Deploying Large Scale AVB/TSN Networks

Jeff Koftinoff, Meyer Sound Laboratories, Inc.

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Deploying Large Scale AVB Networks

ACT 1

Deploying Large Scale AVB Networks

What does putting audio/video on a network mean to me?

Deploying Large Scale AVB Networks

How does media get on a network ?

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The original intent of ethernet...

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Network Hardware from the start to today

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Making latency as important as reliability

Deploying

AVB/TSN

AVB/TSN Standards

- gPTP: IEEE Std 802.1AS
- FQTSS: IEEE Std 802.1Q-2011 Clause 34
- SRP: IEEE Std 802.1Q-2011 Clause 35
- AVTP: IEEE Std 1722-2011
- AVDECC: IEEE Std 1722.1-2013

gPTP : IEEE 802.1AS-2011

- Based on IEEE Std 1588-2008 (ptpv2)
- Generalized Precision Time Protocol
- Provides +/- 40 ns clock accuracy

IEEE 802.1Q-2011 Clause 34 - FQTSS

- Forwarding and Queuing of Time Sensitive Streams
- Shapes traffic so the worst case latency is bounded for an arbitrary network and with worst case interference packets

IEEE 802.1Q-2011 Clause 35 - SRP

- Stream Reservation Protocol
- A distributed database managed by the switches and the end stations to keep track of all streams and bandwidth reservation on all links in a network
- Implemented with MRP
- Requires MVRP for managing VLANs

IEEE Std 1722-2011

- Audio Video Transport Protocol (AVTP)
- Transports various ‘subtypes’ of media and control
- Audio, Video, SMPTE Time Code and other formats

IEEE Std 1722-2011 adds:

- iec61883-6: 24 bit fixed point audio transport, 32 bit floating point audio transport
- iec61883-4 and iec61883-8: Camera (IIDC) video and MPEG Video
- SMPTE Time Code
- Audio clocking transport
- IEEE 1722.1 (AVDECC)
- Layer 3 UDP Transport of media and control via IPv4 and IPv6

IEEE P1722-rev Subtypes

- AVTP Audio Format, supporting Dolby E Encoded AES-3 streams
- Compressed Video Format - including H.264 and MJPEG and striped JPEG-2000
- Clock Reference Format for transporting arbitrary clocks
- SDI Video Format for transporting SDI video
- Raw Video Format for transporting arbitrary uncompressed video without meta-data
- Time Synchronous Control Format
- Encryption and Signing formats for session security

First Question Period

Deploying Large Scale AVB Networks

ACT 2

Deploying Large Scale AVB Networks

Moving audio/video over ethernet:
The challenges

AVB Performance

- Low latency
- Guaranteed network latency
- Guaranteed network bandwidth for media
- No need to reconfigure switches because of audio routing changes

What happens as a network increases in size?

- Tiny networks
- Small scale networks
- Medium scale networks
- Large scale networks
- Considerations for deploying large scale networks

Tiny scale AVB networks

- Either direct connection or a single low port count switch
- One or two talkers
- **No need for media clock management**

Tiny scale AVB networks

- 1 Talker, 1 Listener, 1 Stream
- 1 to 24 channels of audio @ 48 or 96 kHz
- Digital Snake
- Computer to AVB Speaker
- Audio input box to AVB Speaker
- Tunnelling 8 MADI connections point-to-point through a GigE network (448 channels)

Small scale AVB networks

- Home media centre
- Home studio
- More than a few different Talker streams
- Ability to manage media clock separately from media

Small scale AVB networks

- One Controller, possibly embedded in a Talker or Listener
- One or two switches
- All media fits on one network link
- **All media can go everywhere**

Small scale AVB networks (home)

- 100baseT Ethernet
- 4 AVB Talker devices
- 8 channels per stream (48 kHz)
- 1 stream per AVB Talker device (8 ch)
- 4 media streams + 1 media clock stream
- 32 channels
- 74 688 000 bps

Small scale AVB network (studio)

- Gigabit Ethernet
- One 24 port switch
- 14 AVB Talker devices
- 8 channels per stream (48 kHz)
- 3 streams per AVB Talker device (24 ch)
- 42 media streams + 1 media clock stream
- 336 channels
- 724 032 000 bps

Medium scale AVB Networks

- Live theatre / musical
- Live concert
- One or two Controllers
- Multiple 24 port switches
- Mostly Gigabit Ethernet
- One 10 Gigabit Ethernet Fibre link for long runs
- **All media does not fit on just one link**

Medium scale AVB networks

- 50 AVB Talker Devices, each with multiple stream sources
- 50 AVB Listener Devices
- 150 talker stream sources (48 or 96 kHz)
- 200 listener stream sinks

