Monitoring Audio-over-IP Audio

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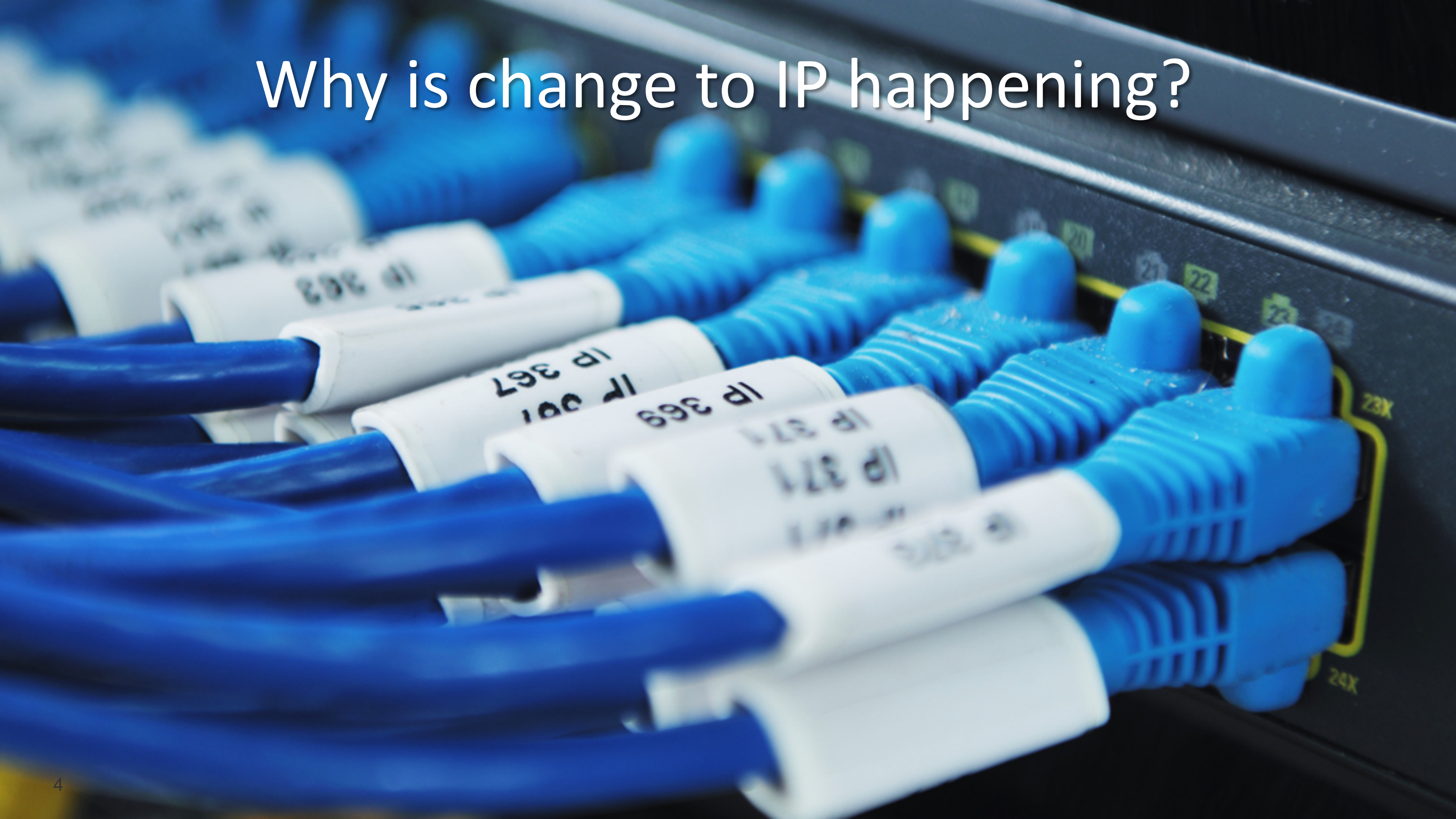
Overview

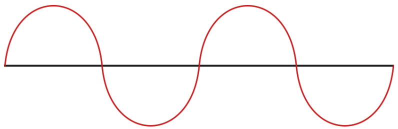
- Why is change to audio-over-IP happening?
- Audio-over-IP networking standards
- How does audio-over-IP work?
- PoE and single cable connectivity
- Setting up networked audio monitoring
- Case examples
    - Broadcast case examples
    - AV install case examples

Why is change to IP happening?



Traditional connectivity of devices

Traditional signal types, analogue

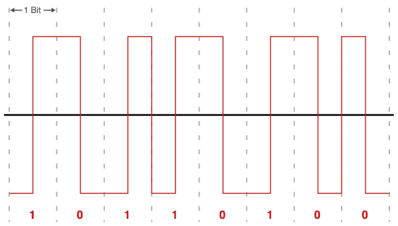


Analogue

Continuous voltage describes the audio signal

- one-to-one connectivity
- one-way signal
- one cable (two wires) per signal
- → N signals, N x 2 wires (balanced connections)
- limited dynamic range (max-noise)

Traditional signal types, digital PCM

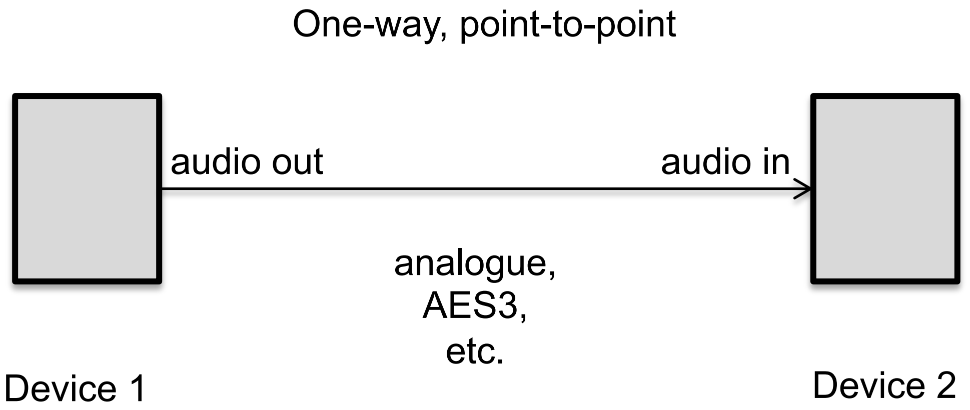


Digital
PCM STREAM

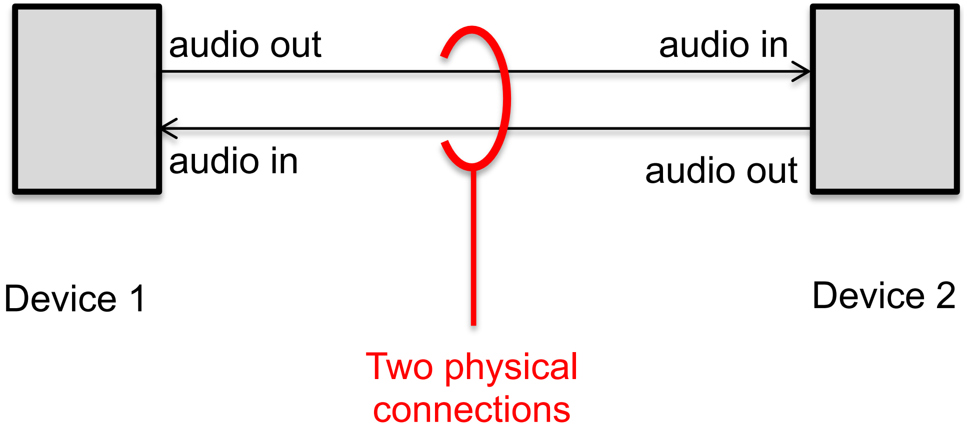
Sample values describes the audio signal

- one-to-one connectivity
- one-way signal
- one cable (two wires) per N signals (can be multiplexed)
  - max bit rate limits capacity of one cable
- flexible dynamic range (max-noise)
  - fixed point = fixed dynamic range
  - floating point

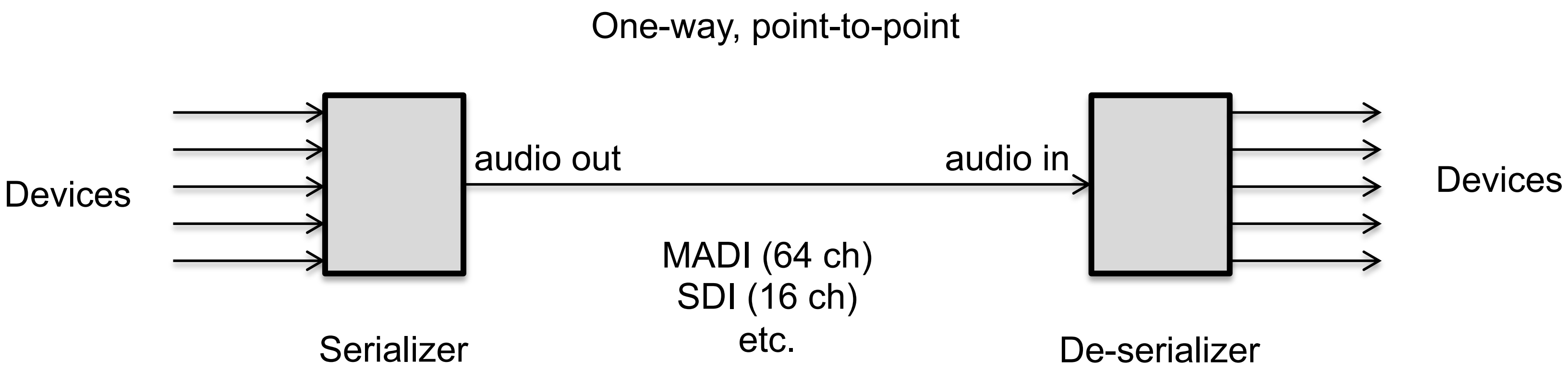
Traditional interconnection



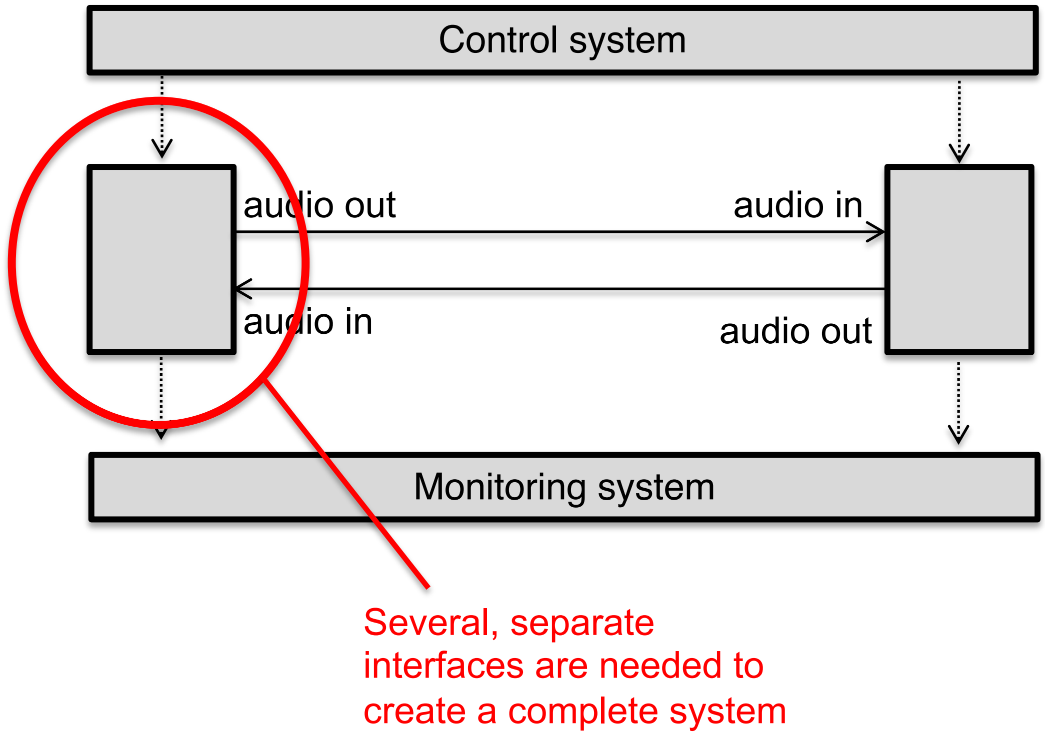
Traditional two-way interconnection



Digital interconnection allows serialization



Two-way interconnection with control and monitoring



Connectivity, good old days

Batch bay, one-to-one physical links between devices in studio

- Expensive
- Custom build
- Cabling requires experts to build and maintain/service

Connectivity on IP networks

OLD

NEW

analog, AES3, MADI
and SDI solutions

dedicated, special
technology for
audio only

IT technology

standard technology:
IP switch infrastructure,
standard cables, low cost

analog, AES3, MADI
and SDI solutions

limited technical life time,
new technology generations
outdate previous systems

IT technology

IP technology has a long
lifetime and good backwards
compatibility, technology does
not become obsolete suddenly

analog, AES3, MADI
and SDI solutions

interface has hard limits: format, speed, channel count, etc.

IT technology

- IP network speeds continuously increase;
- **network is agnostic**
- no fundamental limitations to formats, channel counts, precision, clock rates, etc.

