Broadcast Media Networks Over IP

The View From the AES and SMPTE Worlds

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RCDD, WD, AES, SMPTE
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Presentation Outline

1. Professional Media Organizations
2. Streaming and Production Standards
3. Precision Time Protocol (PTP)
4. Pro Media Over IP – Milestones
5. SMPTE IP Broadcasting Roadmap
6. The IP Production Landscape
7. Software Defined Networking - SDN
8. Fog and Mist (and Dew)
9. Conclusion

Professional Media Organizations

What Do AES and SMPTE Do and Why Do I Care?

The Audio Engineering Society (AES) defines interfaces, production, distribution and consumption standards for Audio.

Notable standard:

- **AES67** attempts to bridge competing proprietary AoIP protocols, such as Livewire (Telos), QLAN (QSC), Ravenna , Wheat-Net (Wheatstone) and Dante (Audinate). All use standard Ethernet switches & Cat cable.

What Do AES and SMPTE Do and Why Do I Care?

The Society of Motion Picture and Television Engineers (SMPTE) researches and creates interoperability standards for imaging and broadcast equipment, similar to the AES, but with a broader scope, focusing on moving images.

SMPTE IP media networks will use ICT cabling standards with lots of optical fiber and 10/25/100Gbs Ethernet switches. Current solutions on market can be supported with Cat6A at 10Gbps for each equipment drop. Many vendors are developing edge devices based on 25 Gbps fiber to the desk.

Who Are All These Organizations?

Alphabet Soup #1

Video Services Forum (VSF) – a trade group comprising a diverse worldwide membership from telco carriers, broadcasters and equipment makers:

- Developing technical recommendations to move to an all IP plant
- Creating the TR-03 and TR-04 documents for video
- Working to define the media flows

Advanced Media Workflow Association (AMWA) – a trade group tasked with developing workflow protocols for IP media flows. It publishes the following Standards:

- NMOS standards (Networked Media Open Specification)
- AMWA IS-04 Standard
- IS-05 Standard

Alphabet Soup #2

European Broadcasting Union (EBU) – is the European public service media organization that acts as a broadcast advocate and assists with frequency allocations. The European counterpart of the SMPTE, however members are Radio & TV stations.

EBU
OPERATING EUROVISION AND EURORADIO

- Sets technical standards, like the SMPTE in Europe
- Produces the Eurovision song and dance contests

Alliance for IP Media Solutions (AIMS) – an industry consortium dedicated to an open-standards approach that helps broadcast and media companies move from SDI systems to a virtualized, IP-based environment. AIMS is a key player in defining the set of standards for IP production**.**

AIMS
Alliance for IP Media Solutions

Alphabet Soup #3

International Association of Broadcast and Media (IABM) - a trade group made up of manufacturers of broadcast and media hardware and software, located in the UK.

Media Networking Alliance (MNA) – a trade group of primarily pro audio over IP companies, with its principal focus on the promotion of AES 67. It is also promoting AES 70, which is the device discovery and registration add-on to AES 67.

Streaming and Distribution Standards

- MP3, MP4
- MOV, FLV
- AAC, FLAC
- WMV, Quicktime
- H.264
- H.265
- HTML5/WebM/Ogg Theorem

What Are These Streaming Standards?

In most cases, these file types are ‘containers’, which include multiple encoded, compressed ‘essence’ types, in a synchronized wrapper.

The file type tells the decoding device how it should be played and the player adjusts accordingly.

Typically the encode/decode process is asymmetrical.

The file is typically appended to a ‘transport stream’ that does the transport negotiation and also provides some basic error correction.

What AES and SMPTE Efforts Have in Common?

IEEE 1588 - Precision Time Protocol (PTP):

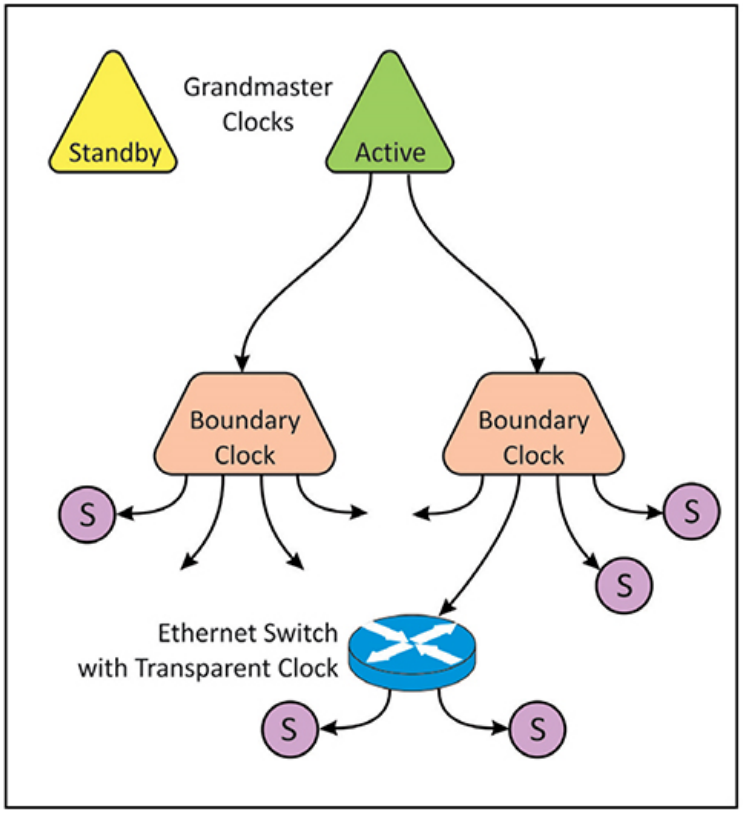
PTP is a super high precision 64 bit word sent every second, that defines the complete time to 1ns accuracy, based on a reference to the Epoch, midnight January 1, 1970.

The first 32 bits have the time down to the 1s mark, the last 32 bits define the time down to the 1ns mark.

See: *the last slide for links to SMPTE webinar called 'Its About Time" by Paul Briscoe*

PTP Grandmaster Clock

- Grandmaster clocks are referenced to an Atomic Clock accurate to 1 sec in 300 million years, with a corresponding offset to UTC that takes into account leapseconds, leapdays and leap years.
- Used by industry, airlines, science (Large Hadron Collider) and the international cell phone system to keep all of the devices synchronized. Timing input typically GPS/GNSS to grandmaster.



Status of Pro Media Over IP – Recent History

Serial Digital Interface (SDI) – is a standard for digital video transmittal over a coaxial cable that was standardized by SMPTE in 1989:

- SDI is a digital version of analog TV, complete with blanking intervals
- The SDI container has space for 16 audio channels, as well as metadata that are transmitted “all together”
- Latest 12G SDI supports UHD, 2160/60 HDR, 4:4:4 uncompressed over a single 75 ohm coax cable, up to about 100 meters with 16 channels of audio

Status of Pro Media Over IP – Current History

Why coaxial cabling is becoming obsolete:

