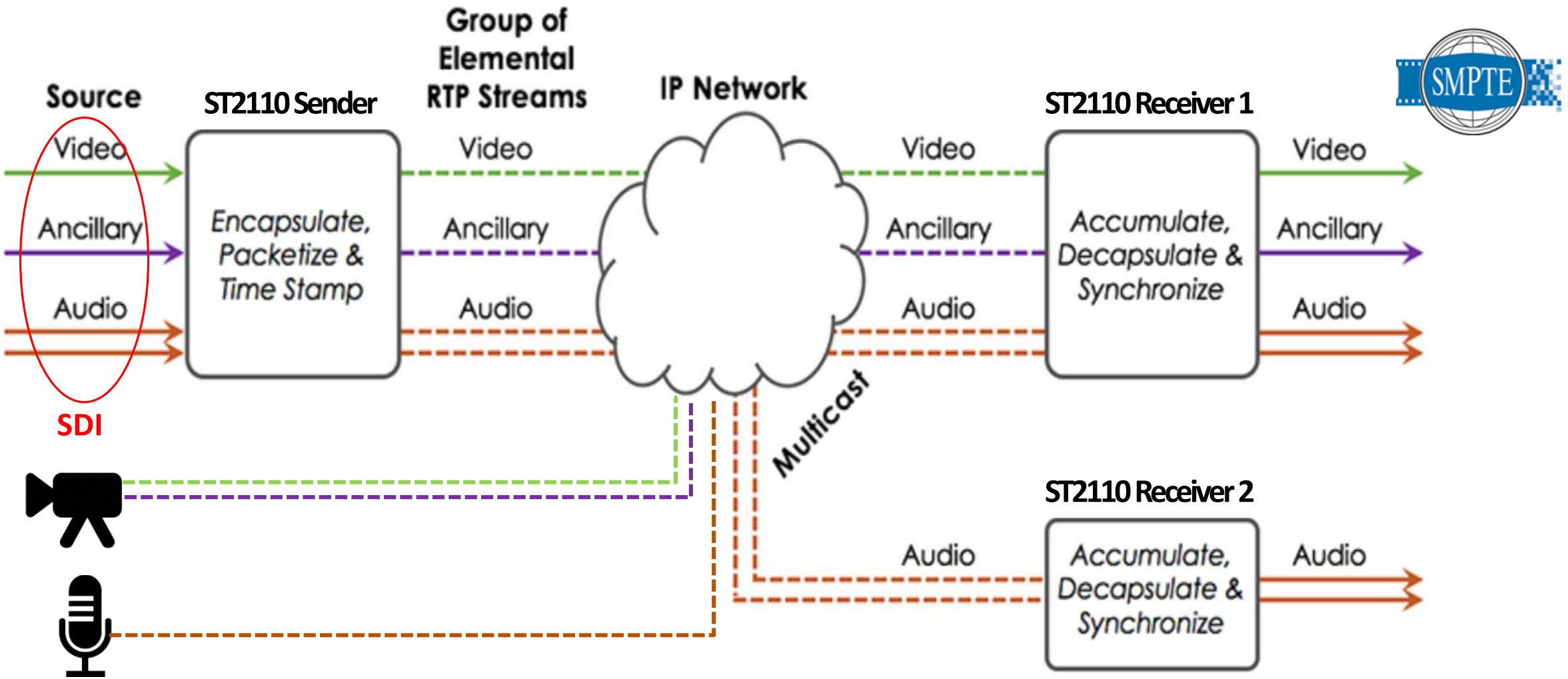
ST 2022-6



ST 2110



The Essence Based Approach: SMPTE ST 2110



The SMPTE ST 2110 Suite of Standards

Document structure (published)**:**

- 2110-10: System Timing & Definitions
  - defines transport layer and synchronization (SMPTE2059, clocks, RTP, SDP etc.)
- 2110-20: Uncompressed Active Video
  - defines payload format for raw video (RFC4175, RTP, SDP, constraints)
- 2110-21: Traffic Shaping and Delivery Timing for Uncompressed Active Video
  - defines timing model for senders and receivers (traffic shaping requirements)

The SMPTE ST 2110 Suite of Standards

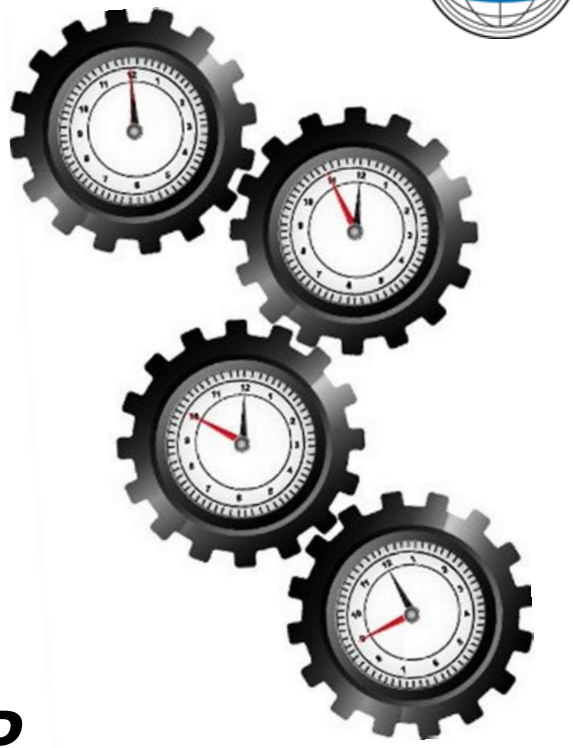
Document structure (published)**:**

- 2110-30: PCM Digital Audio
  - defines payload format for linear audio (AES67, constraints)
- 2110-31: AES3 Transparent Transport
  - defines payload format for non-linear audio (RAVENNA AM824)
- 2110-40: Transport of SMPTE Ancillary Data
  - defines RTP payload format for SDI ancillary data (new IETF draft)

Synchronization and Alignment in ST 2110

Precision Time Protocol (IEEE 1588-2008)

- A method for distributing precise, GPS-referenced time over an IP network
- Proven technology used in multiple industries
- Used for synchronization and alignment of devices and media signals

