What Every AV Engineer & System Designer Should Know About IPMX

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infocomm

MACNICA

Agenda

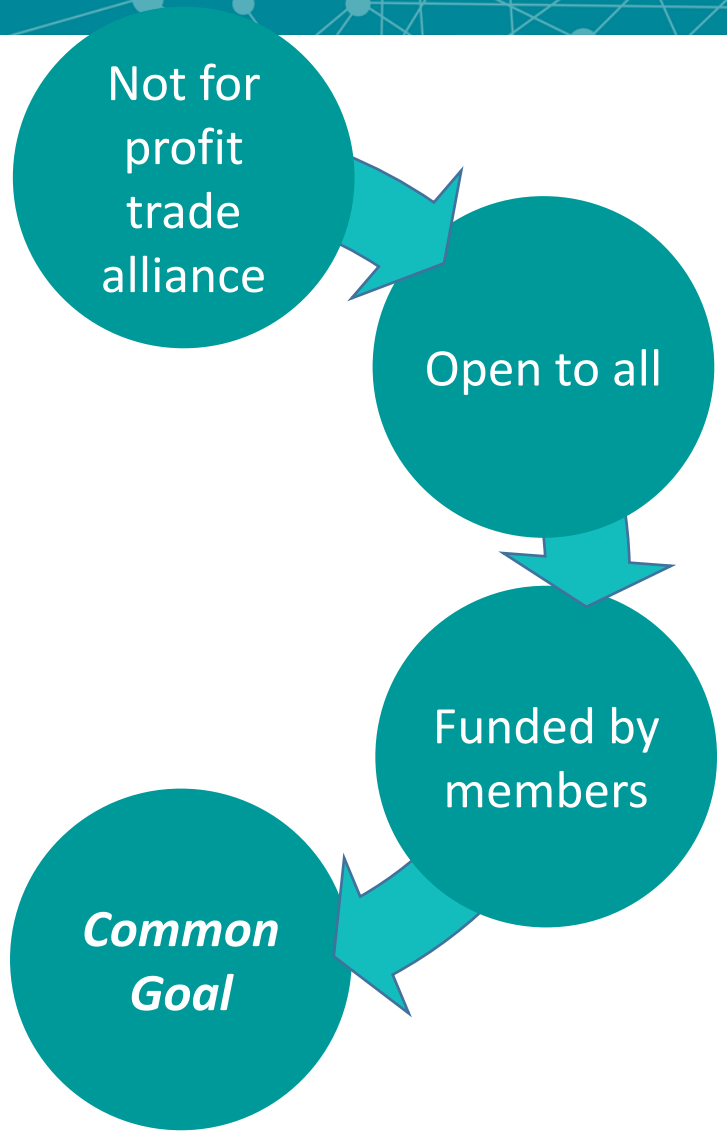
- Whirlwind through the basics
- Protocols and standards in use by IPMX
- Overview of the Architecture
- Some cool details about timing, HDCP and EDID
- Time for questions from you to me and the other way backwards.

IPMX defined

IPMX is an AV-over-IP open standard that enables the transmission of high-quality video, audio, and control signals over standard Ethernet networks.

= general, open standard for AV over IP networks

Where does IPMX come from?



Members List

67 Members

AIMS Alliance for IP Media Solutions

Organizations Involved…

VSF VIDEO SERVICES FORUM

AMWA

Technical Recommendations

SMPTE

EBU

AUDIO ES

Standards

JT-NM

SMPTE EBU VSF

JT-NM TESTED SMPTE ST 2110

Reference Architecture

AIMS Alliance for IP Media Solutions

Market Adoption

One common goal…

Distinct roles…

Powerful Partnership

The Basics

Established

ST 2110 and NMOS:
100Ks of deployed devices

Open API

NMOS: Registration & Discovery,
Registry or P2P, Control

Video

SD → 32K, JPEG-XS, EDID/HPD
Compression, Uncompressed

Security

Oath2, HTTPS, and HDCP 2.3

Transport

Multicast & Unicast,
Elementary Streams, UDP, RTP,
1-100+ GbE

Timing

All devices support PTP, optional within system. Asynchronous and Synchronous sources supported .