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analog, AES3, MADI
and SDI solutions

IT technology

basic balanced line connection is (fairly) standard

interface conventions can be limited to one vendor

standard protocols are recognized by all devices, standardization improves cross-vendor compatibility

audio-over-IP is (being) standardized by AES (AES67) and SMPTE (ST2110)

analog, AES3, MADI
and SDI solutions

expensive to design and build,
needs specialists to maintain

IT technology

low-cost to build and maintain:
systems use the same backbone technology

analog, AES3, MADI
and SDI solutions

control, monitoring and management need a separate network/connectivity/system

IT technology

same IP network works for all functions, media (audio, video) + monitoring + management + all else

Options for audio-over-IP connectivity

Multichannel HW
interfaces and converters

Adapter w/
standard
loudspeakers

Audio-over-IP
connectable
loudspeakers
(two-cable
connectivity)

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Minimum audio monitoring system

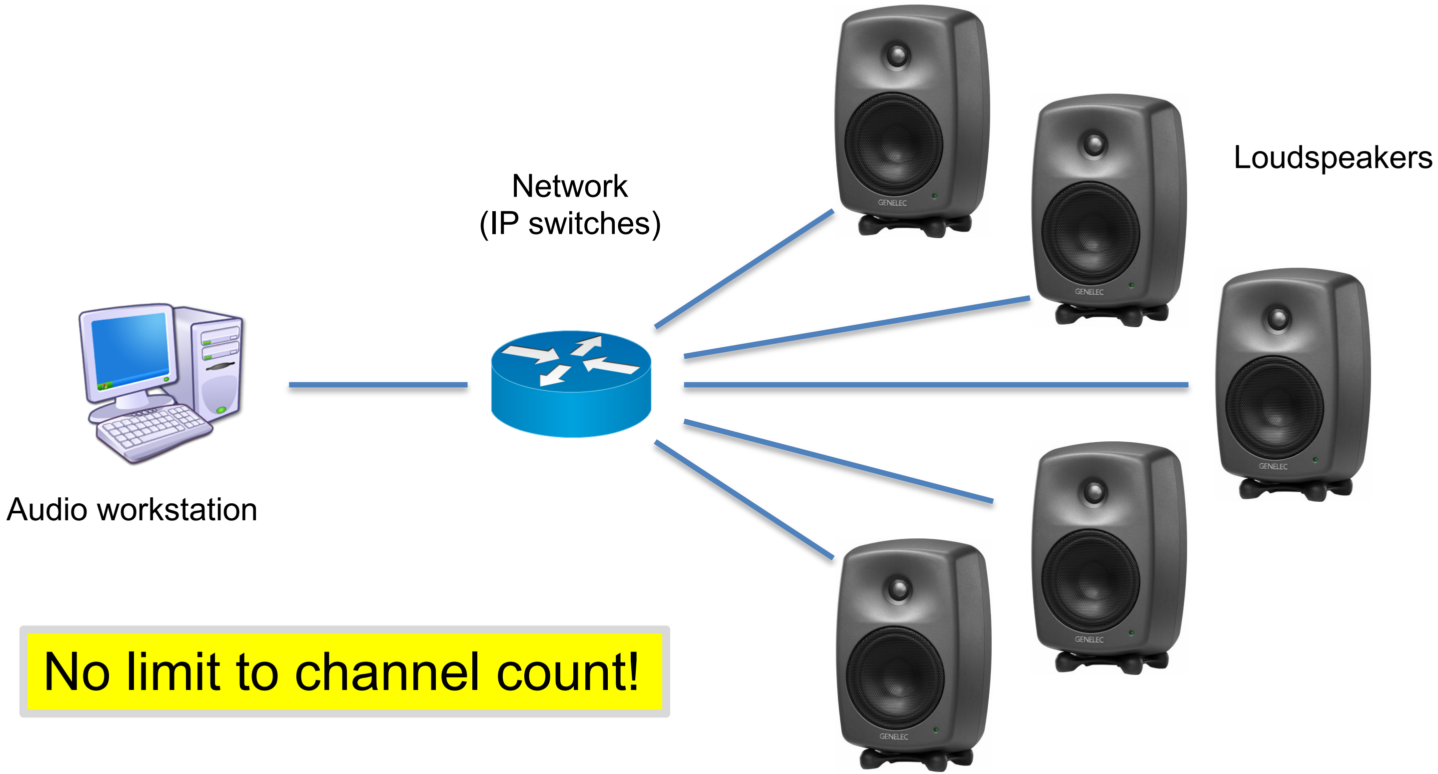
Loudspeakers with audio-over-IP input

IP switch

Computer for graphical user interface and possibly software soundcard

PTP clock source (HW audio inputs)

Simple audio-over-IP monitoring network



No limit to channel count!

Standards for Networking Audio

IP protocols can create efficient communication

IP protocols, the agreed methods of interacting

Used with Audio-over-IP

UDP

PTP

RTP

RTCP

SDP

IGMP

URI

SIP

SAP

Bonjour

QoS

DiffServ

DSCP

Open System Interconnect (OSI) model

OSI Model				
Layer		Data unit	Function	Examples
Host layers	7. Application	Data		HTTP, FTP, SMTP, SSH
	6. Presentation		Translation of data between a networking service and an application;	HTML, CSS
	5. Session		Managing communication sessions, i.e. continuous exchange of information	RPC, PAP, SSL, SQL
	4. Transport	Segments/ Datagram	Reliable transmission of data segments between points on a network,	TCP, UDP
Media layers	3. Network	Packet	addressing, routing and traffic control	IPv4, IPv6, IPsec, ICMP
	2. Data link	Frame	Reliable transmission of data frames	MAC
	1. Physical	Bit	Transmission and reception of raw bit streams	Ethernet PHY (physical layer)

Audio-over-IP

Legacy Audio-over-IP technologies

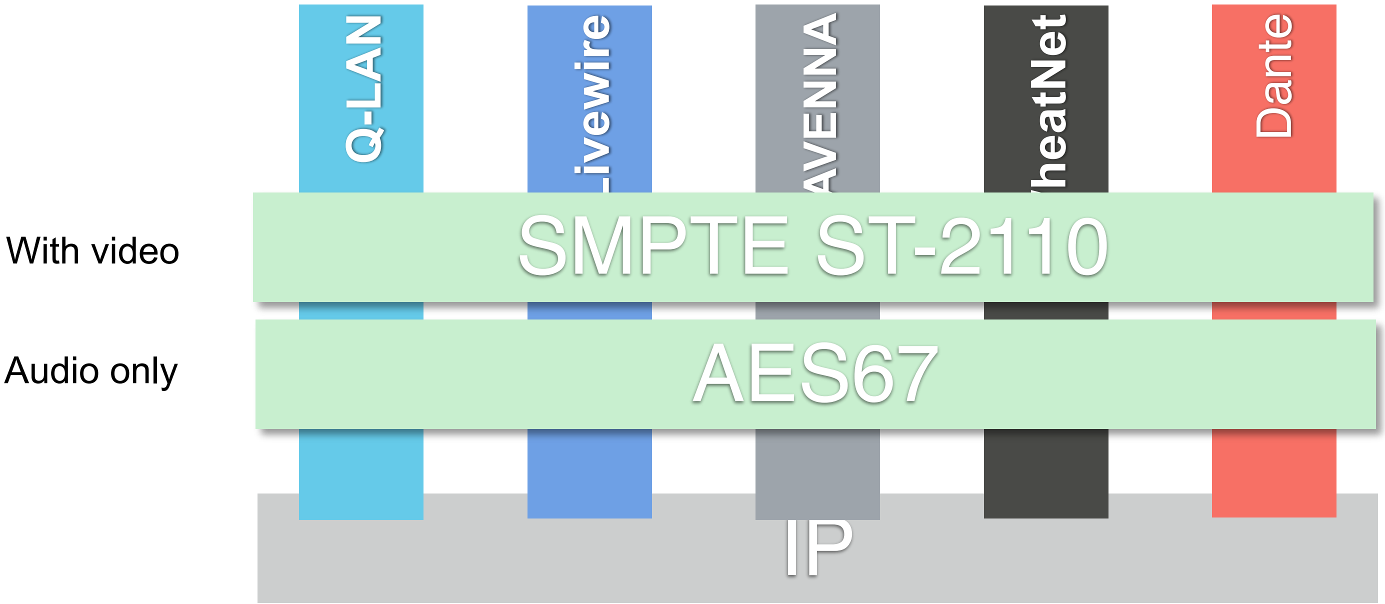
Technology	Purveyor	Date introduced	Synchronization	Transport
Livewire	Telos/Axia	2003	Proprietary	RTP
Wheatnet-IP	Wheatstone	2005	Proprietary	RTP
Dante	Audinate	2006	IEEE 1588-2002	UDP
N/ACIP	EBU	2007	Adaptive (per stream)	RTP
Q-LAN	QSC Audio Products	2009	IEEE 1588-2002	UDP
RAVENNA	ALC NetworX	2010	IEEE 1588-2008	RTP
AVB	IEEE, AVnu	2011	IEEE 802.1AS	Ethernet, RTP

Some RAVENNA Partners

Some Dante partners

Dante Domain Manager version 1.1. enables support for SMPTE 2110 and AES67 within Dante domains, allowing broadcasters to integrate SMTPE 2110/AES67 compliant devices in a managed Dante environment.

AES67 – AES Standard for Interoperability in High-performance Audio-over-IP Streaming



Standards: EBU and SMPTE

The SMPTE ST 2110 Professional Media Over Managed IP Networks suite of standards is a major contributing factor in the movement toward one common internet protocol (IP)-based mechanism for the professional media industries.

Task Force on Networked Media (JT-NM) Open Interoperability

What is AES67

AES67 is a technical standard for audio over IP and audio over Ethernet interoperability. The standard was developed by the Audio Engineering Society.

http://www.aes.org/publications/standards/search.cfm?docID=96

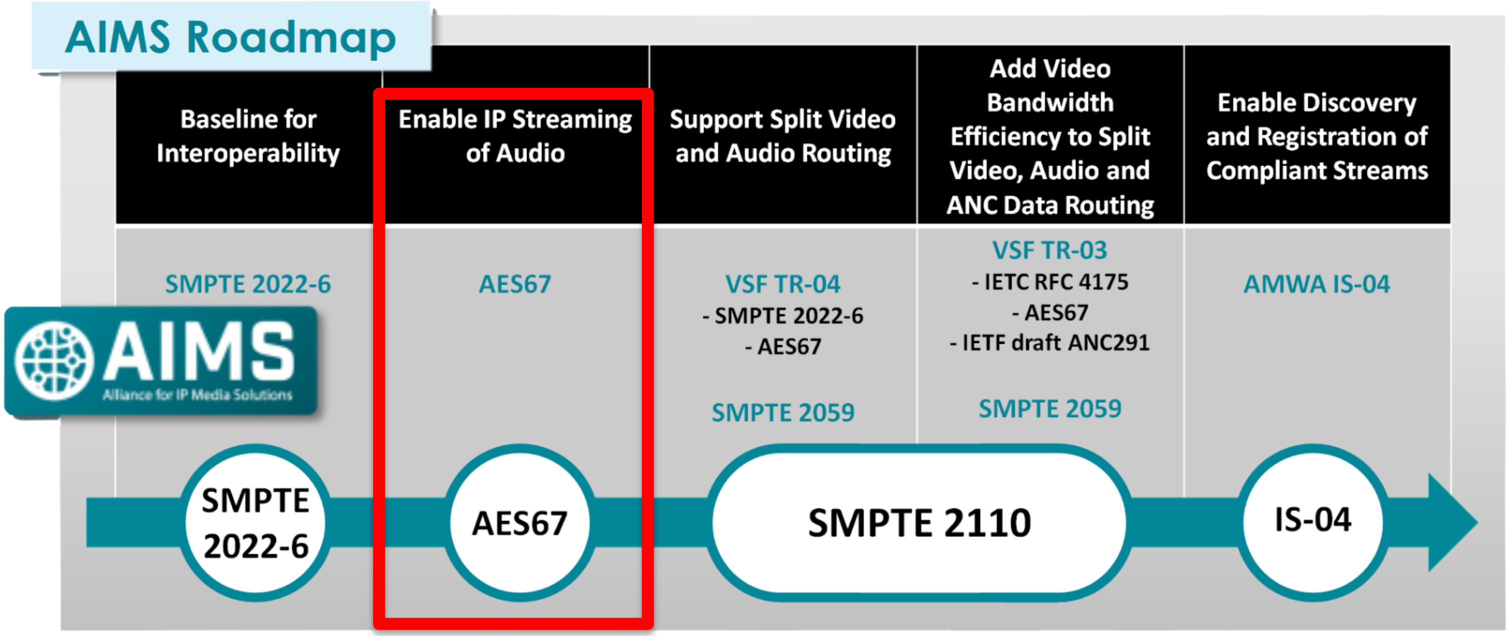
What is SMPTE ST-2110

ST 2110

The SMPTE ST 2110 routes video, audio, and ancillary data streams separately to gain efficiency.

The standards suite is multipart. The following is the current status of documents included in the suite as of 10 September 2018:

- SMPTE ST 2110-10/-20/-30 — addressing system concerns and uncompressed video and audio streams
- SMPTE ST 2110-21 — specifying traffic shaping and delivery timing of the uncompressed video
- SMPTE ST 2110-31 - specifies the real-time, RTP-based transport of AES3 signals over IP networks, referenced to a network reference clock
- SMPTE ST 2110-40 — maps ancillary data packets (as defined in SMPTE ST 291-1) into Real-Time Transport Protocol (RTP) packets that are transported via User Data Protocol/Internet Protocol (UDP/IP) and enables those packets to be moved synchronously with associated video and audio essence streams



"The Alliance for IP Media Solutions (AIMS), is a non-profit trade alliance that promotes the open standards that broadcast and media companies use to move from legacy SDI systems to a virtualized, IP-based future"

https://www.aimsalliance.org/

AIMS alliance

https://aimsalliance.org/

The Alliance for IP Media Solutions (AIMS), is a non-profit trade alliance that fosters the adoption of one set of common, ubiquitous, standards-based protocols for interoperability over IP in the media and entertainment, and professional audio/video industries

EBU position: Technology Pyramid

Minimum User Requirements to Build and Manage an IP-Based Media Facility

https://tech.ebu.ch/pyramid

The Technology Pyramid for Media Nodes

Minimum User Requirements to Build and Manage an IP-Based Media Facility.