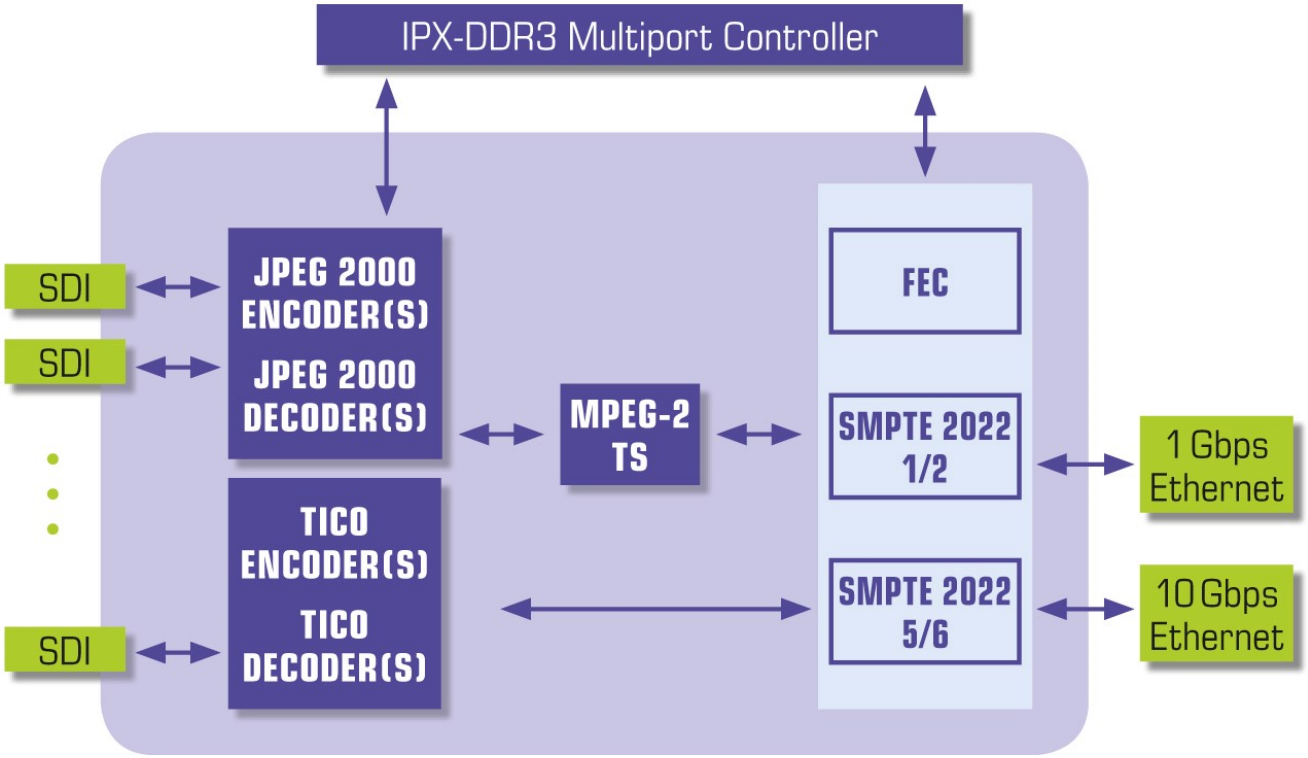
- Inflexible in deployment for moves, adds and changes;
- No assured roadmap for coax cable to support the next iteration of SDI, 24G, UHD 2160/120fps or 8K at 30 fps.

Alternatives:

- Optical Fibre cables, but SDI itself cannot provide the flexibility that broadcasters are demanding;
- 10/25 Gbps Ethernet Network Interface Cards (NIC).

RG-7 single link 12G SDI cable

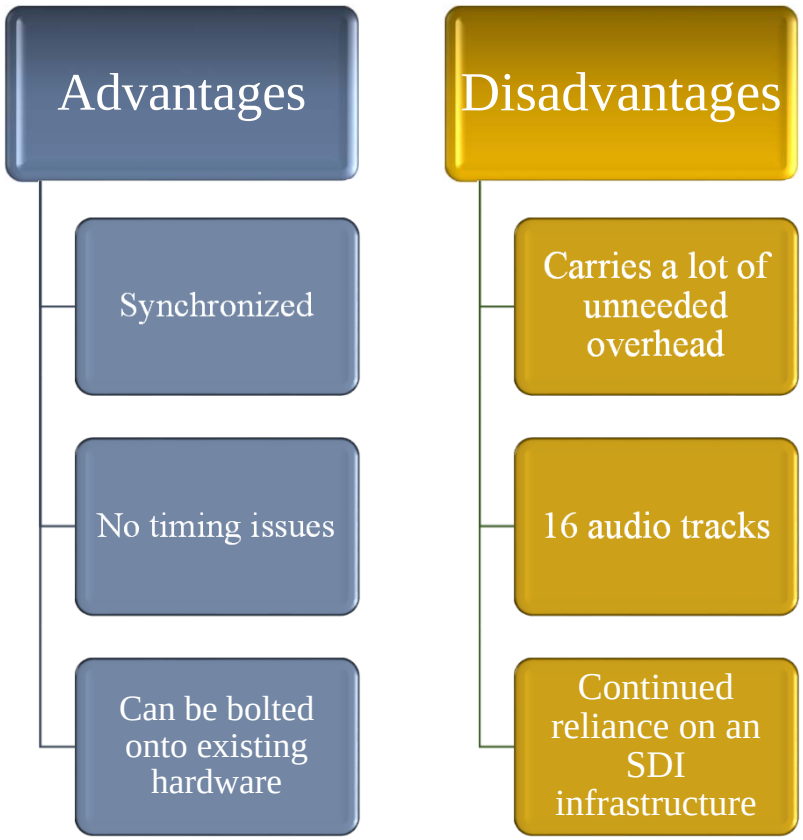
AES and SMPTE Media Over IP Standards - 1



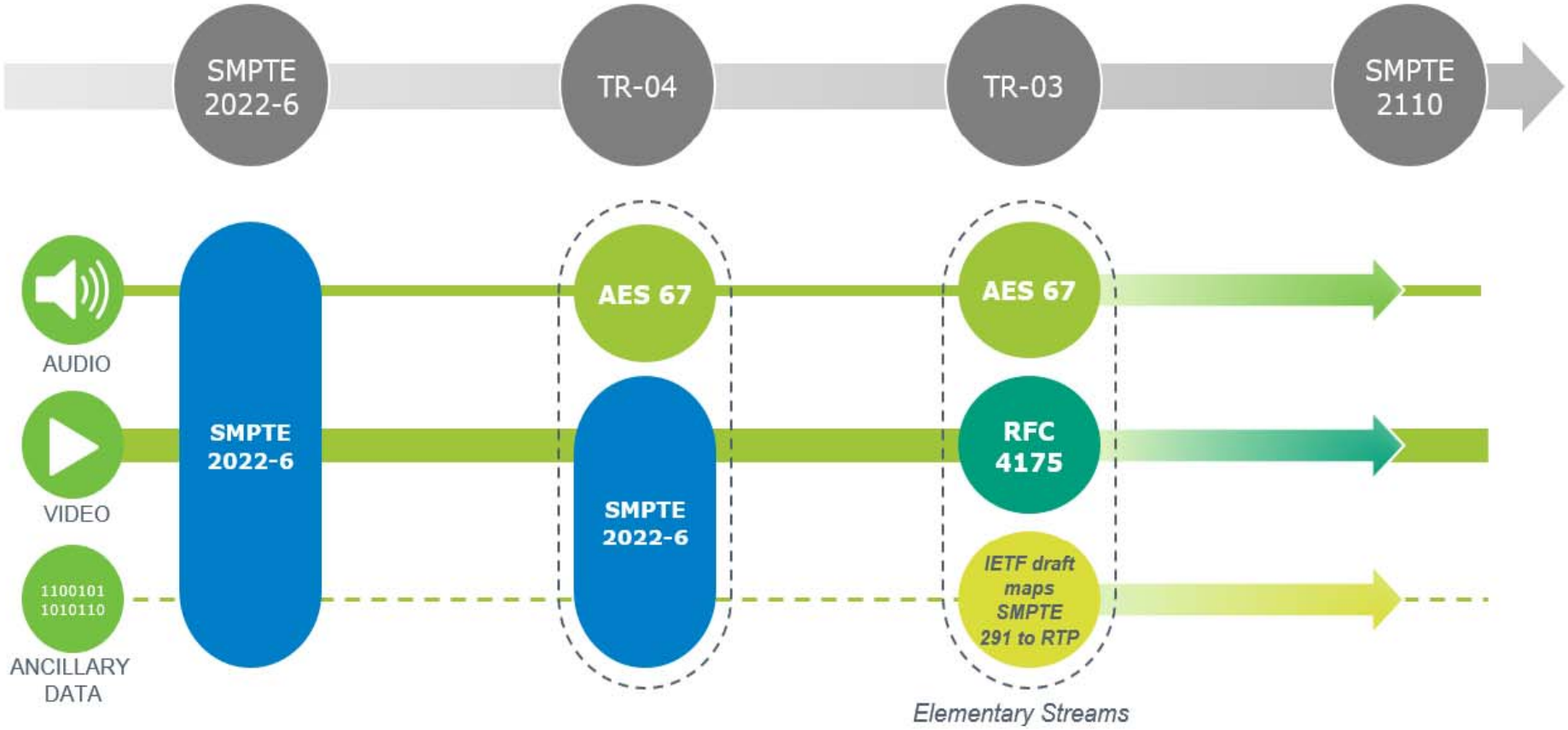
AES and SMPTE Media Over IP Standards - 1

