Deploying an Intra and Inter-facility IP Media Production Network

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Robert Welch - Arista
TV 2 Norway

- Largest Commercial Broadcaster in Norway
- News and sports operation (7 studios)
- Large MCR operation
- 9 linear channels
- 31 OTT event channels
- VOD and web services
**Objective:** move to IP in facilities

- **Driven by:**
  - **Facilities relocation** to Bergen (08/2017) and Oslo (12/2017)

- **Wanted to:**
  - **Reduce OPEX**
  - **Avoid SDI Infrastructure**
  - **Platform Flexibility** (reduce impact of distance)
  - **Share resources** (on demand access)
Basic **target set-up**

**BERGEN**
- Studio Control Rooms
- Studios
- Contribution
- IP (LAN)
  - Playout
  - Ingest
  - MCR

**OSLO**
- Contribution
- Studios
- Studio Control Rooms
- IP (LAN)
  - Ingest

460km
290 miles
TV 2 choices

**Project**
Collaborative but managed by Orchestration partner

**Architecture**
Distributed with spine-leaf topology (fully redundant)

**SDN**
Single management across WAN and 2 LANs, with active bandwidth management

**Standards**
SMPTE 2022-6/7 and AES67 initially then SMPTE 2110
Standards evolution for IP production

- SMPTE 2110
  - Based on TR-03/04
  - PTP/SMpte 2059
  - Some parts are now published (10/20/30)
- VSF TR-03
  - AES-67 audio
  - RFC 4175 video
  - RTP ANC data
  - PTP/IEEE 1588
- VSF TR-04
  - AES-67 audio
  - SMPTE 2022-6
  - PTP/IEEE 1588
- Audio over IP
  - AES-67
  - PTP /IEEE 1588
- SIPS/LDO/EPP
  - SMPTE 2022-7
- SDI over IP
  - SMPTE 2022-5/6
- TS over IP
  - SMPTE 2022-1/2
  - H.264/AVC
  - JPEG 2000

2000 2010 2015 2016 2017 2018
Standards – Not ready in 2017

- **ST 2110**
  - 10: System Timing
  - 20: Uncompressed Video
  - 30: PCM Audio
  - 40: Ancillary Data

- **NMOS**
  - IS-04 Registration & Discovery
  - IS-05 Control
  - IS-06 Network API
  - IS-07 Event & Tally
AMWA IS-04 & IS-05 Connectivity Management

- Endpoint Real Time Identity & Capabilities
- Configurable Text for Relevancy
- Playout and Automation Integration
Thunderbolt 2 Edit Bay Network

**Shared 40GbE Uplink Example**

- USB 3.1 Exceeds the Speed of 10GbE
- Thunderbolt 1 Exceeds the Speed of 10GbE
- Throughput = Increased Productivity and Flexibility
- Adoption of 10G Edit Bays => 40G Edit Bays
- 10GbE Standard Interface Speed on New Systems
- There is More Network Capacity at the Edge than in Your 10GbE Network.

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**More Speed**

- **40Gbps Thunderbolt**
  - PCI Express Gen 3 and DisplayPort
- **Double** the speed of previous generation
- **Four times** the data and **twice** the video bandwidth of any other cable

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**Diagram:**

- Sonnet Echo Express – SE1
- Chelsio – T580-SO-CR PCIe NIC
- Chelsio – SM40G-SR Transceiver -> MPO
- MPO -> MPO Patch Panel
- MPO -> MPO Patch Panel
- QSFP-40G Transceiver MPO -> QSFP
- Arista DCS-7060CX2-32S-R
- Arista DCO QSFP+

Thunderbolt

10G Thunderbolt 40G Ethernet

1x MPO Jumper

2x MPO Cables in Wall
1 Active, 1 Spare
1x MPO Jumper

Arista DCS-7060CX2-32S-R

opendrives

nevion
Thunderbolt 2 Edit Bay Network

Per Device Uplink Example

iMAC Pro:
• 1x 10GbE, 4x Thunderbolt 3, 4x USB 3

Mac Pro (Trash Can Mac):
• 2x 1GbE, 6x Thunderbolt 2, 4x USB3
Typical architecture options