Media Transport

- Single link video SMPTE ST 2110-20
- Software-friendly SMPTE ST 2110-21 Wide video receivers
- Universal, multichannel and low latency audio SMPTE ST 2110-30 Level C
- Stream protection with SMPTE ST 2022-7

Widely available
Partially available
Rarely available

EBU

EBU TECH 3371 - December 2018

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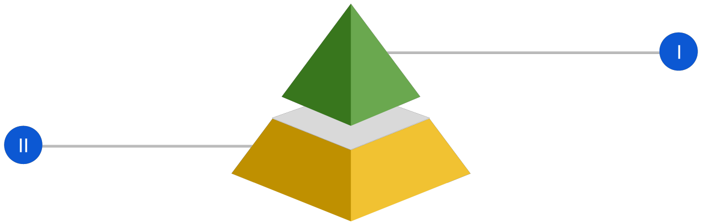
Time and Sync

- PTPv2 configurable within SMPTE and AES profiles
- Multi-interface PTP redundancy
- Synchronisation of audio, video and data essences



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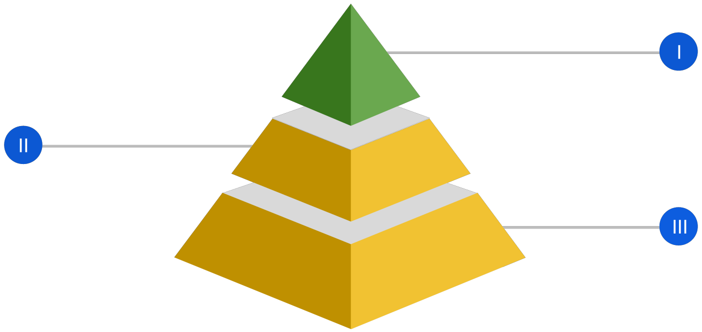

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Discovery and Connection

- Discovery and Registration: AMWA IS-04
- Connection Management: AMWA IS-05
- Audio channel mapping: AMWA IS-08 (in dev.)
- Topology discovery: LLDP

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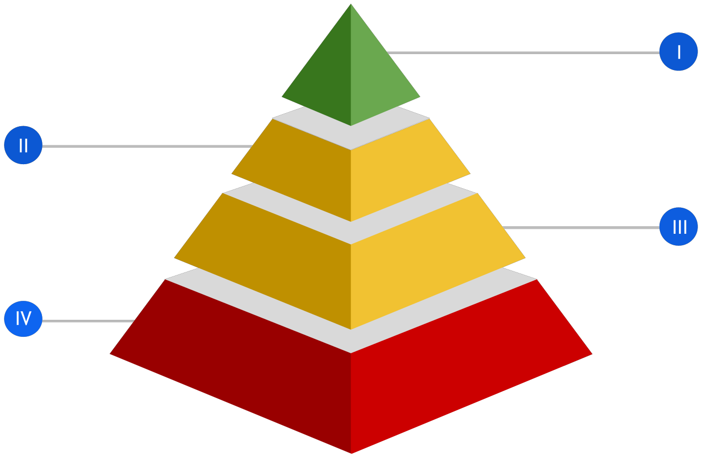
Configuration and Monitoring

- IP assignment: DHCP
- Open configuration management - e.g., API, config file, SSH CLI, etc.
- Open monitoring protocol - e.g., syslog, agent, SNMPv3, etc.



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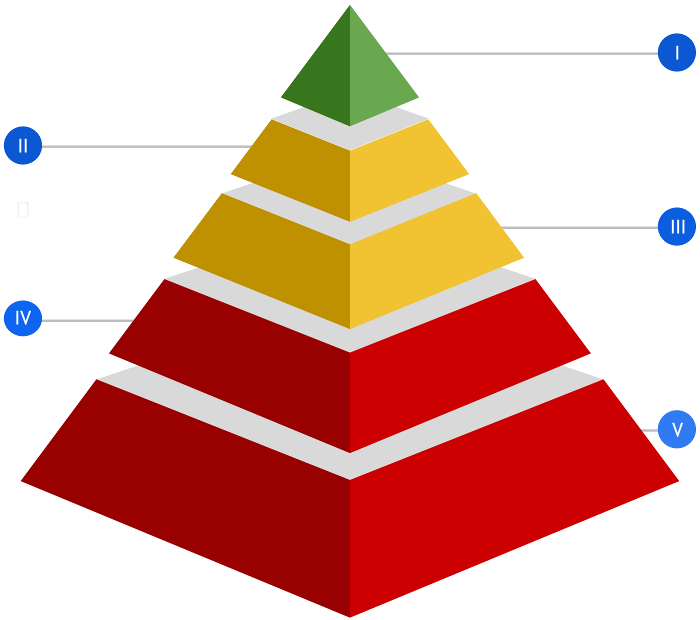

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Security

- EBU R 148 Security Tests
- EBU R 143 Security Safeguards
- Secure HTTPS API calls

Widely available

Partially available

Rarely available

EBU TECH 3371 - December 2018

AES 67 Covers a part of the EBU Full Stack

Time and Sync

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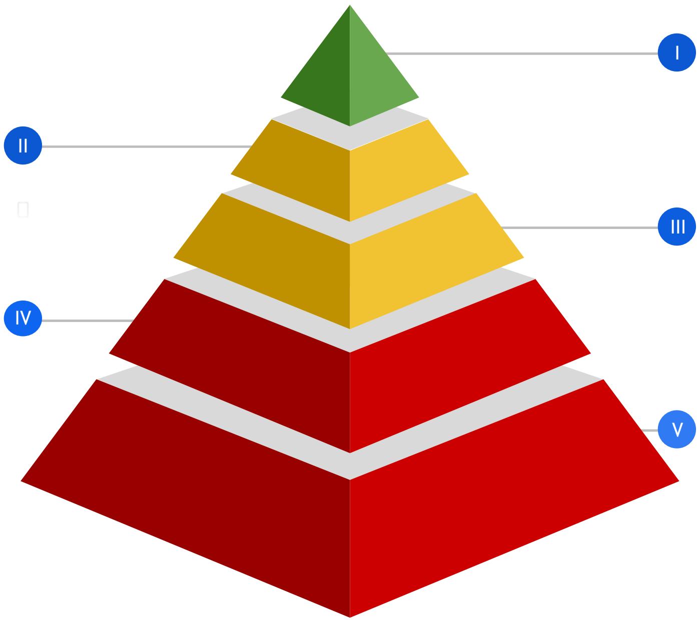

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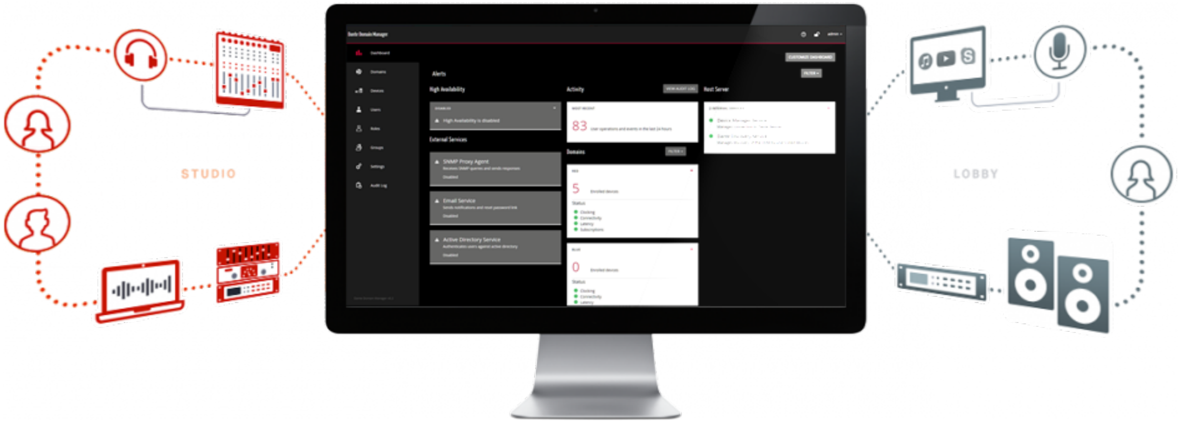
EBU

EBU TECH 3371 - December 2018

Examples of implementing ST2110 compliance



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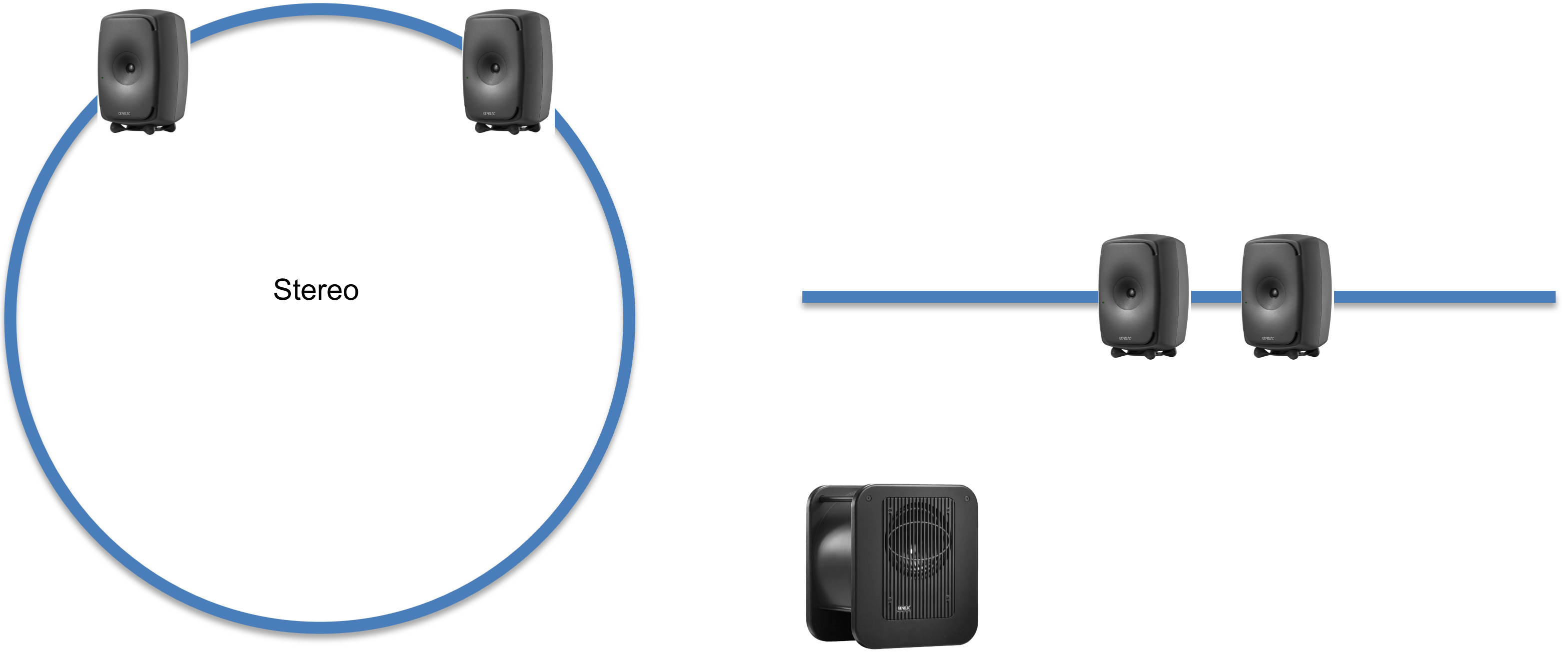
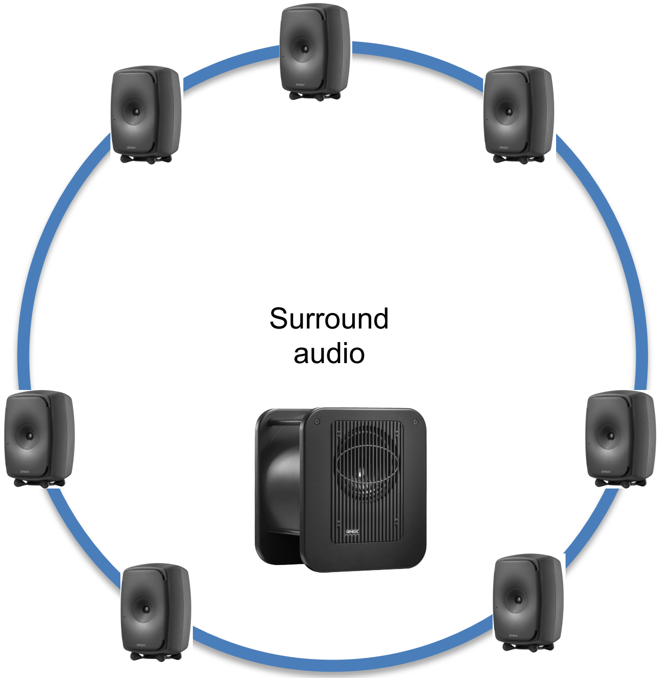
Monitoring Networked Audio

