

# AoIP/AES67: Anatomy of a Full-Stack Implementation

levgen Kostiukevych  
IP Media Technology Architect  
European Broadcasting Union

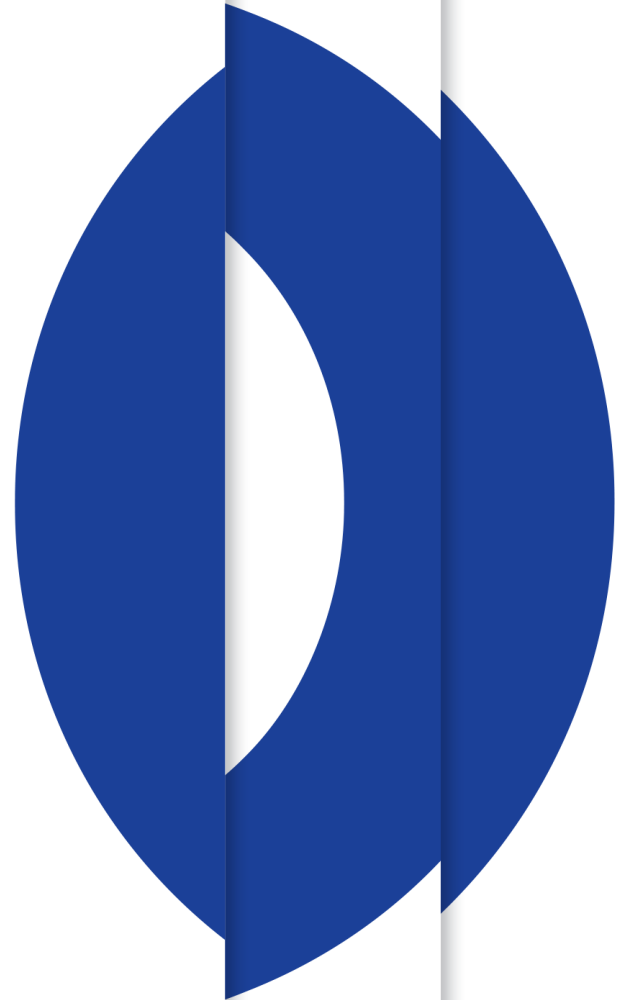
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## AOIP IP STACK ON OSI LAYERS

- Layer 1: 100BASE-T, 1000BASE-% (T, X, etc.)
- Layer 2: Ethernet
- Layer 3: IPv4, IGMPv2, DiffServ
- Layer 4: UDP
- Layer 5: RTP
- Layer 6: PCM Audio
- Layer 7: “Network-aware” A/D-D/A

# AUDIO OVER IP IMPLEMENTATION ANATOMY



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The logo features a stylized blue icon of a signal or connection point to the left of the text. The text "AES67" is in blue, "Livewire+" is in black, and "Connect To More" is in blue below it.

**AES67**  
**Livewire+**  
Connect To More

The logo consists of a stylized icon of a speaker or sound wave to the left of the text. The text "Dante" is in black, and "SPOKEN HERE" is in black below it.

**Dante**  
SPOKEN HERE



**RAVENNA**  
AES67 built-in

**QSC** SYSTEMS  
Q-LAN™

W H E A T N E T  
**WIP**

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# AES 67



## SMPTE ST 2110-30

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## AUDIO OVER IP IMPLEMENTATION ANATOMY

- Audio over IP protocols are packet-based
- Utilize connectionless, unreliable protocol – UDP
- Require additional protocols
- I.E. DiffServ to maintain reliable performance
- I.E. IEEE1588 to keep stable clock and synchronization
- I.E. IGMP to utilize network properly and efficiently

# AUDIO OVER IP IMPLEMENTATION ANATOMY

- Core of all implementations – PCM audio
- Additional functionality is required to be fully operational, configurable and user-friendly
- This functionality is provided by implementation and can vary from one to another

- How to discover devices?
- How to advertise streams?
- How to subscribe to streams?

