What is SMPTE ST2110?

Andreas Hildebrand
RAVENNA Evangelist

2019-02-06
ISE Amsterdam

SMPTE ST2110

SMPTE ST2110 – Professional Media over Managed IP Networks

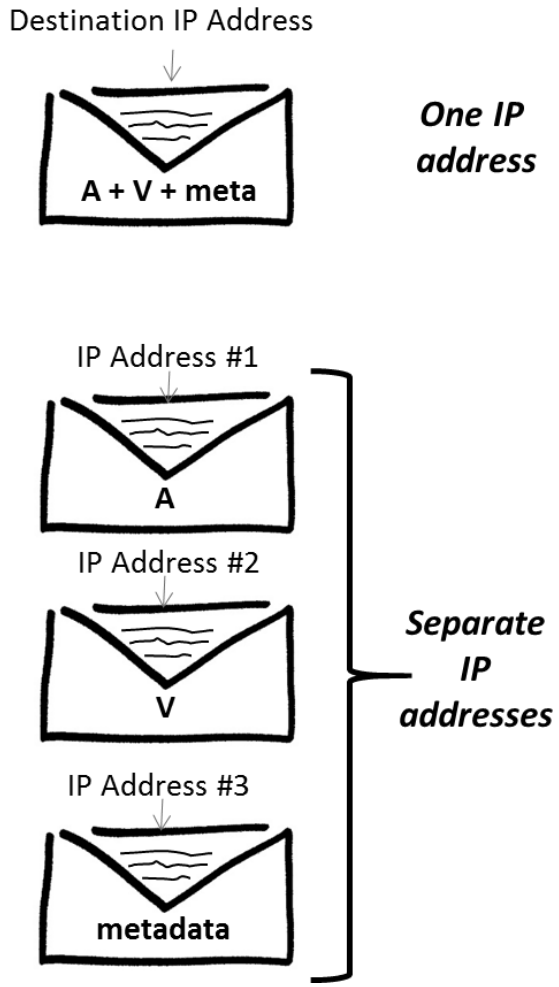
The SMPTE ST 2110 standards suite specifies

- 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.

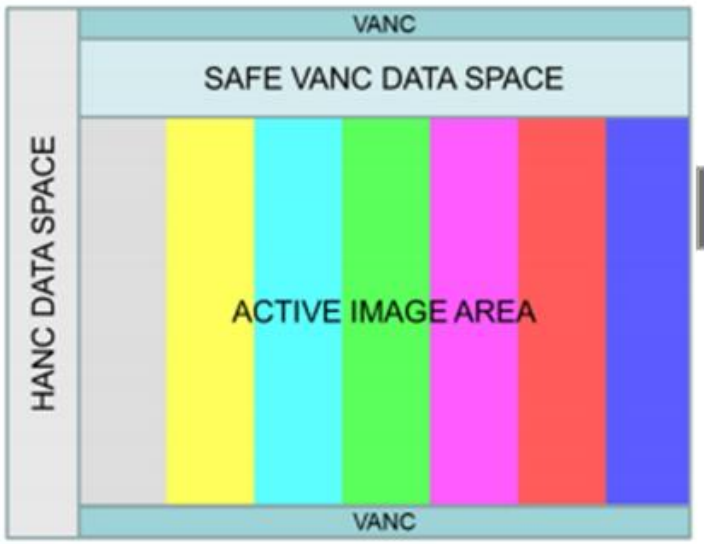
Two Fundamental Approaches to IP Transport

- **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



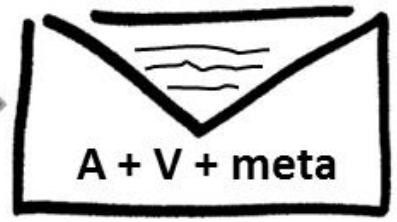
SDI Raster

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**

IP Address #1

Audio

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

IP Address #2

Metadata

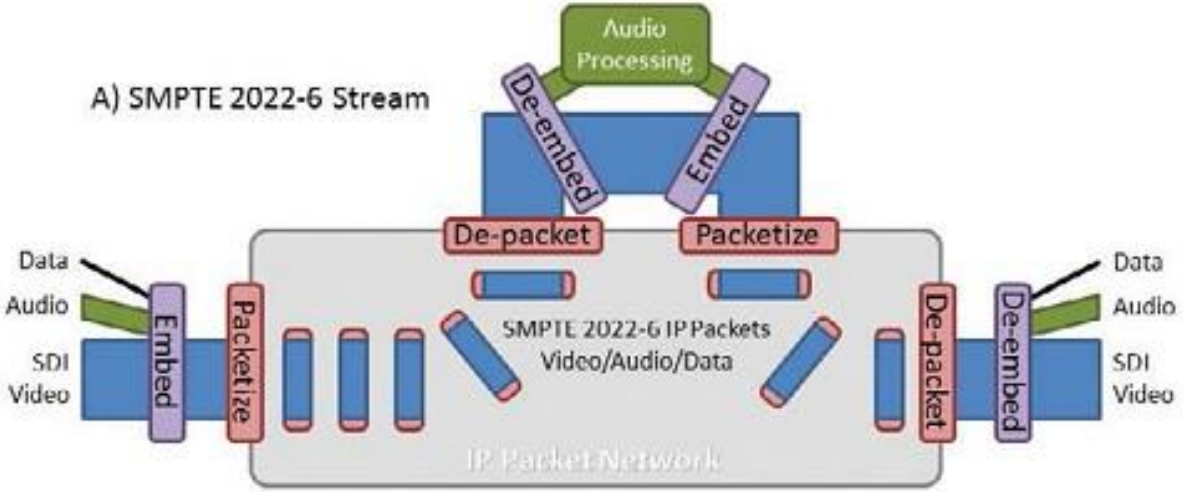
IP Packetization of ANC Data
Method: **SMPTE ST 2110-40**