Centralized Star

True Leaf-Spine

Pseudo Leaf-Spine (Dual Star)
Network Topology Options

**Spine / Leaf – Distributed**
- Distributed Cabling
- Shared Uplink Bandwidth
- PTP Boundary Mode Considerations
- Mix and Match Spine and Leaf Options
- Inter-Switch Bandwidth Consideration
- Oversubscription Ratio

**Monolithic Switch**
- Non Blocking Architecture
- No SDN Requirement to Manage Inter-Switch Links
- PTP Boundary Mode Considerations
- Mix and Match Spine and Leaf Options
- Increase East / West Traffic Flow Bandwidth
Some challenges to overcome

- Mixed vendor environment
- Multiple control systems
- Devices with various degrees of PTP support
- Existing playout system using ASPEN
- Pace of evolution
Signal flows in the system

SDN – software defined network

Cameras
Audio mixer
Vision mixer
Multi-viewer
Audio processing
J2K compression
SDI->IP
Audio->IP
IP->HDMI
Monitor wall
Playout/distribution
PTP grand master
Grand Master Placement and Redundancy

- **Switch Considerations**
  - Boundary Mode
  - Boundary Mode Scale
  - E2E Transparent Mode
  - ST 2059-2 Support
  - Routed Interface Requirement
  - In or Out of Band PTP?
  - 1 or 2 Step Support
Grand Master Placement and Redundancy

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PTP Boundary Mode
- Increases PTP Grand Master Scale
- Is Master to Connected Nodes
- Improves System Wide Clock Synchronization
Grand Master Placement and Redundancy

**Switch Considerations**
- Boundary Mode
- Boundary Mode Scale
- E2E Transparent Mode
- ST 2059-2 Support
- Routed Interface Requirement
- In or Out of Band PTP?
- 1 or 2 Step Support

PTP Boundary Mode – Grand Master Change
- Reduces Effect on Connected Nodes
- Enables Geographic Redundancy
- Improves System Wide Clock Synchronization
Technology Partners

Cisco Nexus 9K Switches
Meinberg M1000 PTP
SAM Kahuna IP vision mixer
GV IP multiviewer
Embrionix IP to HDMI
Riedel Ravenna audio
Lawo V_link4 and A_mic8
Lawo Nova 73 IP audio router/mixer
Lawo VSM control system
Vizrt graphics
Skyline Dataminer alarm and monitoring
Nevion’s Contribution

- **Nevion VideoIPath**: SDN control and platform management
- **Nevion eMerge**: 10/40/100 Gb leaf switches with Openflow
- **Nevion Virtuoso**: Processing units
Gateway XMUX Video/Audio router

Maximum total audio router size 192 x 192 Mono audio channels

4 x HD-SDI
(Each with up to 16 embedded mono channels)

8 x AES67 streams
(each stream can contain up to 8 mono channels)

4 x SMPTE 2022-6
(Each with up to 16 embedded mono channels)
eMerge
Cisco
VideoIPath
Netconf
Openflow
VSM
Ember+
VIP
Multicast At A Glance

- **Broadcast:** One to all within the subnet

- **Unicast:** One to one, routable. Destination defined by sender.

- **Multicast:** One to none, one or many, routable. Destination defined by receiver!

- **Multicast is a good fit for live uncompressed media**
  - Typically there is a one to many fan out
  - The senders do not know who needs to consume their output
  - More efficient for sending endpoints, and network infrastructure – no traffic redundancy
  - Receiver redundancy is easy to achieve
**Multicast At A Glance**

- (S,G), **Source Specific** Multicast. The *subscriber* asks for traffic that was sent to a multicast group address (G), **from a specific source** (S).

- An IGMPv3 infrastructure is required to support (S,G) requests. (*,G) requests are supported in all IGMP versions.