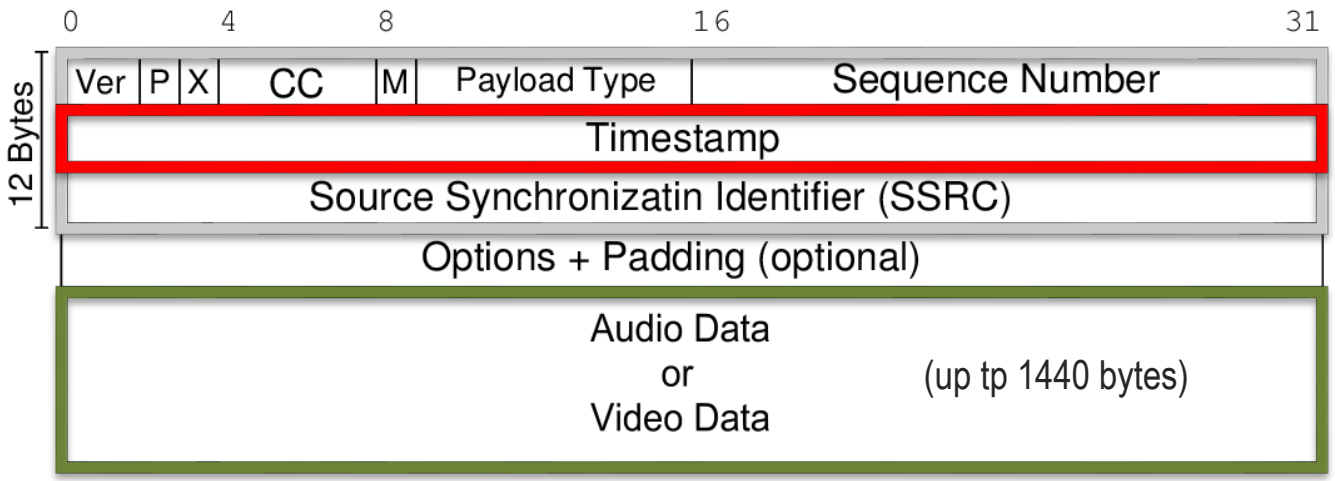


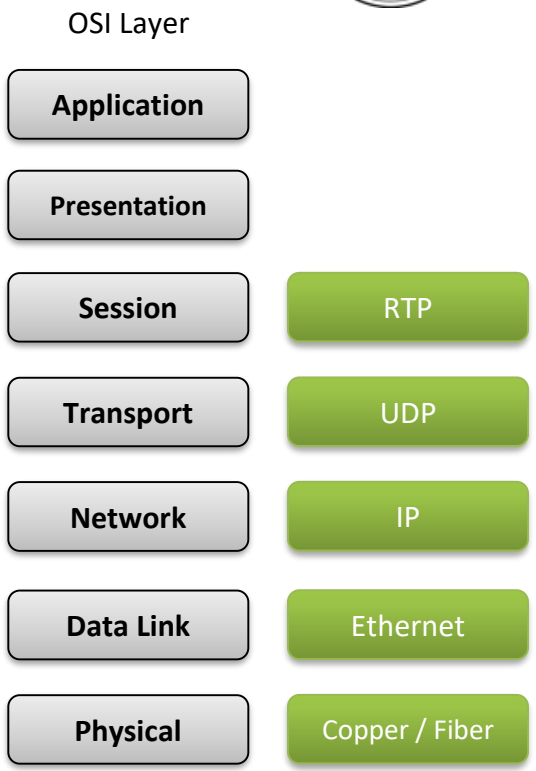
Both AES67 and SMPTE ST 2110 use PTP

Media Transport in ST 2110

Real-time Transport Protocol (RFC 3550)

- A format-agnostic transport protocol for real-time media data
- Includes time information for precise media alignment





Signalization in ST 2110

Session Description Protocol (RFC 4566)

- Required to describe stream formatting, synchronization and connection information
- Provided by a sender (or management instance) for each stream
- Human-readable text:

```
v=0
o=1 0 IN IP4 192.168.1.100
s=RAVENNA demo stream
t=0 0
a=ts-refclk:ptp=IEEE1588-2008:00-60-6e-ff-fe-7c-23-0f:0
a=mediaclk:direct=0
m=audio 5004 RTP/AVP 98
a=rtpmap:98 L24/48000/2
c=IN IP4 239.3.14.142
a=recvonly
a=ptime:1
```

SMPTE ST 2110-20 Video - Uncompressed

Specifies the payload format for **uncompressed active video** essence

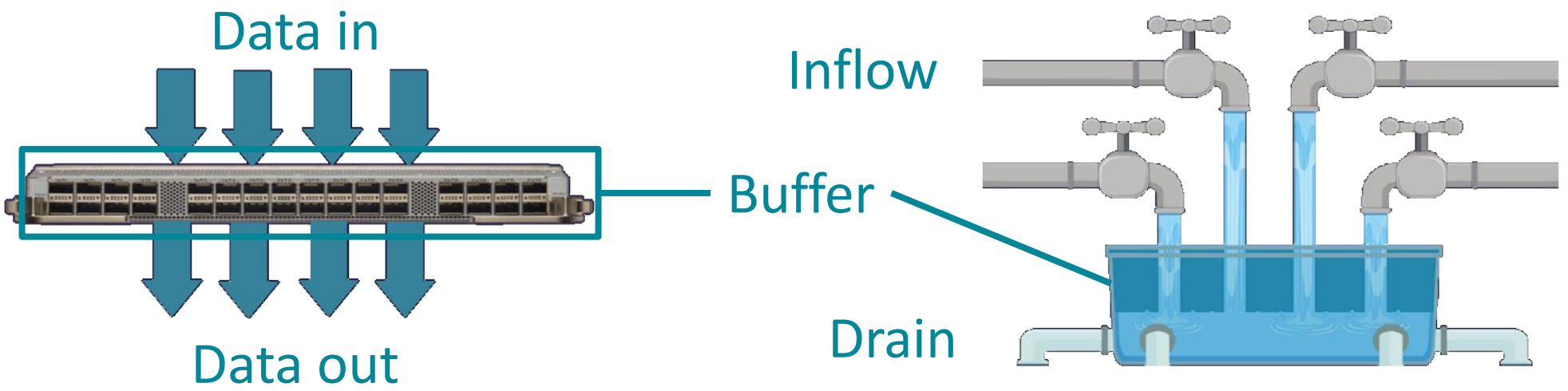
- Raster size independent ▸ up to 32K x 32K pixels
- Agnostic to:
  - Colour sampling: 4:1:1 to 4:4:4+
  - Bit depth: 8 to 16-Bit+
  - Frame-rate: 23.98 to 120 fps+
- Support for HDR ▸ PQ & HLG
- Significant bandwidth efficiency,

  i.e. 1080p50:
  - ST 2022-6 = 3,074Gbps
  - ST 2110-20 = 2,143Gbps ⇨ 30% bandwidth saving!

SMPTE ST 2110-21
Traffic Shaping and Delivery Timing for Video

Problem Overview

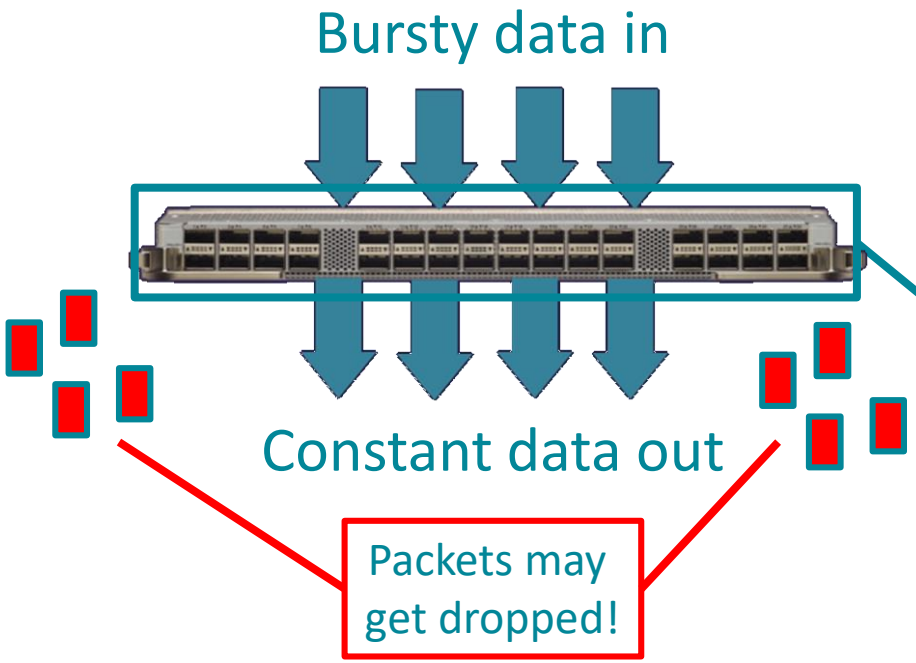
- Video flows require fairly high data rates
- Multiples flows are concurrently traversing the network
- Network switches (and receivers) have limited buffer capacity
- Constant data flow will not overload the buffers as long as total used bandwidth stays below maximum bandwidth