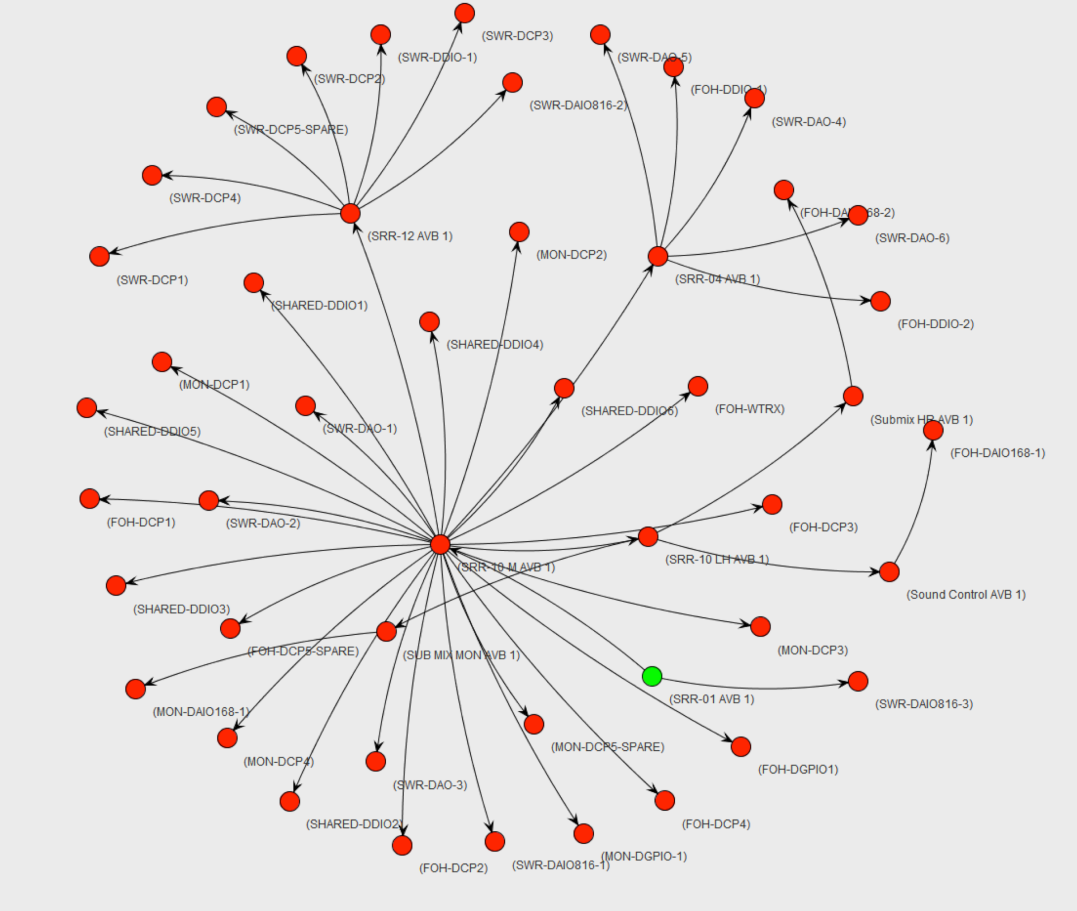
Medium scale AVB networks

- 8 channels per stream (48 kHz)
- 3 streams per AVB Talker device (24 ch)
- 150 media streams + 1 clock stream
- 1200 channels: 2 569 536 000 bps

Medium scale AVB networks – Real Example

- 8 Switches
- 40 various AVB modules including I/O, Processing, and Media playback
- The Following graph was automatically generated by an AVDECC Controller querying the “802.1AS PATH” to the Grand Master of each module.
- The path includes the switches
- The green dot is the Grand Master device

AVB Network graph generated from 802.1AS path as reported by Each AVDECC entity on the network



Second Question Period

Large scale AVB Networks

- Spectacular
- Theme Park
- Airport

Large Scale AVB Networks (Theme park/Spectacular)

- Multiple controllers with redundancy
- Multiple network server rooms
- Multiple performance and audience areas with some shared audio
- Gigabit and 10 Gigabit links
- up to 1000 talker devices
- up to 2000 streams
- up to 1000 listener devices
- 48 kHz, 8 ch * 2000 streams = 16000 channels
- 34 182 336 000 bps network bandwidth for media

Deploying Large Scale AVB Networks

What issues exist on a large scale network that do not exist at a smaller scale?