AUDIO TRANSPORT

AUDIO PAYLOAD AND ENCODING

SYNCHRONIZATION AND CLOCK

QUALITY OF SERVICE

CONNECTION MEDIUM



REDUNDANCY

DEVICE CONTROL AND MONITORING

DISCOVERY AND REGISTRATION

CONNECTION MANAGEMENT

SESSION DESCRIPTION

AUDIO TRANSPORT

AUDIO PAYLOAD AND ENCODING

SYNCHRONIZATION AND CLOCK

QUALITY OF SERVICE

CONNECTION MEDIUM

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Device control and monitoring	HTTP, Proprietary	HTTP	Proprietary
Discovery and registration	Proprietary	mDNS/DNS-SD (Bonjour)	SAP
Connection management	Proprietary, HTTP, IGMP	RTSP, SIP, IGMP	Proprietary
Session description	By channel number	SDP	Proprietary
Transport	RTP, IPv4	RTP, IPv4	Proprietary, IPv4
Quality of Service	DiffServ/802.1pq	DiffServ	DiffServ
Synchronization	Proprietary	IEEE 1588-2008 (PTPv2)	IEEE 1588-2002 (PTPv1)
Encoding/channel count	PCM, L24 mono, stereo, 5.1	PCM, L16-32 Unlimited ch. per stream	PCM, L16-32 Up to 64 ch. per flow
Audio payload	48 kHz	44.1 – 384 kHz	44.1 – 192 kHz

IP

Device control and monitoring

HTTP, Proprietary

HTTP

Proprietary

Discovery and registration

Proprietary

mDNS/DNS-SD (Bonjour)

SAP

Connection management

Session description

Transport

Quality of Service

Synchronization

Encoding/channel count

Audio payload



**AES67**

UNDERSTOOD HERE

IP

Device control and monitoring

HTTP, Proprietary

HTTP

Proprietary

Discovery and registration

Proprietary

mDNS/DNS-SD (Bonjour)

SAP

Connection management

IGMPv2 (multicast stream) / SIP (unicast stream)

Session description

SDP (RFC 7273 for RTP clock offset announcement)

