Real world IP deployments on SMPTE 2110 / 2059

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The Challenge

• Design a COTS based infrastructure solution for a Top 10 US market station.

• Customers core requirements:
  o COTS based infrastructure - Cisco
  o Standards based –TR04 with ability to upgrade to ST-2110
  o Mixed Reference Environment – Black Burst and PTP
  o Signal agnostic – HD 1080i 60, with ability to transport UHD
  o Future-ready - HDR (High Dynamic Range) and 1080p
  o Simplified wiring– multi-mode and single-mode fiber
  o TOR and EOR Design
The Challenge

- Studio technical requirements:
  - 3 Studios
  - As Much IP at the Edge as Possible
  - Traditional SDI switcher
  - Very large multi-viewer requirement
  - Master Control and Live Production
  - Extensive IP/SDI Connectivity with Video & Audio Processing
  - Remote Production Requirement
  - Large video Ingest and Playout requirement
The Challenge

• Studio technical requirements:
  o Distributed IP infrastructure
  o Spans multiple floors
  o Multiple sites around city
  o Uncompressed and compressed feeds
  o Multiple Codecs
    o J2k
    o H.264
    o MPEG 2
Key that the users don’t know or care about the technology
IEEE Ethernet Standards
(date of first new MAC rate)

6 rates in 35 yrs

6 new rates happening now

*Only shows the first time a new rate is standardized. Many subsequent variants are standardized over time.
WHOA, THIS IS RUNNING MS-DOS! IT'S WEIRD HOW NEW TECHNOLOGY TAKES FOREVER TO REACH SOME INDUSTRIES.

YEAH. LIKE HOW WE STILL USE GUNPOWDER FOR FIREWORKS, EVEN THOUGH WE'VE HAD NUCLEAR WEAPONS FOR OVER 70 YEARS.
Table 1 – Cost and Bandwidth Efficiency

This table shows the simple story of cost by comparing 10 GbE, 40 GbE (provided by four 10 Gbps links), 25 GbE and 50 GbE (coming soon). The video format is 4K, 10 bit 4:2:2 with the frame rate indicated in each column.

<table>
<thead>
<tr>
<th></th>
<th>10 GbE x 2</th>
<th>10 GbE x 2</th>
<th>25 GbE</th>
<th>40 GbE</th>
<th>50 GbE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of 4K Channels</strong></td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Relative Cost</strong></td>
<td>2.00</td>
<td>2.00</td>
<td>4.25</td>
<td>4.00</td>
<td>6.00</td>
</tr>
<tr>
<td><strong>Cost per Channel</strong></td>
<td>1.000</td>
<td>2.000</td>
<td>2.125</td>
<td>1.333</td>
<td>1.500</td>
</tr>
<tr>
<td><strong>% BW Used</strong></td>
<td>0.87</td>
<td>0.52</td>
<td>0.84</td>
<td>0.79</td>
<td>0.84</td>
</tr>
</tbody>
</table>

* The Relative Cost is normalized per Gbps, and based on street pricing for SFP+, QSFP+, SFP28 and QSFP28 optical components. For example, if a SFP+ is $60.00 USD, then the 40 GbE QSFP is $240.00 USD.
HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC.)

**SITUATION:**
THERE ARE 14 COMPETING STANDARDS.

14?! RIDICULOUS!
WE NEED TO DEVELOP
ONE UNIVERSAL STANDARD
THAT COVERS EVERYONE’S
USE CASES.  YEAH!

**SITUATION:**
THERE ARE 15 COMPETING STANDARDS.

SOON:
SMPTE ST 2110 – 21 (Traffic Shaping and Delivery Timing)

Specifies the packet emission timing and other network traffic parameters to ensure error free data transmission through an IP network. It provides for 3 traffic profiles: N, NL and W which are suitable for different devices such as pure software senders or FPGA based senders. It sets basic parameters for bandwidth overhead in a network segment and memory capacity in a router.

- **Type N Senders** - Distribute the pixels of the video raster during the active portion of the frame with nearly zero latency and packet delay variation.

- **Type NL Senders** - Distribute the pixels of the video raster across the entire duration of the frame with nearly zero latency and packet delay variation.

- **Type W Senders** - Allow for increased variation, or bursts, in packet emission. Care should be taken to ensure that traffic design supports simultaneous peak bursts without packet loss in the router.

- **Beta**, or Bandwidth overhead is recommend to be 1.1 (10%)

- **Cmax**, varies by type, and sets the peak rate for packet burst duration

- **Published**
**SMPTE ST 2110 – 30** (uncompressed audio – RFC 3190)

Specifies the real-time, RTP-based transport of PCM digital audio streams over IP networks by reference to AES67. An SDP-based signalling method is defined for metadata necessary to receive and interpret the stream