Considerations for Large Scale AVB Networks

- Legacy Traffic Broadcast Domain Limitations
- Multicast group limits
- Switch backplane limits
- Stream Reservation Protocol “attribute packing”
- Management CPU Limitations

Legacy Traffic Broadcast Domain Limitations

- Devices with low capability management CPUs are limited in the number of Ethernet frames they can handle receiving
- As more devices are added to one broadcast domain, legacy broadcast traffic may adversely affect management CPUs of these devices
- A reasonable limit is 300 devices per legacy broadcast domain

Legacy Traffic Broadcast Domain Limitations

- The network can split into different VLANs for management messages
- Higher capability devices can join multiple VLANs in order for them to participate with devices in many VLANs at once
- Stream Reservation Attributes span VLANs
- Devices in different management VLANs can participate with Streams in multiple VLANs at the same time
- For larger networks, it is reasonable to partition the network into different subnets and use devices capable of routing media between subnets

Multicast group limits

- AVB streams are multicast
- Some enterprise switches have a limit of 1,000 multicast groups
- Some have a limit of 4,000

Switch backplane limits

- Typically not a problem as “Enterprise” level switches handle wire-speed switching and “backplane bandwidth” and “backplane packets per second”

SRP Packing

- The Stream Reservation Protocol (SRP) is a distributed database that allows all the bridges and nodes to keep track of all of the stream reservations on the network
- For AVB networks larger than 250 Talker devices the information about the streams must be “Packable”

SRP Talker Attributes are packable when:

- They have the same bandwidth
- They have the same latency
- The Stream IDs are consecutive
- The Destination Addresses are consecutive

Management CPU Limitations

- gPTP, SRP, IGMP, ICMPv6, FQTSS, and Diffserv management all contribute to management CPU usage
- Underpowered management CPUs in switches and routers can cause problems in large scale networks

Third Question Period

Deploying Large Scale AVB Networks

ACT 3

Deploying Large Scale AVB Networks

Managing AVB Networks

Putting things together...

- Optimizing media traffic and “legacy Traffic” between nodes with IEEE 1722.1-2013 (AVDECC)

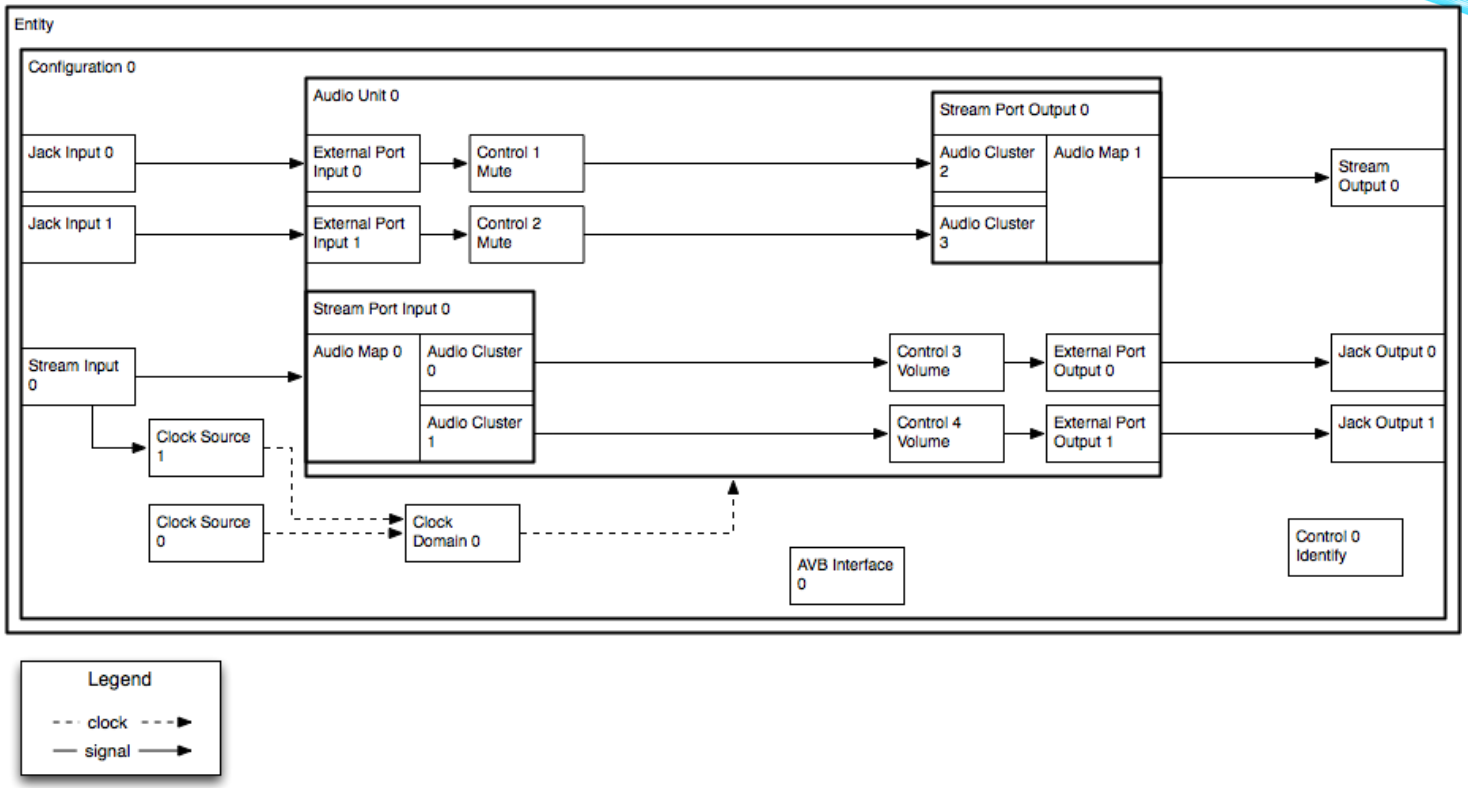
IEEE 1722.1-2013 (AVDECC)