Audio

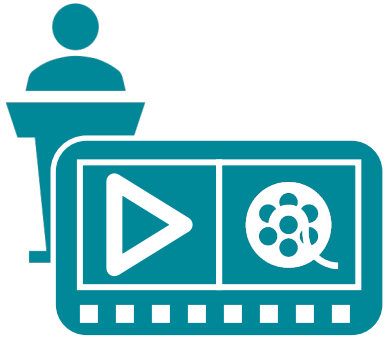
Can be AES 67 compliant, Common Pro AV & Consumer Formats

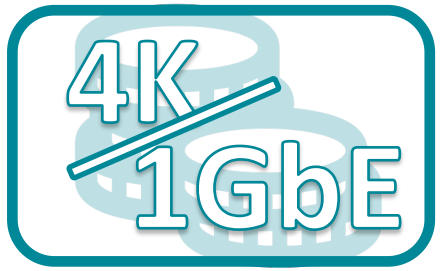
Control

USB/KVM, CEC, Serial, GPIO Extension

Main Differences from existing solutions

- An **open standard** based on SMPTE ST 2110 and AMWA NMOS
- **Multiple implementations** from multiple manufacturers are already in interoperability testing.
- Works perfectly in **live production**, **interactive** and **presentation** applications.
- **Common control** plane API (NMOS)
- Supports **multiple profiles** for different bit rates and applications: Uncompressed, Mezzanine/Sub-Frame Latency, High-Compression/WAN
- **Very flexible,** not tied to a specific bandwidth.





ProAV Format Comparison

Capability/Feature	IPMX	ST 2110	SDVoE	HDBaseT
Uncompressed 4K60p Video	Yes	Yes	No	Yes
Visually Lossless Compression	Yes	Yes	Yes	No
Network-based Precision Clock (PTP)	Optional	Required	No	No
Open Standard	In process	Yes	No	No
HDCP Support	Yes	No	Yes	Yes
ST 2110 Compatibility	Yes	Yes	No	No
IR Control Link	No	No	No	Yes
PoE (Power over Ethernet)	Possible	No	No	Yes
Infrastructure	Any	Any	10 GbE	CAT 5 (Not IP)
Data Channel*	Not Required	Not Required	Up to 1 Gbit/s	Up to 100 Mbit/s

*IPMX and ST 2110 work over standard IP/Ethernet infrastructure. As such, other IP and Ethernet data flows can easily be transported over the same networks. Therefore, there is no need to make provisions within these specifications for a designated data channel.

What about NDI?

- NDI intellectual property owned by Vizrt
  - NDA required for licensing, plus royalty payments
  - Free version includes tool kit and high-level SDK, email address required
- NDI technology attributes
  - Well-suited for live production
  - Strong registration and discovery capabilities
  - Based on DCT, 16 lines of delay in tuned system
  - Minimum 1 field of delay per encode/decode hop
  - **Currently no support for 4:4:4 (?), HDCP or EDID**
- Gaining popularity in live production space, along with ST 2110.

