Overview on IP Audio Networking
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ALC NetworX GmbH, Munich

Topics:

• Audio networking vs. OSI Layers
• Overview on IP audio solutions
• AES67 & RAVENNA
• Real-world application examples
• Brief introduction to SMPTE ST2110
• NMOS
• Control protocols
Overview on IP Audio Networking

- **Layer 1**: Audio over IP
  - ACIP
  - TCP
  - RTP
  - UDP

- **Layer 2**: AVB
  - EtherSound

- **Layer 3**: Audio over Ethernet
  - unicast
  - multicast
  - Media streaming
  - AES67
  - X192
  - Dante
  - Livewire
  - CobraNet

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*Overview on IP Audio Networking - A. Hildebrand*
Overview on IP Audio Networking

Terminology often
- ambiguous
- used in wrong context
- marketing-driven
- creates confusion
Overview on IP Audio Networking

Layer 1

ACIP

Layer 3

Audio over IP

Terminology often

• ambiguous
• used in wrong context
• marketing-driven
• creates confusion

TCP
RTP
AVB
Layer 2

Audio over Ethernet

unicast
multicast
Media streaming

Dante
Livewire
CobraNet

Overview on IP Audio Networking - A. Hildebrand
Overview on IP Audio Networking

Layer 7: Application
Layer 6: Presentation
Layer 5: Session
Layer 4: Transport
Layer 3: Network
Layer 2: Data Link
Layer 1: Physical

Application and protocol-based layers:
HTTP, FTP, SMNP, POP3, Telnet, TCP, UDP, RTP

Internet Protocol (IP)
Ethernet, PPP…

Physical transmission
Classification by OSI network layer:

Layer 1 Systems
Layer 1 systems:

- Examples: SuperMac (AES50), A-Net Pro16/64 (Aviom), Rocknet 300 (Riedel), Optocore (Optocore), MediorNet (Riedel)
- Fully proprietary systems
- Make use of layer 1 physical transport (e.g. CAT5 or fiber)
- Mostly point-to-point or daisy-chain topologies ("switches" need to be custom-built)
- Ring topology may provide high availability

- Ruggedized due to proprietary infrastructure
- Usually very low latencies achievable
- Fixed device & channel capacity (varying between solutions)
- Limited to selected media formats (due to proprietary use of physical layer)
Overview on IP Audio Networking

Classification by OSI network layer:

Layer 2 Systems

Transmit

Receive

Layer 2

Data Link

Physical

Layer 1

Data Link

Physical

Physical transmission

Ethernet, PPP...

10011101
Layer 2 systems ("Audio-over-Ethernet"):  
- Examples: CobraNet (Cirrus), EtherSound (Digigram), SoundGrid (Waves)  
- Proprietary systems based on layer 2 (data link level)  
- Mostly utilizing Ethernet infrastructure (e.g. FE or GbE)  
- Operate on structured topologies (star / tree), but may also be limited to daisy-chain or ring topologies  
- Size of network limited to LAN segment (or lower)  
- Fixed device & channel capacity (varying between solutions)  
- Limited to selected media formats (due to proprietary end points)  
- Usually low to very low latencies achievable  
- Ruggedized due to exclusive infrastructure usage
Classification by OSI network layer:

Layer 3 Systems
Layer 3 systems ("Audio-over-IP"):

- (Proprietary) systems based on layer 3 (Internet Protocol)
- May run on any IP-capable infrastructure, mostly Ethernet (sometimes limited to selected network equipment)
- Uses structured topologies (star / tree / mesh), but may also run on daisy-chain or ring topologies
- Size of network not limited (includes routing capabilities)
- Can operate in shared traffic environments
- Flexible / scalable device & channel capacity & flexible choice of media formats
- Latencies vary depending on network environment (and payloads etc.)
## Existing Audio-over-IP solutions / technologies / initiatives:

<table>
<thead>
<tr>
<th>Technology</th>
<th>Purveyor</th>
<th>Date introduced</th>
<th>Application</th>
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</thead>
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<tr>
<td>Livewire</td>
<td>Telos/Axia</td>
<td>2003</td>
<td>Radio Broadcast</td>
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<tr>
<td>Wheatnet-IP</td>
<td>Wheatstone</td>
<td>2005</td>
<td>Radio Broadcast</td>
</tr>
<tr>
<td>Dante</td>
<td>Audinate</td>
<td>2006</td>
<td>Install &amp; Live Sound</td>
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<tr>
<td>N/ACIP</td>
<td>EBU</td>
<td>2007</td>
<td>Broadcast</td>
</tr>
<tr>
<td>Q-LAN</td>
<td>QSC Audio Products</td>
<td>2009</td>
<td>Install &amp; Live Sound</td>
</tr>
<tr>
<td>RAVENNA</td>
<td>ALC NetworX</td>
<td>2010</td>
<td>Broadcast</td>
</tr>
</tbody>
</table>
**Overview on IP Audio Networking**

*Selected solutions / technologies compared to OSI layer model:*

<table>
<thead>
<tr>
<th>OSI Layer</th>
<th>A-Net</th>
<th>EtherSound</th>
<th>CobraNet</th>
<th>Livewire, Dante &amp; ...</th>
<th>RAVENNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Presentation</td>
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<tr>
<td>Session</td>
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<td>RTP</td>
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<tr>
<td>Transport</td>
<td></td>
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<td>UDP</td>
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<tr>
<td>Network</td>
<td></td>
<td></td>
<td></td>
<td>IP</td>
<td></td>
</tr>
<tr>
<td>Data Link</td>
<td></td>
<td>Ethernet</td>
<td>Ethernet</td>
<td>Ethernet</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Physical</td>
<td>Copper</td>
<td>Copper / Fiber</td>
<td>Copper / Fiber</td>
<td>Copper / Fiber</td>
<td>Copper / Fiber</td>
</tr>
</tbody>
</table>
Overview on IP Audio Networking

- Q-LAN
- Livewire
- RAVENNA
- WheatNet
- Dante

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Overview on IP Audio Networking

- Q-LAN
- Livewire
- RAVENNA
- WheatNet
- Dante

AES67

IP
AES67-2013 Standard for Audio Applications of Networks:

High-performance Streaming Audio-over-IP Interoperability

published on September, 11th, 2013
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Scope:

- **Interoperability guidelines** for professional, low-latency audio over campus and local area IP networks **using existing protocols wherever possible**.

- Excludes:
  - Non-IP networking
  - Low-bandwidth media
  - Data compression
  - Low-performance WANs and public Internet
  - Video (should provide good basis for follow-on video project)

Goal:

- Technology providers may choose to implement interoperability as a special mode, or transition to it as their native mode

VSF TR-03/04 - AIMS - ST-2110
AoIP general technology components

- Discovery
- Connection Management
- Session Description
- Encoding
- QoS
- Transport
- Media Clock
- Synchronisation
Timing & Synchronization - Requirements

- Bit transparency → no sample rate conversion → streams need to run on same media clock
- Concurrent operation of different sample rates
- Determinable (low) latency
- Time alignment between streams
- Phase-aligned local word clocks according to AES11 (replacement for “house clock” distribution)
  ⇒ Clock reassembly from stream data not appropriate
  ⇒ Distribution of master clock beats not sufficient
  ⇒ Common understanding of absolute time required (“wall clock”)
AES67 technology components

- Media Clock: 48 kHz
- Synchronisation: IEEE 1588-2008 (PTPv2)
AES67 synchronization & media clocks

- All nodes are running local clocks
- Local clocks are precisely synchronized to a common wall clock via PTP
**IEEE1588 (PTP) – principle of operation**

Basic calculations:

\[ t_2 - t_1 = \text{Delay} + \text{Offset} \]
\[ t_4 - t_3 = \text{Delay} - \text{Offset} \]

Delay = \((t_2 - t_1) + (t_4 - t_3)) / 2\]

Offset = \((t_2 - t_1) - \text{Delay}\)
AES67 synchronization & media clocks

- All nodes are running local clocks
- Local clocks are precisely synchronized to a common wall clock via PTP
- Media clocks are generated locally from synchronized local clock
AES67 synchronization & media clocks