Transport

RTP/AVC (RFC 3550 & 3551) over UDP over IPv4/IPv6

Quality of Service

DiffServ: DSCP 46 (EF) - PTP, DSCP 34 (AF41) - RTP, DSCP 0 (BE) - else

Synchronization

IEEE 1588-2008 (PTPv2), AES-R16-2016 profile is recommended

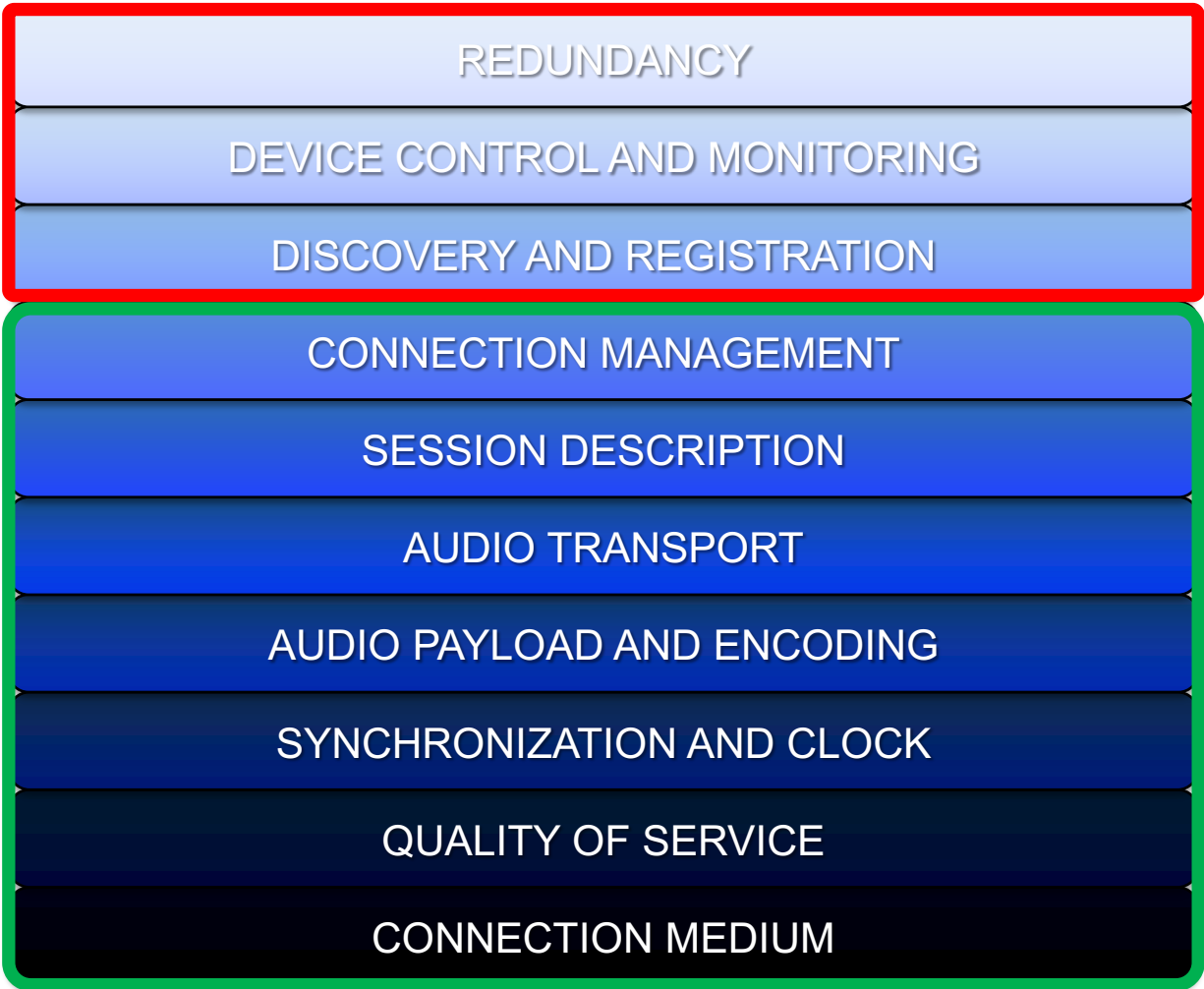
Encoding/channel count

PCM, L16 (for 44.1/48 kHz) or L24 (for 48/96 kHz), 1 to 8 channels

Audio payload

48 kHz recommended default (44.1/96 kHz are possible)

IP



Out of scope

Covered in AES67

## RAVENNA

Streamname	Origin	Multicast	SAP	RTSP
From CALL1 Digigram				rtsp://192.168.11.30:554/by-n...
From CALL2 Digigram				rtsp://192.168.11.34:554/by-n...
Hapi_90105_2	192.168.9.1	239.67.9.10/1		rtsp://192.168.9.1:80/by-nam...
Hapi_90105_3	192.168.9.1	239.67.9.11/1		rtsp://192.168.9.1:80/by-nam...
Lawo PGM out	192.168.2.1	239.67.2.100/1		rtsp://192.168.2.1:8081/by-na...
MNA_Montone_Demo_1	192.168.10.50	239.67.10.1/120		rtsp://192.168.10.50:80/by-na...
MoniLoop	192.168.2.1	239.1.2.1/1		rtsp://192.168.2.1:8081/by-na...
Monitor	192.168.4.2	239.67.222.222/1		rtsp://192.168.4.2:8081/by-na...
SRC 7@xnode401587	192.168.255.3	239.192.3.52		rtsp://192.168.255.3:554/by-n...
SRC 8@xnode401587	192.168.255.3	239.192.3.53		rtsp://192.168.255.3:554/by-n...
TOHE@xnode401587	192.168.255.3	192.168.255.3		rtsp://192.168.255.3:554/by-n...
uNet Mini 1 ch 1-2				rtsp://192.168.15.11:554/by-n...
uNet Mini 2 ch 1-2				rtsp://192.168.15.12:554/by-n...
uNet Standard ch 1-8 from ...				rtsp://192.168.15.10:554/by-n...
uNet Standard ch 9-16				rtsp://192.168.15.10:554/by-n...
uTrack24 ch 1-8				rtsp://192.168.14.10:554/by-n...
uTrack24 ch 17-24				rtsp://192.168.14.10:554/by-n...
uTrack24 ch 9-16				rtsp://192.168.14.10:554/by-n...
YAMAHAFinal@xnode401587	192.168.255.3	239.10.8.3		rtsp://192.168.255.3:554/by-n...

