Deploying Large Scale AVB/TSN Networks - *Handout*

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AVB/TSN Standards

Table 1 – Existing AVB/TSN IEEE Standards

Acronym	Standard	Purpose
gPTP	IEEE Std 802.1AS	Time Synchronization
FQTSS	IEEE Std 802.1Q-2011 Clause 34	Traffic Shaping
SRP	IEEE Std 802.1Q-2011 Clause 35	Stream Reservation
AVTP	IEEE Std 1722-2011	Media Packetization
AVDECC	IEEE Std 1722.1-2013	Discovery, Connection, Control

gPTP

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

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

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

AVTP

IEEE Std 1722-2011 Subtypes

- Audio Video Transport Protocol (AVTP)
- Transports various 'subtypes' of media and control
- Audio, Video, SMPTE Time Code and other formats:
    - iec61883-4: MPEG2 Video
    - iec61883-6: Audio
        - 24 bit and 32 bit fixed point audio transport
        - 32 bit floating point audio transport
        - Audio Clocking
        - MIDI
        - SMPTE Time Code
    - iec61883-8: Camera (IIDC) video
    - IEEE 1722.1 (AVDECC)

IEEE P1722-rev adds:

- 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
- Layer 3 UDP Transport of media and control via IPv4 and IPv6

AVDECC Features

- Discovery
- Enumeration
- Connection management
- Control

Tiny Scale AVB Networks

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

Example

- 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

- 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**

Example 1: Home use

- 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

Example 2: Music 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

Example

- 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
- 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

Large Scale AVB Networks

- 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

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
- 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

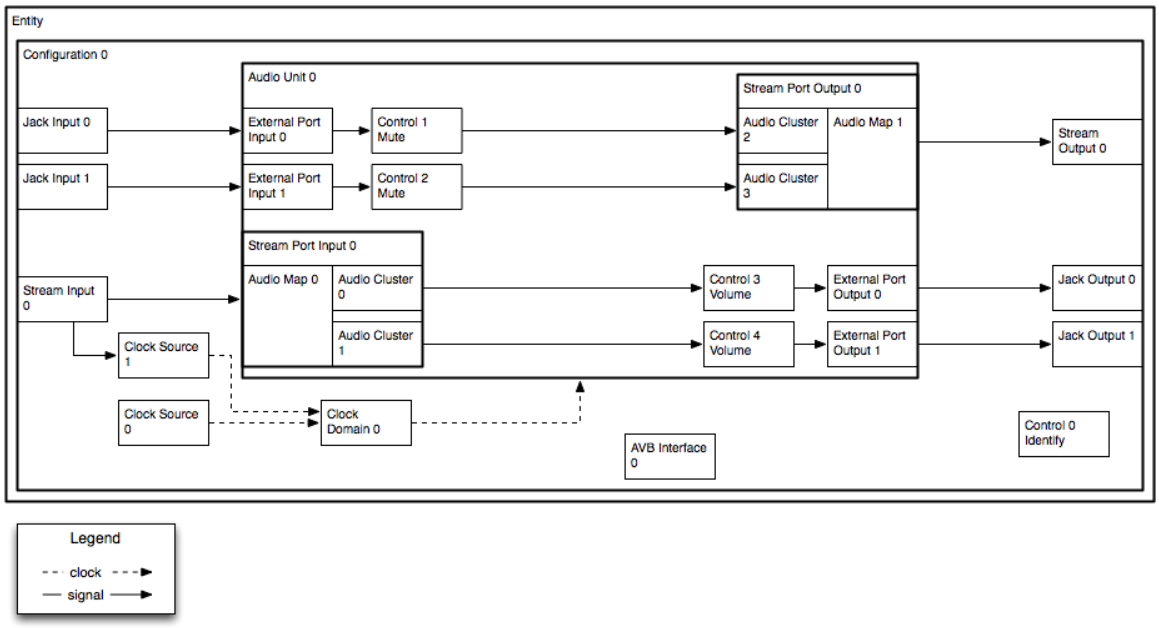
- gPTP, SRP, IGMP, ICMPv6, FQTSS, and DiffServ management all contribute to management CPU usage
- Underpowered management CPUs can cause problems in large scale networks

Managing networks with AVDECC

Features

- Discovery
- Enumeration
- Connection management
- Control

Entity Model Example



Discovery

Enumeration

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

Control

- 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