- **2022-7** and destination based switching enabled by multicast. (Make before break)

- **2022-6** is a single essence stream. 2110-x defines individual essence streams for video (-20), audio (-30) and ancillary data (-40)
Multicast At A Glance

• (*,G), Any Source Multicast. The subscriber asks for ALL (*) traffic that was sent to the multicast group address requested (G).

  (*) is very useful when you want all the traffic, from all participants – it’s a good model for video/voice conferencing, or for services – you know the service you want, but not the source.
Hybrid SDN network control

Orchestration and SDN Management

- Static endpoint configuration
- OpenFlow flow rules
- Explicit Multicast routing entry (NetConf)
- OpenFlow flow rules and NAT rules
- Static endpoint configuration

Security
Stream resilience
Deterministic QoS
Media and data flows coexistence
Adapt to changing needs
Fast and clean switching

Fast and clean switching
Adapt to changing needs
Media and data flows coexistence
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Stream resilience
Security

Nevion Confidential
NAT – Driver-less deployment

Virtual Static endpoints

239.0.0.1

Pass

239.2.2.1

Drop

239.0.0.1

239.0.0.1

239.0.0.1

230.2.2.2

Virtual Static endpoint

224.1.1.1

224.1.1.1

NAT

239.0.0.1

239.0.0.1

230.2.2.2

Virtual Static endpoint

OpenFlow flow rules

Explicit Multicast routing entry (NetConf)

OpenFlow flow rules and NAT rules
<table>
<thead>
<tr>
<th>Sources</th>
<th>Destinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>3050</td>
<td>3455</td>
</tr>
</tbody>
</table>

**3050 sources**

**3455 destinations**
## Fun Facts – Uncompressed 2110-20 Video Essence

<table>
<thead>
<tr>
<th>Format</th>
<th>Sampling</th>
<th>Depth</th>
<th>Gen Pkt Mod</th>
<th>Per 10G</th>
<th>Per 40G</th>
<th>Per 100G</th>
</tr>
</thead>
<tbody>
<tr>
<td>720p59.94</td>
<td>YCbCr-4:2:2</td>
<td>10</td>
<td>1,176 Mbps</td>
<td>7</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>1080i59.94</td>
<td>YCbCr-4:2:2</td>
<td>10</td>
<td>1,325 Mbps</td>
<td>6</td>
<td>26</td>
<td>65</td>
</tr>
<tr>
<td>1080p59.94</td>
<td>YCbCr-4:2:2</td>
<td>10</td>
<td>2,650 Mbps</td>
<td>3</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>2160p59.94</td>
<td>YCbCr-4:2:2</td>
<td>10</td>
<td>10,600 Mbps</td>
<td>~1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4320p59.94</td>
<td>YCbCr-4:2:2</td>
<td>10</td>
<td>42,397 Mbps</td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

32x 100G Switch = 2,560 x 2560 SD
Note: Ethernet is Bi-Directional
Why Merchant Network Silicon is Winning

Merchant Silicon Firsts

- 2008: First ultra-low latency 24-port 10G single chip
- 2010: First Large Buffer 10G Chip with VOQ Fabric
- 2011: First 64-port 10G single chip switch
- 2012: First 32-port 40G single chip
- 2013: First Large Buffer 40G Chip with VOQ Fabric
- 2015: First 32-port 100G single chip
- 2016: First Router 100G Chip with VOQ Fabric
- 2017: First 64-port 100G single chip
- 2018: First 32-port 400G single chip (forecast)

Bandwidth Improvement

Merchant Silicon: Faster Time-to-Market, Better Execution and Faster Innovation
Live on-air August 12, 2017
What’s next for TV2?

- Migration to **SMPTE 2110**
  - **Timing** already based on **2110-10** (2059-1/2)
  - **Audio** already based on **2110-30** (AES67)
  - **Video** using 2022-6, move to **2110-20**
  - **Metadata** using 2022-6, move to **2110-40**
- Adopt **NMOS** architecture
- Dynamic essence flows (**SDP**)
- **Orchestration** of workflows
THANK YOU!

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