![Diagram showing AES67 synchronization and media clocks]

- **Master Clock**
- **Slave Clocks (nodes)**
- **Media Clocks**
- **GPS**
- **PTP**
### AES67 technology components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
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<tbody>
<tr>
<td>Transport</td>
<td>RTP / UDP / IP, unicast &amp; multicast</td>
</tr>
<tr>
<td>Media Clock</td>
<td>48 kHz</td>
</tr>
<tr>
<td>Synchronisation</td>
<td>IEEE 1588-2008 (PTPv2)</td>
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AES Standard for Audio Applications of Networks - High-performance Streaming Audio-over-IP Interoperability
AES Standard for Audio Applications of Networks - High-performance Streaming Audio-over-IP Interoperability

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Overview on IP Audio Networking - High-performance Streaming Audio-over-IP Interoperability

1. Physical
   - Ethernet, 802.11, MAC/LLC, VLAN, ATM, HDP, Fibre Channel Frame Relay, HDLC, PPP, Q.921, Token Ring, ARP

2. Data link
   - RS-232, RJ45, V.34, 100BASE-TX, SDH, DSL, 802.11

3. Network
   - IP, IPsec, ICMP, IGMP, OSPF

4. Transport
   - TCP, UDP, SCTP, SSL, TLS

5. Session
   - DNS, WWW/HTTP, P2P, EMAIL/POP, SMTP, Telnet, FTP
     - Recognizing data: HTML, DOC, JPEG, MP3, AVI
     - Sockets, Session establishment in TCP, SIPv, RPC - Named pipes

6. Presentation
   - RTP

7. Application
   - Google, email, network process to application, application

Interhost Communication
Data Representation and Encryption
Presentation
Session
Transport
Application
Network
Data link
Physical
Layered Packet Encapsulation

Ethernet Header | IP Header | UDP Header | RTP Header | RTP Payload (PCM Modulated Data) | Ethernet Trailer

Layer 5 (Session Layer)

Layer 4 (Transport Layer)

Layer 3 (Network Layer)

Layer 2 (Link Layer)

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Layered Packet Encapsulation - RTP

Diagram showing the encapsulation process:
1. Layer 0: Audio Data (0..1460 bytes)
2. Layer 2: Ethernet
   - Destination Address
   - Source Address
   - Type/Length
   - Priority/VLAN
3. Layer 3: IP
   - Version
   - IHL
   - Type of Service
   - Total Length
   - Identification
   - Flags
   - Fragment Offset
   - Time to Live
   - Protocol
   - Header Checksum
   - Source Address
   - Destination Address
4. Layer 4: UDP
   - Source Port
   - Length
   - Destination Port
   - Checksum
5. Layer 5: Real Time Protocol
   - Timestamp
   - Sequence Number
   - Synchronization Source
6. Layer 6: Data
7. Layer 7: Check
AES67 technology components

- **Synchronisation**: IEEE 1588-2008 (PTPv2)
- **Media Clock**: 48 kHz
- **Transport**: RTP / UDP / IP, unicast & multicast
- **QoS**: Differentiated Services (DiffServ w/ 3 CoS)
QoS – Differentiated Services (DiffServ)

- Defined in RFC 2474
- Defines up to 64 traffic classes (i.e. EF, AFx, CSx, BE etc.)
- Packets are tagged with DSCP value (0 – 63)
- Switches store packets in different priority queues (requires proper configuration)
- Egress scheduler forwards packets from higher prioritized queues first (strict priority / weighted round robin / guaranteed minimum bandwidth ...)