Uncompressed Video Data Rates			
Video Format	**SDI**	**Data rates**	**SMPTE 2022-6**
1080i/720p	HD-SDI	1.4835 Gbps	1.56 Gbps
1080p29.97	3G-SDI	2.967 Gbps	> 3 Gbps
2160p29.97	6G UHD-SDI (2 x 3G-SDI)	5.934 Gbps	> 6 Gbps
2160p59.94	12G UHD-SDI (4 x 3G-SDI)	11.868 Gbps	> 12 Gbps

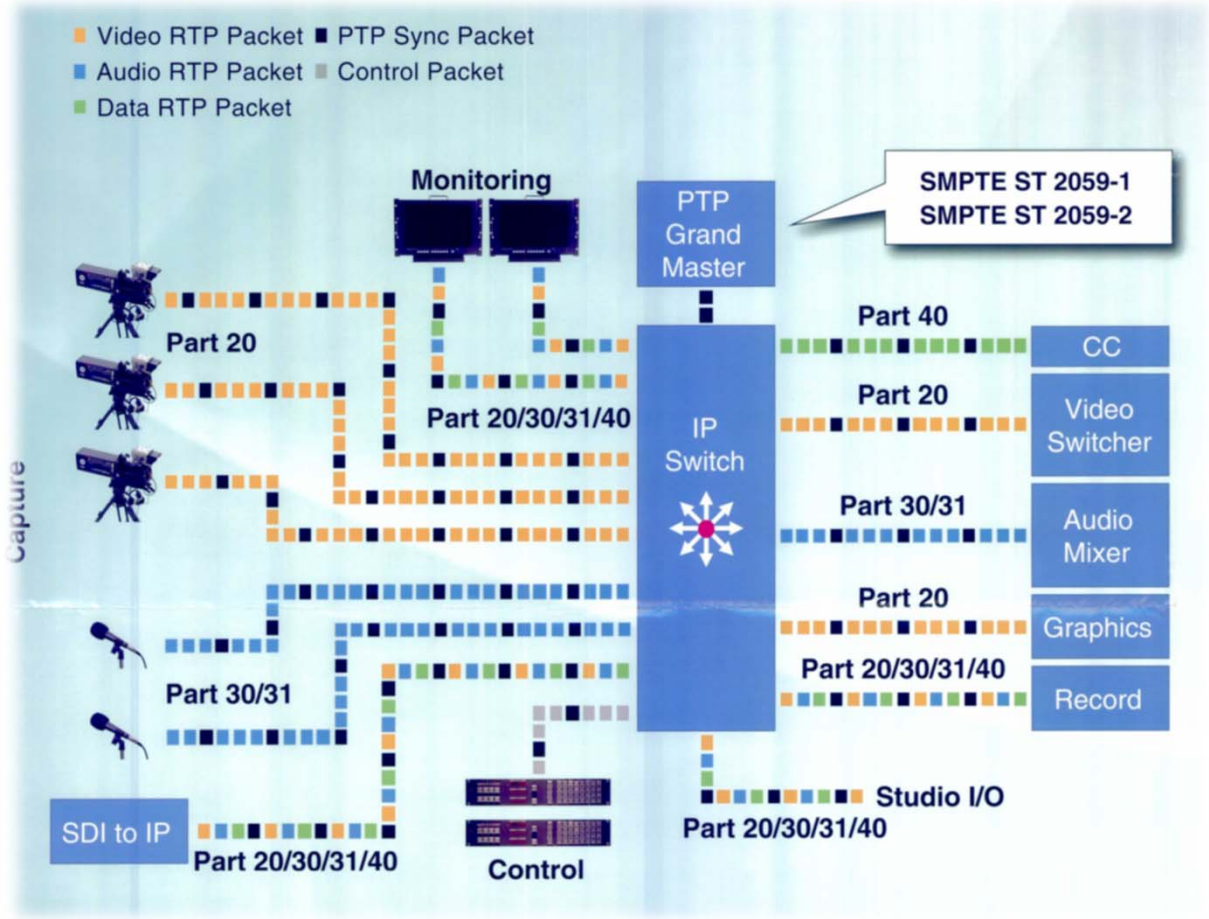
SMPTE 2022 (SDI Over IP)