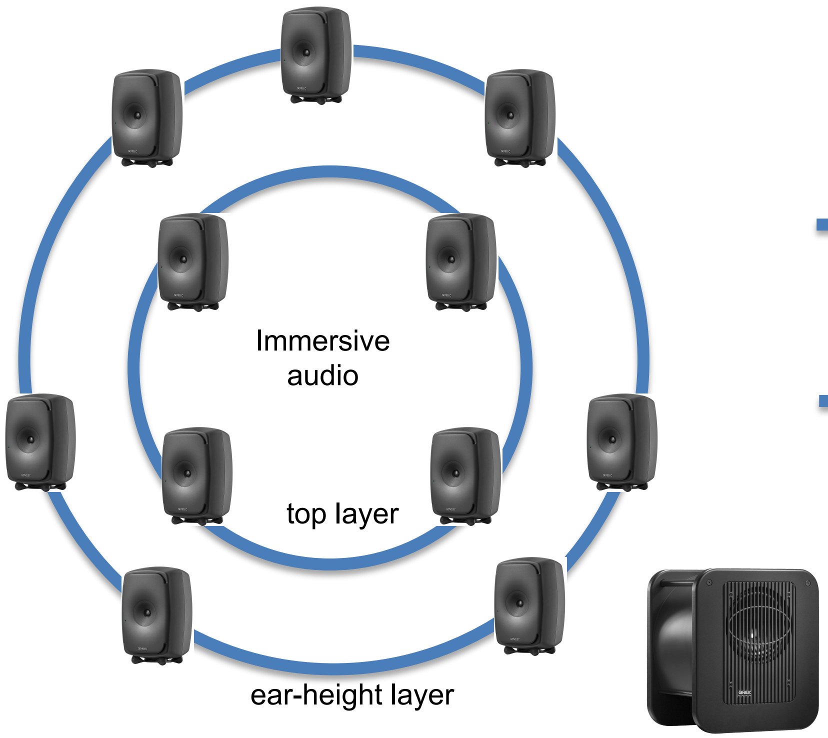
Single-layer systems: stereo

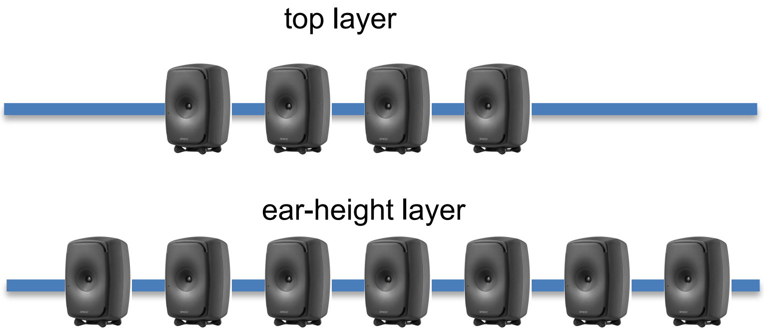


Single-layer systems: surround (typically 5…7 ch)



Two-layer immersive systems





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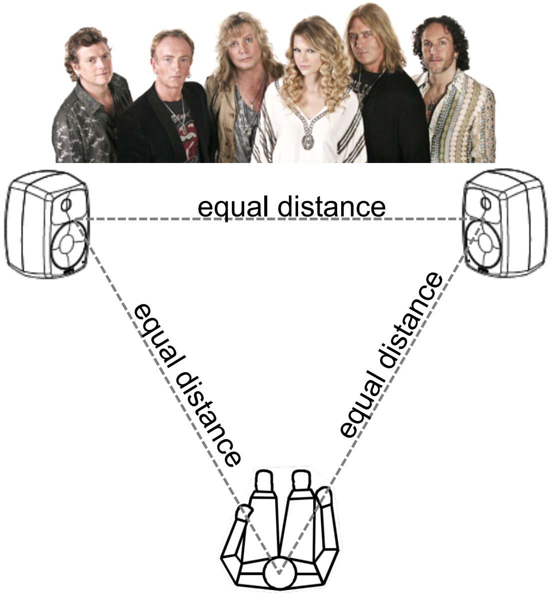
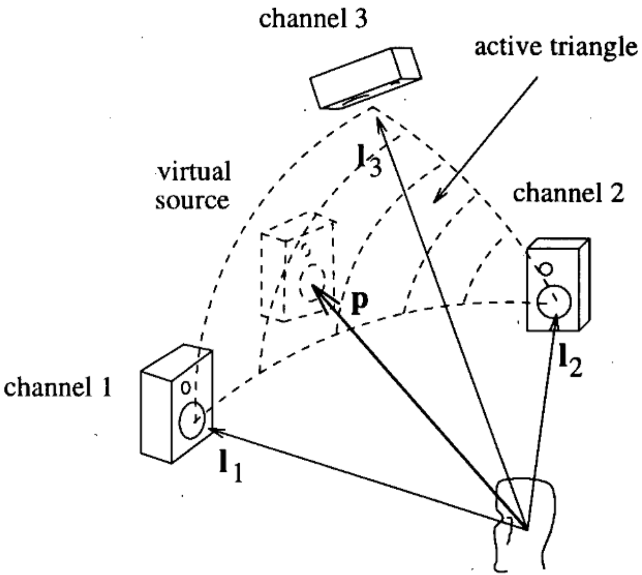
Creating immersive sound stage

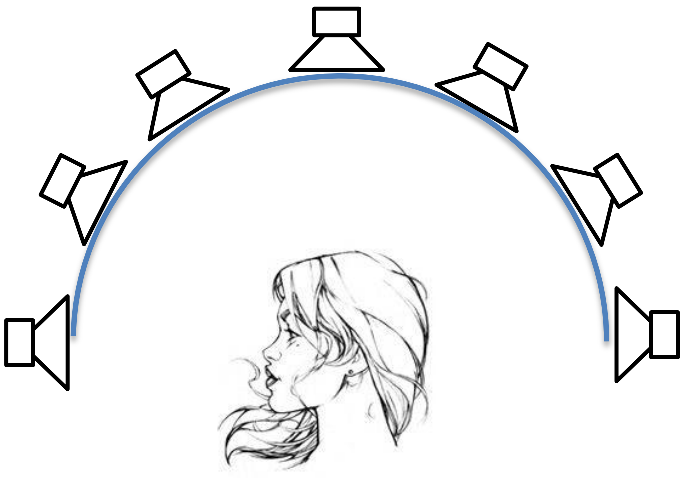


Single-layer virtual images can be created using level panning

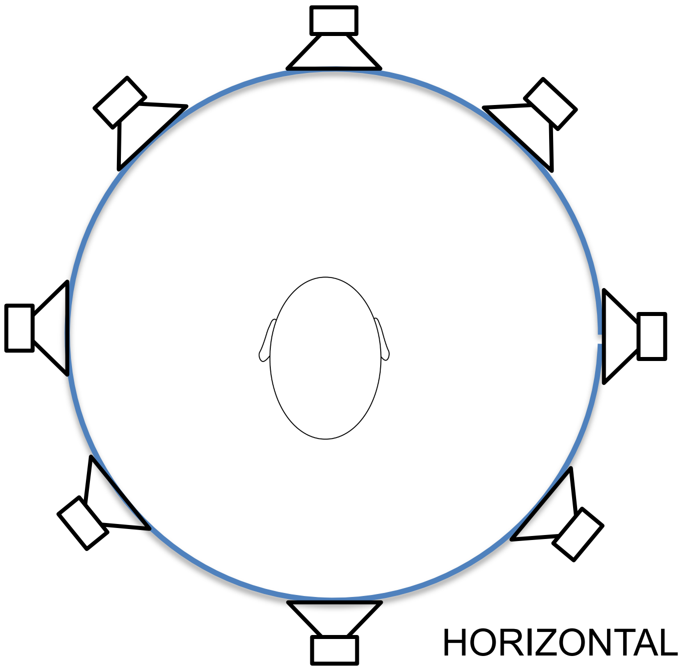


Interlayer virtual images created using Vector Base Amplitude Panning (VBAP)