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QoS – Differentiated Services (DiffServ)
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- Switches store packets in different priority queues (requires proper configuration)
- Egress scheduler forwards packets from higher prioritized queues first (strict priority, weighted round robin, guaranteed minimum bandwidth)
- Needs to be supported along full path from the transmitting to the receiving end
- No admission control → congestion / packet dropping possible when bandwidth is exceeded
## AES67 technology components

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<tr>
<td>Discovery</td>
<td>Not specified</td>
</tr>
<tr>
<td>Connection Management</td>
<td>SIP (unicast), IGMP (multicast) + ???</td>
</tr>
<tr>
<td>Session Description</td>
<td>SDP (RFC4566, RFC7273)</td>
</tr>
<tr>
<td>Encoding</td>
<td>L16/L24, 1..8 ch, 48 samples</td>
</tr>
<tr>
<td>QoS</td>
<td>Differentiated Services (DiffServ w/ 3 CoS)</td>
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Discovery & Connection Management in AES67

Read all about it!
Discovery & Connection Management in AES67

- **Discovery**: excluded, but several possibilities mentioned (i.e. ZeroConf, SAP and others)
  - Discovery enables enumeration / registration devices & streams
  - Announces protocol / location (uri) for SDP data

- **Connection management**: SDP, IGMP (multicast), SIP (unicast)
  - SDP data required for connection setup and stream description
  - SDP transport: unicast - SIP, multicast - no protocol specified (assuming manual means available via device-specific UI)

- **Real-world problem**:
  - different discovery methods used by various systems (i.e. mDNS vs. SAP)
  - No common method for (multicast) SDP exchange
  - Lack of means for manual read-out / entry of SDP data

⇒ **No simple interoperability!**
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Discovery & Connection Management in AES67

- **RAVENNA®**: DNS-SD (mDNS), rtsp for SDP transfer
  - Works with multicast & unicast (side-by-side with SIP)
  - Method supported by virtually any media player and / or streaming application

- **Dante™ (in AES67 mode)**: SAP
  - Experimental protocol for announcing multicast sessions
  - Periodically multicast transmission of full SDP data records
  - No manual read-out / entry of SDP data

- **Problem solver #1**: **RAVENNA-2-SAP Converter**
  - Converts selected or all RAVENNA announcements into SAP and vice versa
  - Provides full SDP read-out and manual entry through UI
RAVENNA-to-SAP Converter

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RAVENNA-to-SAP Converter

Bonjour / RTSP

SAP

AES67 Streams

RAVENNA

AES67 built-in

ALC
NetworX

# 56
RAVENNA to SAP Converter

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Discovery & Connection Management in AES67

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- **Problem solver #2**: Use of **ANEMAN** by Merging (Audio NEtwork MANager).

- **Problem solver #3**: Use of new industry standard **AMWA NMOS IS-04 & IS-05**.
What can it do?
What can it do?
AES67 – the “O negative” of audio networking

(Roland Hemming, Independent Audio Consultant, UK)
AES67 – the “O negative” of audio networking

Who is supporting it?
AES67 – the “O negative” of audio networking

Who is supporting it?

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What is RAVENNA?
An “Open Technology” platform:

- Based on technology publicly available
  - No proprietary “black box” design
- Utilizes standard protocols
  - Proven technology, widely supported
- Designed to work on existing networks
  - No new network equipment required
- No proprietary licensing policy
  - No cost per channel, suits all performance needs
- Draft on operating principles published since June 10th, 2011
What is RAVENNA?

RAVENNA Draft on Operational Principles

Ingredients:
- 20 ml PTPv2
- 500 g RTP
- 1 pkt multicast
- 1 pinch of Bonjour

Cooking order:
1. Stew PTP to order
2. Add RTP
3. Mingle with multicast
4. Add Bonjour on top

Serve hot and Enjoy!
An “Open Technology” platform:

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- Supported by renowned companies from the ProAudio industry
Overview on IP Audio Networking - A. Hildebrand
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- Draft on operating principles published since June 10th, 2011
  - Anybody can implement / support RAVENNA technology
- Supported by renowned companies from the ProAudio industry
  - Broad market acceptance
- Active participation in AES X192 standardization TG
  - RAVENNA supports AES67 standard
Overview on IP Audio Networking

- Encoding 48kHz
- 1-8 Audio channels
- 48 Samples per packet
- Media Format L16/L24 PCM
- QoS three classes

+ Discovery
+ Redundancy
+ classes adjustable
+ AES/EBU, DSD/DXD, Video
+ 1, 6, 12, 64...
+ 64, 128...
+ 44.1, 96, 192, 384kHz...
The IP-based Real-Time Media Network

RAVENNA

QoS three classes + classes adjustable
Media Format L16/L24 PCM + AES/EBU, DSD/DXD, Video
48 Samples per packet + 1, 6, 12, 64...
1-8 Audio channels + 64, 128...
Encoding 48kHz + 44.1, 96, 192, 384kHz...