SMPTE IP Broadcasting Roadmap

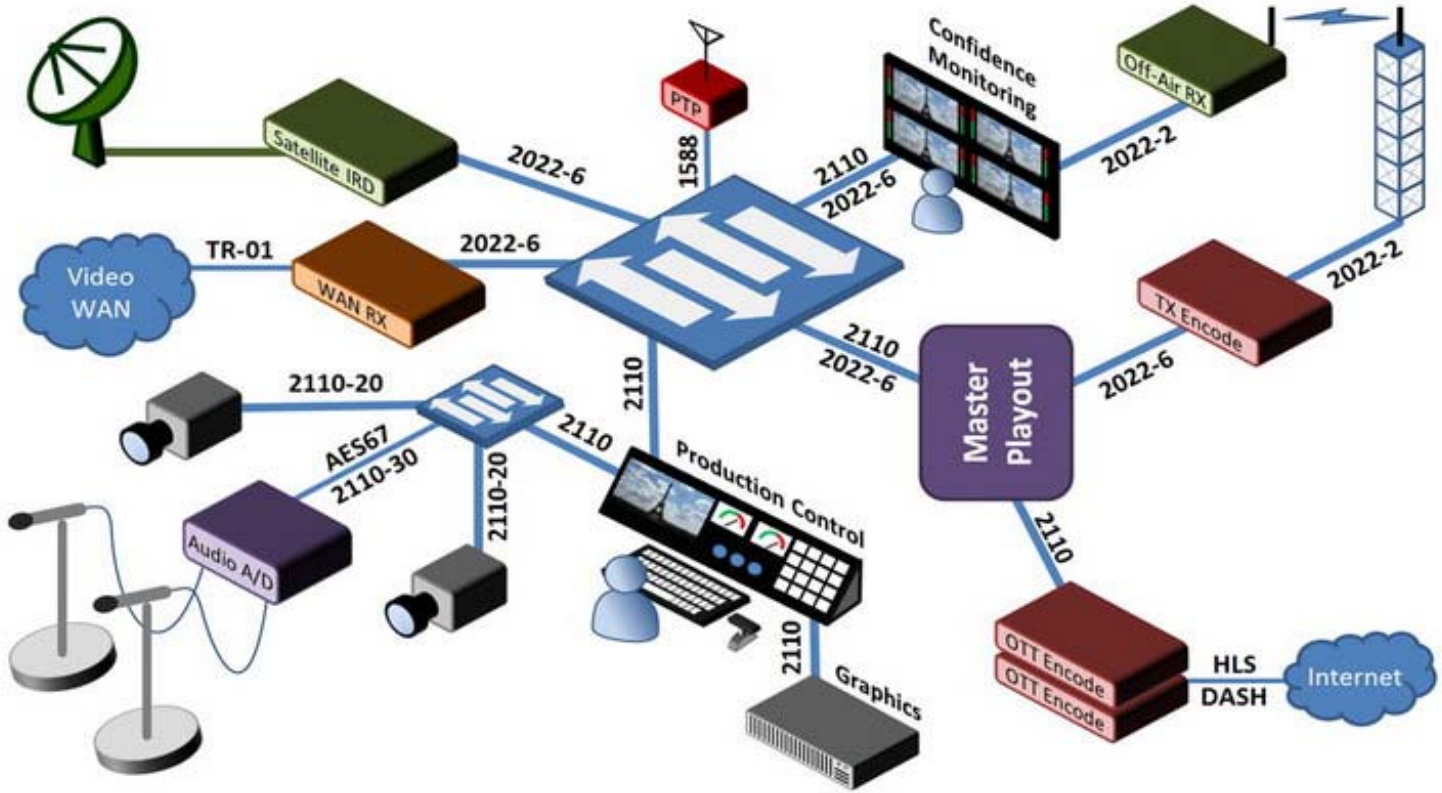


ST-2110 Video over IP Roadmap



AES and SMPTE Media Over IP Standards - 2

The IP Production Landscape -2020



ST-2110 –Status of Development Late 2018

SMPTE 2110 comprises multiple parts	SMPTE ST-2110-10: System Timing and Definitions
	SMPTE ST-2110-20: Uncompressed Active Video
	SMPTE ST-2110-30: PCM Digital Audio (AES 67)
	SMPTE ST-2110-40: Ancillary data
	SMPTE ST-2210-21: Timing Model for Uncompressed Active Video
	SMPTE ST-2210-31: AES3 Transparent Transport
	SMPTE ST-2210-50: Interoperation of ST 2022-6 streams

AES and SMPTE Media Over IP Standards - 3

AES 67 – Interoperability standard important for ST 2110 dis-aggregated model. AES 67 describes audio essence flows and some maximum requirements such as 24bit, 96KHz sampling, Device discovery not included. Uses the PTP IEEE 1588 standard for time keeping like ST 2110. All Dante products now support AES67.

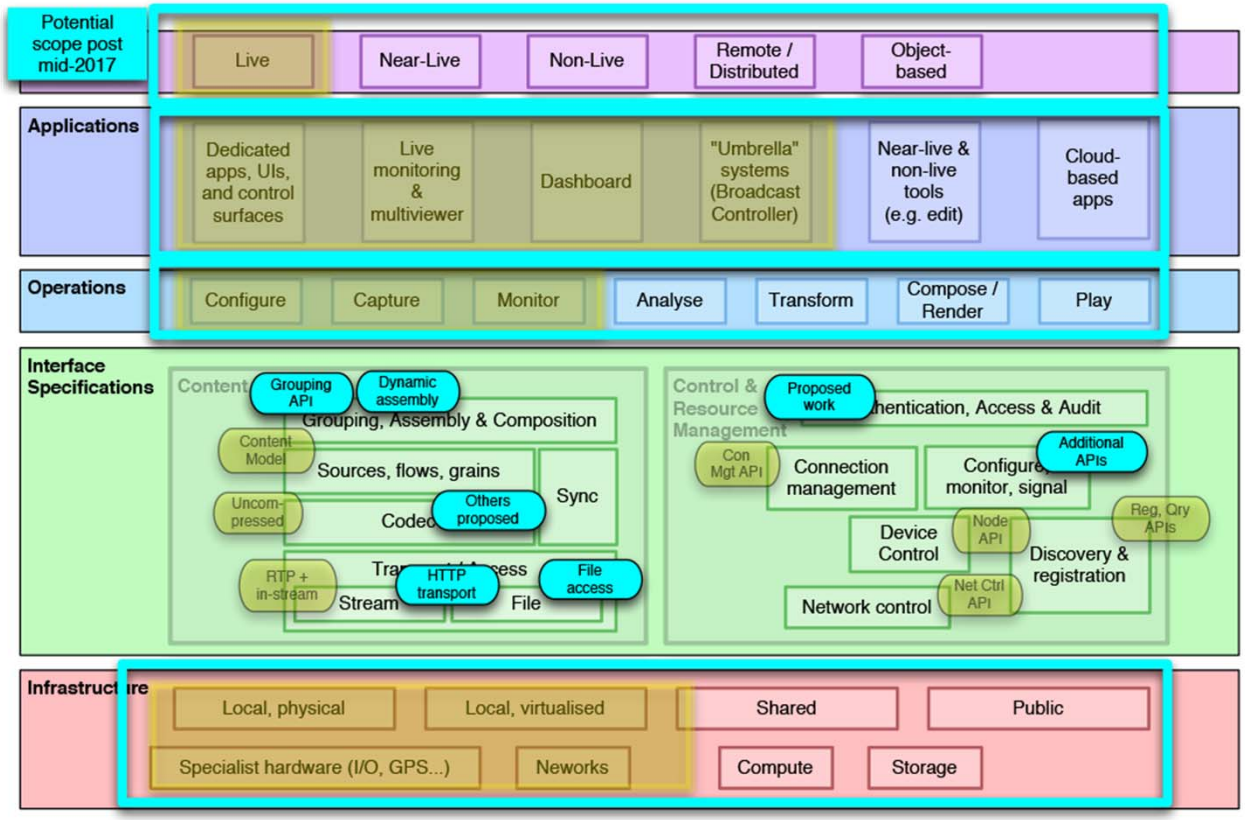
AES67

AES 70 – otherwise known as the Open Control Architecture (OCA). The device discovery, registration and ‘management’ layer that is missing in AES 67. Also includes NMOS model for video and metadata essence flow management. Includes the remote configuration of software configurable DSP’s. These DSP’s could be in ‘smart speakers” and tell the speaker which microphones/audio channels to equalize, combine, mix, mute or duck based on live commands. This is the ‘control plane’ referenced later.

OCA AES70
OPEN CONTROL ARCHITECTURE

NMOS Roadmap

The **AMWA Networked Media Open Specification (NMOS)** is a framework for interoperability between multiple vendors of Media over IP equipment.



Is Ethernet Up to the Task?

256x256 SDI (3G) Router

Fully Non-Blocking

768 Gbits/sec throughput (3G SDI)

COTS Ethernet Switch/Router

36x40GBE in 1RU (full duplex)