SMPTE ST 2110-21
Traffic Shaping and Delivery Timing for Video

Problem Overview

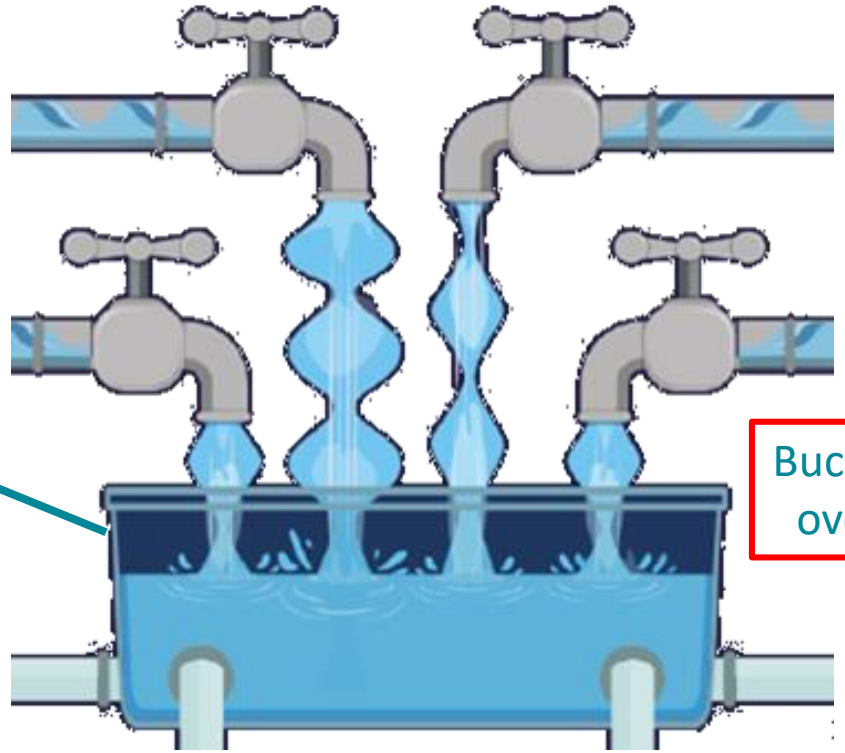
- Random and unregulated traffic patterns may temporarily overflow buffers, even if average bandwidth is not exceeded



Larger buffer required

Bursty inflow

Constant drain



SMPTE ST 2110-21
Traffic Shaping and Delivery Timing for Video

Solution

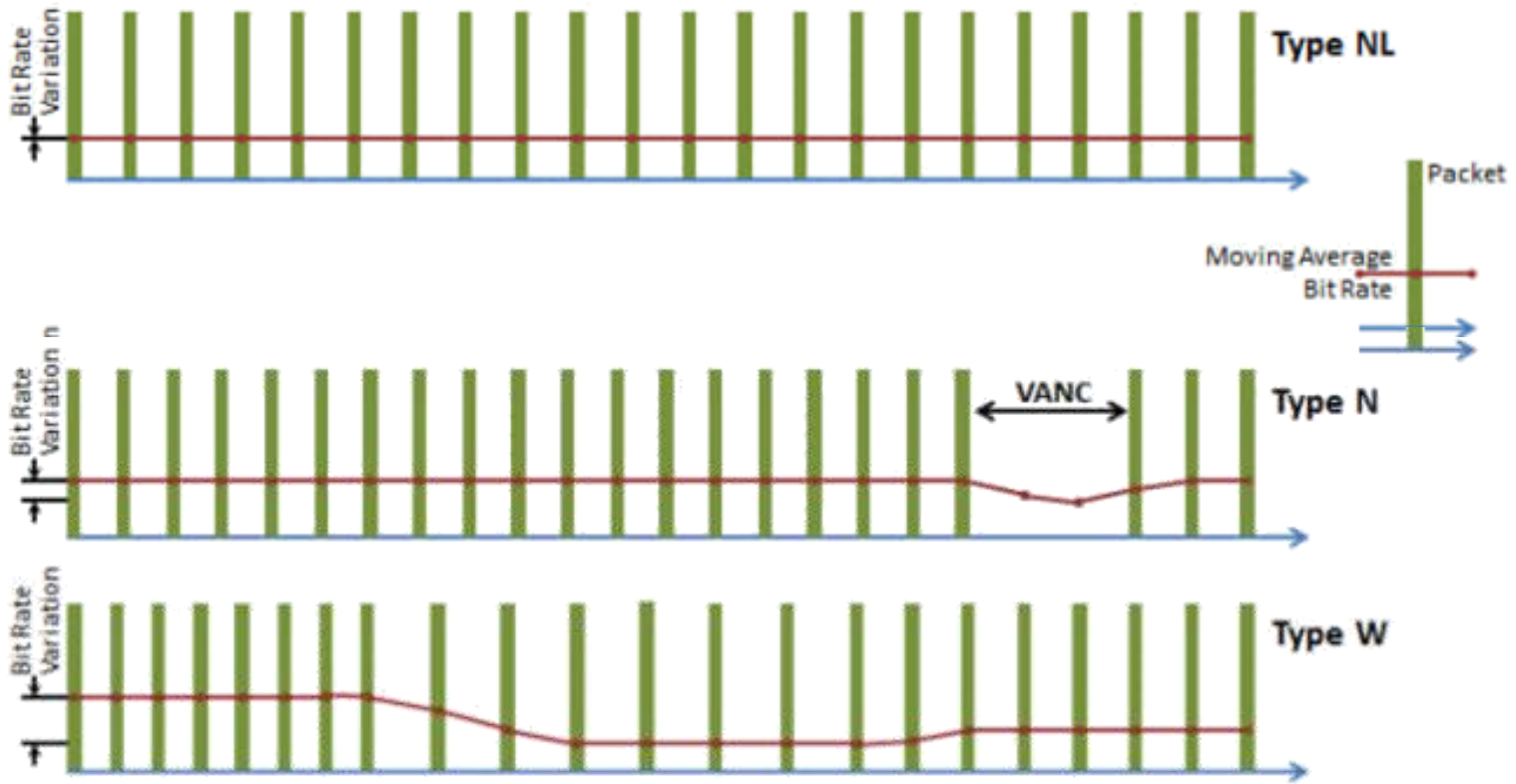
- Define sender drain behaviour (packet egress pacing and spacing)*
- 3 models for sender traffic shaping:
  - Narrow-linear (NL) – packet are drained evenly distributed across frame period
  - Narrow (N) – packet drain closely follows SDI signal timing (no packets during VBI and VANC)
  - Wide (W) – allows increased burstiness (accommodates SW-based senders)

*and (receiver) buffer requirements

SMPTE ST 2110-21
Traffic Shaping and Delivery Timing for Video

Solution

- Define sender drain behaviour (packet egress pacing and spacing)
- 3 models:
  - Narrow-linear
  - Narrow
  - Wide



SMPTE ST 2110-21
Traffic Shaping and Delivery Timing for Video

Solution

- Define sender drain behaviour (packet egress pacing and spacing)
- 3 models for sender traffic shaping :
  - Narrow (N) – packet drain closely follows SDI signal timing (no packets during VBI and VANC)
  - Narrow-linear (NL) – packet are drained evenly distributed across frame period
  - Wide (W) – allows increased burstiness (accommodates SW-based senders)
- Sender behaviour is signalled in the SDP in the a=fmtp: line:
  - TP=2110TPN
  - TP=2110TPNL
  - TP=2110TPW
- Has impact on buffer requirements of network switches and receiver devices and sender / receiver compatibility