IPMX Roadmap

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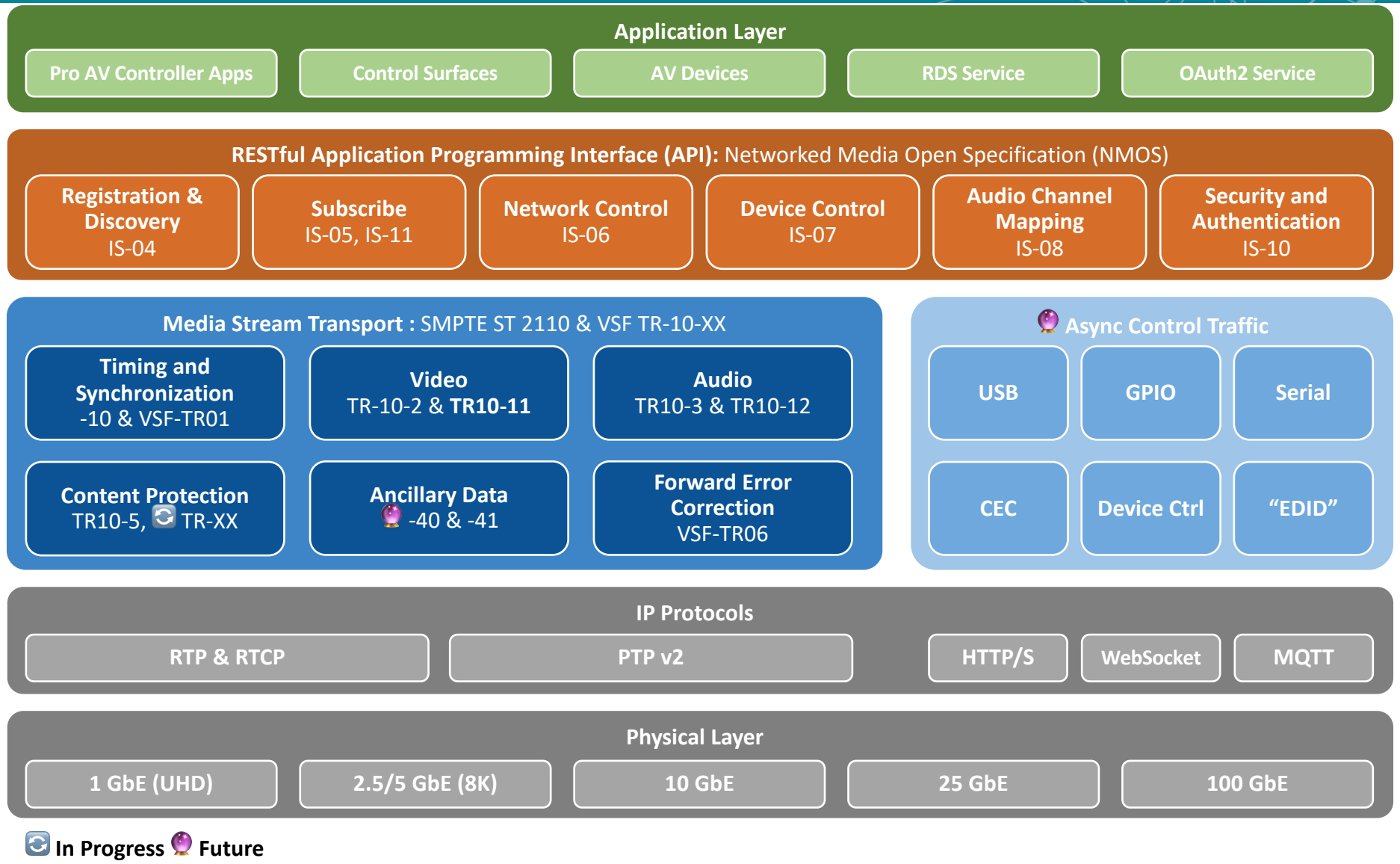
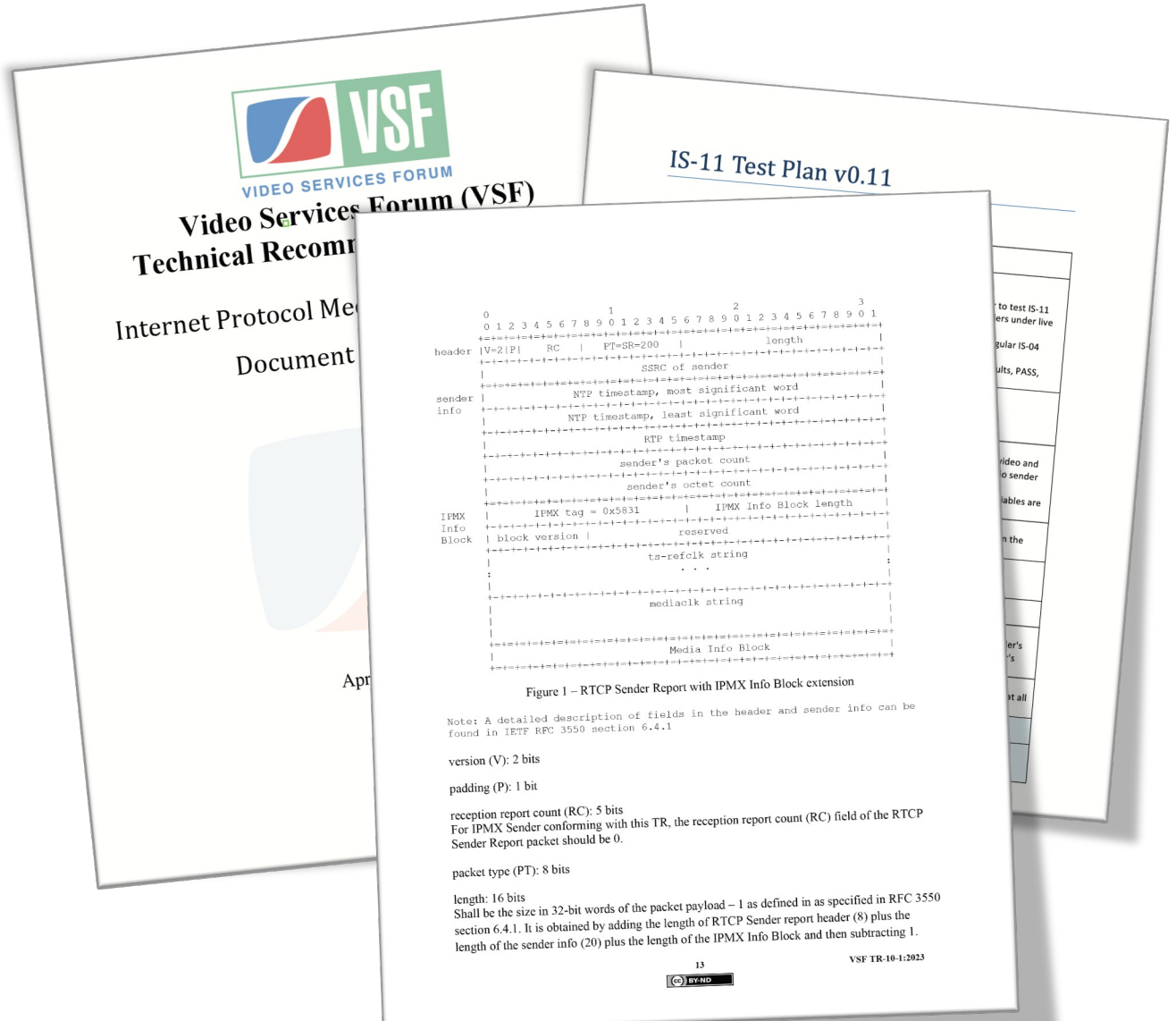
	in progress	phase 1	phase 2	
control	✅ **Discovery, Registration, Connections** NMOS IS-04 & 05 🔄 **Dynamic Connections** NMOS IS-05 & 07, IS-11 Receiver Capabilities, EDID / HPD	🔄 **Services and Node Behavior** Pro AV version of TR-1001-1 ✅ **Audio channel mapping** NMOS IS-08 **Support for Legacy Integration** ARC, CEC, IR, GPIO, RS-232, … ✅ **Network addressing** IPv4/IPv6	🔄 **Training and Certification** Curriculum, Materials, … **Device / Content Control** Open, public control framework **USB – HID** Registration, Discovery, and Connection with support for Touch Screens	true plug & play
media	✅ **Uncompressed Video & Audio** ST 2110-20 & 30, AES67, AES3 🔄 **Compressed Video** Open, Freely Available CODEC ✅ **Precise Timing** SMPTE ST 2110-10, ST 2059 ✅ **Simplified Timing** VSF-TR10-1	✅ **Forward Error Correction** VSF-TR10-06 ✅ **Pro AV Audio Formats** VSF-TR10-3	🔄 **WAN & Internet Compression** Codecs widely implemented in the AV over IP market 🔄 **WAN Error Correction** Automated Return Request (RIST or SRT, tbd) **Access Services** (e.g. Closed Captioning) SMPTE ST 2110-40 or 41	full flexibility
security	✅ **Access, Authentication & Control Encryption** NMOS IS-10	✅ **Copy protection** HDCP 2.3, VSF-TR10-5 🔄 **Content Encryption** PEP, VSF-TRxx	✅ **Complete** 🔄 **In Progress**	secure by design