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The IP-based Real-Time Media Network

RAVENNA

Overview on IP Audio Networking - A. Hildebrand
AES67 – the “O negative”
of audio networking

Who is supporting it?

AES67 “real-world” example applications:
The IP-based Real-Time Media Network

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RAVENNA @ Soccer World Cup 2014
RAVENNA

@ Soccer World Cup 2014

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The IP-based Real-Time Media Network

RAVENNA @ Soccer World Cup 2014

Brazilian Telco to IBC in Rio

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The IP-based Real-Time Media Network

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The IP-based Real-Time Media Network
The IP-based Real-Time Media Network

Conventional system setup:

RAVENNA @ Asian Games 2014

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The IP-based Real-Time Media Network

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RAVENNA @ Asian Games 2014

IP-based setup:
The IP-based Real-Time Media Network

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The IP-based Real-Time Media Network

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120x V_link4
(12 pro venue)

264x V_remote4
(19-20 per venue, 73 at IBC)

130x A_mic8
(13 pro venue)

480 video streams
~1000 audio channels

22x Arista 7150S (2 per venue, 2 at IBC)

RAVENNA @ EURO 2016
The IP-based Real-Time Media Network

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The IP-based Real-Time Media Network

AES67 Installed Sound Pilot: Nallikari restaurant complex, Oulu, Finland:

- Multi-zone restaurant environment with programmable background music
- Audio processing, playout, routing and remote control functions
- Wireless user control via Android tablets
AES67 Installed Sound Pilot: Nallikari restaurant complex, Oulu, Finland:

- Jutel HIPman audio management, processing & play-out system w/ RAVENNA Virtual Sound Card
- 30 IP-driven Genelec speakers
- Axia xNode for PTP GM and utility audio I/O (mic, monitoring)
- Android tabs for wireless control
- Remote maintenance access
- Common network for all services
- RAVENNA/AES67 audio streaming
The IP-based Real-Time Media Network

- 10 Neumann DMI-8 (78 digital mics)
- 2 Lawo MC²56
- 1 Merging Pyramix
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RAVENNA @ Elbphilharmonie Hamburg 2017
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Common infrastructure for live mixing and broadcast production
1 mc²66 + 5 mc²36 consoles, DALLIS I/O + Nova73 router
Common access to all sources w/ integrated access rights management
Uplink to OB van
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### Beyond AES67 - other important standards / industry alliances

<table>
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<tr>
<th>Standard/Protocol</th>
<th>Description</th>
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<tbody>
<tr>
<td>AES67, AES70</td>
<td>Promoting adoption of AES67</td>
</tr>
<tr>
<td>ST2110, ST2059</td>
<td>Promoting adoption of IP standards for media industry</td>
</tr>
<tr>
<td>IP-related suite of protocols</td>
<td>NMOS IS-04/05/06 (D&amp;R, connection management)</td>
</tr>
<tr>
<td>Ethernet authority (802.x), PTP (1588)</td>
<td>Important tech docs on broadcasting (ACIP)</td>
</tr>
</tbody>
</table>
Beyond AES67 - other important standards / industry alliances

ST2110 - Professional Media over Managed IP Networks
- Defines transport and synchronization of elementary essence streams (video, audio, ancillary data)
- Primarily targeting at live production applications
- AES67 referenced as transport standard for audio essence

Network Media Open Specifications (NMOS)
- IS-04 – discovery & registration of network objects (devices, resources, streams etc.)
- IS-05 – connection management
- IS-06 – network control (SDN)
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SMPTE 2110 – illustration of principle
Overview on IP Audio Networking