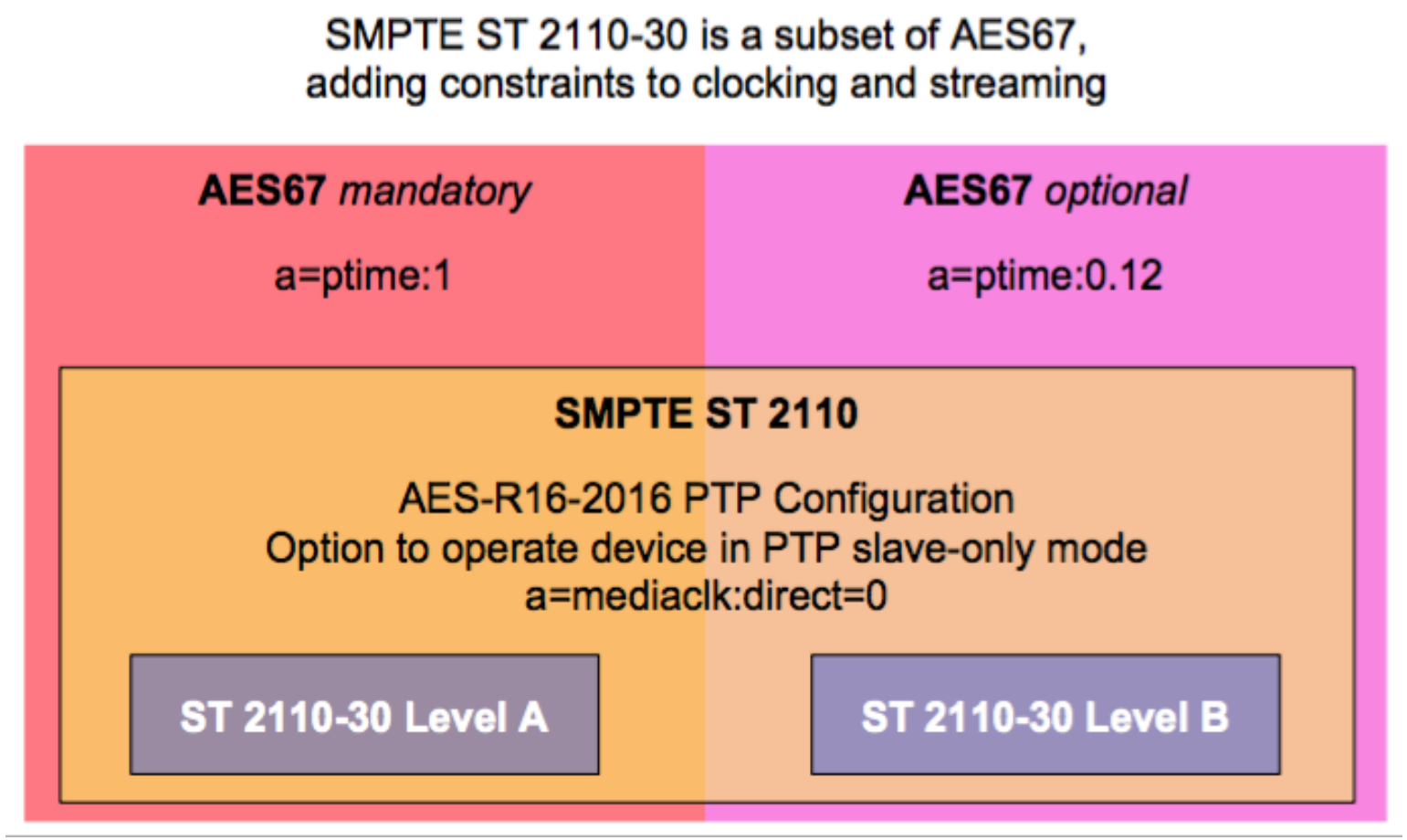
SMPTE ST 2110-30 Linear PCM Audio

Specifies the payload format for PCM digital audio streams

- Uncompressed Linear PCM Audio only
- Based on AES67
- Relatively flexible:
  - 48kHz and 96kHz sampling
  - 16 and 24-bit depth
  - Variable packet timing - 125us to 1ms
  - Channel-count based on packet timing

    - 8 channels @ 1ms up to 64 channels @ 125us (conformance levels A / B / C)
- Low-bandwidth consumption, i.e.
  - 8 channels x 24 bits x 48,000 samples = 9.9Mbits/sec (incl. packet overhead)

SMPTE ST 2110-30 and AES67 Compatibility

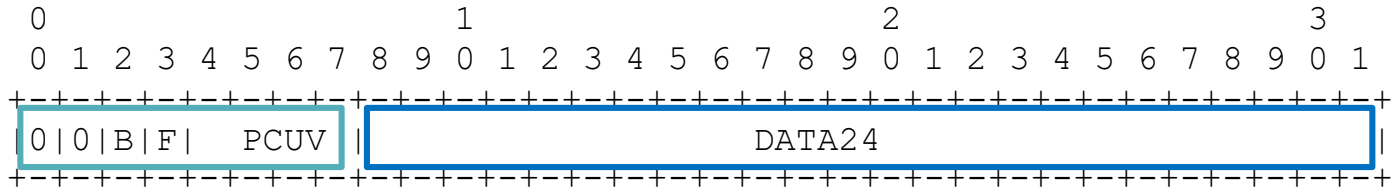


AES67

SMPTE ST 2110-31 AES3 Audio Data

Specifies the payload format for transparent transport of AES3 audio data

- Can transport any format which can be encapsulated in AES3:
  - L24 PCM w/ AES3 subframe meta data (PCUV bits)
  - non-PCM audio and data formats as defined by SMPTE ST 337 / 338 (i.e. Dolby®E etc.)
- Builds on RAVENNA's AM824 (IEC 61883-6) payload definition:
  - retains AES67 definitions for synchronization and RTP usage
  - uses 3 bytes for PCM24 + 1 byte for AES3 meta data



  - RTP payload format signaled in SDP:

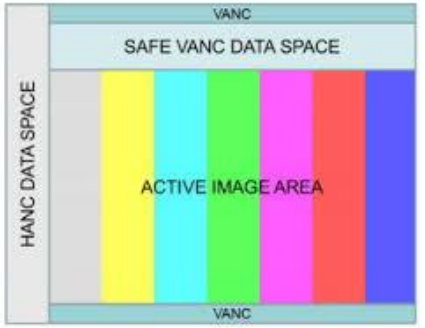
    a=rtpmap:<pt> **AM824**/48000/<nchan>

  - retains all other SDP parms

SMPTE ST 2110-40 Transport of Ancillary Data

Specifies the method of transporting (SDI) ancillary data via RTP

- Covers ancillary data as specified in SMPTE ST 291-1, i.e.:
  - Timecode
  - Closed captions
  - Subtitles
  - Active format descriptions
- Not intended for the carriage of audio data (→ SMPTE ST 2110-31) or EDH (error, detection and handling)



The SMPTE ST 2110 Suite of Standards

Document structure (in development)**:**

- 2110-22: Constant Bit-rate Compressed Video
  - defines payload format for CBR compressed video and a SMPTE registry for various payload formats (codecs)
- 2110-23: Single Video Essence Transport over Multiple 2110-20 Streams
  - defines how to split high-bandwidth signals into several lower-bandwidth 2110-20 tributary streams (constraints, grouping, addressing, RTP timestamps, SDP …)
- 2110-41: Extensible Fast Metadata Transport
  - defines how to transport extensible, dynamic meta data in ST2110 context (including synchronization)

Further Work in SMPTE DGs

ST 2110

- 1-year review of: -10 / -20 / -21 / -40
- New work: -24 (SDO Definitions)
- PICS (analog to AES67-2018)

ST 2059

- 1-year review of: -1 & -2
- ST 2059 Security
- PTP Monitoring

Related:

VSF

- ST 2110-over-WAN, ST 2110 format enumeration

IEEE1588-2020 (PTPv2.1)

- Improvements and extensions, fully backwards-compatible

What else is required for a working system?