IP Address #3

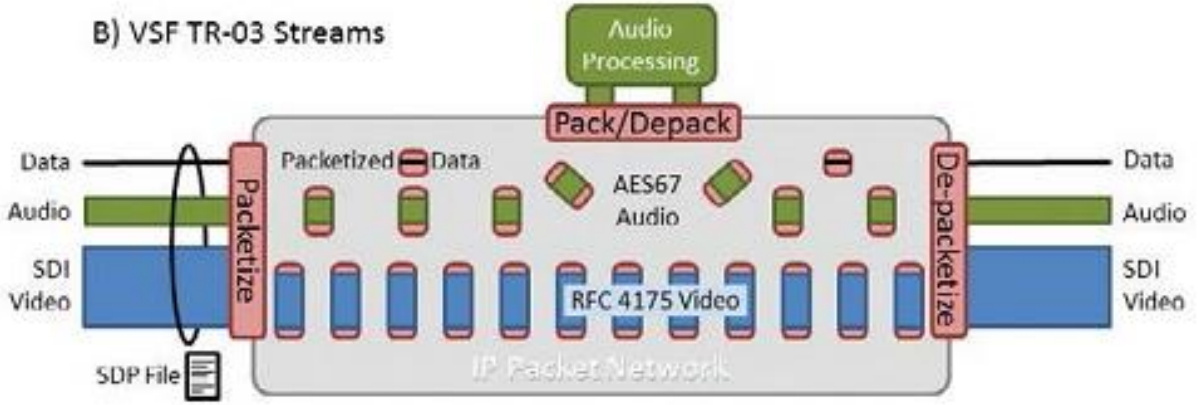
Published beginning in 2017

Bundled vs. Essence-based Approach

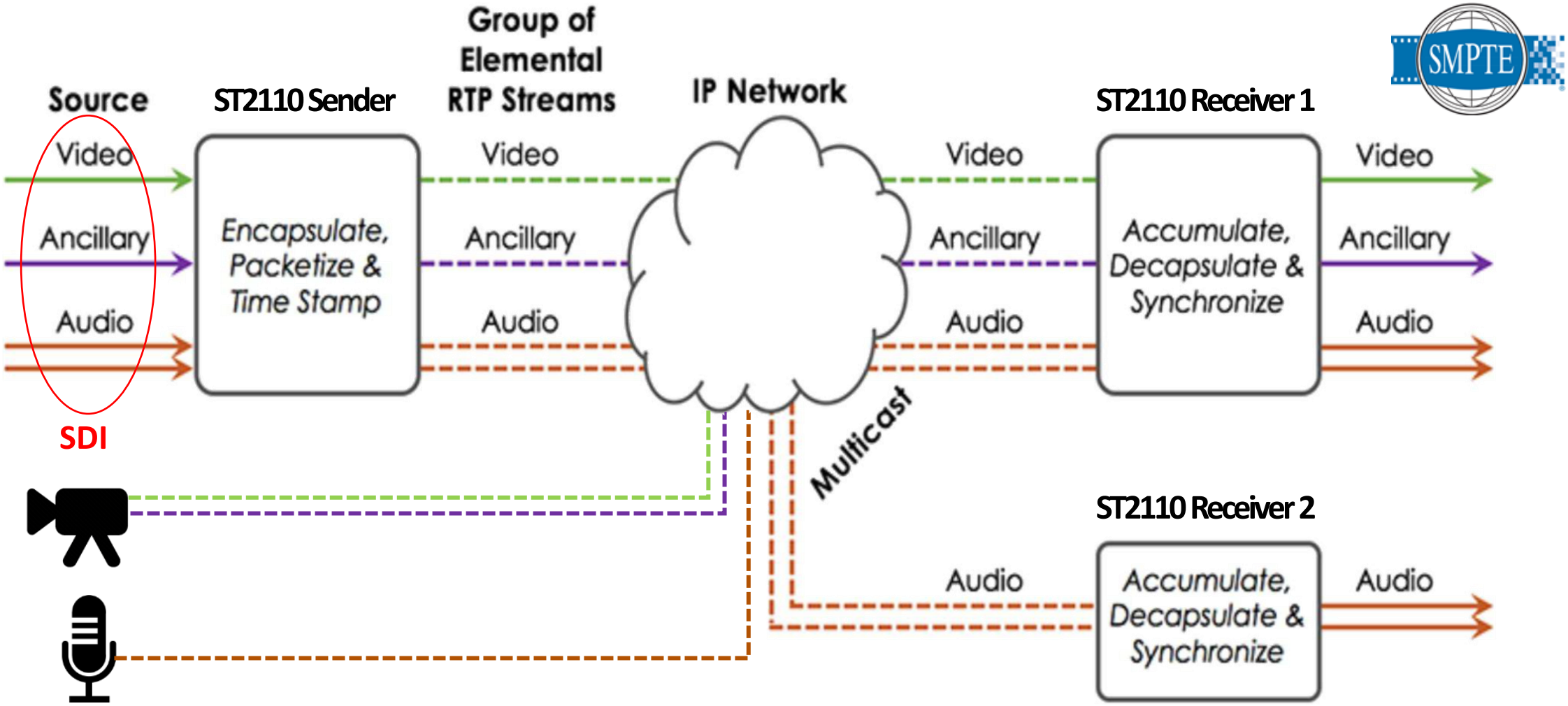
ST 2022-6



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)