## SAP

Streamname	Origin	Multicast	R...
FocusriteRedNetA16R : 32	192.168.5.22	239.67.31...	
Hapi_90105_2	192.168.9.1	239.67.9.1...	
Hapi_90105_3	192.168.9.1	239.67.9.1...	
MNA_Montone_Demo_1	192.168.10.50	239.67.10...	
NTP-Penta-720 : 32	192.168.7.11	239.67.253...	
uNet Mini 1 ch 1-2	192.168.15.11	239.67.15...	
uNet Mini 2 ch 1-2	192.168.15.12	239.67.15...	
uNet Standard ch 1-8 from andrew	192.168.15.10	239.67.15...	
uNet Standard ch 9-16	192.168.15.10	239.67.15...	
uTrack24 ch 1-8	192.168.14.10	239.67.14...	
uTrack24 ch 17-24	192.168.14.10	239.67.14...	
uTrack24 ch 9-16	192.168.14.10	239.67.14...	
Y001-Yamaha-QLI-06eScc : 29	192.168.12.12	239.67.64...	
Y001-Yamaha-QLI-06eScc : 31	192.168.12.12	239.67.127...	
Y001-Yamaha-QLI-06eScc : 32	192.168.12.12	239.67.1.1...	

## LOCAL

AUTO	Streamname	Multicast	Sou...	R...	SAP
RAVENNA					
AUTO					
+ x					
SAP					
AUTO					
+ x					

# RAVENNA-2-SAP AES67 CONNECTION MANAGEMENT CONVERTER

## [HTTPS://WWW.RAVENNA-NETWORK.COM/AES67/RAV2SAP/](https://www.ravenna-network.com/aes67/rav2sap/)

```

13.09.2016 08:53:34,441 Received SAP announce for: uNet Standard ch 9-16
13.09.2016 08:53:34,501 Received SAP announce for: uTrack24 ch 9-16
13.09.2016 08:53:36,902 Received SAP announce for: uNet Standard ch 1-8 from andrew
13.09.2016 08:53:37,842 Received SAP announce for: uNet Mini 2 ch 1-2
13.09.2016 08:53:38,333 Received SAP announce for: uTrack24 ch 17-24
13.09.2016 08:53:38,335 Received SAP announce for: uTrack24 ch 1-8
13.09.2016 08:53:38,367 Received SAP announce for: uNet Mini 1 ch 1-2
13.09.2016 08:53:38,501 Received SAP announce for: uNet Standard ch 9-16
13.09.2016 08:53:39,334 Received SAP announce for: uTrack24 ch 9-16
13.09.2016 08:53:40,501 Received SAP announce for: uNet Standard ch 1-8 from andrew

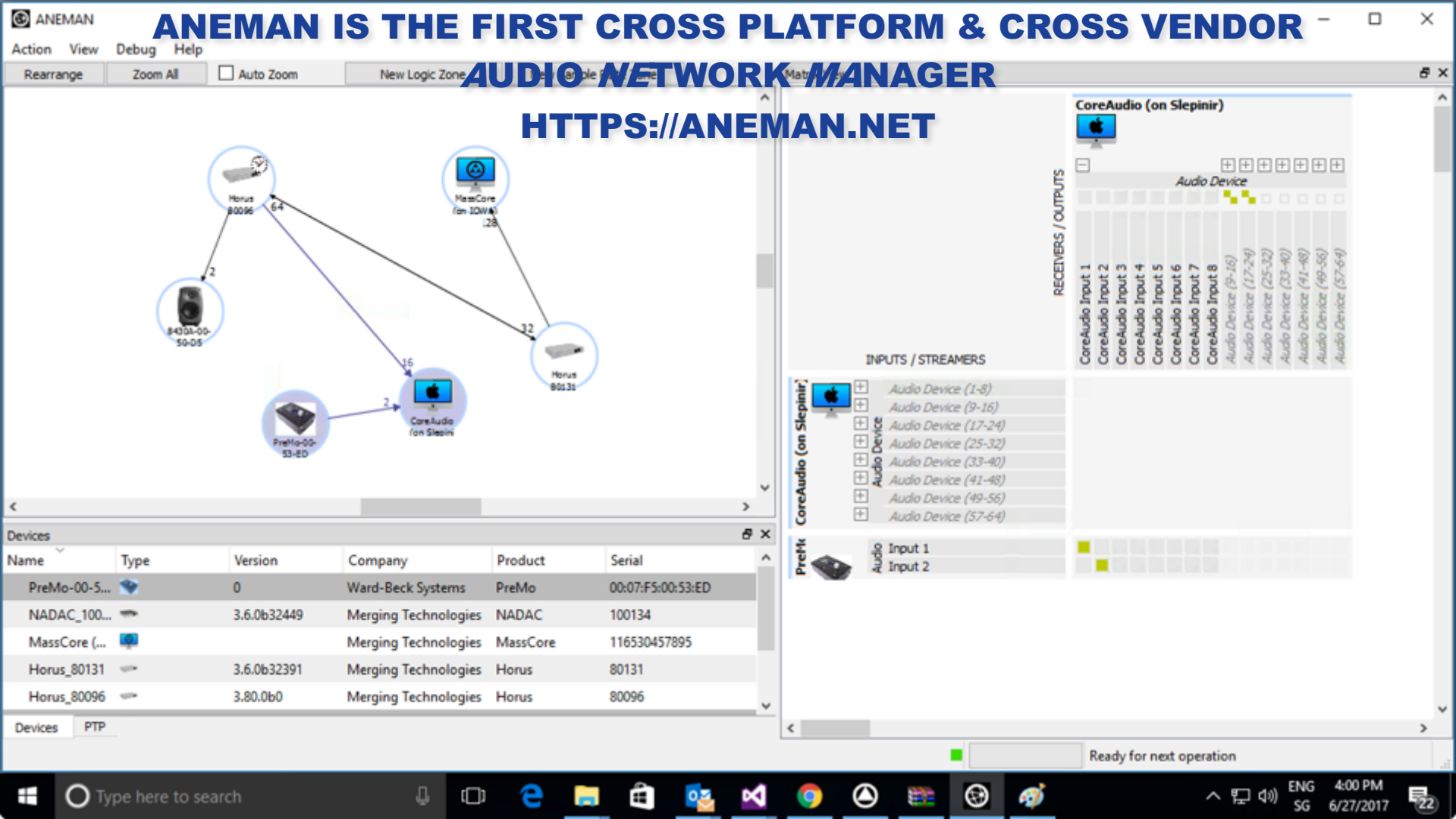
```