Comparison

**ST2022-6**

A) SMPTE 2022-6 Stream

**ST2110**

B) VSF TR-03 Streams
Comparison

**ST2022-6**
- Single stream transport of audio, video and ancillary data
- All media in sync
- Efficient for WAN and point-to-point applications
- Not flexible, requires de-embedding of the whole stream for audio

**ST2110**
- Separate audio, video and ancillary data streams
- Inter-stream synchronization via RTP, PTP (method is identical to AES67)
- Provides greater flexibility in production networks
- Audio stream transport & format is based on AES67
SMPTE 2110 - Professional Media over Managed IP Networks

Document structure:

• 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)
Overview on IP Audio Networking

SMPTE 2110 - Professional Media over Managed IP Networks

Document structure:

• 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 and meta data (RAVENNA AM824)

• 2110-40: Transport of SMPTE Ancillary Data
  – defines RTP payload format for SDI ancillary data (new IETF RFC (draft))

• 2110-50: Interoperation of ST 2022-6 Streams
  what it says... (VSF TR-04)
SMPTE 2110 - Professional Media over Managed IP Networks

Constraints of 2110-10 & -30 w/ respect to AES67

- Synchronisation & Timing -

- PTP:
  - support of SMPTE 2059-2 required
  - message rate according to AES-R16-2016 (AES67 PTP Media profile)
  - defaultDS.slaveOnly=true for devices not capable of entering PTP master state
  - a=ts-refclk:ptp=traceable and a=tsrefclkts-refclk:localmac=<mac_addr> allowed

- RTP clock: offset= 0 w/ respect to media clock / network clock
  - a=mediaclk:direct=0
Overview on IP Audio Networking

AES67 synchronization & media clocks

- Relations T and R are established on node start-up
- Relation S is established on stream start-up
- S may be random to defeat crypto attacks
- This offset will be constant throughout the stream’s lifetime
- The overall offset (T + S) will be conveyed via SDP (a=mediaclk:direct=<offset>)
Overview on IP Audio Networking

AES67 synchronization & media clocks

- Relations **T** and **R** are established on node start-up
- Relation **S** is established on stream start-up
- **S** may be random to defeat crypto attacks
- This offset will be constant throughout the stream’s lifetime
- The overall offset (**T** + **S**) will be conveyed via SDP (a=mediackl:direct=<offset>) – **must be “0” in ST2110**
SMPTE 2110 - Professional Media over Managed IP Networks

Constraints of 2110-10 & -30 w/ respect to AES67

- Protocols -

• Support of RTCP not required (but must be tolerated)
• Support of SIP (or any other connection management protocol) not required
• Redundancy (optional): SMPTE 2022-7
  ─ no identical IP source and destination addresses
• Channel assignment map (SDP attributes - optional)
  ─ a=fmtp:<payload type> channel-order=<convention>.<order>
  ─ Example: a=fmtp:101 channel-order=SMPTE2110.(51,ST)
### Constraints of 2110-10 & -30 w/ respect to AES67

- **6 conformance levels:**

<table>
<thead>
<tr>
<th>Level</th>
<th>Supported by the Receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (mandatory)</td>
<td>Reception of 48 kHz streams with 1 to 8 audio channels at packet times of 1 ms</td>
</tr>
<tr>
<td>B</td>
<td>Level A + 1 to 8 channels at packet times of 125 μs</td>
</tr>
<tr>
<td>C</td>
<td>Level A + 1 to 64 channels at packet times of 125 μs</td>
</tr>
</tbody>
</table>
SMPTE 2110 - Professional Media over Managed IP Networks

Constraints of 2110-10 & -30 w/ respect to AES67

• 6 conformance levels:

<table>
<thead>
<tr>
<th>Level</th>
<th>Supported by the Receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>AX</td>
<td>Level A (⇒ 48 kHz) + Reception of 96 kHz streams with 1 to 4 audio channels at packet times of 1 ms</td>
</tr>
<tr>
<td>BX</td>
<td>Level B + AX + 1 to 8 channels at packet times of 125 μs</td>
</tr>
<tr>
<td>CX</td>
<td>Level C + AX + 1 to 32 channels at packet times of 125 μs</td>
</tr>
</tbody>
</table>
Overview on IP Audio Networking