- ⇨ Establishing connections!* (*and control…)
  - Not covered by SMPTE 2110
- ⇨ 

  - AMWA: Advanced Media Workflow Association
  - NMOS: “A growing family of specifications […] which are complementary to and co-exist with industry specifications like ST2110 and AES67”

Networked Media Open Specifications

NMOS specifications:

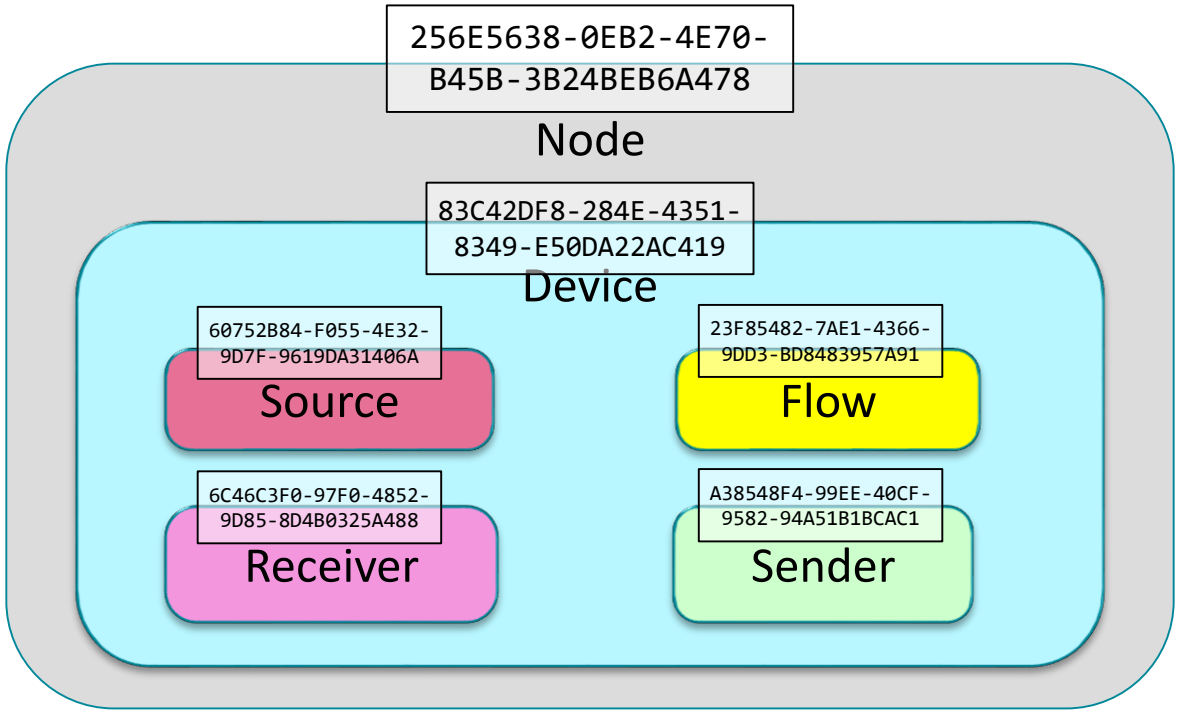
- IS-04: Discovery & Registration
  - enumeration and registration of available system resources
- IS-05: Connection Management
  - connecting receivers to available streams
- IS-06: Network Control
  - controlling network resources (configuring routing tables)

NMOS specifications:

- IS-07: Event & Tally Specification
  - communicate current states and state changes
- IS-08: Audio Channel Mapping
  - how to match flow channels with inputs / outputs
- BCP-002-01: Grouping of NMOS Resources
  - identifying which flows are related to each other
- … more in the works…

Key elements

Identity

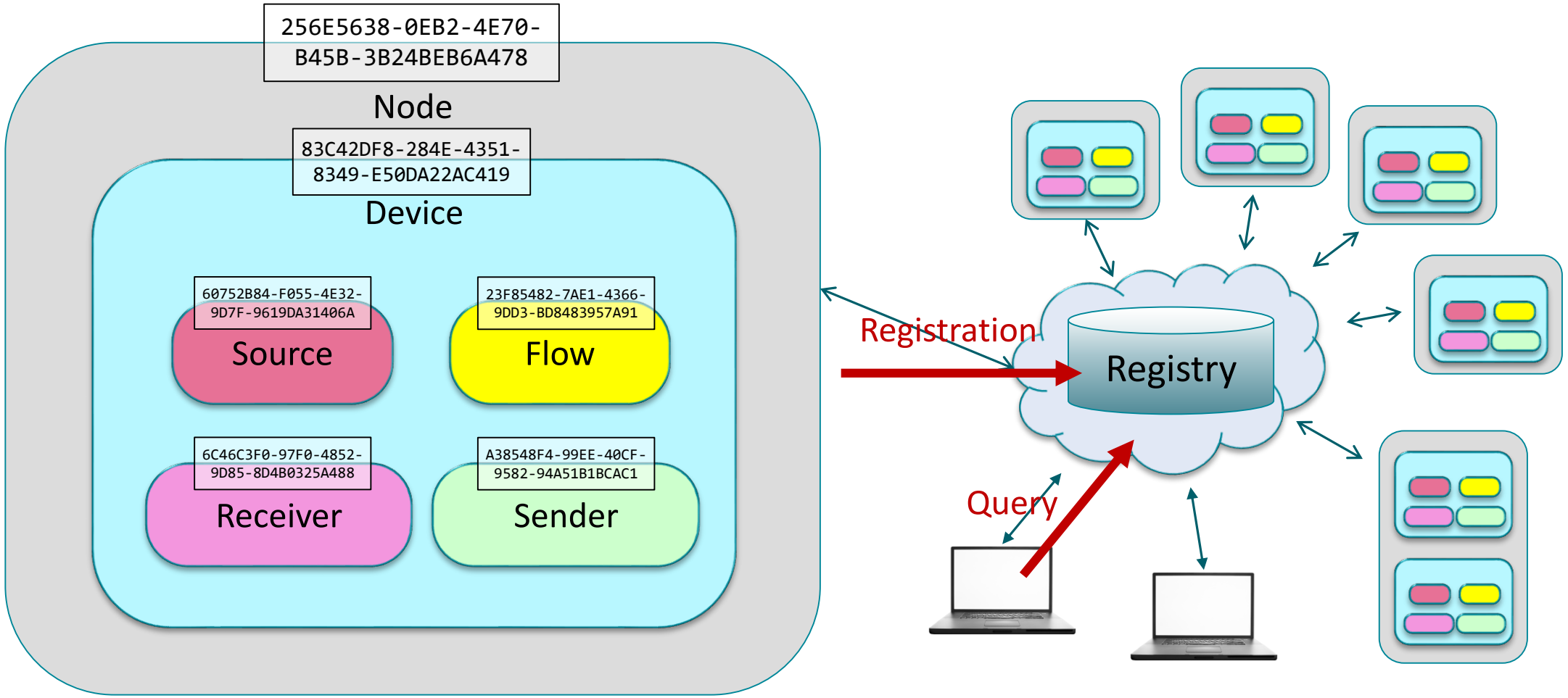

256E5638-0EB2-4E70-B45B-3B24BEB6A478
Node
83C42DF8-284E-4351-8349-E50DA22AC419
Device
60752B84-F055-4E32-9D7F-9619DA31406A
Source
23F85482-7AE1-4366-9DD3-BD8483957A91
Flow
6C46C3F0-97F0-4852-9D85-8D4B0325A488
Receiver
A38548F4-99EE-40CF-9582-94A51B1BCAC1
Sender