Equivalent of 144x10G ports

1RU Fully Non-Blocking

1440 Gbits/sec throughput

Cost Comparisons of SDI and Ethernet End-Points

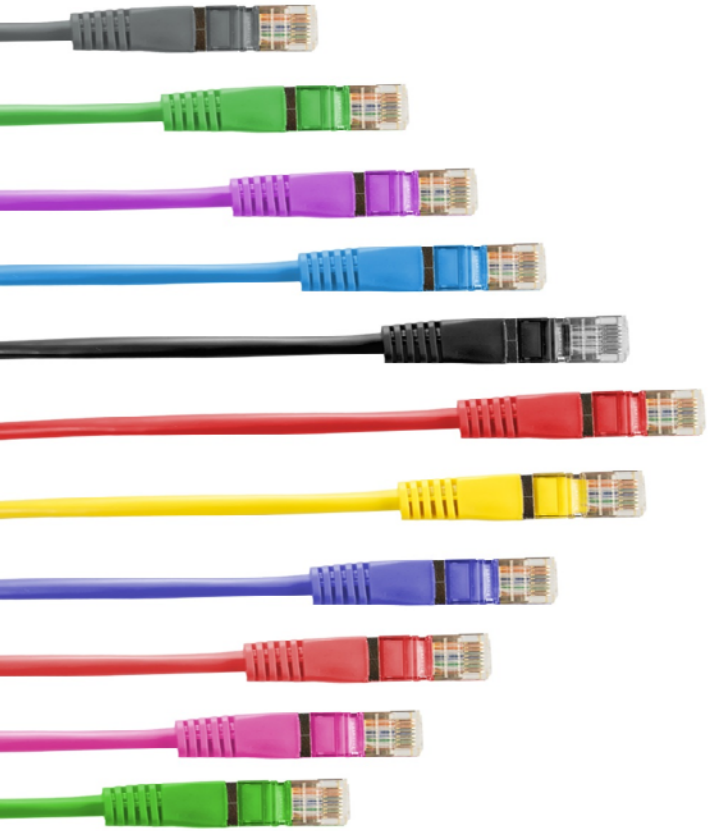
Dual 10Gbe NIC –Intel – **$110**

10Gb SFP+, Intel – **$35**

6G SDI input/output PCIE card – **$1000**

Hybrid IP/SDI PCIE i/o including compression – **$2500**

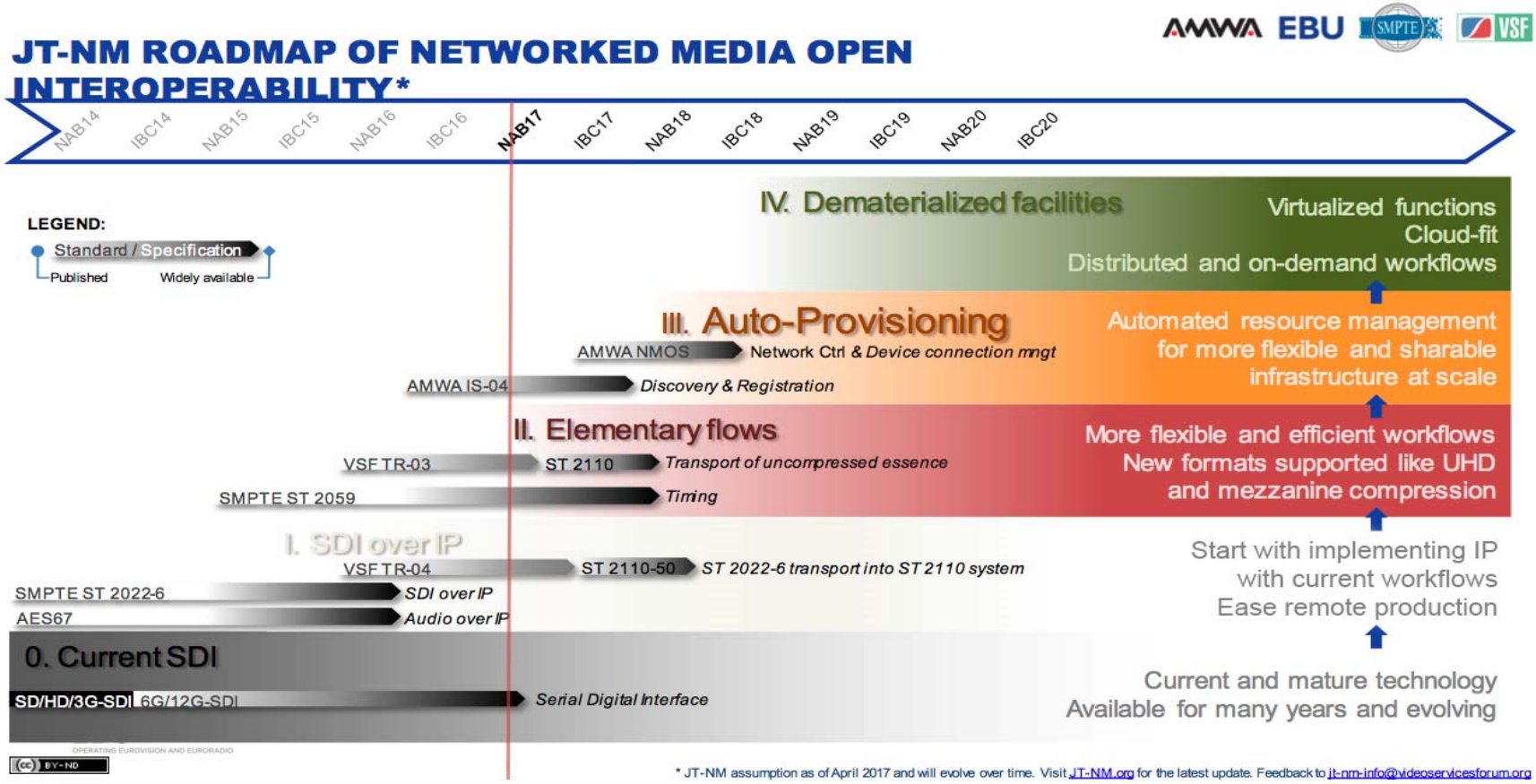
Production Versus Distribution



- **Streaming solutions** are designed for low-bit rate, asynchronous networks, usually with heavy lossy compression applied.

- **Production environments** must be uncompressed at the best bit rates that the systems can tolerate. A single video signal at UHD resolution, 2160/30, without any associated audio or metadata, needs almost 6Gbps in bandwidth, when converted to IP packets and sent over an Ethernet network.

IP Video Roadmap to Beyond 2020



FPGA's – Video Over IP Building Blocks

Field Programmable Gate Arrays (FPGA)
- very fast compute engines that can be programmed to do digital signal processing and compression common in the media world, faster and more reliably than general purpose CPUs, GPUs or ASIC's.

Xilinx, Altera (Intel), Lattice and Microsemi are big players.

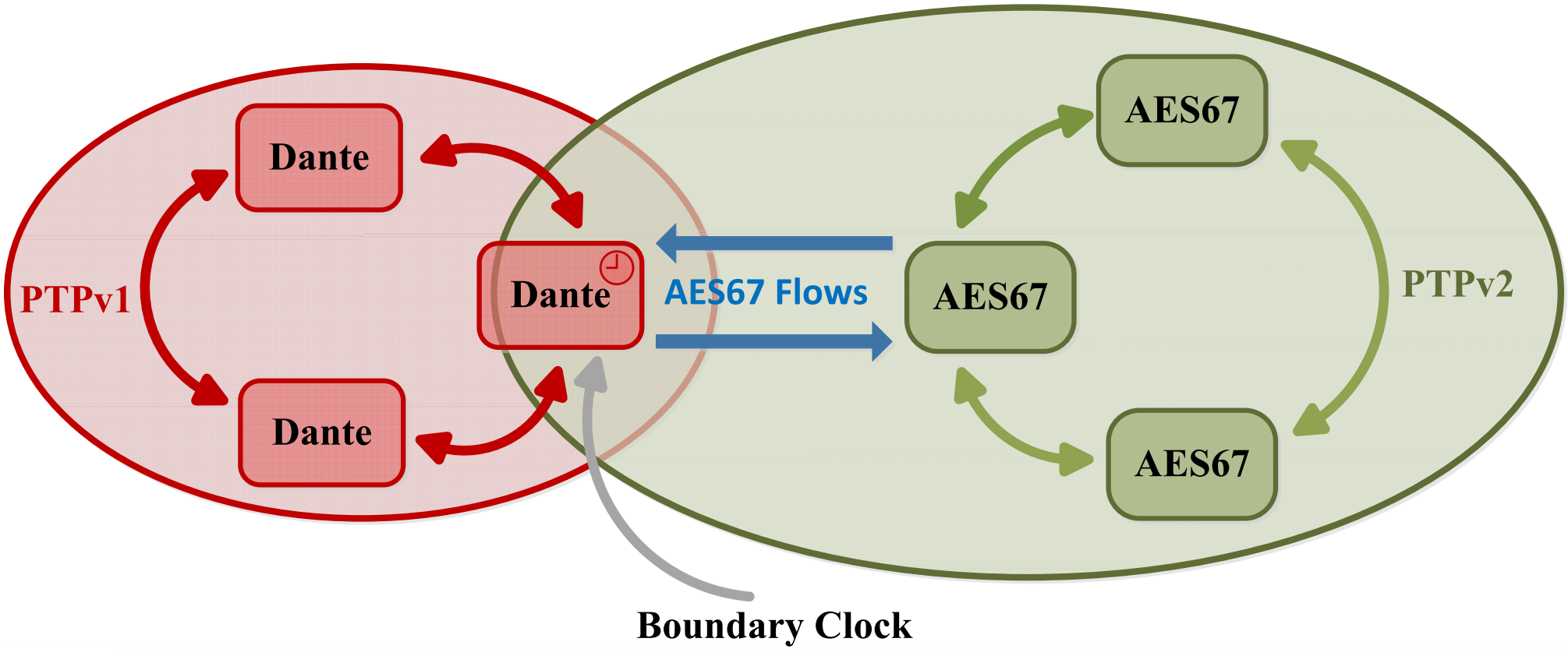
Dante & Ravenna – Audio Cousins

- **Dante** was developed by Audinate in the early 2000's and released to the market in 2006. It is based around proprietary chips that implement the protocol in FPGA firmware.
- **Ravenna –** is an Audio Over Ethernet Protocol developed by ALC NetworX of Germany and released in 2010. It depends on PTP for timing and works with standard COTS Ethernet products. More common in Europe.
- Both protocols are AES67 compliant.