**RAVENNA**  
AES67 built-in

The RAVENNA-2-SAP Converter  
is freeware developed by  
to help connecting AES67





## DEVICE CONTROL AND MONITORING

OCA<sup>AES  
70</sup>  
OPEN CONTROL ARCHITECTURE

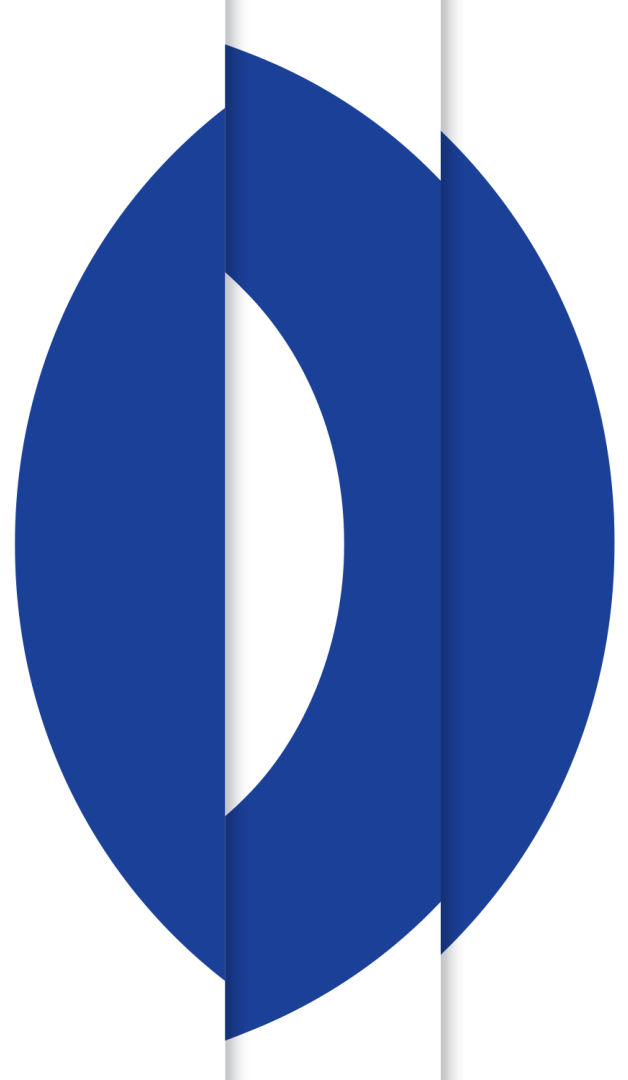
EMBER+

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# AUDIO OVER IP IN SMPTE ST 2110