High-level IPMX Protocol Stack

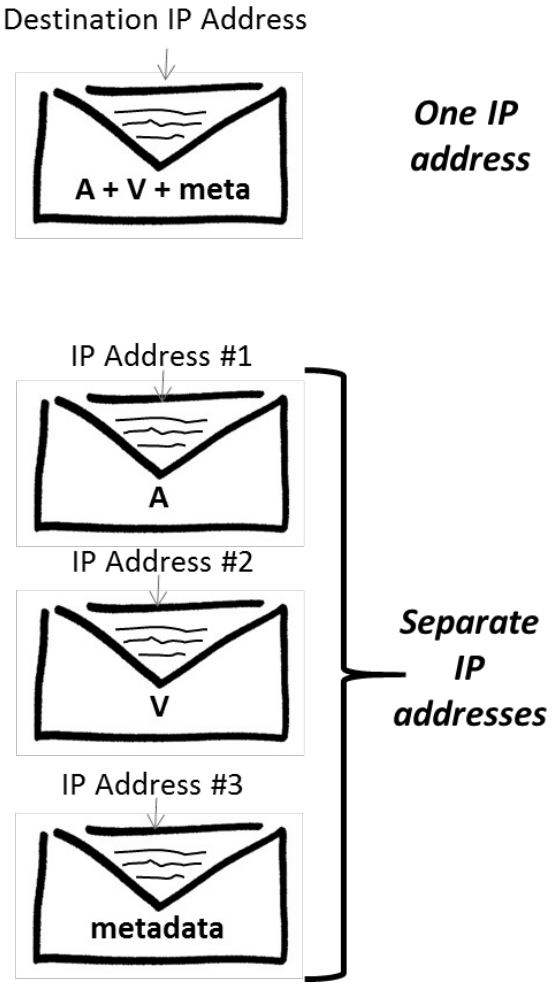


Architecture & Technical Details

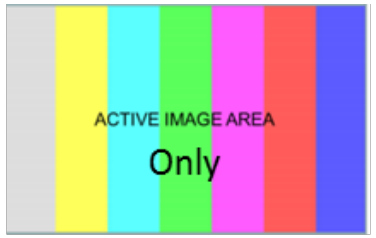


Two Fundamental Approaches to IP Transport

- **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 ***dedicated endpoint devices***
  - Individual essence kept in sync using PTP timing