Equidelay, equidistance, and equal level at listening location

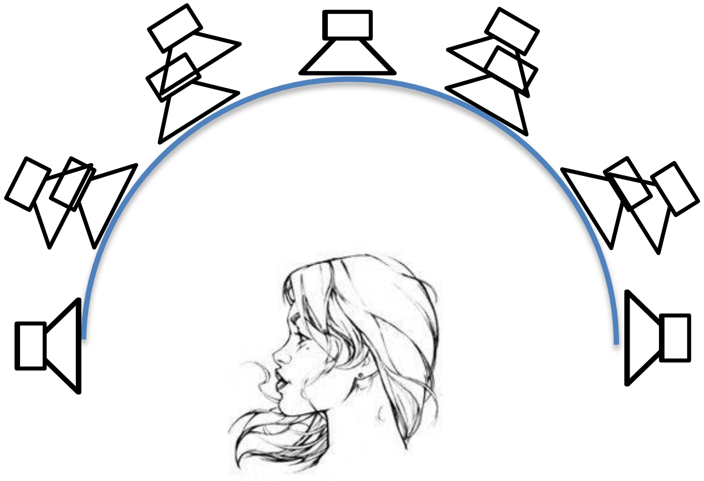


VERTICAL ORIENTATION

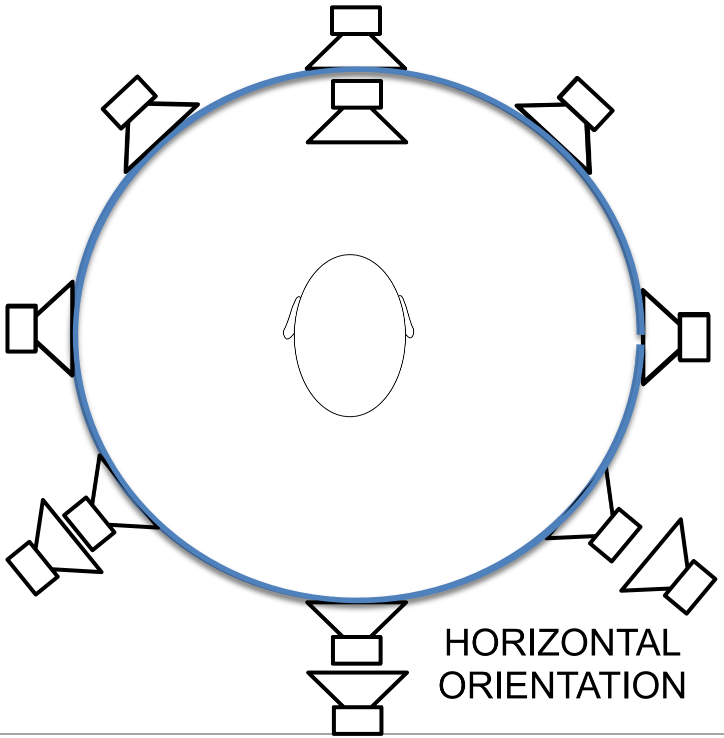


HORIZONTAL ORIENTATION

Compensating for delay and level differences

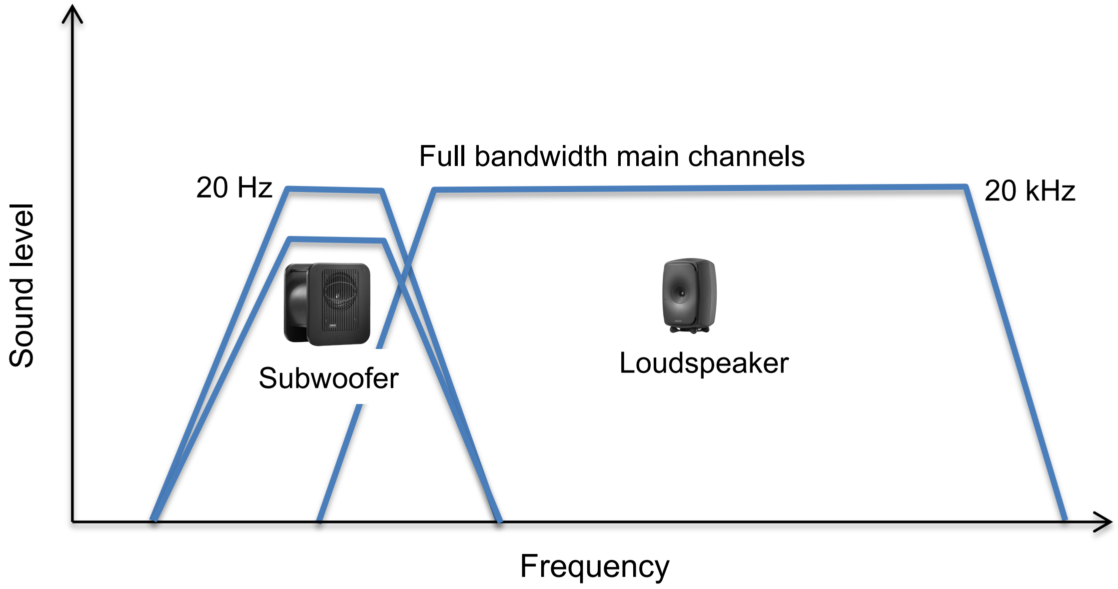


VERTICAL
ORIENTATION



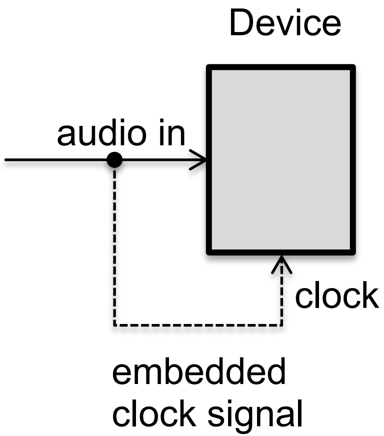
HORIZONTAL
ORIENTATION

Subwoofer alignment

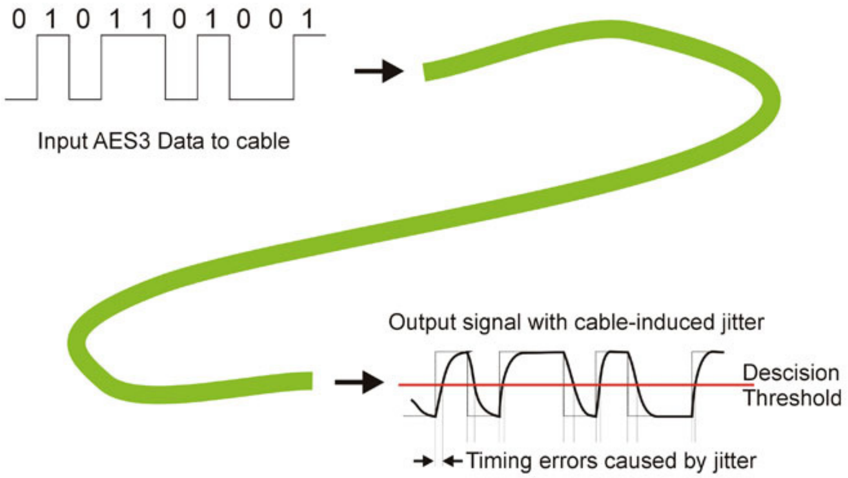


Clock and time synchronization

Self-clocking digital interconnects can have jitter

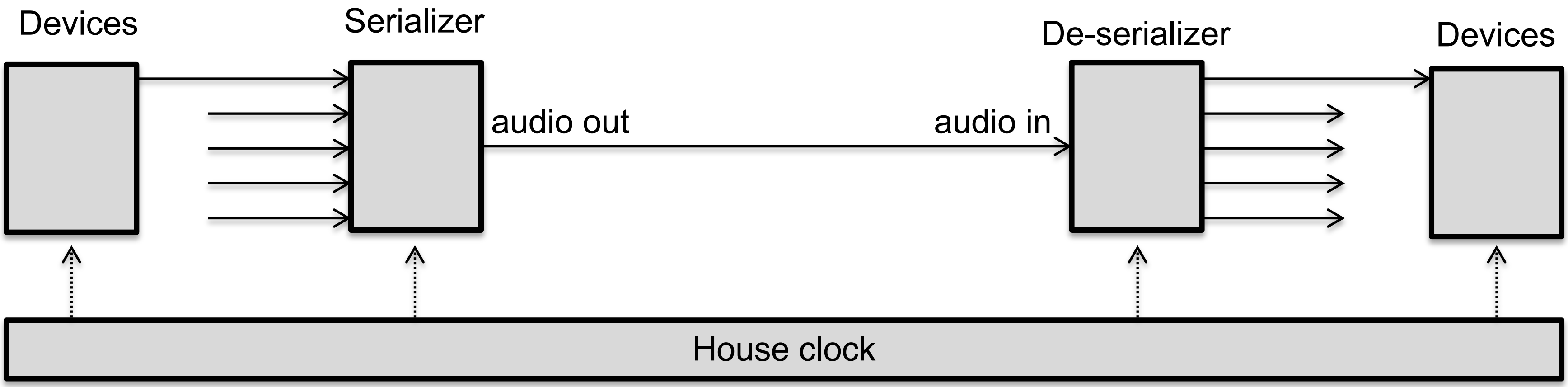


AES3



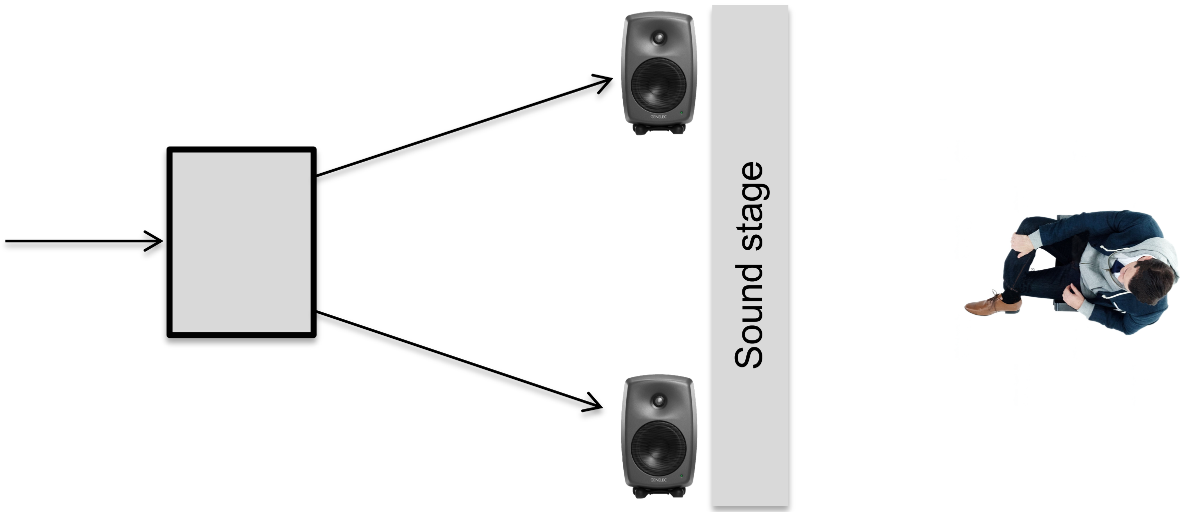
https://www.soundonsound.com/techniques/digital-interfacing

Traditional digital interconnection uses a house clock



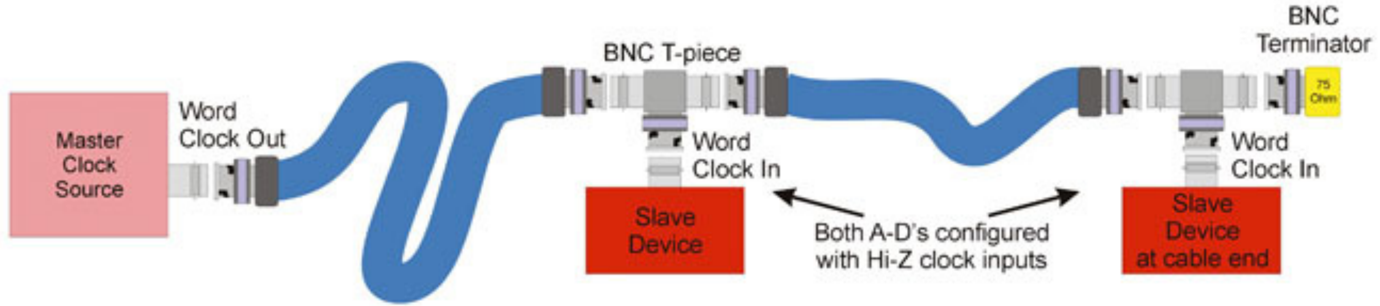
The House Clock ensures that all devices work at the same speed and that clock jitter is at minimum.

Traditional loudspeaker interconnection



Time synchrony to form the stereo stage is guaranteed by the fact that all channels originate in one piece of equipment

All devices see the same house clock signal

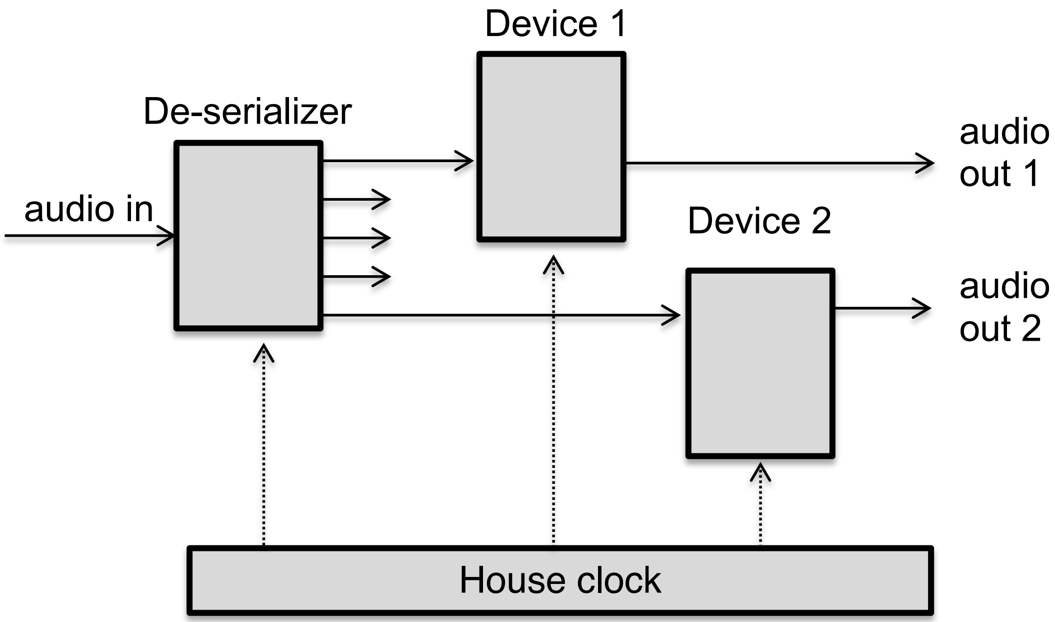


A typical way of distributing the House Clock signal.

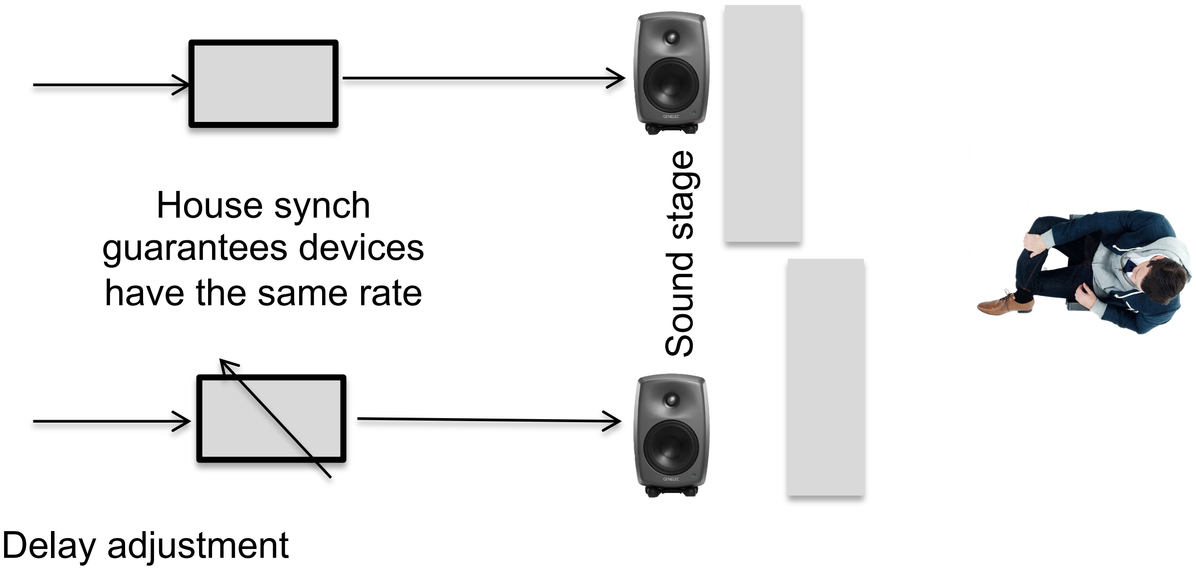
https://www.soundonsound.com/techniques/digital-interfacing

House clock does not create absolute time reference

- Devices do not know about absolute time
- Device 1 and Device 2 can have different latency for audio output
- This is typically a fixed value, latency can be manually trimmed off in most cases
- House Clock does not guarantee time synchrony for outputs (but helps in achieving it)
- use of House Clock **assumes fixed timing in the signal transport**