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# SMPTE 2110 - PROFESSIONAL MEDIA OVER MANAGED IP NETWORKS

## Document structure:

- 2110-10: System Timing & Definitions
- 2110-20: Uncompressed Active Video
- 2110-21: Traffic Shaping and Delivery Timing for Uncompressed Active Video
- 2110-30: PCM Digital Audio
- 2110-31: AES3 Transparent Transport
- 2110-40: Transport of SMPTE Ancillary Data

## SMPTE ST 2110-30: PCM DIGITAL AUDIO

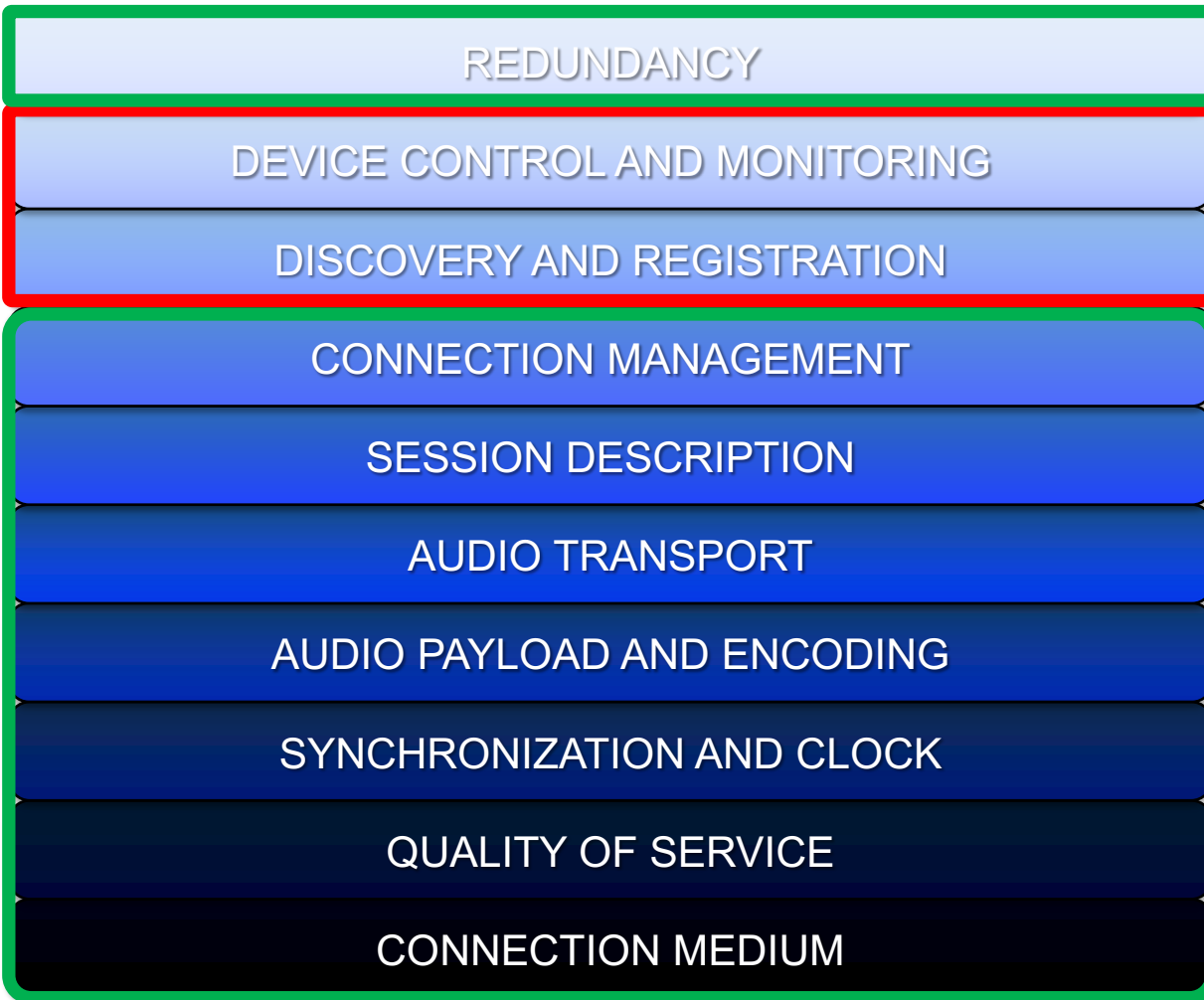
- Defines payload format for uncompressed PCM audio
- Based on AES67
- Introduces additional constraints