The SMPTE ST 2110 Suite of Standards

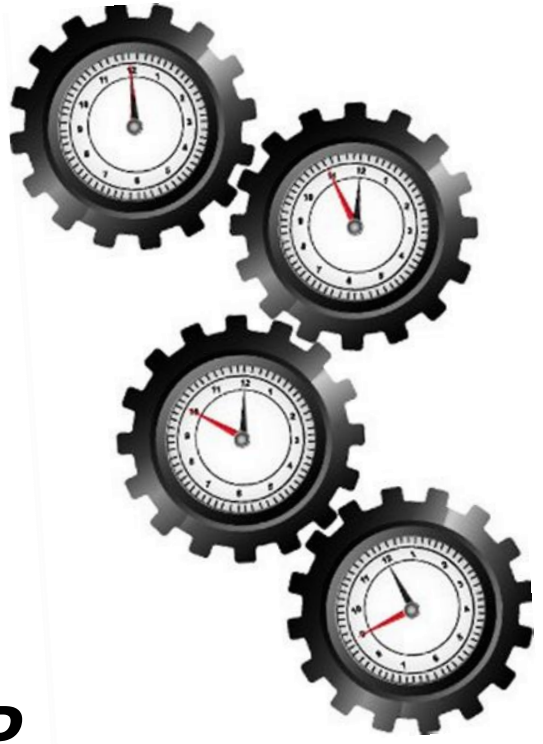
Document structure (in development)**:**

- 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)