Achieving synch with house clock



House synch does not guarantee time synchrony automatically

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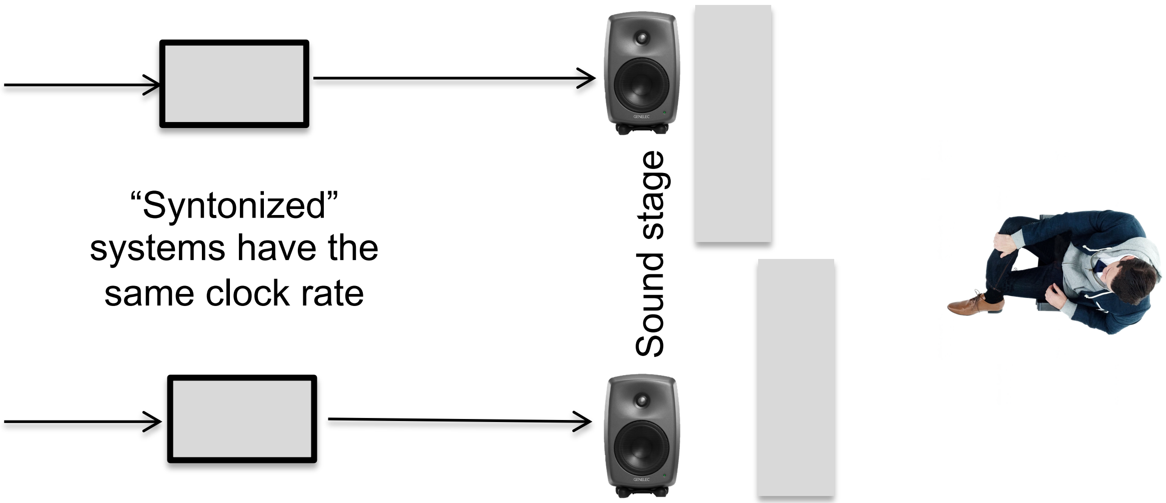
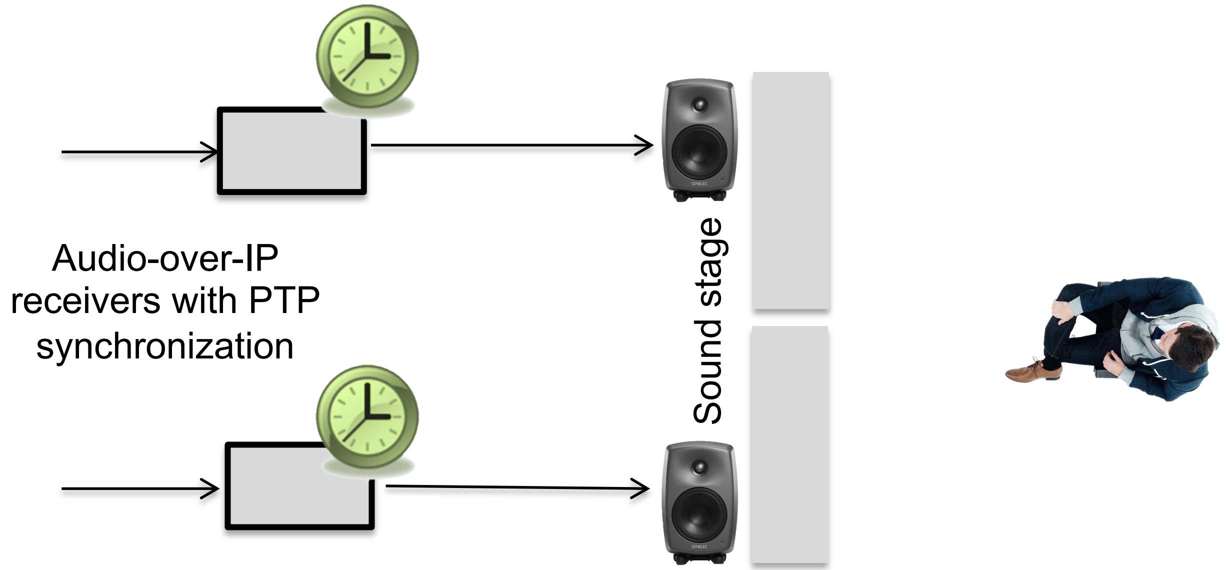
Audio-over-IP loudspeaker interconnection



Syntonized clocks guarantee the same clock rate but no absolute time synchrony

Audio-over-IP loudspeaker interconnection

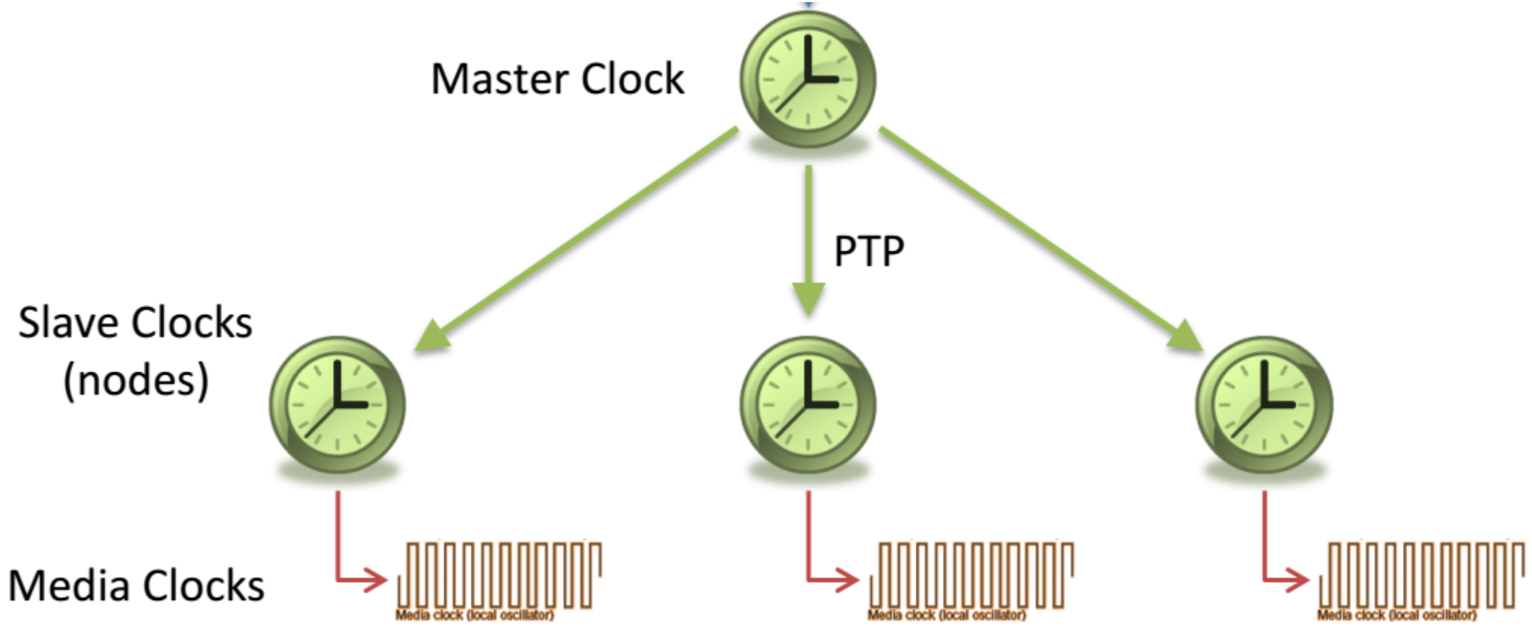


Time synchrony can be guaranteed using PTP clock synchronization protocol

Time

- House clock sets the correct speed for clocks but does not represent absolute time
- Time concepts for audio-over-IP
  - Presentation time (link offset: ingress time and egress time, link offset)
  - Packet time
  - Jitter absorption buffer
- “Buffer too late” or “wrong PTS value”
- relativity of time
  - synchronized vs. syntonised (PTP standard, IEEE 1588)

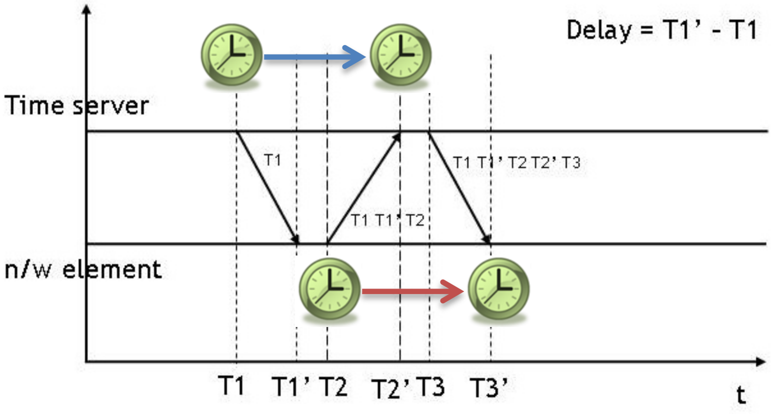
Clock synchronization using IEEE 1588-2008 (PTP v2)



AES67 – synchronizing devices

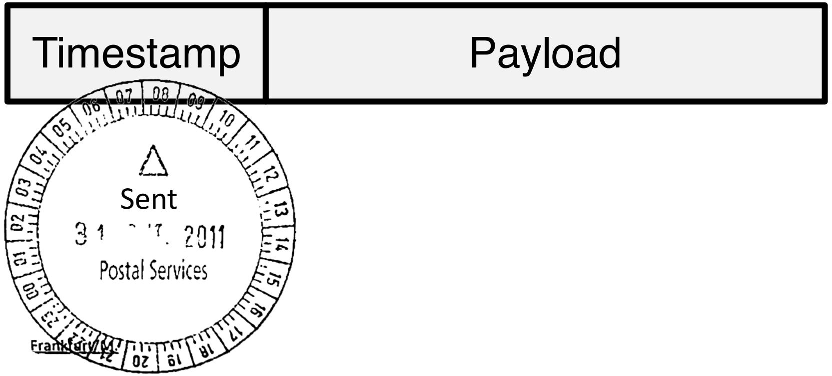
- The Precision Time Protocol (PTP) is a protocol used to synchronize clocks throughout a computer network
- PTP version 2 achieves clock accuracy in the sub-microsecond range
  - all devices synch to one device (called grandmaster)
  - timestamps in packets are corrected with the packet transport delay in network
- PTP was originally defined in the IEEE 1588 standard "Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems"

Method of synchronizing clocks

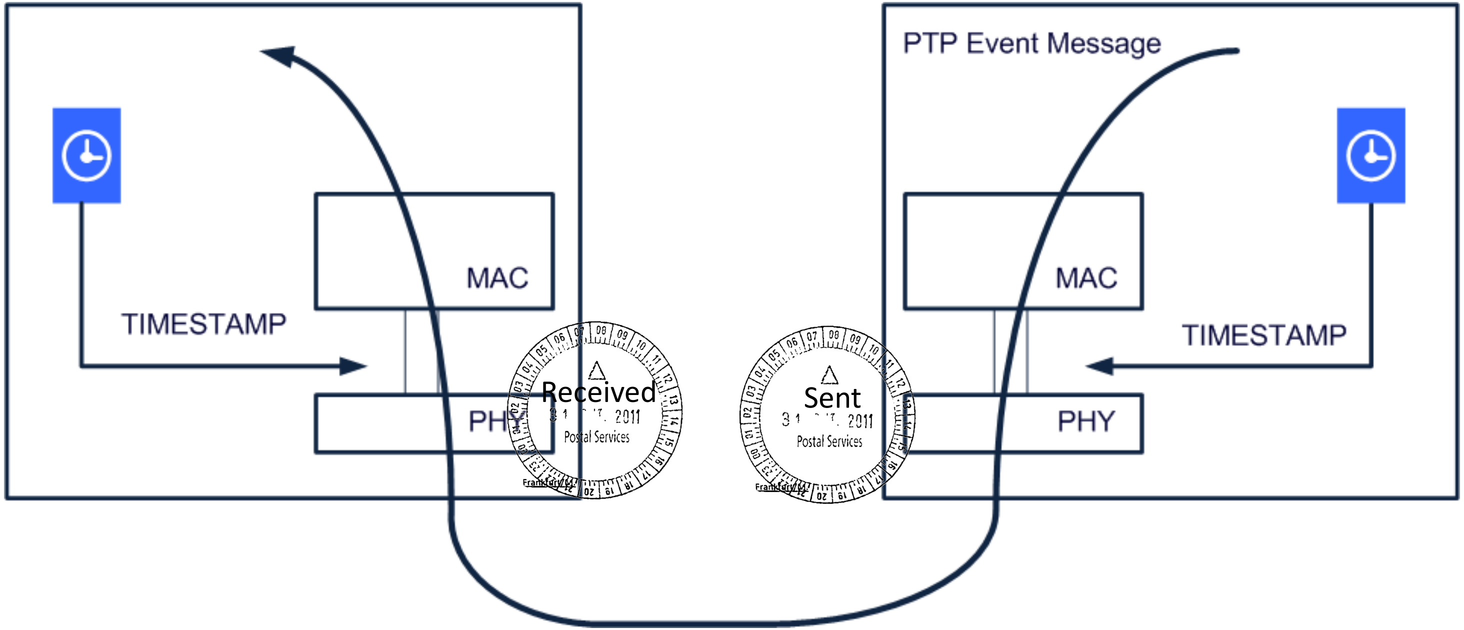


Timestamp

- Each audio packet is timestamped
- The timestamp reflects the sampling instant of the first octet (i.e. start of data) in the RTP data packet (RFC 3550)
- *Truncated* IEEE 1588v2 *PTP timestamp format* uses 64 bits, including a 32-bit seconds field and a 32-bit nanoseconds field
- Timestamp is the **origination time** of the packet on the network
  - → timestamp is set by the sender
- Presentation time = origination time + link offset