# SMPTE ST 2110-30: ADDITIONAL CONSTRAINTS TO AES67

- ST 2110-10 requires usage of SMPTE 2059-2 PTP profile
- AES-R16-2016 (AES67 PTP Media profile) addresses this
- PTP setting “defaultDS.slaveOnly=true” required for devices that shouldn’t become PTP grandmaster (i.e. I/O nodes)
- Media clock to RTP clock offset ( $\Delta t_s$ ) must equal zero (a=mediaclk:direct=0)

# SMPTE ST 2110-30: ADDITIONAL CONSTRAINTS TO AES67

- Support of SIP **not** required
- Support for optional redundancy with SMPTE 2022-7
- Support for Channel assignment map as SDP attributes required



Covered in  
ST 2110

Out of  
scope

Covered  
in AES67

# JT-NM Roadmap of Networked Media Open Interoperability\*



**LEGEND:**

- Standard / Specification (arrow icon)
- Published (arrow icon)
- Widely available (arrow icon)
- Study / Activity (rectangle icon)

## IV. Dematerialized facilities\*\*

Cloud-fit

Open, secure, public/private (on-premises) cloud solutions

EBU R146 Cloud Security for Media Companies

AMWA Content Model and APIs Agile Media Machine Core

JT-NM Security Recommendations Top-Ten Security Tests

EBU R148 Recommended minimum Security Tests

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

## III. Network & Resource Management

AMWA NMOS Audio Simple broadcast audio manipulation

AMWA Timing and Identity Including mapping to ST 2110

AMWA IS-07 Event & Tally

AMWA IS-06 Network Control

AMWA IS-05 Connection management

AMWA IS-04 Discovery & Registration

System-level management and automated provisioning for flexible and sharable infrastructure at scale

## II. Elementary flows

VSF TR-03

SMPTE ST 2110-22 Transport of compressed video

SMPTE ST 2110 Transport of separate essences

SMPTE ST 2059 Timing profile

AES67

SMPTE ST 2022-8 Bridging SDI over IP with Elementary flows

SMPTE ST 2022-6

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

0. SDI Current and mature technology



\* JT-NM assumption as of August 2018 and will evolve over time. Visit [JT-NM.org](http://JT-NM.org) for the latest update. Feedback to [jt-nm-info@videoservicesforum.org](mailto:jt-nm-info@videoservicesforum.org)

\*\*See Dematerialized Facilities FAQ at [JT-NM.org](http://JT-NM.org) for more information.

networked media



open specifications

- IS-04 - NMOS Discovery & Registration API
- IS-05 - NMOS Device Connection Management API
- IS-06 - NMOS Network Control
- IS-07 - NMOS Event & Tally
- IS-0X - NMOS Audio

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# DEVICE CONTROL AND MONITORING