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

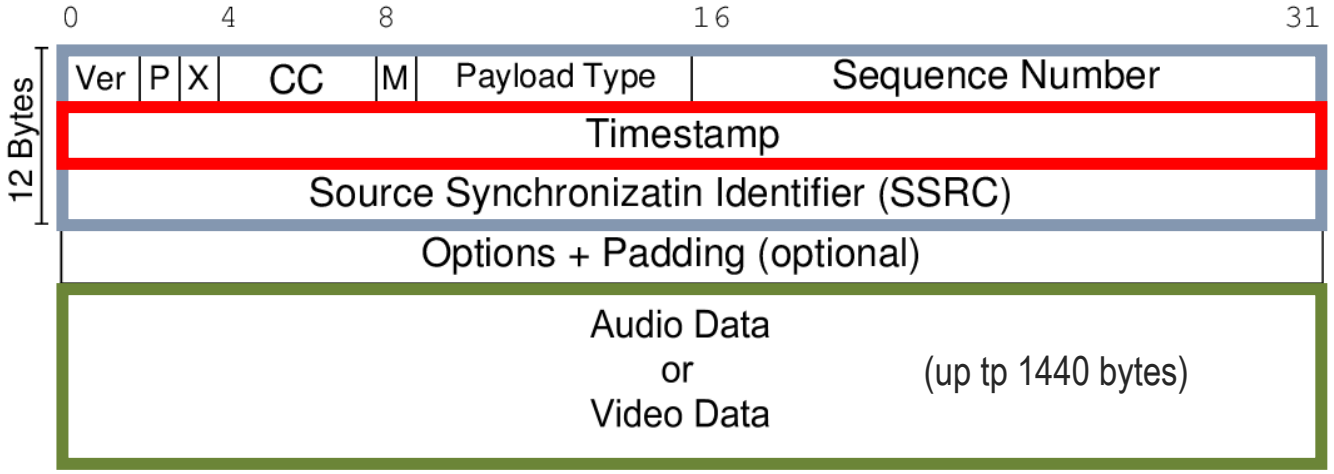


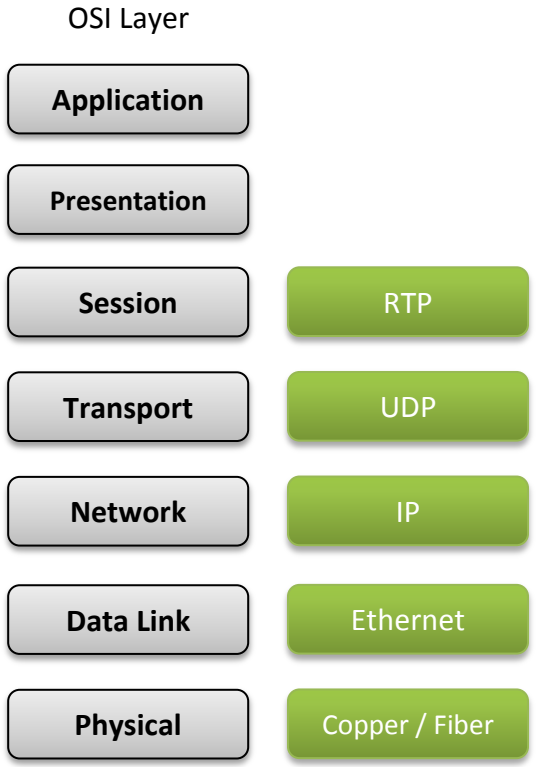
Both AES67 and SMPTE ST 2110 use PTP

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,

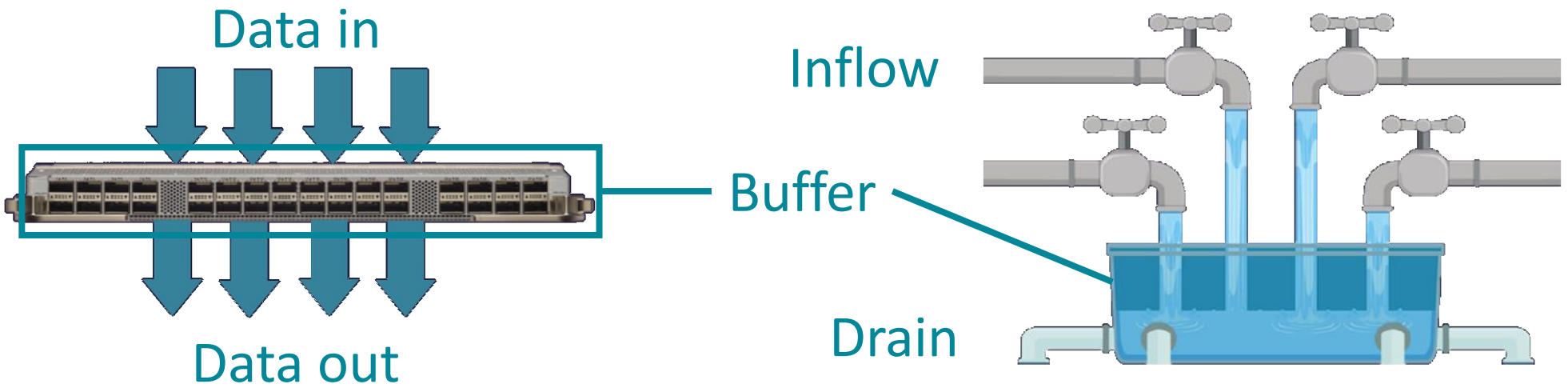
  i.e. 1080p50:
  - ST 2022-6 = 3,074Gbps
  - ST 2110-20 = 2,143Gbps

⇨ 30% bandwidth saving!

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

Problem Overview

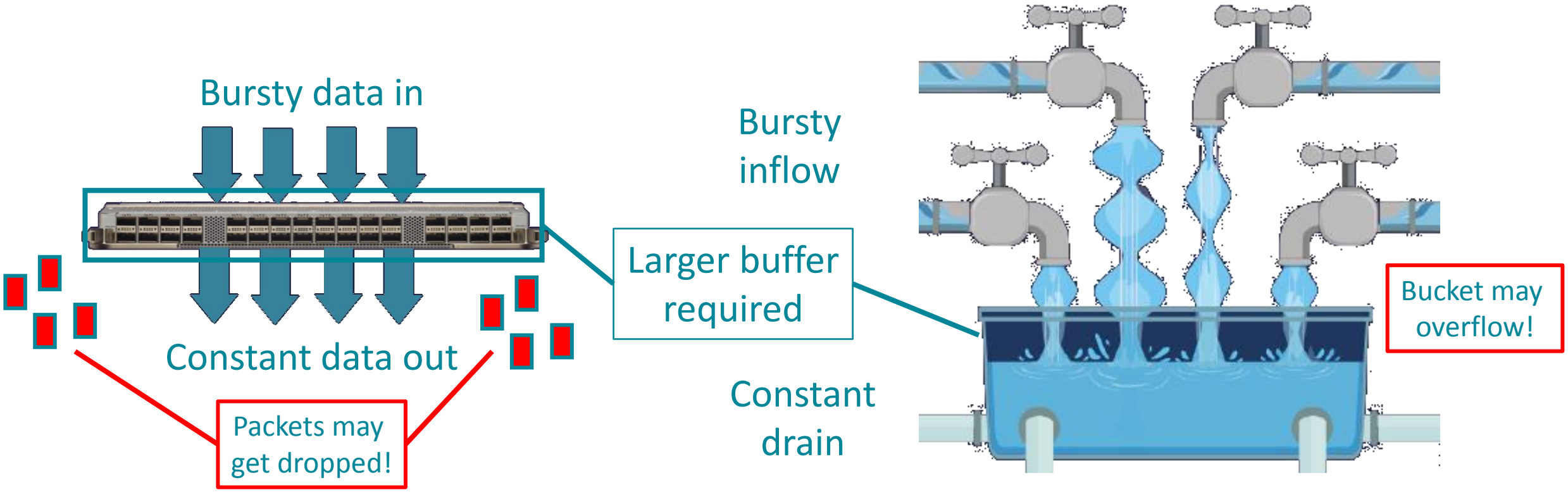
- Video flows require fairly high data rates
- Multiples flows are concurrently traversing the network
- Network switches (and receivers) have limited buffer capacity
- Constant data flow will not overload the buffers as long as total used bandwidth stays below maximum bandwidth