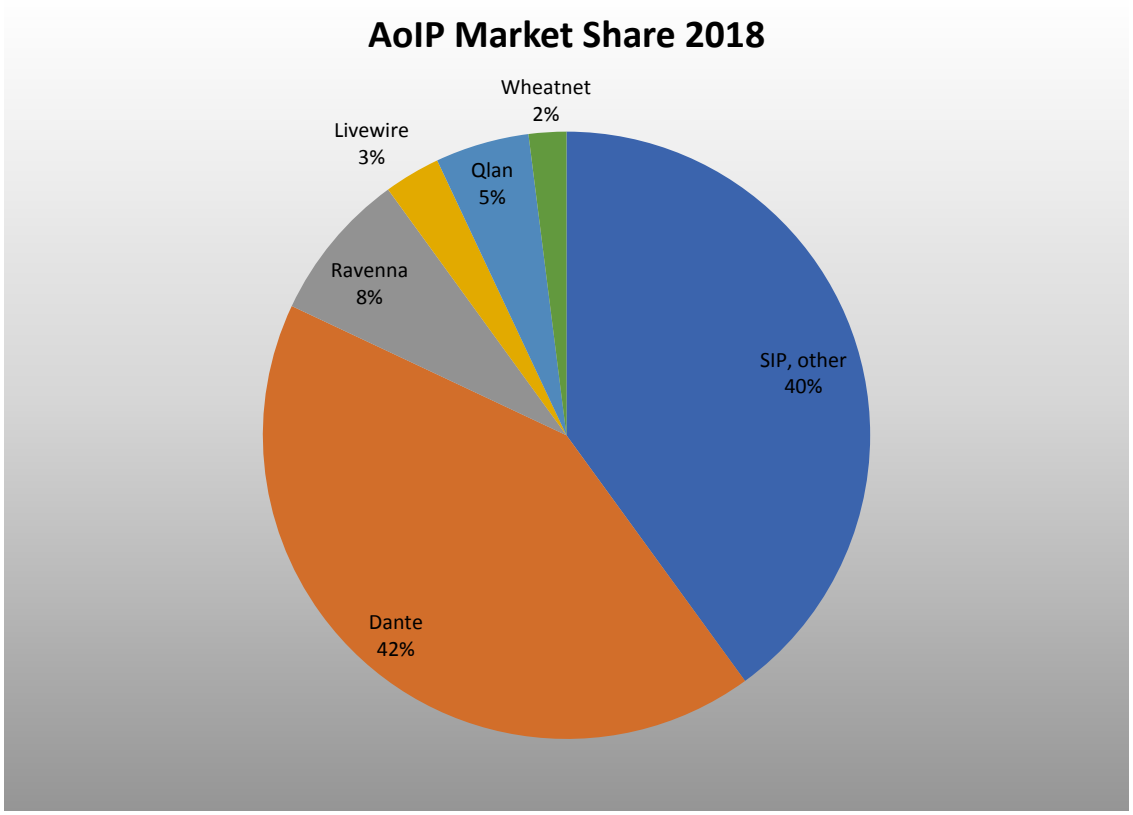
Dante audio interface

Ravenna audio interface

Interoperability Between Dante and AES 67



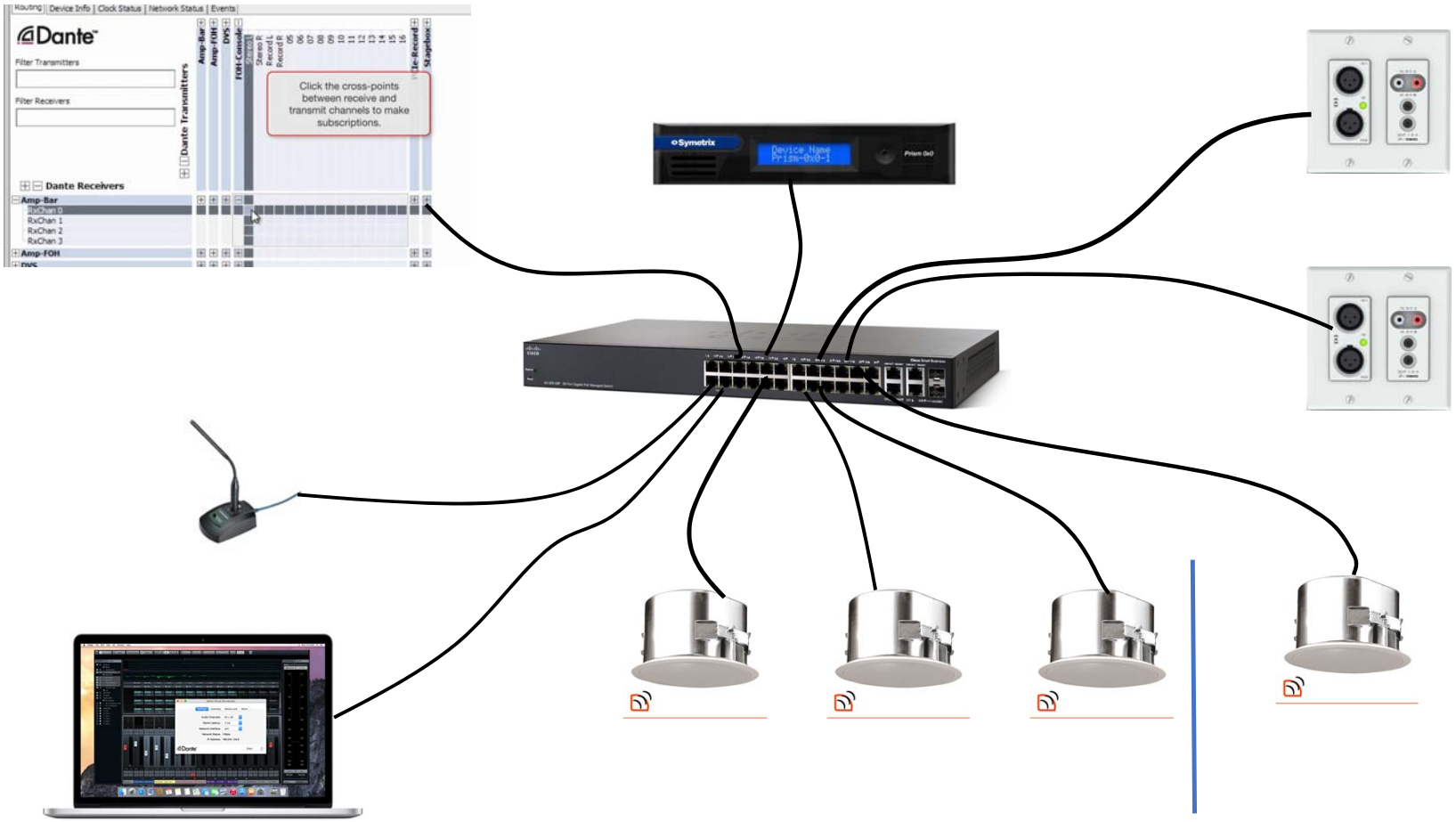
Audio Over IP Adoption -2018



Networked Audio?