Timestamp



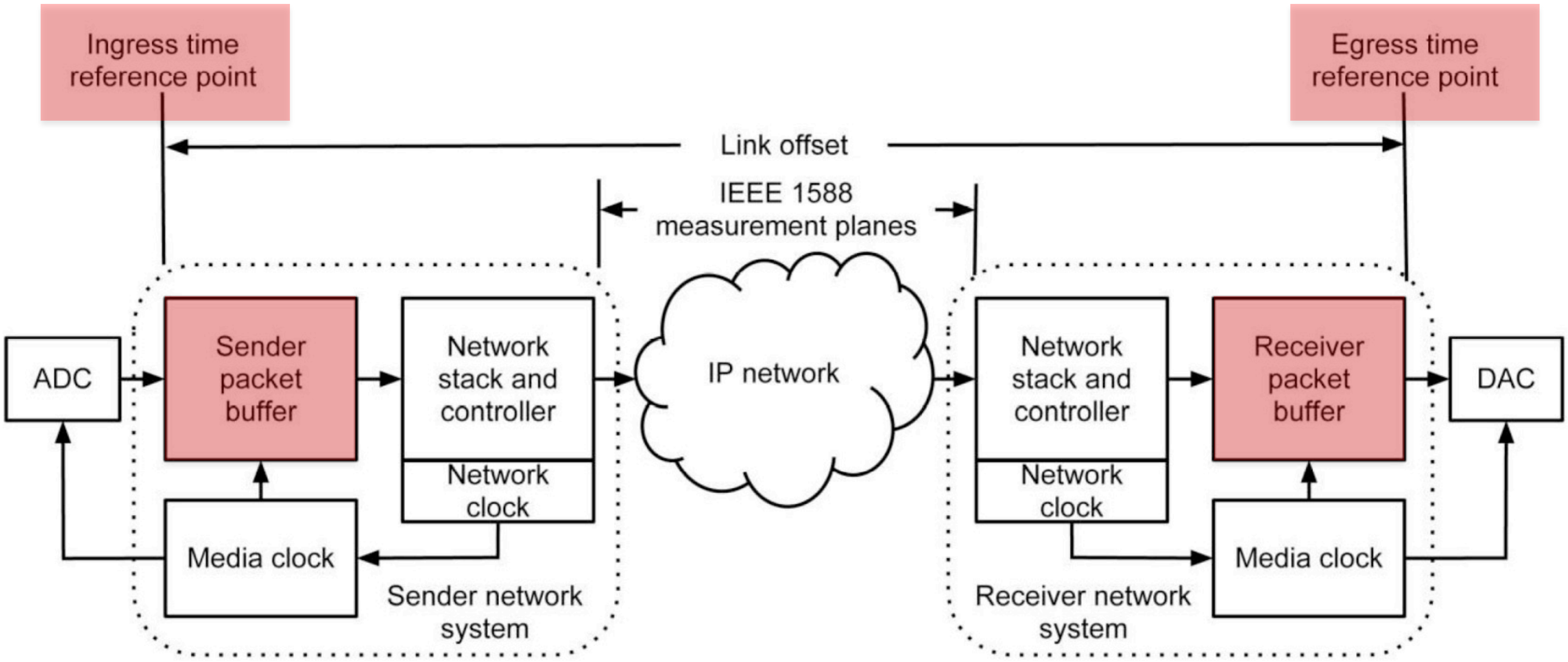
PTP Event Message
MAC
TIMESTAMP
PHY
Received
Postal Services
Sent
Postal Services
MAC
TIMESTAMP
PHY

Quality of Service (QoS) using DiffServ DSCP

Differentiated Services Code Points (DSCP) is a 6 bit value in the IP header DS field, guiding the switch device priority of handling packets.

increasing importance

Class name	Traffic type	Default DiffServ class (DSCP decimal value)
Clock	IEEE 1588-2008 *Announce, Sync, Follow_Up, Delay_Req, Delay_Resp, Pdelay_Req, Pdelay_Resp* and *Pdelay_Resp_Follow_Up* packets	EF (46)
Media	RTP and RTCP media stream data	AF41 (34)
Best effort	IEEE 1588-2008 signaling and management messages. Discovery and connection management messages.	DF (0)

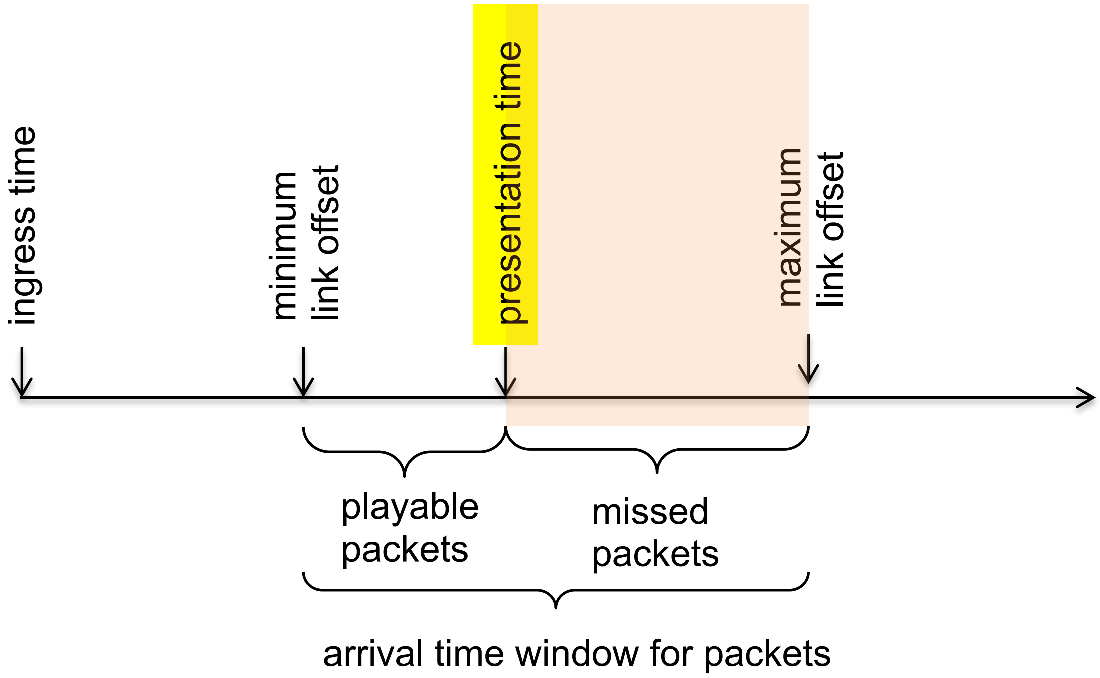

Ingress time reference point
Egress time reference point
Link offset
IEEE 1588 measurement planes
ADC
Sender packet buffer
Network stack and controller
Network clock
Media clock
Sender network system
IP network
Network stack and controller
Network clock
Receiver packet buffer
Media clock
Receiver network system
DAC

Link offset and packet jitter allowance

AUDIO ES AES67

Packet time (ms)	Minimum link offset (2 x packet time) (ms)	Maximum link offset (ms) (20+1) x packet time (max 20 ms)	Sender maximum jitter (ms) (17 x packet time) (max 17 ms)
0,125	0,25	2,625	2,125
0,25	0,5	5,25	4,25
0,333	0,666	6,993	5,661
1	2	20	17
4	8	20	17

Missing the presentation time window

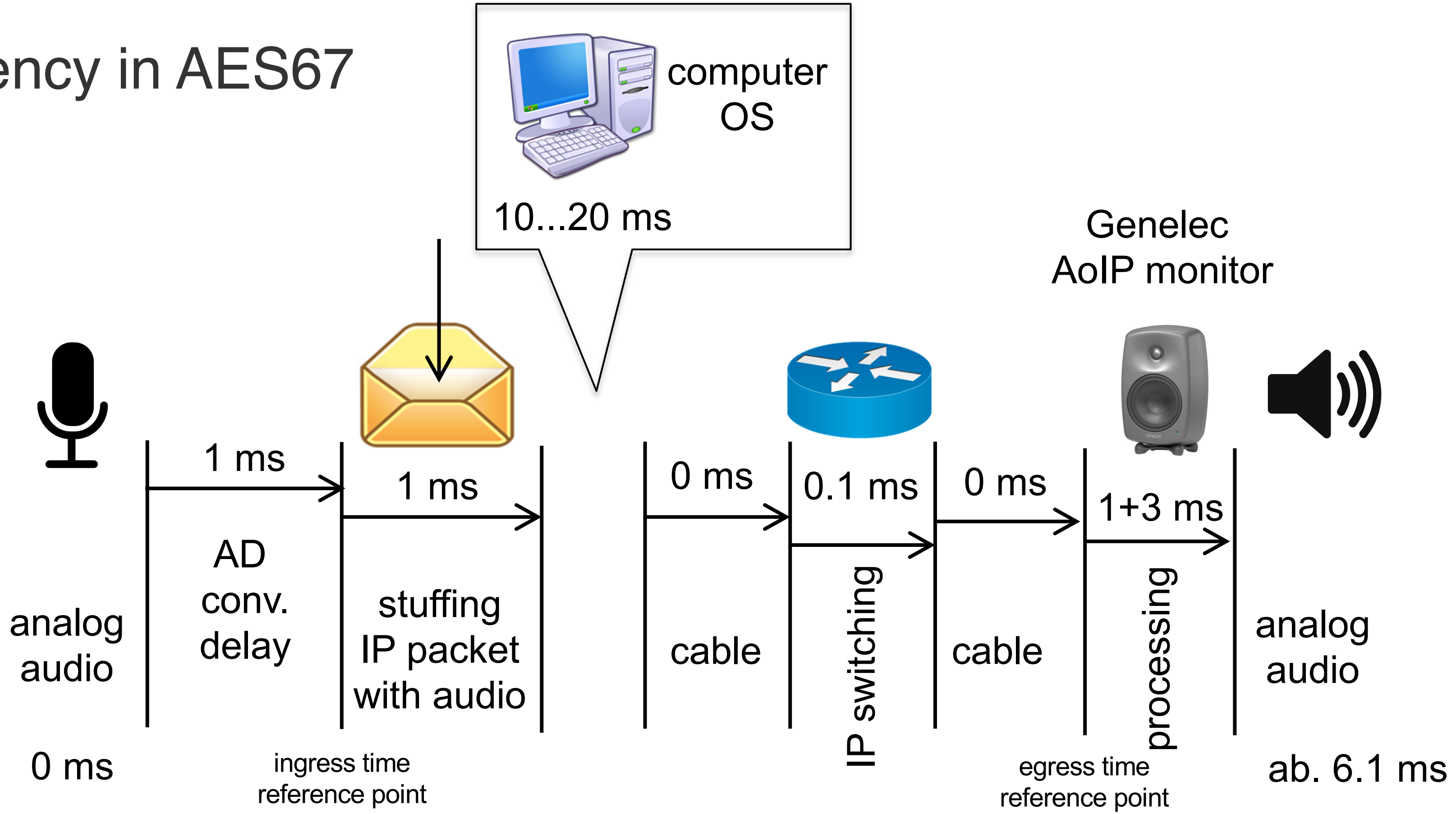


Synchronized vs. syntonised (PTP standard, IEEE 1588)

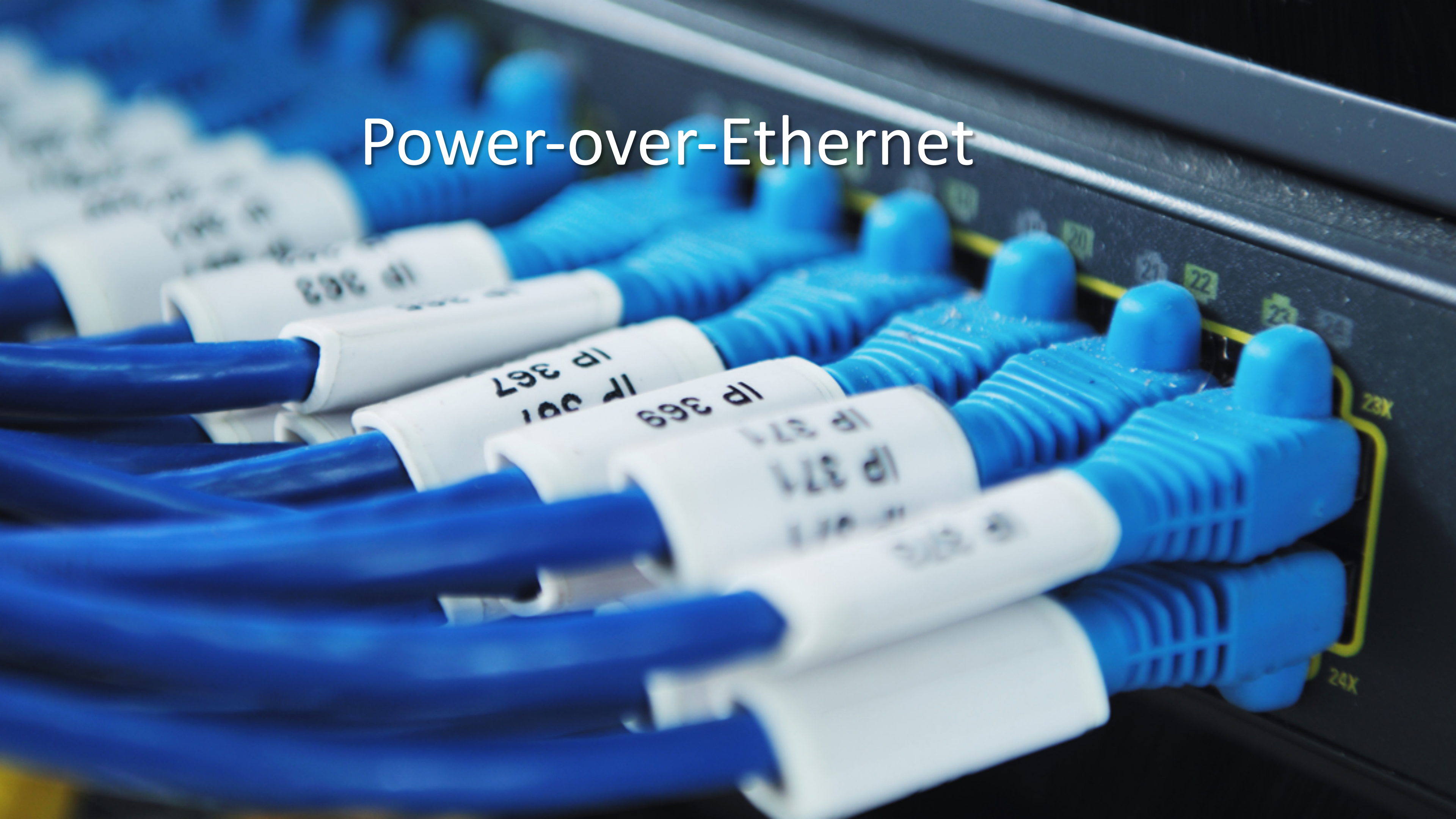
- synchronized clocks:
    - Two clocks are synchronized to a specified uncertainty if they have the same epoch and their measurements of the time of a single event at an arbitrary time differ by no more than that uncertainty.
    - → Clock shows the same time