IS-04

Discovery & Registration

Ensure that parts of a networked media system can find each other

Networked Media Open Specifications

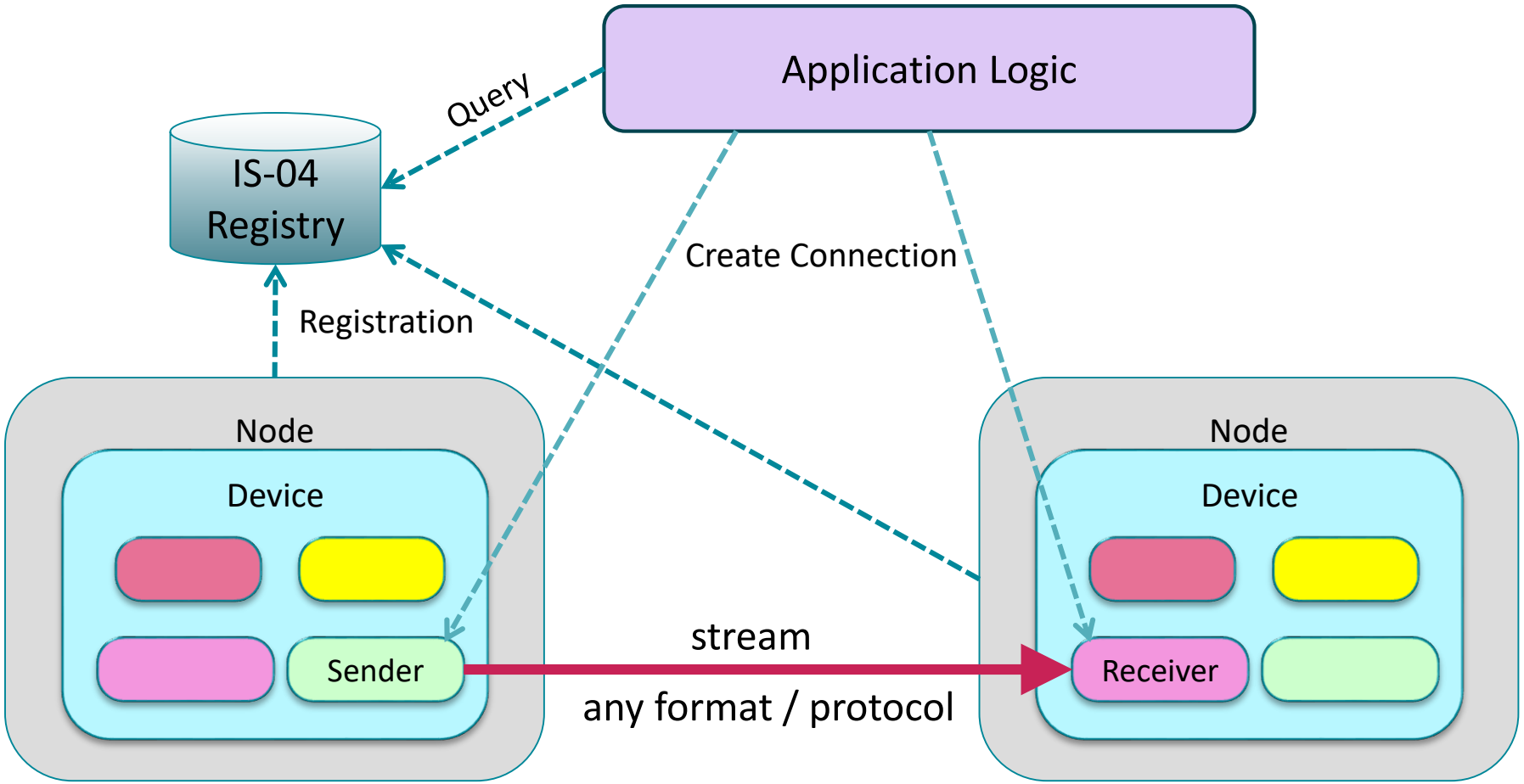


IS-05

Connection Management

Make it simple for applications
to (dis)connect flows

Networked Media Open Specifications



Challenge:

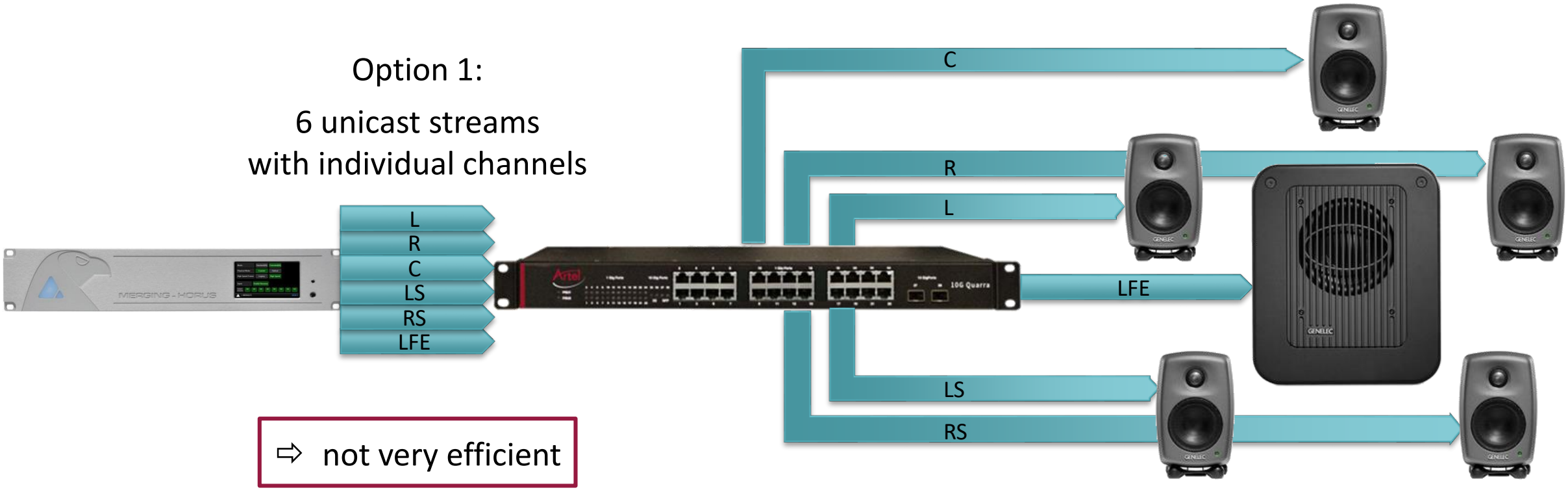
6 channel surround audio

Challenge:

Challenge:

Option 1:

6 unicast streams
with individual channels

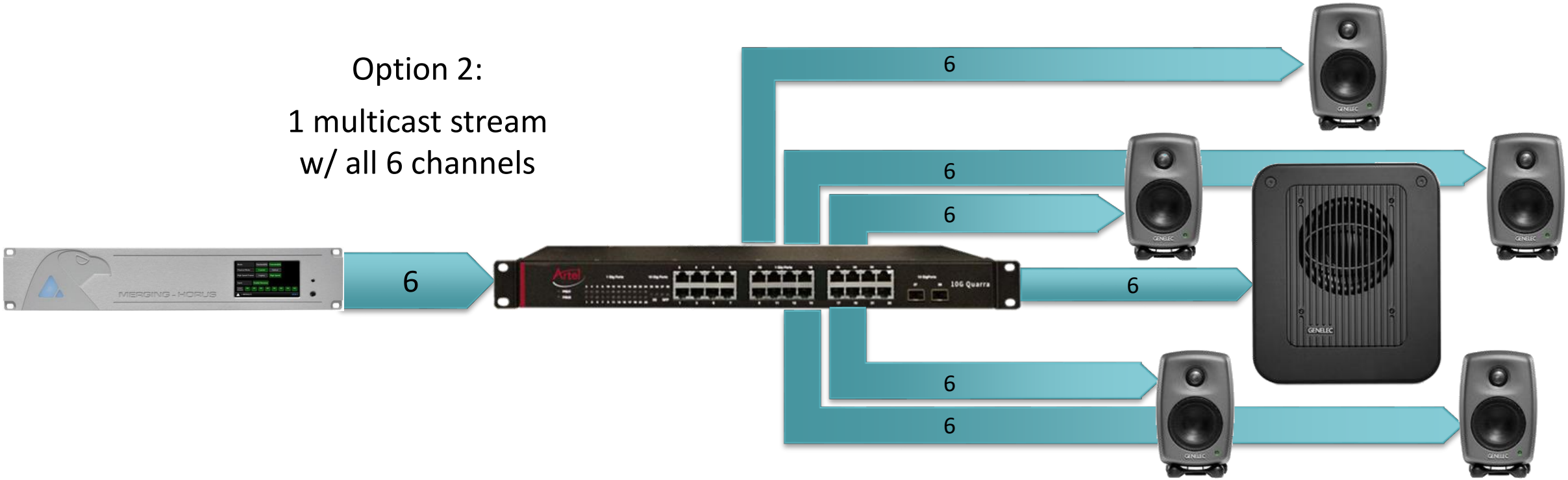


⇨ not very efficient

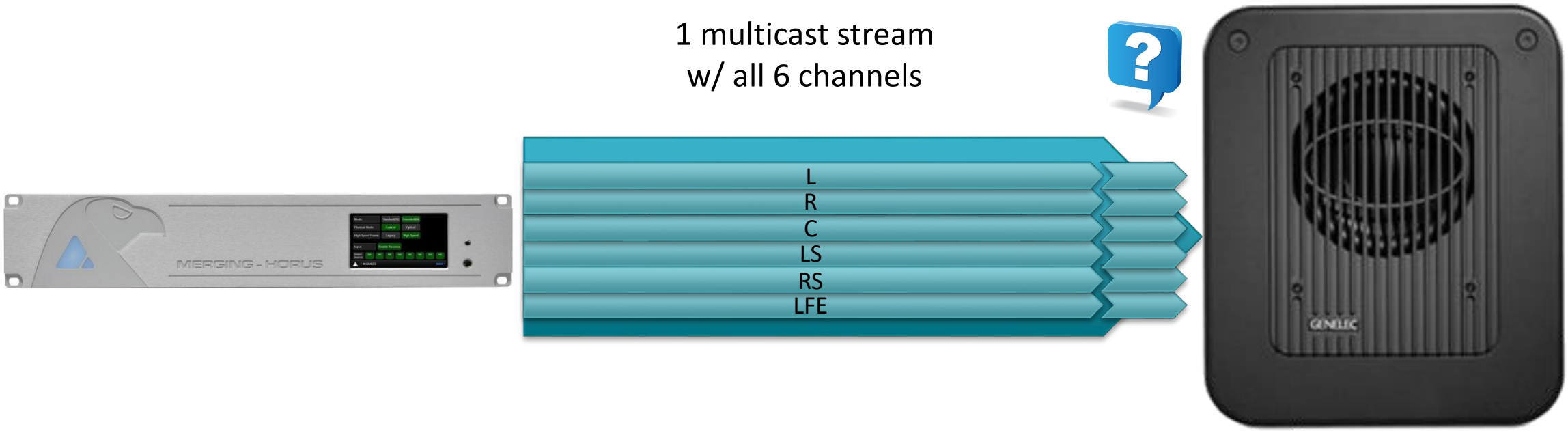
Challenge:

Option 2:

1 multicast stream
w/ all 6 channels



Challenge:

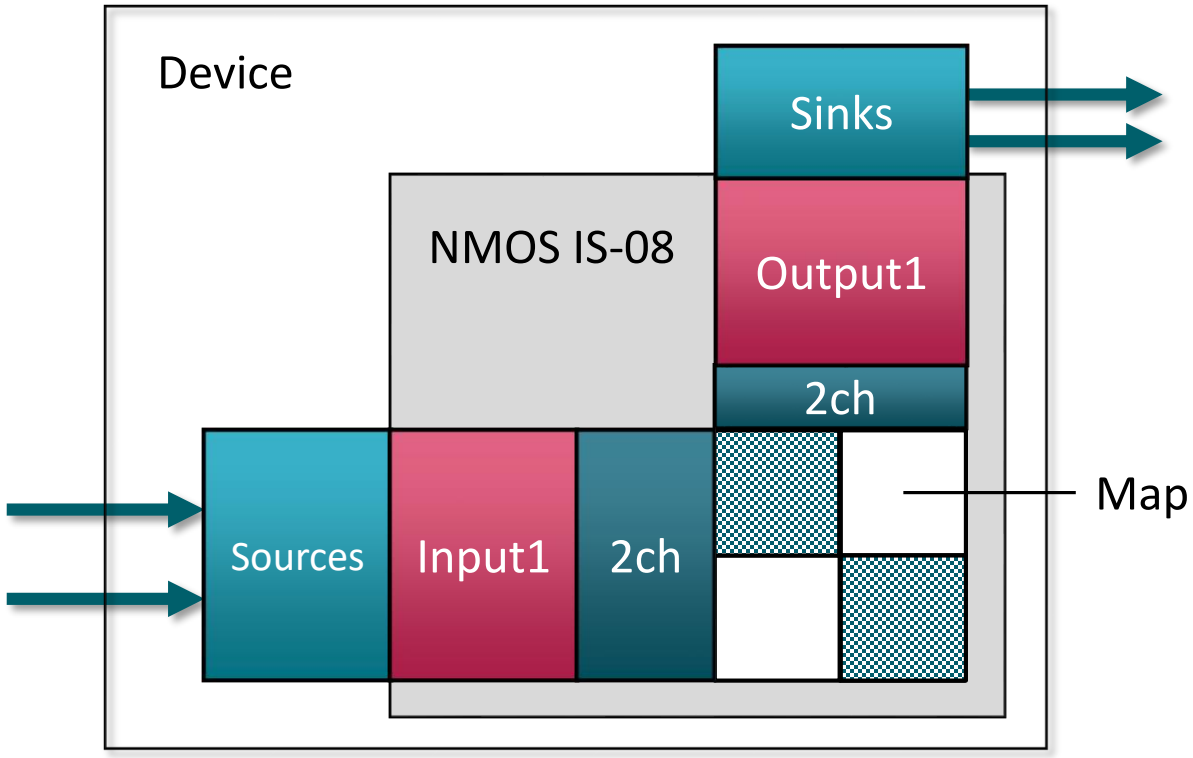

1 multicast stream
w/ all 6 channels
L
R
C
LS
RS
LFE
MERGING · HORUS
GENELEC

IS-08

Audio Channel Mapping

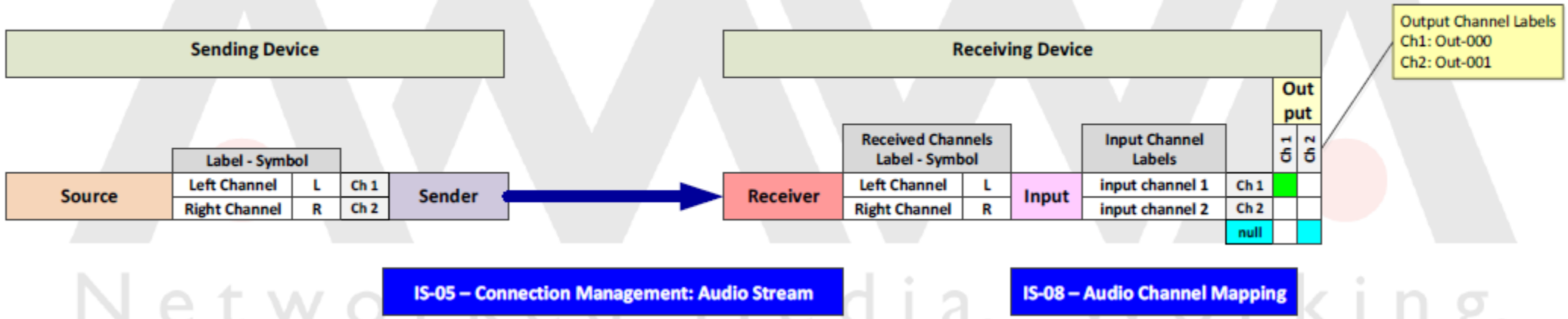
Map flow channels (tracks) to device I/O channels