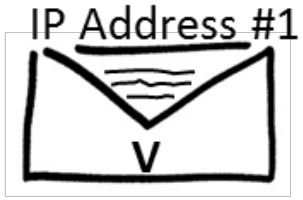


The Essence-based Approach: SMPTE ST 2110



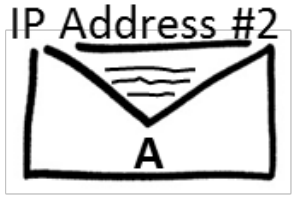
Active Video

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



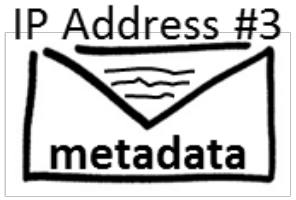
Audio

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



Metadata

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



SMPTE

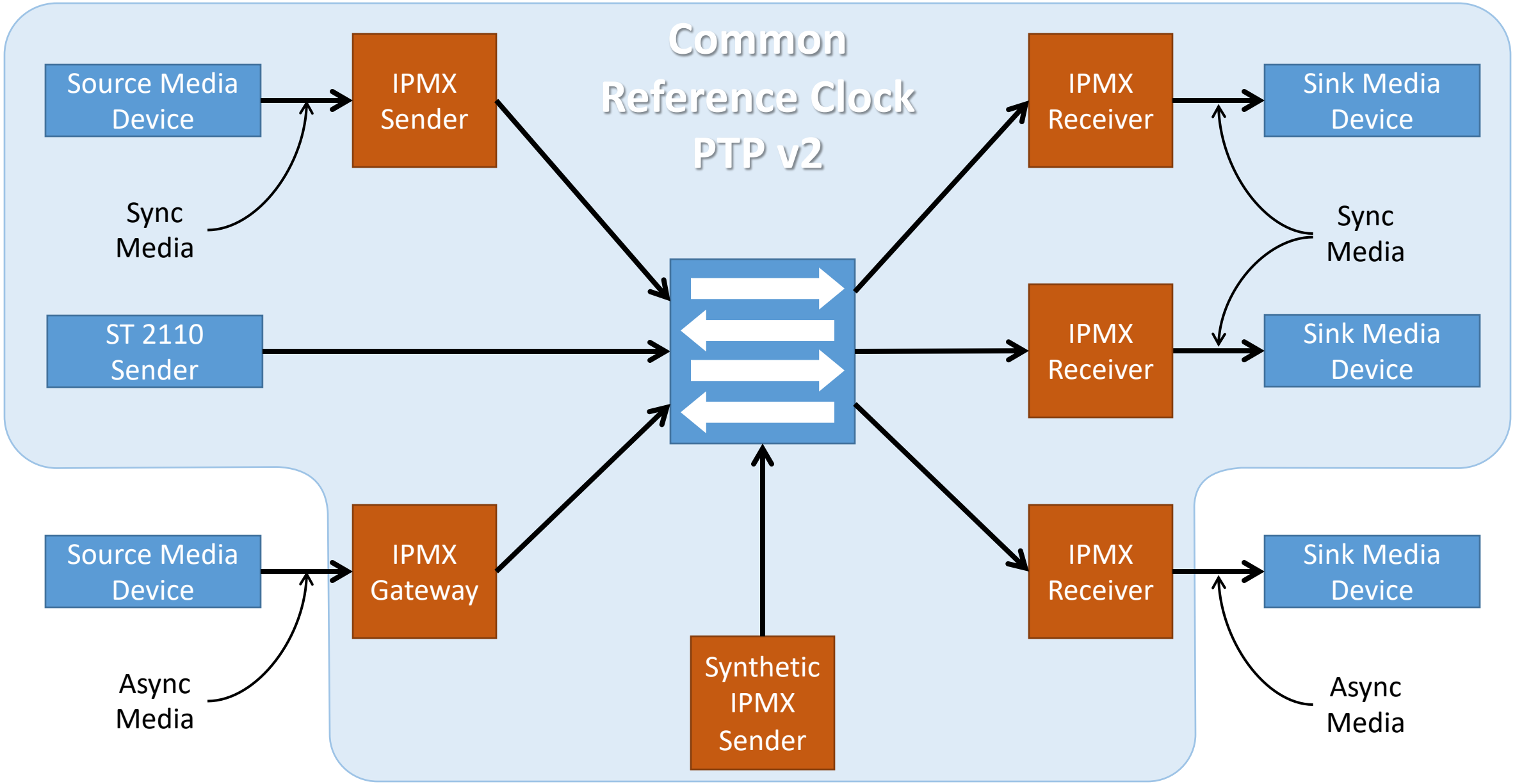
ST 2110

&

IPMX
IP MEDIA EXPERIENCE

.. The approach is extensible

IPMX Timing Architecture

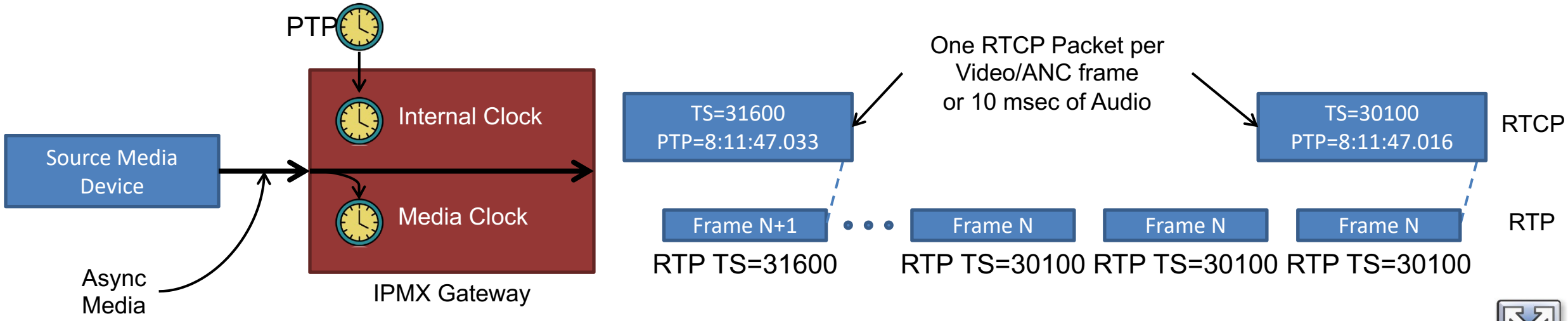


IPMX Timing: 3 Modes

	Synchronous Sources	Asynchronous Sources
PTP	• Compliant with ST 2110 and AES67 • Best for low-latency applications like live production and interactive displays. • Most complex setup • Can add latency to async sources. • Seamless switching is possible here.	• Quick clock recovery (short break between switching) • Possible to achieve very accurate re-alignment at the receiver. • Best for every-day use when PTP is available.
No PTP	**Undefined.** [Behaves as high-performance "No PTP / Asynchronous".]	• Longer clock recovery • Re-alignment is be possible with RTCP sender report data. • Best for ad hoc systems, single source systems or when sync between different media sources is not important. • Easy, low-complexity, similar to NDI • Sub-frame latency is still possible here!

