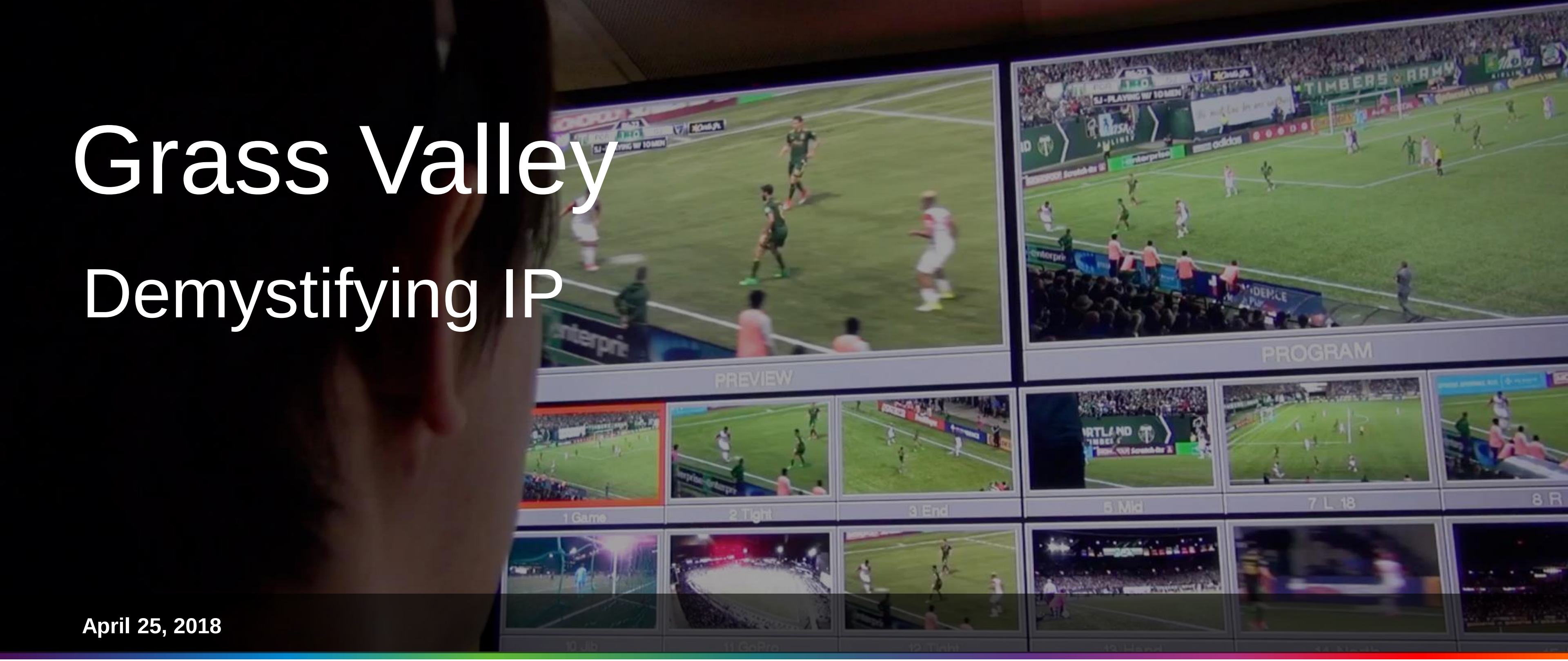
Grass Valley

Demystifying IP



April 25, 2018

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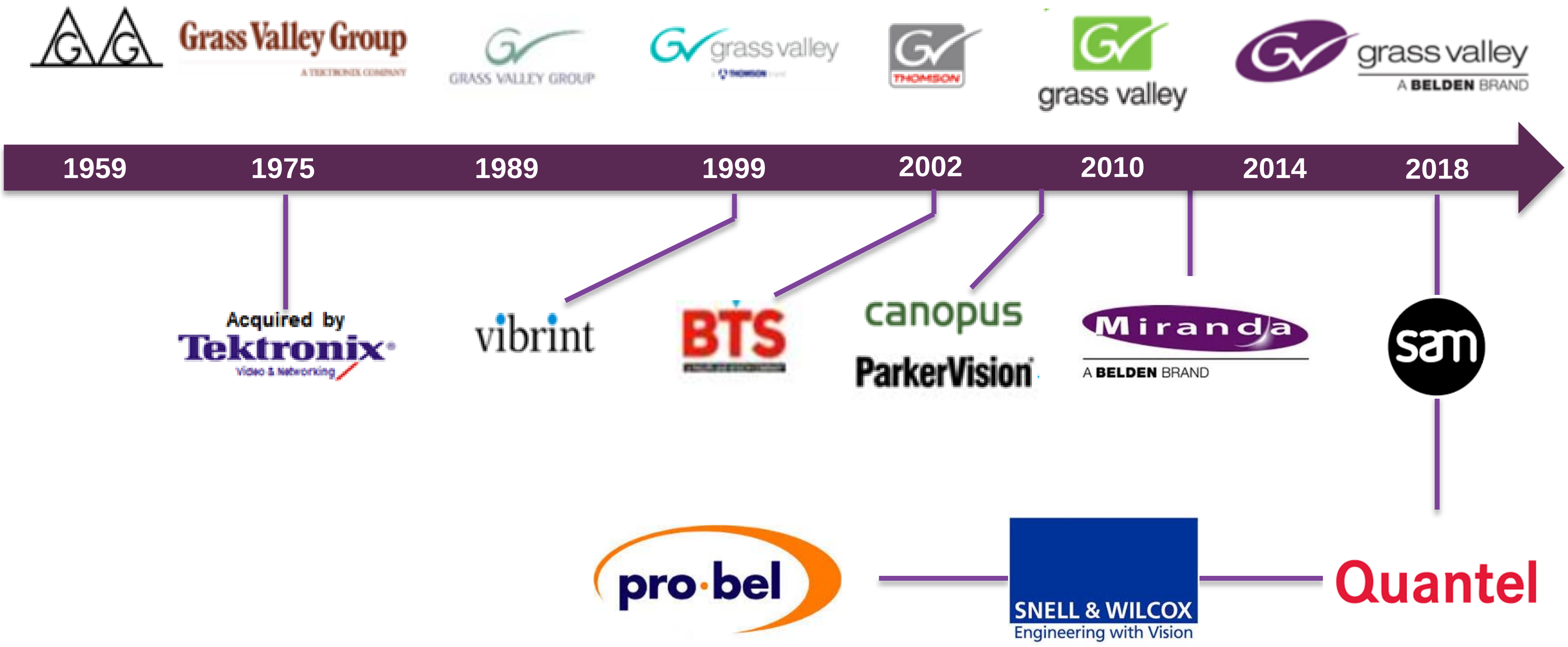
Create Control Connect
Content Your Way.

cisco
Solution Partner

ARRIVAL & INTRODUCTION

The **Grass Valley** Brand Just Got Stronger



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Intellectual Property Power House

14 Technical Emmys

+

21 Technical Emmys

=

35 Technical Emmys

102 Patents Worldwide

+

261 Patents Worldwide

=

363 Patents Worldwide

Financial Stability

	REVENUE	EBITDA MARGIN	FREE CASH FLOW	RETURN ON INVESTED CAPITAL[1]
2005	$1.246B	8.5%	$37M	4.1%
2017E[2]	$2.445B	18.9%	$225M	13.5%
	6% CAGR	Improvement of 1,040 bps	16% CAGR	Improvement of 940 bps

$20M R&D Budget

+

$60M R&D Budget

=

$82M R&D Budget

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Unrivalled Commercial Coverage

- Extensive Presence across the region
- Best-in-Class Partners
- Experience & Expertise in all Broadcast Domains

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Our Guiding Principles

The combination of Grass Valley and SAM will:

- Provide un unmatched Customer Experience
- Bring forward best-in-class products
- Ensure customers investments are protected
- Provide a path forward to future innovations

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Morning Agenda

Arrival & introduction

09:45 - 10:15	Attendees arrive
10:15 – 10:30	Welcome and Introduction
10:30 – 12:00	**Demystifying IP and IP Standards Update**
12:00 – 12:15	Coffee break & opportunity to visit demos
12:15 – 12:30	**Cisco Media Blueprint**
12:30 – 13:00	**IP Fabric Update**
13:00 - 13:45	Lunch and Demos

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Create Control Connect Content Your Way.