- Uncompressed linear PCM audio only
- Relatively flexible
  - 48kHz sampling
  - 16 and 24-Bit depth
  - Variable packet timing - 125us to 1ms
  - Channel count based on packet timing - 8 channels @ 1ms vs 64 channels @ 125us
- Low bandwidth consumption - 8 channels x 24 bits x 48,000 samples x 1.5 (RTP) = 9.7Mbits/sec
- Published
<table>
<thead>
<tr>
<th>Level(s)</th>
<th>Supported by the Receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Reception of 48 kHz streams with from 1 to 8 channels at packet times of 1 ms</td>
</tr>
<tr>
<td>AX</td>
<td>Reception of 48 kHz streams with from 1 to 8 audio channels at packet times of 1 ms. Reception of 96 kHz streams with from 1 to 4 channels at packet times of 1ms</td>
</tr>
<tr>
<td>B</td>
<td>Reception of 48 kHz streams with from 1 to 8 channels at packet times of 1 ms or 1 to 8 channels at packet times of 125 µs</td>
</tr>
<tr>
<td>BX</td>
<td>Reception of 48 kHz streams with from 1 to 8 channels at packet times of 1 ms or 1 to 8 channels at packet times of 125 µs. Reception of 96 kHz streams with from 1 to 4 channels at packet times of 1ms or 1 to 8 channels at packet times of 125 µs</td>
</tr>
<tr>
<td>C</td>
<td>Reception of 48 kHz streams with from 1 to 8 channels at packet times of 1 ms or 1 to 64 channels at packet times of 125 µs</td>
</tr>
<tr>
<td>CX</td>
<td>Reception of 48 kHz streams with from 1 to 8 channels at packet times of 1 ms or 1 to 64 channels at packet times of 125 µs. Reception of 96 kHz streams with from 1 to 4 channels at packet times of 1ms or 1 to 32 channels at packet times of 125 µs</td>
</tr>
</tbody>
</table>
• Hardware must support multiple video standards and compression technologies
  • Firmware Upgradeable
  • Field Deployable
  • Easily Done by Customer Maintenance Staff
• Third Party Device Control
  • Easy in baseband
  • Required an open communication protocol between control system, switches and edge device
  • IS-04
  • IS-05
Not all Switches are the same!
High Level Overview

BLAN is Broadcast LAN
- Management of all broadcast devices

Media LAN is all TR-04 Media Transport
### SMPTE 2110 for 1 video, 4x4 channel Audio and ANC

<table>
<thead>
<tr>
<th>Source IP Addy</th>
<th>Dest IP Addy</th>
<th>RTP Header</th>
<th>Video SMPTE 2110-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source IP Addy</td>
<td>Dest IP Addy</td>
<td>RTP Header</td>
<td>Audio SMPTE 2110-30</td>
</tr>
<tr>
<td>Source IP Addy</td>
<td>Dest IP Addy</td>
<td>RTP Header</td>
<td>Audio SMPTE 2110-30</td>
</tr>
<tr>
<td>Source IP Addy</td>
<td>Dest IP Addy</td>
<td>RTP Header</td>
<td>Audio SMPTE 2110-30</td>
</tr>
<tr>
<td>Source IP Addy</td>
<td>Dest IP Addy</td>
<td>RTP Header</td>
<td>Audio SMPTE 2110-30</td>
</tr>
<tr>
<td>Source IP Addy</td>
<td>Dest IP Addy</td>
<td>RTP Header</td>
<td>ANC and Metadata over SMPTE 2110-40</td>
</tr>
</tbody>
</table>
• Not all switches are the same
  • Non-blocking architecture
  • Depends on ASIC’s and Firmware
  • Lab test all deployments
  • Multiple Data Rate Flows
  • 2022-6
    • Single Flow Rate high bandwidth
  • 2022-2
    • Single Flow rate low bandwidth
• Pick your Grand Master Clocks carefully
  • This GM was fixed to 1G SFP, Media Network switches only support 10G+ SFPs
  • Only one NIC on each GM
  • Required the use of extra switches to distributed PTP
• PTP was distributed to Media Network, Broadcast LAN, and station operations network
• On hindsight, PTP was built overly complicated
  • Extra PTP distribution switches added a lot to complexity
PTP High Level

Broadcast LAN

PTP Distribution switches

X-Y Media LAN
PTP into Broadcast LAN

PTP Clocks

Broadcasting LAN
• SFP’s are expensive and add complexity
  • For SDI-IP and IP-SDI conversion, 10G gateways can require hundreds of SFP’s to buy and maintain for large facilities
  • Use of signal aggregators can simplify solutions
  • Failure Impact block is a consideration
IP and COTS Infrastructure - What we learned

288x288 SDI to IP conversion core non-aggregated
288x288 SDI to IP conversion core aggregated

12x40g 12x40g
• **Standards** – Which ones? Do we care?

• **IP Conversion (to/from SDI)** – Amount? **Formats**?

• **IP Conversion (to/from MADI)** - Amount? Formats? Processing?

• **Native IP Devices** – Amount? Format? Control?

• **Signal Processing** – **Video**? **Audio**? **Transportation**?

• **Multi-viewers** – Amount? Formats? Layouts? Tally? Control?

• **Connectivity** – 1.5, 3 or 12Gbps? 10, 25, 40, 50 or 100Gbps?

• **Network Design** – Singular switch? Spine/Leaf? Modular? L2 or L3?

• **Control & Monitoring System** – Topology? **Performance**? Licensing? SNMP?


• **System redundancy** – All or Core Components?
IP and COTS Infrastructure - What we learned

How to fix IT gear

- Restart whatever isn't working
- Quick Google search
- Weird engineering voodoo
• Massive amount data generated by solution
  • Health and status of devices
  • SFP’s
  • Power Supplies
  • Fans
  • Upstream and Downstream bandwidth
  • IP port health
  • IP switch loads
  • Media Flow paths
  • IGMP data
• Having an integrated health and status management tool is key to success
• Customers will not hire more staff just for the migration of Baseband to IP
  • Centralized interface for all information
  • Ability to only show data that is pertinent to the operation of the solution while in nominal state
  • Highlight data that is pertinent to the operation of the solution while in a failed or degraded state
• Engineer training is more important then ever
  • SDI knowledge
  • IP knowledge
    • Switch configuration
    • Topology
    • Flow Controls
  • Standards Knowledge
    • SDN
    • IGMP
    • SMPTE ST-2110
    • PTP SMPTE 2059