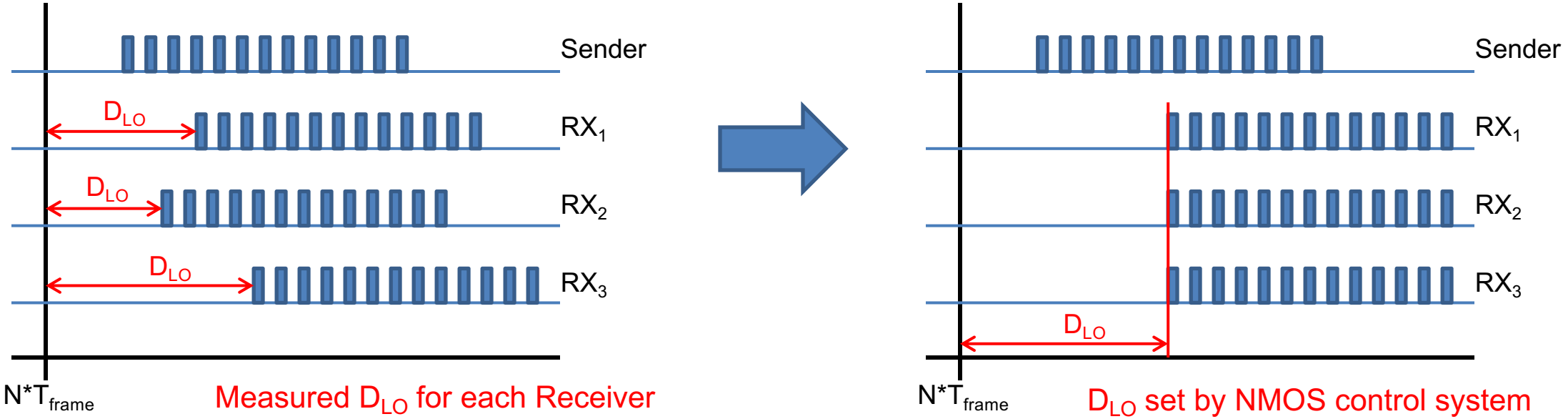
IPMX Sender Timing and Synchronization

- IPMX devices must sync Internal Clocks to Common PTP Reference Clock
  - If PTP is not available, devices use their own Internal Clocks
- Media Clocks do not need to be synchronized to Internal Clock
  - Allows transport of Asynchronous media
  - RTP timestamps generated by Media Clock
  - Truncated PTP Timestamp in RTCP packets to correlate RTP Timestamp to Internal Clock/PTP
  - Only first RTP timestamp of a media flow must be synchronized to Internal Clock



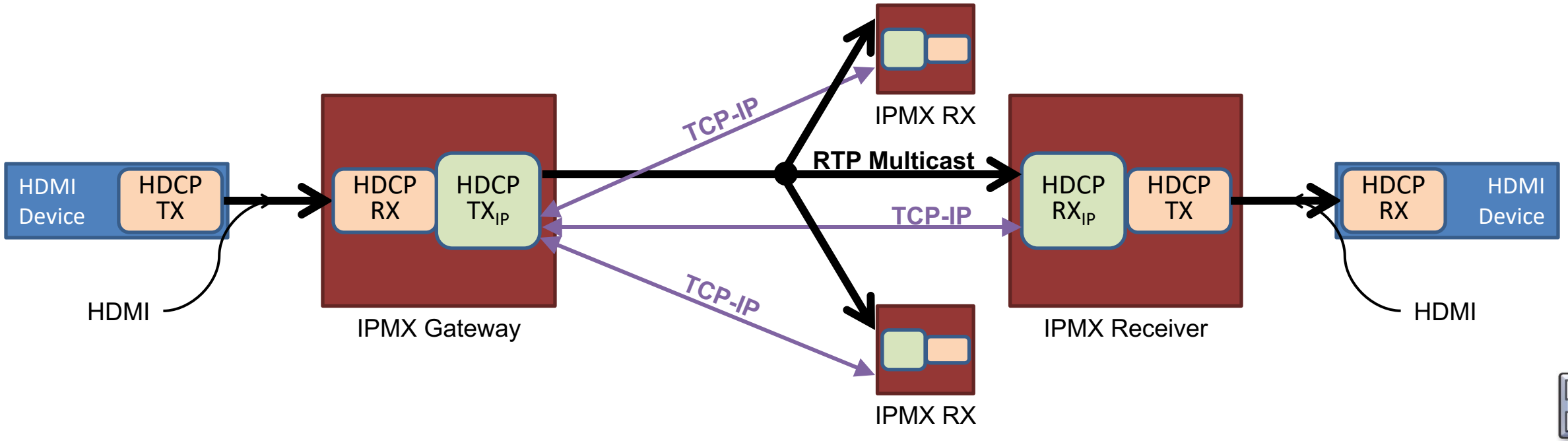
Receiver Synchronization and Display Time Alignment

- Display synchronization is important for many ProAV applications
  - Video walls and other large displays in particular
- IPMX Receivers report their measured D_{LO} Link Offset Delay to NMOS control system
  - Allows control system to find worst case delay for a group of receivers
- IPMX Receivers can play out media at fixed offset from $N*T_{frame}$
  - D_{LO} Link Offset Delay control handle available for NMOS system to use for alignment



HDCP over an IP Network

- HDCP (High-bandwidth Digital Content Protection) can work on an IP network
  - Encrypted media content delivered over RTP/IP multicast
  - Decryption keys delivered via TCP-IP connection to each device
- Every device in chain must be fully authenticated and secured
  - Full compliance with HDCP rules is required to maintain product licenses and keys



HKEP: HDCP Key Exchange Protocol

- Defined in VSF TR-10-5, with references to two HDCP documents:
  - *HDCP Interface Independent Adaptation Specification Revision 2.3: "High-bandwidth Digital Content Protection System: Interface Independent Adaptation, Revision 2.3, March 02, 2018"*
  - *HDCP Direct Adaptation Amendment Rev. 2.3: "High-bandwidth Digital Content Protection System: Direct Adaptation Amendment, Revision 2.3, May 19, 2021"*