AMWA NMOS IS-08 - Audio Channel Mapping



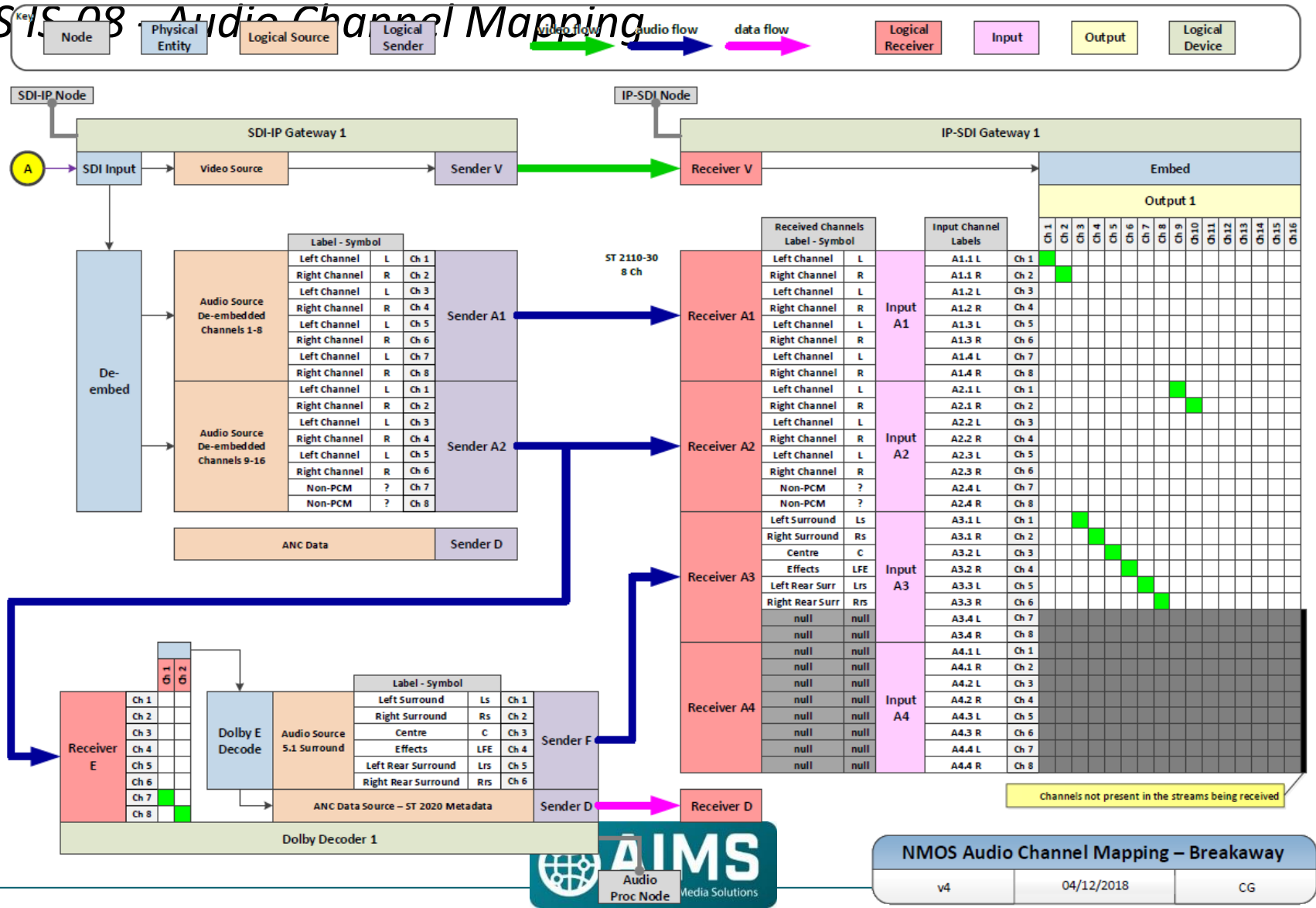
AMWA NMOS IS-08 - Audio Channel Mapping

- Interaction with NMOS IS-05 – connecting incoming stream channels to device output channels



AMWA NMOS IS-08 - Audio Channel Mapping

IP-SDI Gateway



networked media
NMOS
open specifications

Networked Media Open Specifications

Id	Name	Status	Repository
IS-04	Discovery and Registration	AMWA Specification (Stable)	nmos-discovery-registration
IS-05	Device Connection Management	AMWA Specification (Stable)	nmos-device-connection-management
IS-06	Network Control	AMWA Specification	nmos-network-control
IS-07	Event & Tally	AMWA Specification	nmos-event-tally
IS-08	Audio Channel Mapping	AMWA Specification	nmos-audio-channel-mapping
IS-09	System	Work In Progress	nmos-system
IS-10	Authorization	Work In Progress	nmos-authorization
MS-04	ID & Timing Model	Work In Progress	nmos-id-timing-model
BCP-002-01	Natural Grouping	AMWA Specification	nmos-grouping
BCP-003-01	API Security: Communications	AMWA Specification	nmos-api-security
BCP-003-02	API Security: Authorization	Work In Progress	nmos-api-security
n/a	Parameter Registers	Continuing	nmos-parameter-registers

More information on

NMOS wiki on Github:

https://github.com/AMWA-TV/nmos/wiki

Standards:
AES/ IEEE / SMPTE

Standard	Description	Status
AES67-2018	High-performance streaming audio-over-IP interoperability	Approved
IEEE1588-2008	Precision Time Protocol	Approved
SMPTE ST 2022 - 6	High Bit-rate Media Transport (SDI over IP)	Approved
SMPTE ST 2022 - 7	Seamless Protection Switching (RTP streams)	Approved
SMPTE ST 2022 - 8	Timing of ST 2022-6 streams in ST 2110-10 systems	In Progress
SMPTE ST 2059 - 1	Generation of PTP Signals (including definition of Epoch)	Approved
SMPTE ST 2059 - 2	SMPTE Profile for IEEE1588 -2008 (operating parameters)	Approved

Standards:
SMPTE ST 2110 Suite

Standard	Description	Status
SMPTE ST 2110 - 10	System - PTP, RTP and SDP	Approved
SMPTE ST 2110 - 20	Video - Uncompressed	Approved
SMPTE ST 2110 - 21	Video - Traffic Shaping (packet pacing, bursts and gaps)	Approved
SMPTE ST 2110 - 22	Video - Compressed (CBR)	Approved
SMPTE ST 2110 - 23	Video – Multistream (high-bw stream as separate low-bw streams)	In Progress
SMPTE ST 2110 - 30	Audio - Uncompressed (PCM)	Approved
SMPTE ST 2110 - 31	Audio - Compressed (AES3, non-PCM)	Approved
SMPTE ST 2110 - 40	Data - Ancillary (SDI)	Approved
SMPTE ST 2110 - 41	Data - Fast Meta Data	In Progress

Standards ?
Technical Recommendations

Standard	Description
AMWA NMOS IS - 04	Device Discovery and Registration
AMWA NMOS IS - 05	Connection Management
AMWA NMOS IS - 06	Network Control
AMWA NMOS IS - 07	Event & Tally
AMWA NMOS IS - 08	Audio Channel Bundling
AMWA NMOS IS - xy	Flow Grouping, ID & Timing, Scalability, Security & more
SMPTE ST RDD 34	Sony LLVC compression
SMPTE ST RDD 35	IntoPIX TICO compression
JT-NM TR-1001-1	System Environment and Device Behavior

Questions?

Answers!

ST2110 / AES67 Resources:

RAVENNA AES67 built-in — www.ravenna-network.com/resources

AIMS Alliance for IP Media Solutions — www.aimsalliance.org (resources)

SMPTE — www.smpte.org/smpte-st-2110-faq

You've made it!

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RAVENNA booth @ 7-V220

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