# Minimum Stack for IP endpoints

necessary to build and manage a full scale facility

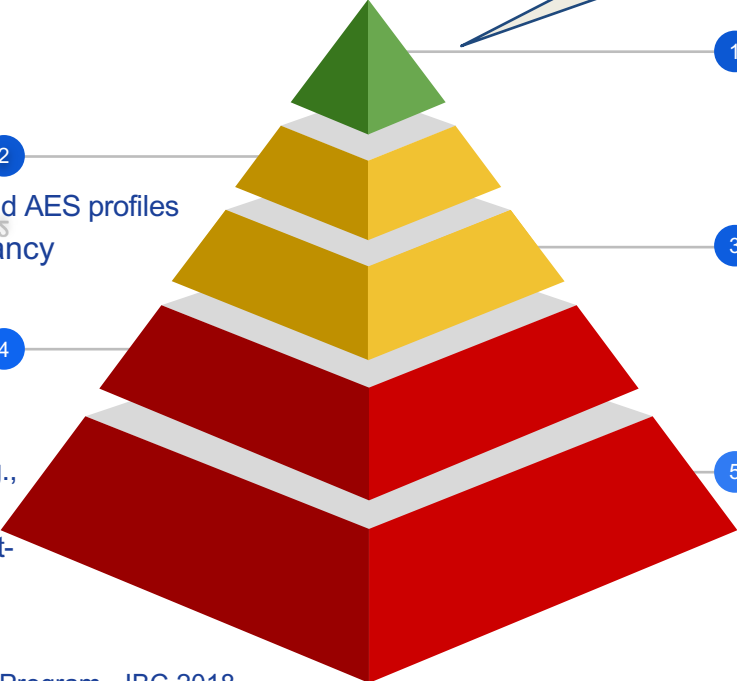
Media is just the "tip of the pyramid"!

## Time and Sync

- PTPv2 configurable within SMPTE and AES profiles
- BMCA for multi-interface redundancy

## Configuration and Monitoring

- DHCP IP assignment
- Open configuration management (e.g., API, config file, SSH CLI, etc.)
- Open monitoring protocol (e.g., Agent-based, SNMPv3, etc.)



## Media Transport

- Video SMPTE ST 2110-20/21 with Wide Rx
- Audio SMPTE ST 2110-30 Level C
- SMPTE ST 2022-7:2018 Protection
- Single link - e.g., UHD on 25 GbE

## Discovery and Connection

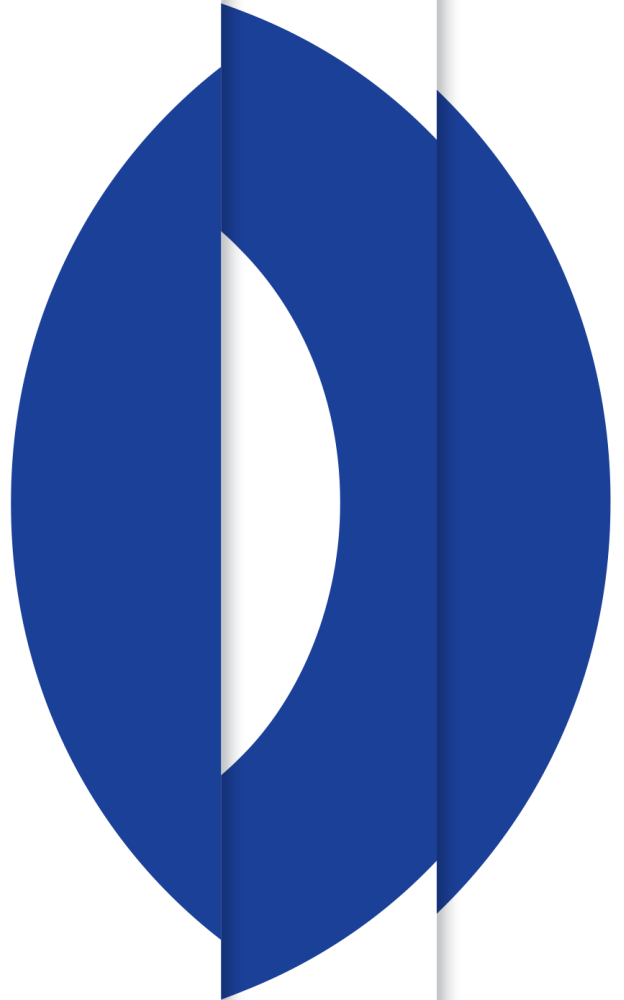
- AMWA IS-04 Discovery and Registration
- AMWA IS-05 Connection Management
- LLDP Topology discovery

## Security

- EBU R148 Tests
- HTTPS API calls
- AD, LDAP or Certificates - Authentication

Widely available
Partially available
Rarely available

# WHAT'S NEXT?..



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## WHAT'S NEXT?

- Evaluate!
- Educate!
- Get your hands dirty!
- Get in touch!
- Get a coffee!

# Thank You

Ievgen Kostiukevych, European Broadcasting Union

[kostiukevych@ebu.ch](mailto:kostiukevych@ebu.ch)

+41 79 225 37 35

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