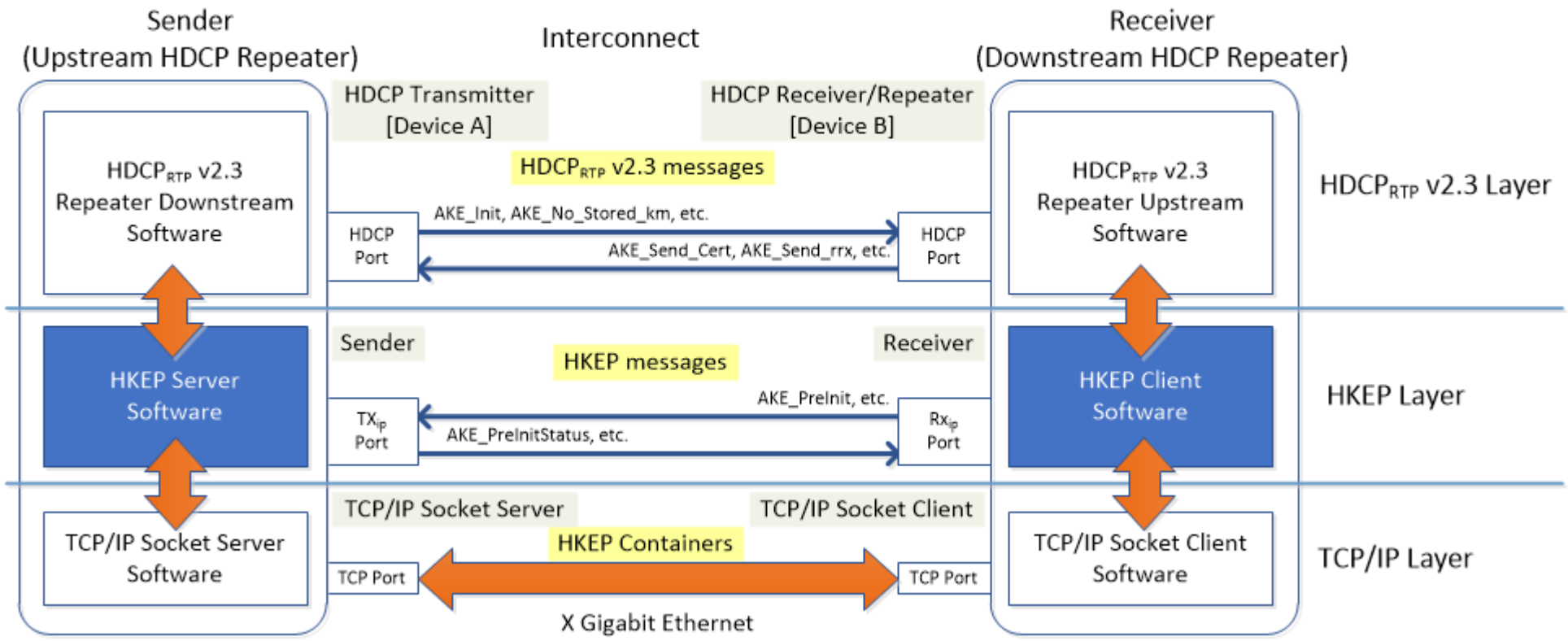


Illustration from VSF TR-05: Internet Protocol Media Experience (IPMX): HDCP Key Exchange Protocol

Important Details

- HDCP
  - Officially compliant with DCP and HDCP 2.x
  - HDCP puts 32 device limit on the number of endpoints that can receive protected content. This includes the source, gateways, DAs, and monitors! IPMX implementations must track this count. This limits multicast.
- EDID
  - NMOS IS-11 does a thorough job of supporting “hot plug detect” and EDID.
  - Constrain resolutions to least common denominator of all receivers.
  - Defines how to represent EDID information from monitors within NMOS.
  - Gives access to raw EDID binary data, for emergencies.

Where are we at today? (June 2023)

- IPMX is in progress
- Video Services Forum (VSF) released the initial “MVP” draft documents. https://vsf.tv/technical_recommendations.shtml#IPMX
- Expectation is that first release of completed standards in Q4 202
- 5+ Implementations in progress
- Roughly a dozen or so products self-declared as “IPMX Ready”
  - FPGA or software based
  - Follows the standard as it is today
  - Will/can be upgraded to comply when standard is complete.
- Recent new members joining AIMS: Barco, MegaPixel VR, AV Pro Edge, Panduit, Sencore/Plexus AV, NetGear, Nextera, [others in progress]

Questions? Feedback?

- What do you need from an AV over IP standard?
- What are the biggest challenges to **specifying** an IP media system?
  - **installing**?
  - **maintaining/troubleshooting/upgrading?**
- What goes wrong in AV over IP systems?
- What do you wish was possible, but isn't?
- What is harder than it needs to be?
- Is the training for IP media systems good enough? What is missing? What should be better?

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Thank you

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