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

Problem Overview

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



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

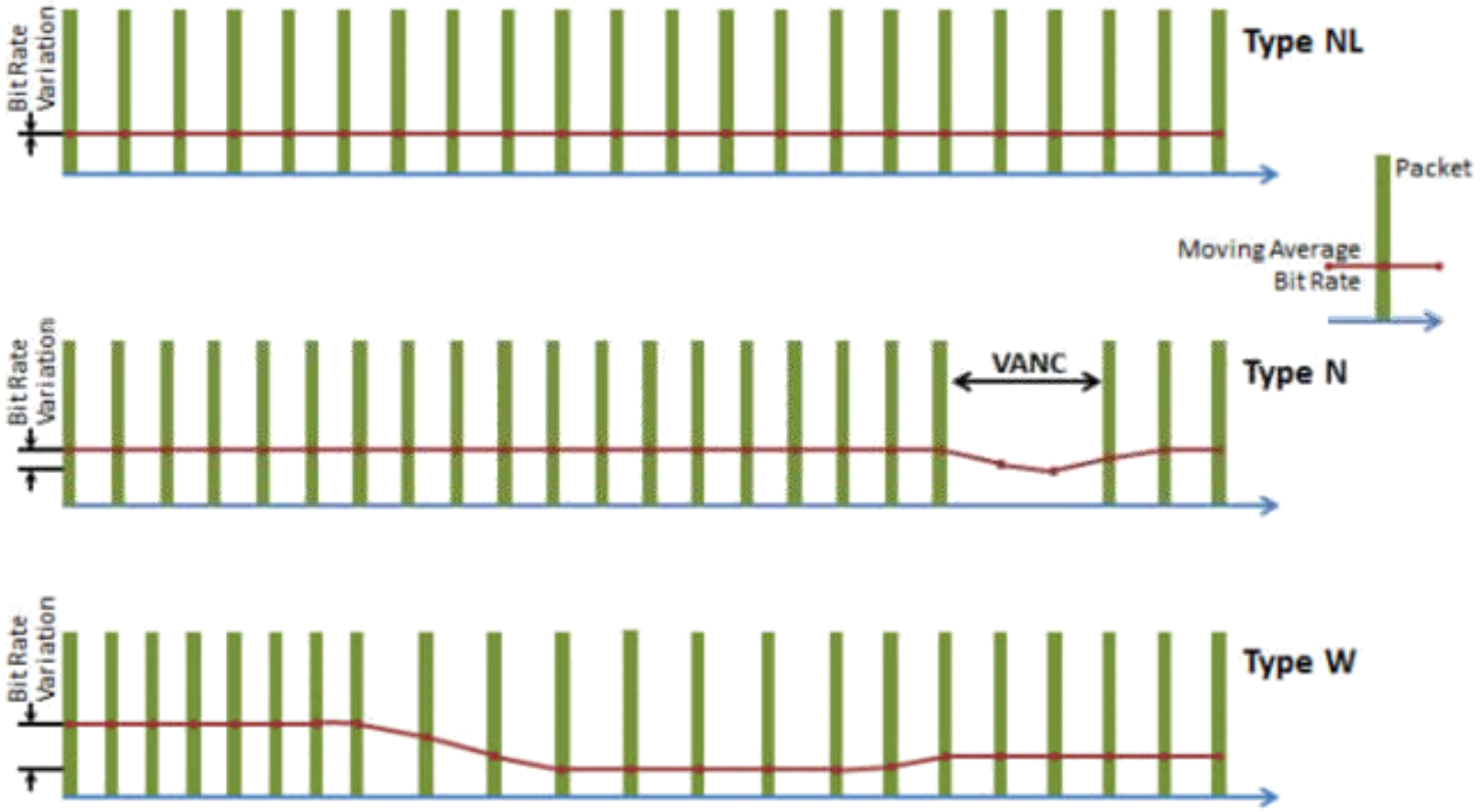
Solution

- Define sender drain behaviour (packet egress pacing and spacing) and (receiver) buffer requirements
- 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)

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

Solution

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



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

Solution

- Define sender drain behaviour (packet egress pacing and spacing)
- 3 models:
  - 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 2110-22
Video - Compressed

Specifies the payload format for **constant bit-rate compressed video** formats

- 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
- Constant bit-rate:
  - no specific codec / compression technology defined
  - codecs registered / enumerated in SMPTE registry,
    i.e. Generic-VC2, HT-J2K, …

SMPTE ST 2110-30
Audio – Linear PCM

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)

AES67

AES67

What was the original goal?

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

What is AES67?

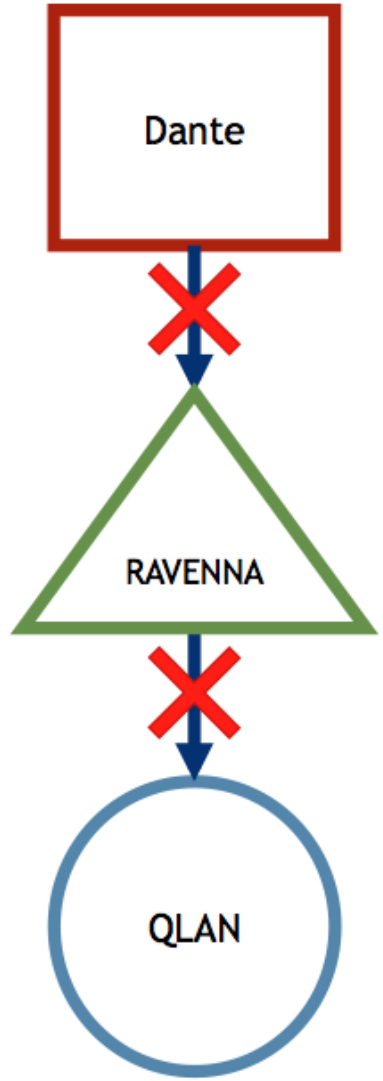
- Interoperability Standard for high performance Audio-over-IP networks
- Based on existing protocols and trusted IT standards
  - This ensures compatibility with existing network infrastructure
  - Allows coexistence with other IT data
  - High adoption rate by all major solution providers