SMPTE 2110 - Professional Media over Managed IP Networks

AES67

if mediaclk offset = 0

compatibility?

constraints

ST2110-30

Overview on IP Audio Networking - A. Hildebrand
Overview on IP Audio Networking

SMPTE 2110 - Professional Media over Managed IP Networks

2110-31 – transparent transport of AES3 audio data

- 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
Overview on IP Audio Networking

SMPTE 2110 - Professional Media over Managed IP Networks

2110-31 – 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.)
Overview on IP Audio Networking

SMPTE 2110 - Professional Media over Managed IP Networks

Compatibility?

AES67

constraints, discovery, ...

ST2110-30 & -31
Overview on IP Audio Networking

Control Protocols

AMWA
Networked Media Working

NMOS
Networked Media Open Specifications

OCA
Open Control Architecture
Overview on IP Audio Networking

JT-NM ROADMAP

of networked media open interoperability

AMWA

EBU

SMPTE

VSF

VIDEO SERVICES FORUM

NetworX

# 127

Overview on IP Audio Networking - A. Hildebrand
Overview on IP Audio Networking

I. SDI OVER IP
   ST2022-6
   CURRENT AND MATURE TECHNOLOGY

II. ELEMENTARY FLOWS
    ST2110
    More flexible and efficient workflows
    New formats supported like UHD and mezzanine compression

III. AUTO-PROVISIONING
    Automated resource management for more flexible and sharable infrastructure at scale

IV. DEMATERIALIZED FACILITIES
    CLOUD FIT
    Open, secure, public/private cloud solutions
    NON MEDIA-SPECIFIC IT
    Self-service open APIs suitable for virtualization

JT-NM Roadmap

networked media
open specifications

nmos
open specifications
Key elements
Identity
Overview on IP Audio Networking

Node

Device

Source

Flow

Receiver

Sender

256E5638-0EB2-4E70-B45B-3B24BE86A478

83C42DF8-284E-4351-8349-E50DA2AC419

60752864-F055-4E32-907F-9619DA81086A

23F85482-7AE1-4366-9D03-8064B395A91

6C6C3F0-97F0-4852-9085-88480125A488

A3854BF4-09EE-48C5-9582-94A51B1C419
Discovery &
Registration
Overview on IP Audio Networking

IS-04
Ensure parts of a networked media system can find each other
Overview on IP Audio Networking

Node

Device

Source

Flow

Receiver

Sender

Registry

Registration

Query

Overview on IP Audio Networking - A. Hildebrand
Connection management
Make it simple for applications to (dis)connect devices
Overview on IP Audio Networking

- Node
- Device
- Sender
- Receiver

Application Logic

IS-04 Registry

Create Connection

Query

Registration

stream

any format / protocol
Network Control
IS-06
(on-going work)
Reserve and manage low-level network flows
Overview on IP Audio Networking

Application Logic (Broadcast controller)

Registry

Network Controller

Network Infrastructure

Query

Create Connection

Registration

Report

Reserve
Overview on IP Audio Networking

Network Infrastructure

Network Controller

Application Logic (Broadcast controller)

Query
Create Connection

Registry
Registration

Report Reserve

Overview on IP Audio Networking - A. Hildebrand
Implementations
Networked Media Incubator
Overview on IP Audio Networking

Incubator launched

London | Salford | Wuppertal | San Jose | Manchester | Basingstoke

IBC '15 | NAB '16 | IBC '16 | NAB '17 | IBC '17
Workshop participants

Aperi
Arista
Atos
Avid
Axon Digital Design
Barco Silex
BBC
Bosch
Calrec Audio
CBC Radio-Canada
Cisco
Coveloz
Dalet
dB Broadcast
DirectOut
EBU
Embrionix Design
Ericsson
Evertz
Fox
Glitch Digital
Grass Valley
Harmonic
Imagine
Communications
IML
Juniper Networks
KBS
LAWO/ALC NetworX