- In 1993 in an email correspondence with Peak Audio, we learned of a method of carrying pro audio on standard Ethernet. This was to become Cobranet.
- We were really excited about this and exclaimed to Rich Zwiebel of Peak Audio (now of QSC Q-LAN) that in a few short years there would be microphones with RJ-45 connectors and loudspeakers with RJ-45 connectors and nothing in between but a ‘control plane’. 25 years later we are finally arriving at this point.

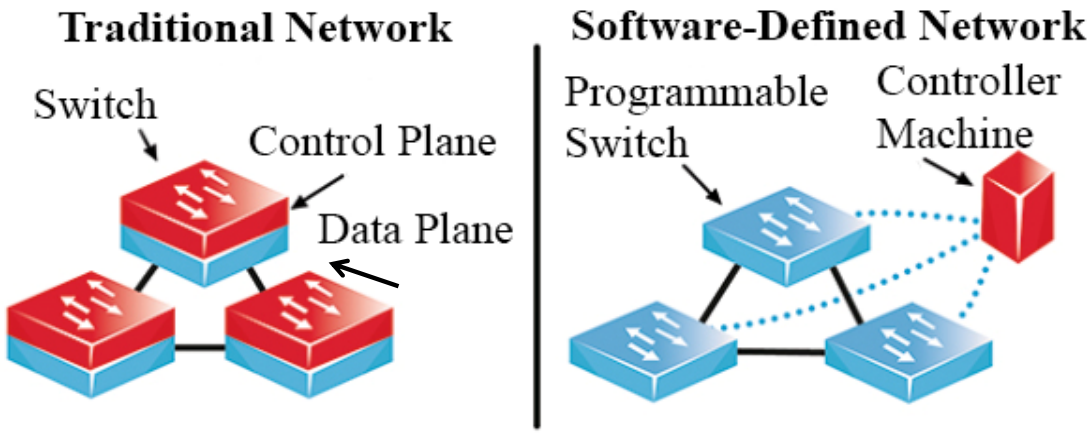
Microphones and Speakers with RJ-45 - 2018


Dante
Filter Transmitters
Filter Receivers
Dante Transmitters
Dante Receivers
Click the cross-points between receive and transmit channels to make subscriptions.
Amp-Bar
RxChan 0
RxChan 1
RxChan 2
RxChan 3
Amp-FOH
Symetrix

Software Defined Networking – SDN

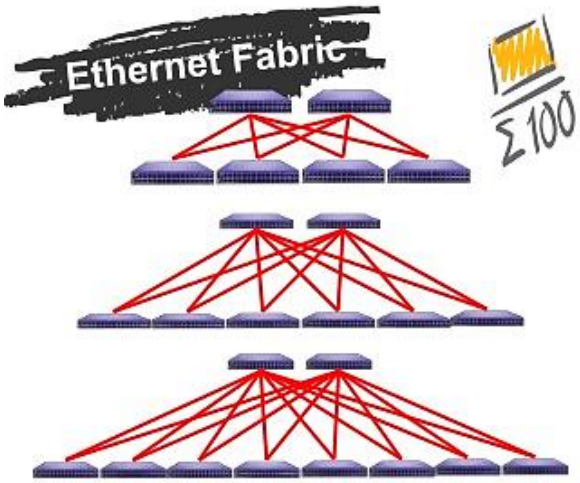
Software Defined Networking (SDN) is a catch-all term to describe many different use-cases. At its simplest, it is defined as generic switching hardware that is being ‘directed’ by a control plane.

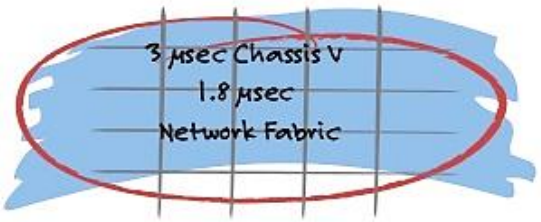
Open Flow is a set of instructions that tell a network switching infrastructure how to behave and to be more ‘deterministic’ than best effort hard-coded Ethernet. Necessary for broadcast production.



Data Centers for Broadcasters

Fully Non-Blocking Architecture





80% Traffic East-West

O/S	Maximum 10GbE Connections	Total Summit X770 Units	40 GbE Ports Downlinks at the Edge	40 GbE Ports Uplinks at the Edge
1:1	256	6	16	16
~2:1	512	8	21	11
3:1	768	10	24	8

Three key Components to Fabric Design...

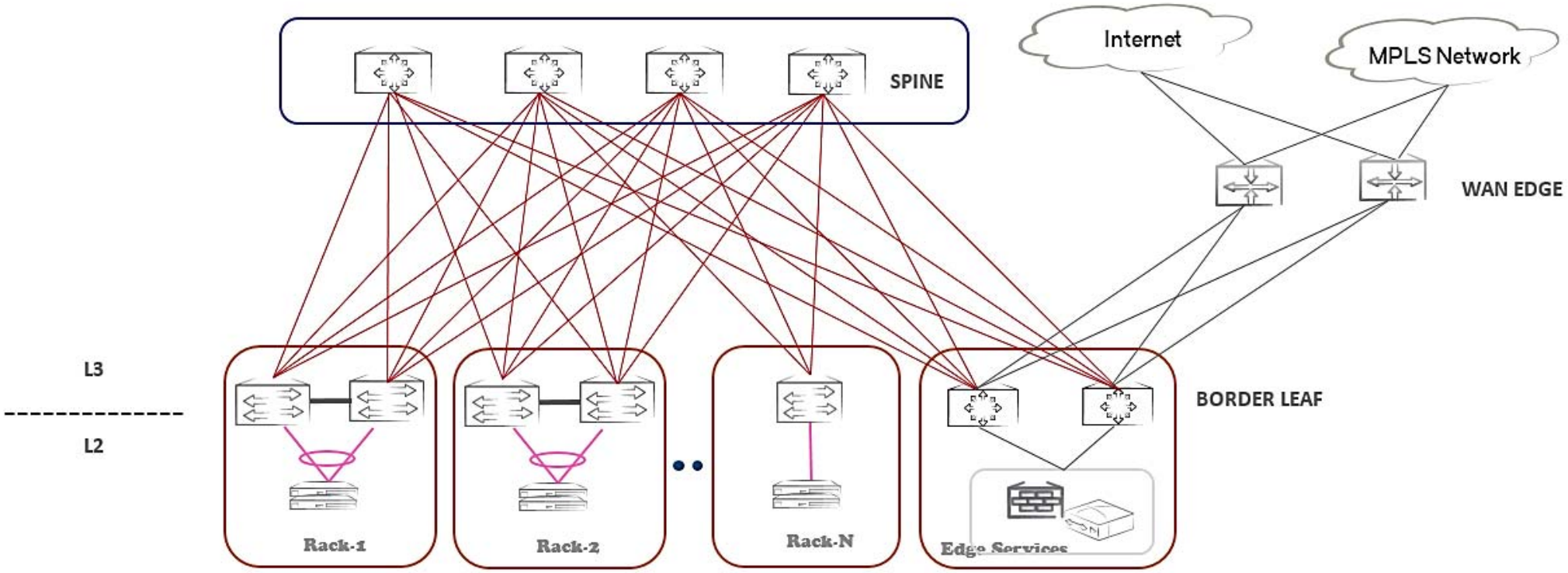
- **Spine** - 10 Gb Spine switches (10Gb - 40Gb - 100Gb Spine) verylow Oversubscription
- **Leaf** - 1/10 Gb Non-blocking (wirespeed) leaf switches Inter-rack latency: 2 to 5 microseconds
- **Compute and Storage** - High performance hosts (VMfarms, IP Storage, Video Streaming, HPC, Low-latency trading)