AES67

AES67

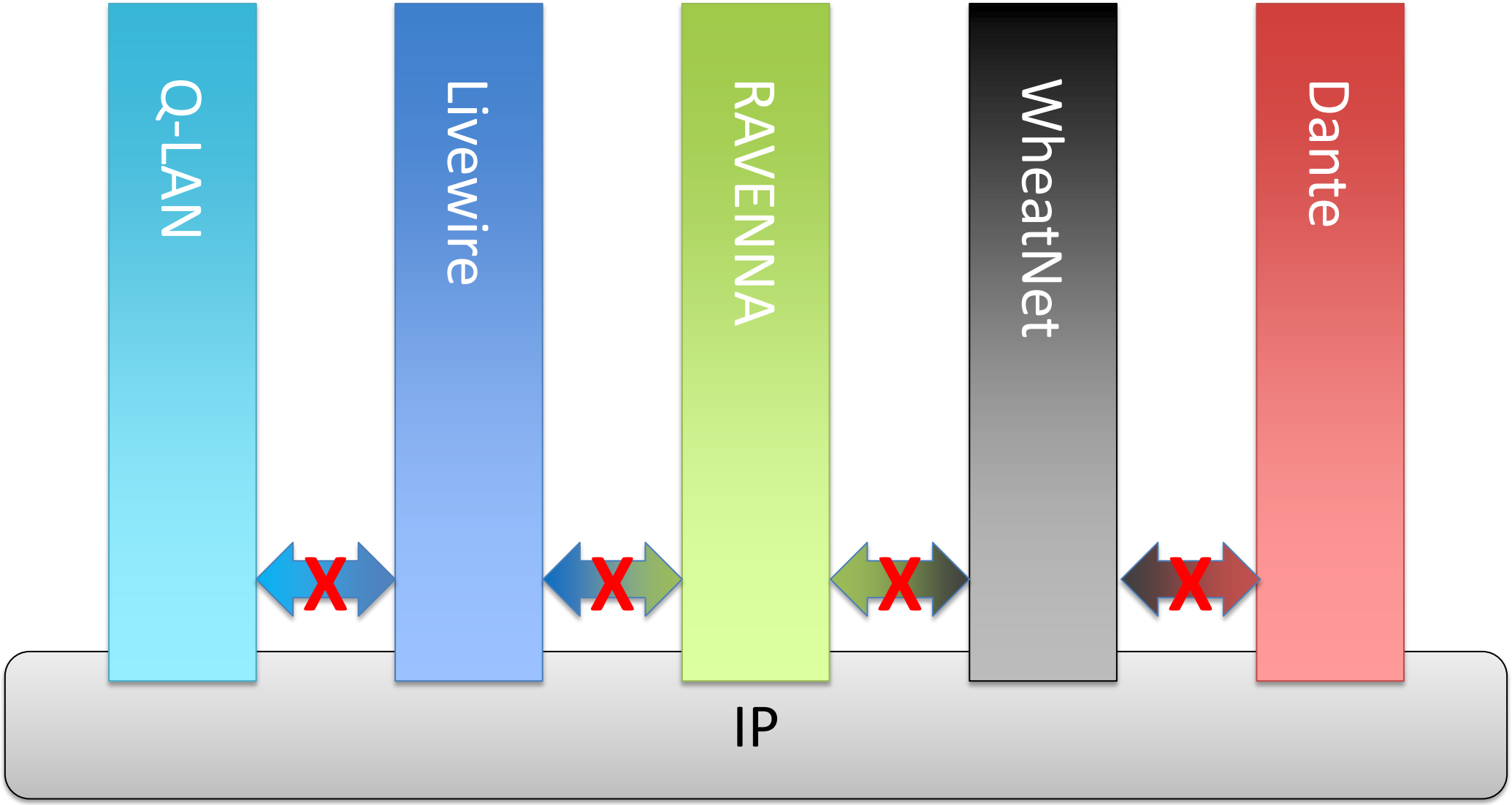
Problem Statement

- 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

AES67

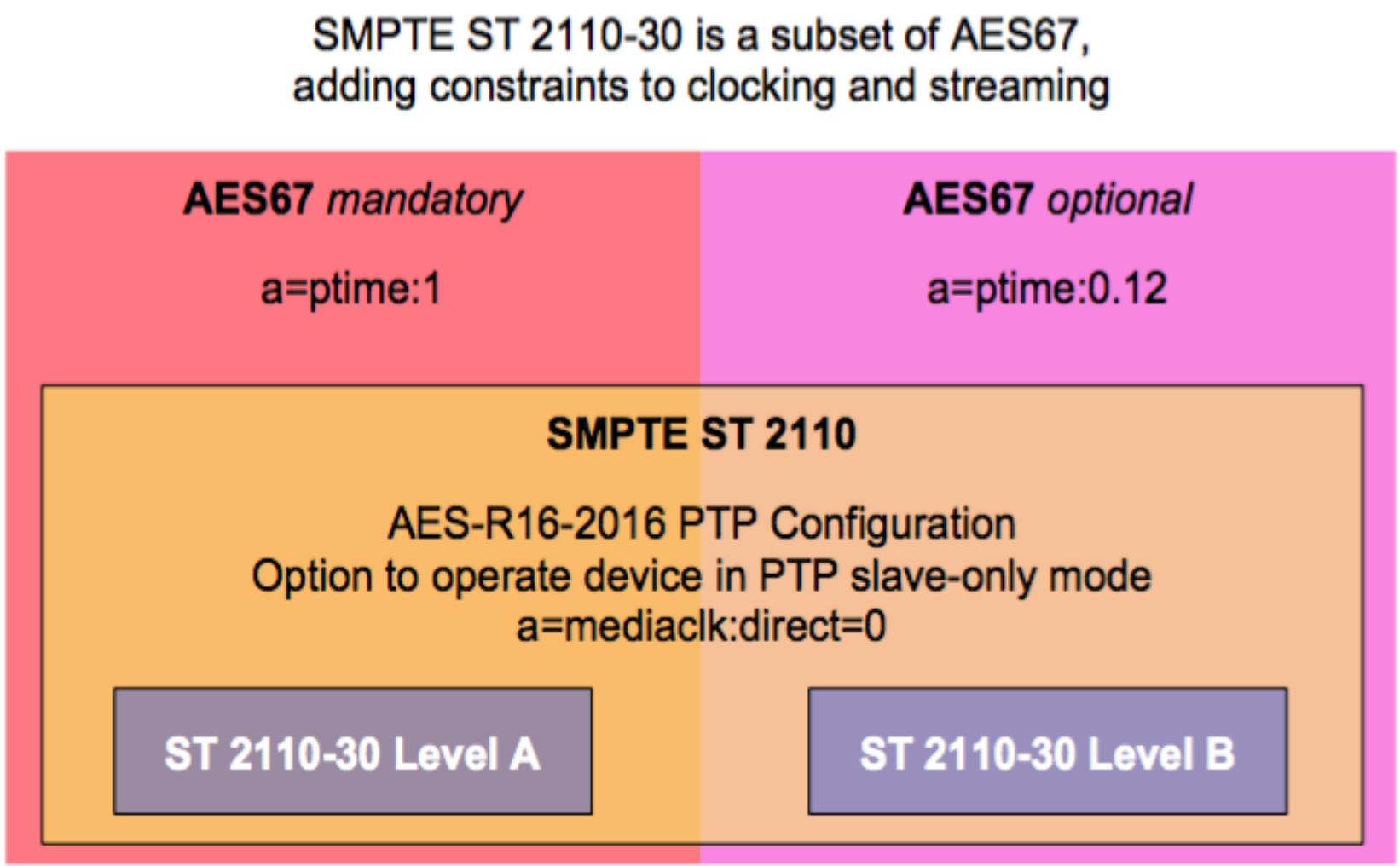
AES67

AES67 technology components

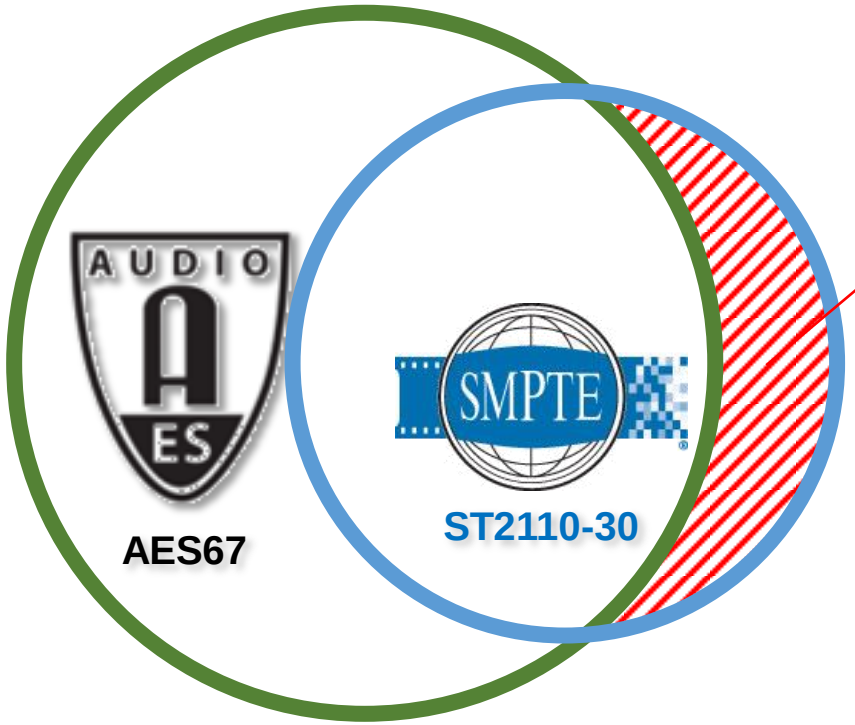
Discovery	Not specified (NMOS IS-04/05)
Connection Management	SIP (unicast), IGMP (multicast)