- syntonized clocks:
    - Two clocks are syntonized if the duration of the second is the same on both, which means the time as measured by each advances at the same rate. They may or may not share the same epoch.
    - → Two clocks may show different time, but advance at the same rate

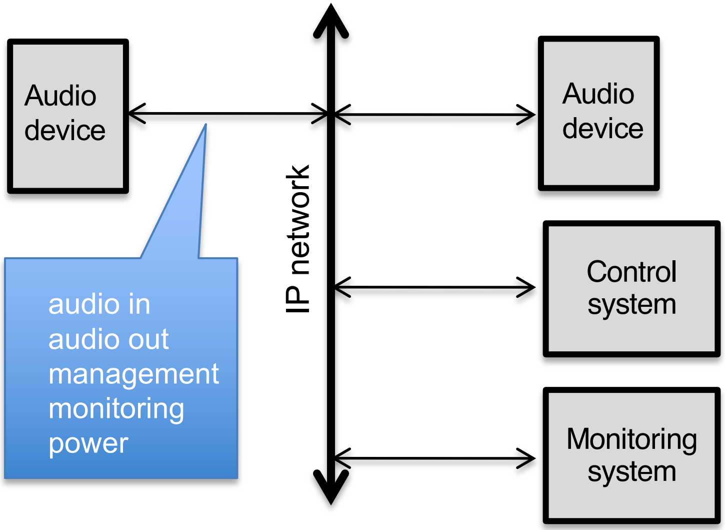
Latency in AES67



Power-over-Ethernet



One-cable-connectivity to a device is possible



- Traffic can co-existing in the same cable
  - audio
  - (video)
  - system management
  - device monitoring
  - system management
  - other data (for example, office)
- Also power to device is available: PoE

Power-over-Ethernet PoE

Name	Standard	Power to Device	Voltage, current at Device	Power management
PoE	IEEE 802.3af-2003	<13 W	37-57 VDC, < 350 mA	signature
PoE+	IEEE 802.3at-2009	< 25.5 W	42.5-57 VDC	signature + LLDP
4PPoE	IEEE 802.3bt-2018	< 51 W (Type 3) < 71 W (Type 4)	42.5-57 VDC, < 600mA 41.1-57 VDC, < 960 mA	signature + LLDP

LLDP, Link-Layer Discovery Protocol

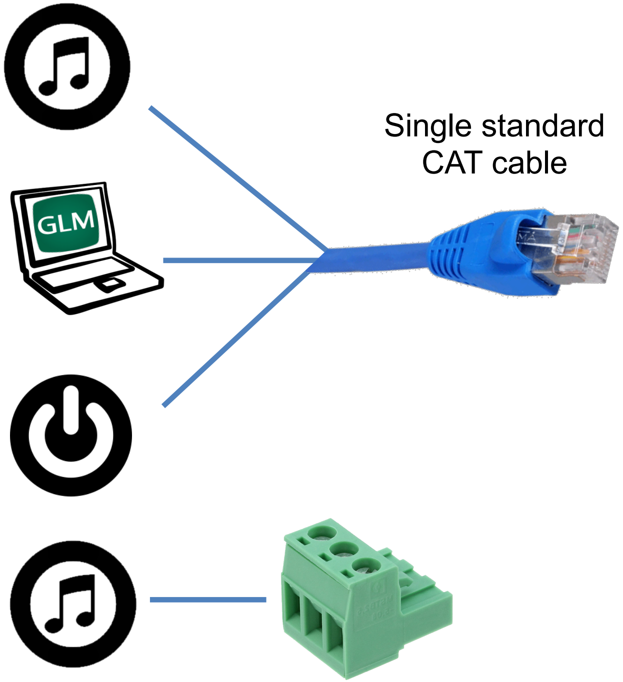
Single cable connectivity solution

Audio-over-IP stream
(all standards available)

Management and monitoring
(GLM-for-Install)

Power-over-Ethernet (PoE+)

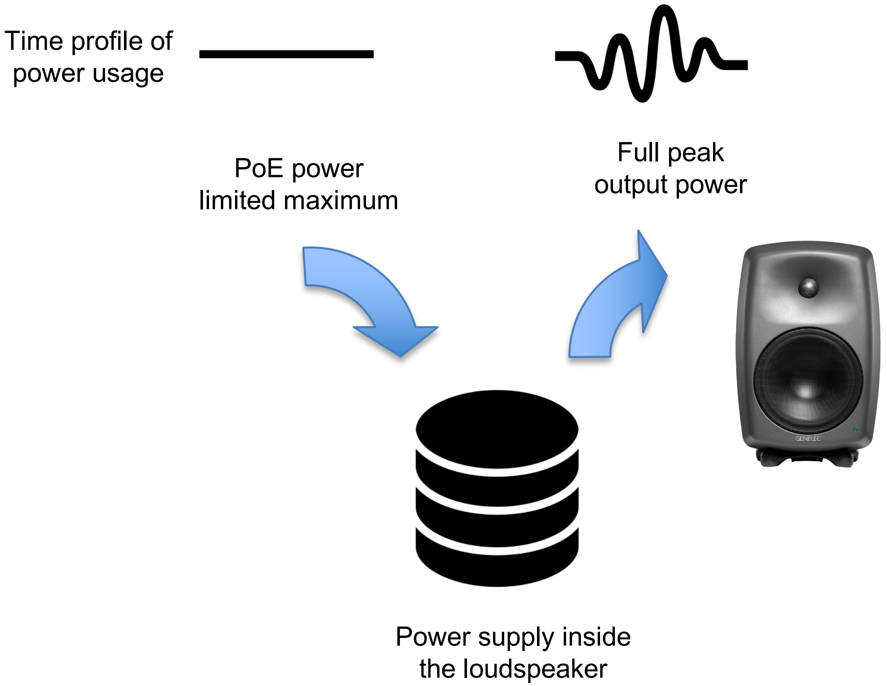
Analogue balanced input
on a Phoenix screw
mount connector



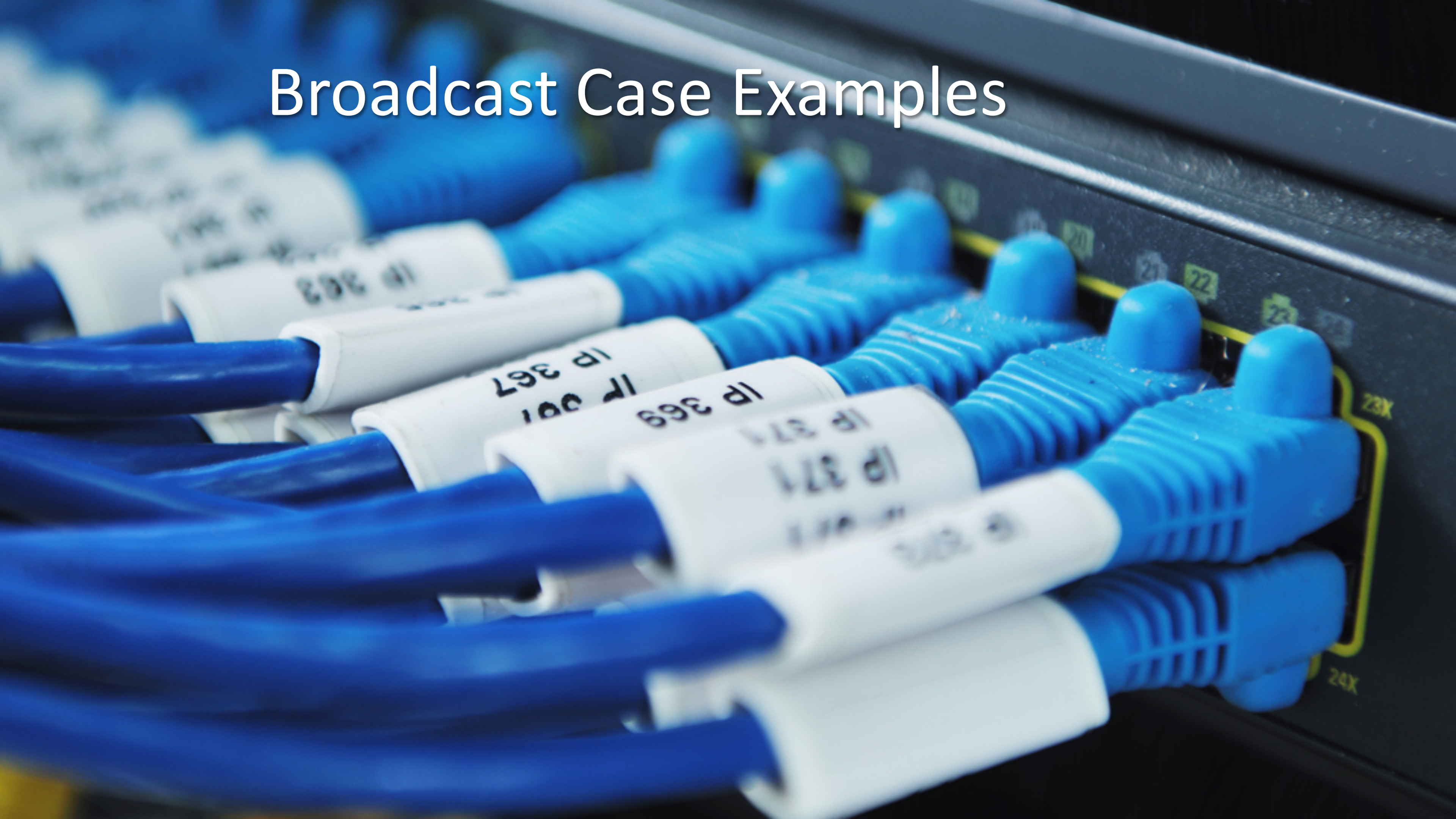
High performance active loudspeaker on IP network with high acoustic flexibility, versatile management and full status monitoring over IP

PoE benefits and use

- Low cost standard cabling
- PoE is intrinsically safe voltage
  - Cost savings: anyone can install cabling and systems
- Standard off-the-shelve technology
- PoE+ supplies max 24.5 W of (constant) power
- Loudspeaker power supply enables high output power at music peak levels



Broadcast Case Examples




Internet Fit Radio
BBC IP Studio Project (2017)

sverigesradio

2017

https://sverigesradio.se/sida/gruppsida.aspx?programid=4282&grupp=24249


sverigesRadio
2017
11:57:00
https://sverigesradio.se/sida/gruppsida.aspx?programid=4282&grupp=24249

2017

https://sverigesradio.se/sida/gruppsida.aspx?programid=4282&grupp=24249

Virtual Radio Studio (2017)

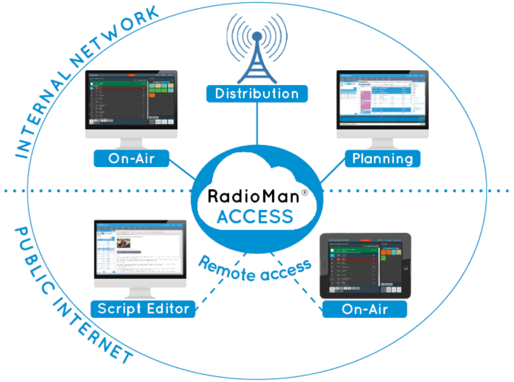
Genelec 8430A

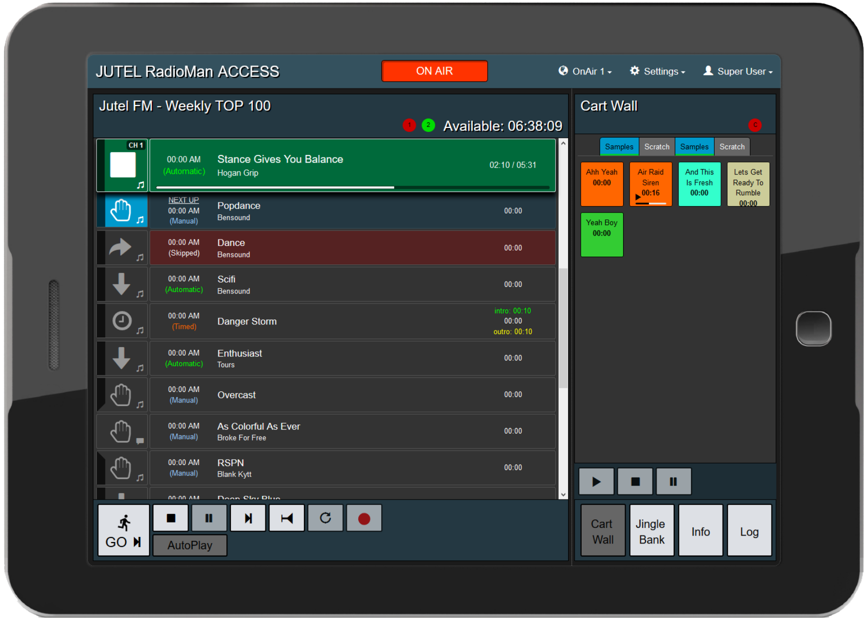
Genelec 8430A

Axia Audio IP-Tablet Virtual Radio software, designed by IP-Studio

https://www.telosalliance.com/Axia/ip-tablet-virtual-radio-software

Jutel RadioMan Access (2018)





RadioMan® ACCESS On-Air tablet interface

https://jutel.fi/products/jutel-radioman-access/

Hogeschool, Utrecht

Hogeschool, Utrecht

CCTV EFP system in Djakarta, control room 1

CCTV EFP system in Djakarta, control room 2

CCTV EFP system in Djakarta, control room 3

AV Install Case Examples

Maaninka Church, Finland

Restaurant Nallikari, Finland

http://www.n4s.fi/2015magazine/article13/

the sonic reference