- Audio
- Video
- Discovery
- Enumeration
- Connection management
- Control

IEEE 1722.1-2013 (AVDECC)

- Controller
- Talker
- Listener
- Responder

AVDECC Entity Model (AEM)



AVDECC Discovery (ADP)

- Advertising
- Querying (Global/Specific)
- Redundancy
- Identification (Signal/Wink)

AVDECC Connection Management (ACMP)

- Connection of AVB streams with audio channel mapping
- Persistent connections
- Stream connection status and health
- Configuration of redundant connections

AVDECC Enumeration (AECP)

- Describe the internal structure of the device from the stream entry/exit through to the "physical" entry/exit
- Describe and control the mapping of media sources and sinks to channels within the stream sinks and sources
- Describe and control the signal chains such as DSP, mute, volume, mixers, selectors, through the device
- Provide user settable names for many objects within the device including stream, media sources and sinks

AVDECC Enumeration (AECP)

- Describes and controls the clocking model within the device to configure media clocking sources, sample rate converters
- Describe the internal latency through the device from the defined timing reference plane to the "physical" world
- Describe the AVB capabilities of the interfaces and provide the current AVB related information such as 802.1AS GMID, and MSRP domain, for each AVB interface

IEEE 1722.1-2013 (AVDECC)

- Provides diagnostic information such as AVB interface event counters and errors, stream packet event counters and errors, and clock domain lock status, as well as vendor specific counters when necessary.
- Describe and control generic control points within the device such as location information, enables, video camera controls, and custom controls

IEEE 1722.1-2013 (AVDECC)

- Performs basic authentication of controllers
- Perform key management for securing the network
- Enable and disable transport and stream security

AVDECC Control (AECP)

- Distributes updates to multiple interested controllers
- Exposes signal path, processing latency and control latency
- Rich set of control meta-data available:
- value data format and encoding
- Min/Max/default/current values
- SI units options:Time, Frequency, Distance, Temperature, Mass,Voltage, Current, Power, Energy, Resistance,Velocity, Level, etc, with scaling.
- single values, multiple values, array values, and bode plots of filters and measurements

Offline Provisioning

- A device's capabilities and control points are described by the set of descriptors that it publishes
- These descriptors are put into a standard XML Schema form which allows manufacturers to publish the Entity Models for their products on their website
- These XML files can then be loaded into an AVDECC Controller which can then be used to instantiate virtual AVDECC Entities based on them.
- The user can then connect them and configure them before arriving at the venue.

Remote Access

- Allows access to AVB networks via TCP/IP for control and management
- Uses the existing HTTP 1.1 protocol which enables it to work over the internet via existing network infrastructure including traversing multiple transparent or non-transparent HTTP proxies
- Secured with existing SSL/TLS encryption tools
- Authentication with existing HTTP Basic/Digest authentication

Deploying Large Scale AVB Networks

Graceful failures and redundancy

Graceful Failures and Redundancy

- Approach depends on the installation
- Cost of failure versus cost of implementation
- For some large systems we have set up talkers and listeners with separate but simultaneous ethernet ports, using two separate AVB networks
- This allows any packet or cable or switch to fail without any impact to the show

Graceful Failures and Redundancy

- Listeners can be set to have a primary, secondary, and tertiary backup stream for content
- The Listener can decide on its own to use the available stream automatically
- Not all Listeners have this capability
- This allows you to have redundant/failover talkers

General info:	https://avb.statusbar.com/
BW Calculator:	https://abc.statusbar.com/
XMOS :	https://github.com/xcore
AVnu:	https://github.com/Avnu/Open-AVB
Jeff Koftinoff:	https://github.com/jdkoftinoff/jdksavdecc-c
	https://github.com/jdkoftinoff/avdecc-cmd
Audioscience:	https://github.com/audioscience/avdecc-lib