Session Description	SDP (RFC4566, RFC7273)
Encoding	L16/L24, 1..8 ch, 48 samples
QoS	Differentiated Services (DiffServ w/ 3 CoS)
Transport	RTP / UDP / IP, unicast & multicast
Media Clock	48 kHz
Synchronisation	IEEE 1588-2008 (PTPv2)

AES67

ST2110 and AES67 Compatibility



ST2110 and AES67 Compatibility



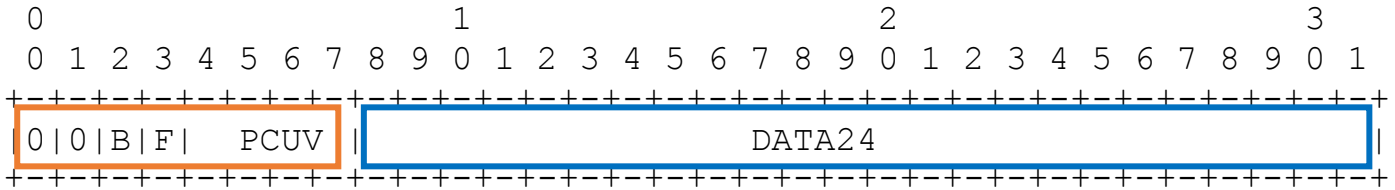
Constraints!