Broadcast Data Centers- Unique Requirements

IP Data Center vs Broadcast Data Center

Process	IP Data Center	Broadcast Data Center
Agility of Service Deployment	✔	✔
Scalability (ease of upgrading)	✔	✔
Non-Blocking	✔	✔
Graceful Fault Tolerance	✔	✔
Ease of Upgrade	✔	✔
High Bandwidth (uncompressed video)	✔	✔
Format Agnostic	✔	✔
Vertically Accurate Video-over-IP Switching (edge- or destination-based)	✘	✔
Native SDI Connections Supported	✘	✔
Low Latency (less than 1 video frame)	▲	✔
Computational Intensity for Encoding (i.e., HEVC)	▲	✔
Programmable FPGA Blades	✘	✔

Spine and Leaf Architecture

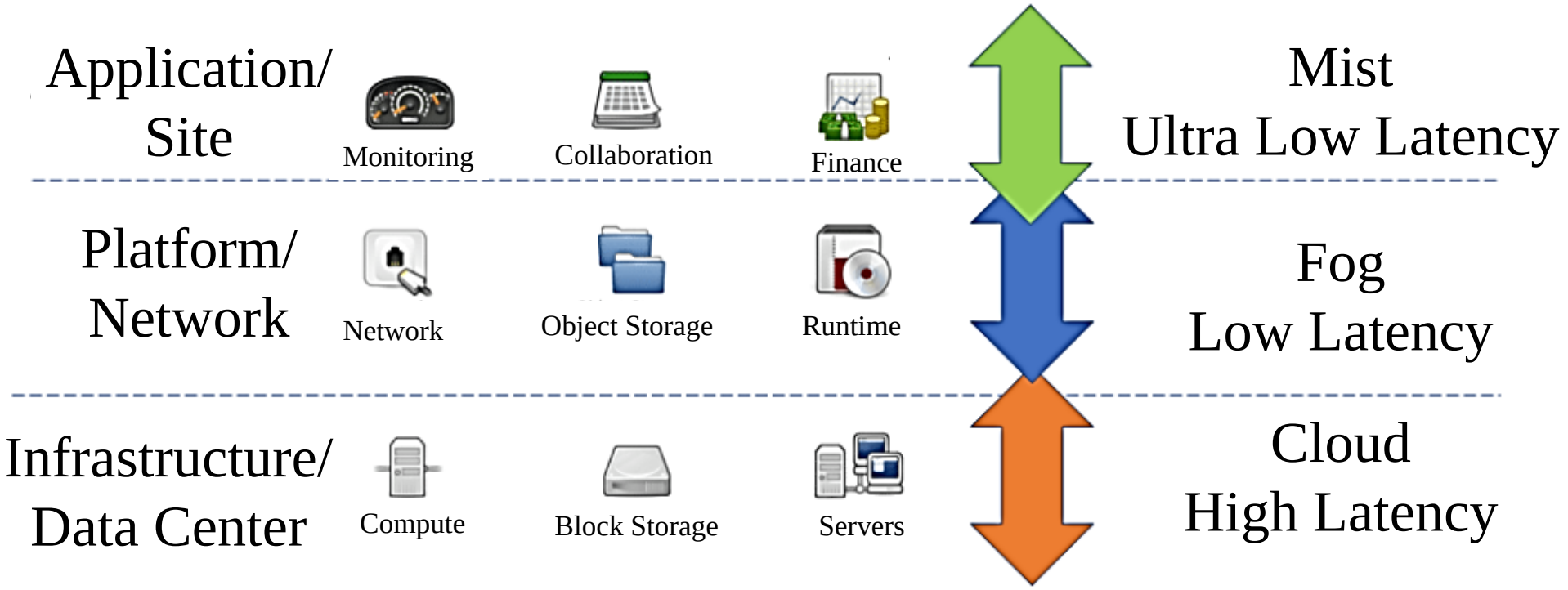


Storage – Never Enough

How do you manage storage file look-up and transport/backup for 100+ TV shows at a time?

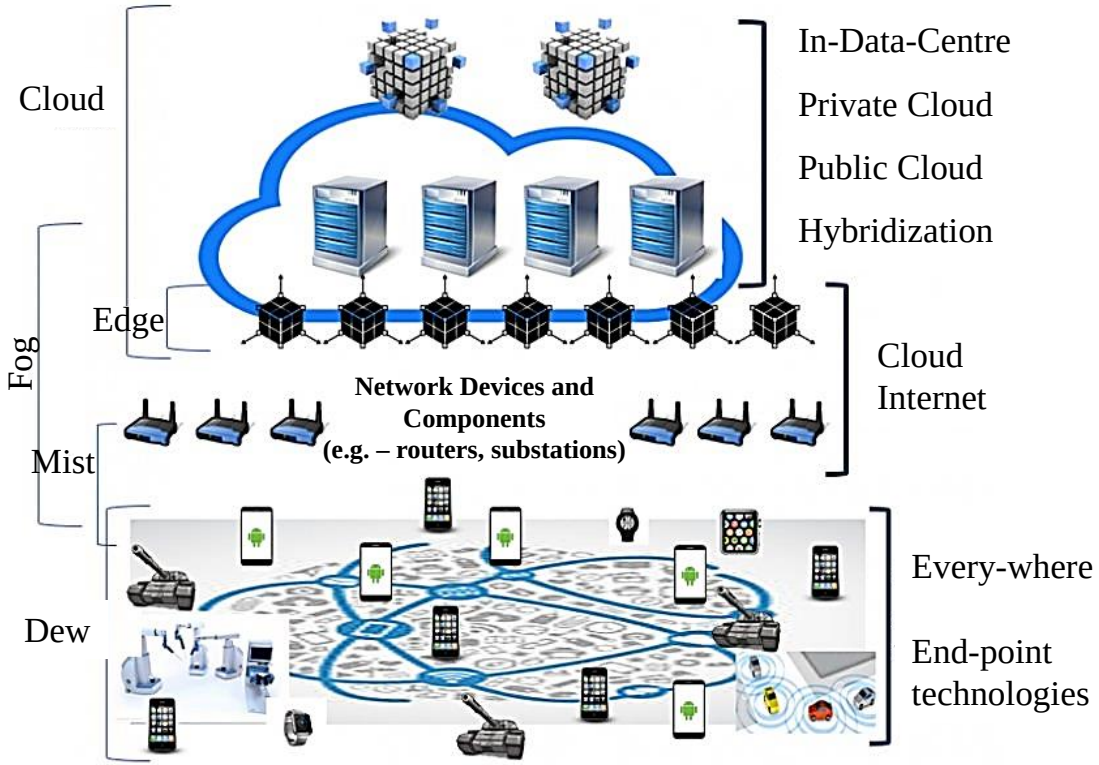
How do you index, search, backup and replicate to remote workers with such huge file storage requirements?

Answer: Use the solutions that look like cloud data centers, linked with fog and mist solutions that move processing closer to the edge.


Application/
Site
Monitoring
Collaboration
Finance
Mist
Ultra Low Latency
Platform/
Network
Network
Object Storage
Runtime
Fog
Low Latency
Infrastructure/
Data Center
Compute
Block Storage
Servers
Cloud
High Latency

Fog and Mist – I Can See Clearly Now!

Cloud, Edge, Mist and Fog Computing Architectures and Locations



Conclusion and Further Study

- This is a really big topic, but additional resources are available
- SMPTE Connect Webinars
  - Precision Time Protocol
    - https://www.youtube.com/watch?v=468120O31Q4&t=2898s
  - ST 2110 Tutorial
    - https://www.youtube.com/watch?v=Eu8N0Z-ZP4U&t=472s
  - ST 2110 and Virtualization – Fox networks
    - https://www.youtube.com/watch?v=D99u41xyMFE&list=PLcla-joGYSbxOCT2Vhd2wlZPLOoe2u8ZU

Questions

- Thank you.
- You can also email me with Questions or comments on this presentation (especially on how to make it better).
- Ward.sellars@hidi.com