Macnica
Matrox
Mellanox Technologies
MOG
Nevion
Nextera Video
NHK
Origami Tech
Panasonic
PBS
Riedel
Ross Video
RTI

Snell Advanced Media
Sohonet
Sony
STORDIS
Streampunk Media
Suitcase TV
Tedial
Tektronix
Teletstream
Telos Alliance
Telstra
Xytech
Yamaha (Music)
Overview on IP Audio Networking - A. Hildebrand
Overview on IP Audio Networking

IP Showcase with ST2110 / AES67 / NMOS IS-04 & IS-05 (IBC 2017)
Overview on IP Audio Networking

JT-NM ROADMAP
of networked media open interoperability

Legend
- Published
- Standard / Specification
- Model Available
- Study / Activity or Other

I. SDI OVER IP
- SMPTE ST 2059

SMPEG 67
- AES67
- Audio
- Timing

II. ELEMENTARY FLOWS
- SMPTE ST 2022-6

III. AUTO-PROVISIONING
- AMWA IS-04
  - Discovery & Registration
- AMWA IS-05
  - Connection Management
- AMWA IS-06
  - Network Control

IV. DEMATERIALISED FACILITIES
- EBU RT-146
  - Cloud Security for Media Companies
- 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 virtualisation

*Additional information on Dematerialised Facilities at jtnm.org * JT-NM assumption as of August 2017 and will evolve over time. Visit JT-NM.org for the latest updates. Feedback to jtnm-info@videoservicesforum.org
Device & system control

“control protocols”
Overview on IP Audio Networking

MEDIA NETWORK

MEDIA TRANSPORT  SYSTEM CONTROL
Overview on IP Audio Networking

PROTOCOLS

AES67
Dante
AVB/TSN
CobraNet
Analog Cable
IP Video
whatever

OCA
AES70
Overview on IP Audio Networking

AES70 Device Model

Box of Objects
## Overview on IP Audio Networking

### AES70-2015 Control Repertoire

<table>
<thead>
<tr>
<th>Media Connection Management</th>
<th>Signal Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Connection control</td>
<td>• Gain controls</td>
</tr>
<tr>
<td>• Directory/discovery</td>
<td>• Mutes</td>
</tr>
<tr>
<td></td>
<td>• Switches (n-position)</td>
</tr>
<tr>
<td></td>
<td>• Delays</td>
</tr>
<tr>
<td></td>
<td>• Equalizers</td>
</tr>
<tr>
<td></td>
<td>• Filters (IIR &amp; FIR)</td>
</tr>
<tr>
<td></td>
<td>• Limiters &amp; Compressors</td>
</tr>
<tr>
<td></td>
<td>• Expanders &amp; Gates</td>
</tr>
<tr>
<td></td>
<td>• Levelers</td>
</tr>
<tr>
<td></td>
<td>• Matrices</td>
</tr>
<tr>
<td></td>
<td>• Signal generators</td>
</tr>
<tr>
<td></td>
<td>• Arbitrary numeric and text parameters</td>
</tr>
</tbody>
</table>

### Additional Functions
- Control grouping (VCA groups)
- Crossfading
- Snapshot & preset management
- Reconfigurable DSP device setup
- Reliable firmware updating

### Signal Monitoring
- Level sensors (meters)
- Frequency sensors
- Time interval sensors
- Temperature sensors
- Arbitrary numeric sensors

*Proprietary extensions as needed*
Other (competing) control protocols:

- AES24 (abandoned)
- AES42 (digital microphone control)
- AES64 (no adoption)
- ST2071 (very complex)
- P1722.1 (AVB-related)
- OSC (MI), DMX (live show control), ...
- myriads of proprietary protocols (Dante, Livewire, QSC, Crestron, AMX, HiQnet, ...)
- EmBer+ (open technology, many adopters incl. Lawo)
- NMOS IS-0x ?
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RAVENNA/AES67 Evangelist

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www.ravenna-network.com