- AES-R16-2016 PTP configuration
- option to operate device in PTP slave-only mode
- a=mediaclk:direct=0

SMPTE ST 2110-31
Audio - 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:

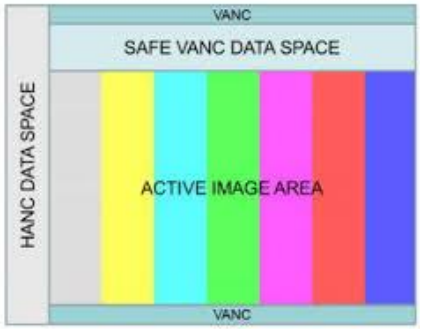
```
a=rtpmap:<pt> AM824/48000/<nchan>
```

  - retains all other SDP parms

SMPTE ST 2110-40
Data – 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)
- Receivers creating SDI output which contains Ancillary Data Packets shall meet the requirements of SMPTE ST 291-1 when constructing the HANC and VANC
- Senders of ANC Data packets may use the “Line_Number” and “Horizontal_Offset” fields to indicate the proposed SDI location information for the ANC Data Packet

Other Key Standards/Specifications

- Seamless Protection Switching: SMPTE ST 2022-7
- Discovery & Registration: AMWA IS-04
- Connection Management: AMWA IS-05
- Network Control: AMWA IS-06
- Event & Tally: AMWA IS-07
- Audio Channel Bundling: AMWA IS-08
- Flow Grouping, ID & Timing, Scalability, Security & more AMWA IS-xy
- “Full stack” JT-NM TR-1001-1

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

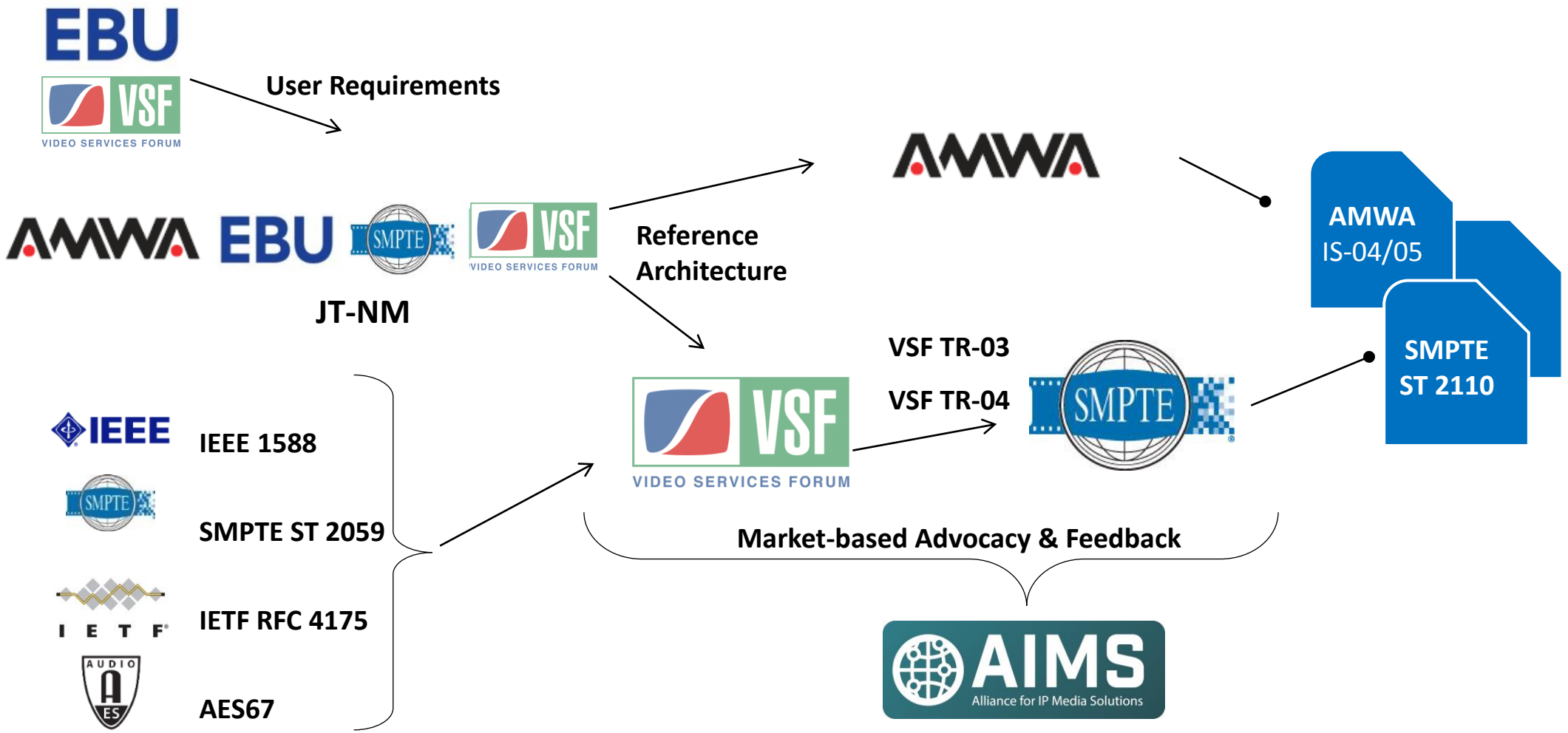
Standards !
SMPTE ST 2110 Suite

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)	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

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 Behaviors for SMPTE ST 2110 Media Nodes in Engineered Networks)

AIMS Role and The Power of Collaboration



Summary

SMPTE ST 2110 is a growing and comprehensive suite of standards enabling carriage, synchronization and alignment of audio, video and metadata over IP for professional media applications and applicable range of use cases, even to low latency applications such as live production, and capable of handling future resolutions, frame rates, color sampling and bit depths.

Thank you!

Andreas Hildebrand

ALC NetworX

RAVENNA@alcnetworx.de