Afternoon Agenda

Use case : Studio facility
13:45 – 14:15 Solution architecture / Lessons Learnt

Use case : Outside broadcast (OB)
14:15 - 14:45 Solution architecture / Lessons Learnt

14:45 – 15:15 Coffee break & Demos

Use case : Remote production
15:15 - 15:45 Solution architecture / Lessons Learnt

Closing session
15:45 - 15:55 Final remarks
15:55 - 16:15 Final opportunity for demos as well as workshops sessions on any topic

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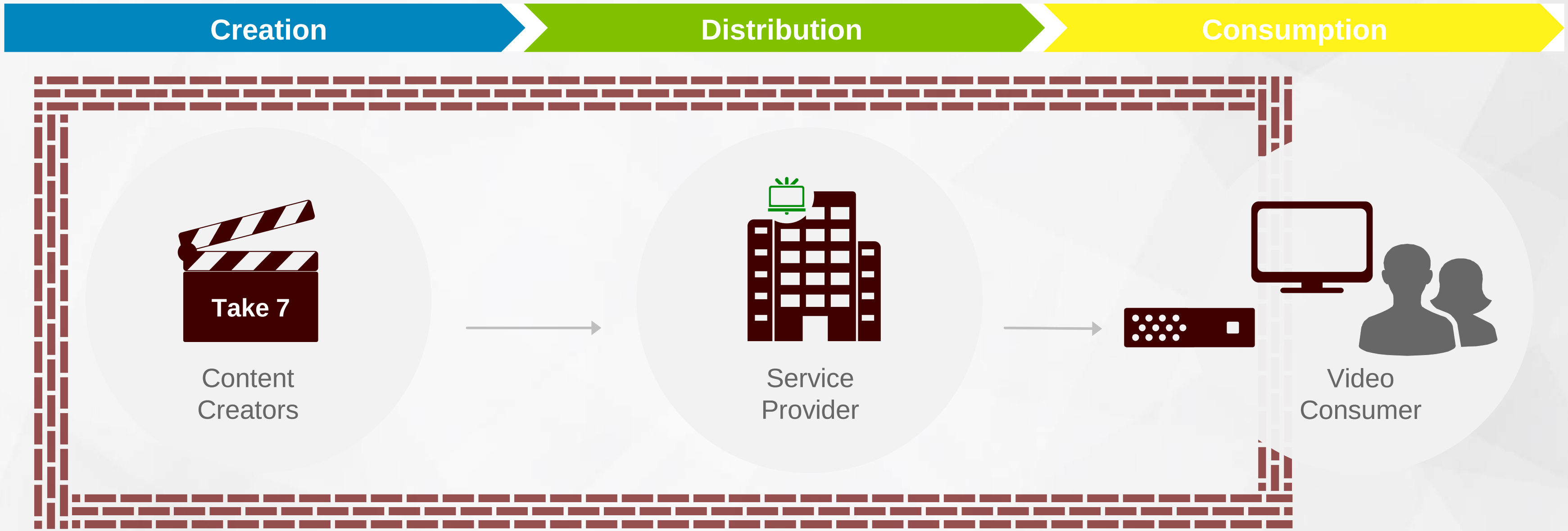
Create Control Connect Content Your Way.

DEMYSTIFYING IP
THE BUSINESS CASE

Not long ago, content delivery was straightforward



The format drove the business

- HDTV Was the last Government regulated format
  - FCC Telecommunications Act 1996
  - EU 2005 Switch over from analog to digital
  - Current regulatory activity concerns broadband data

- The Format set the bit rate
  - 1080i
  - 1080p
  - 720p

- The Bit Rate determined the plant infrastructure
  - 1.5 Gbps and 3 Gbps data rate
    - COAX, Connectors, Patch Bays, Equipment

- New format required a new plant

Changes in viewer preference

- Immediacy
  - Consumers want the latest information they can get
- Choice
  - Consumers do not restrict access to content.
  - Any device
  - Any time
  - Any where
- Quality
  - If all else is equal, then quality is a deciding factor

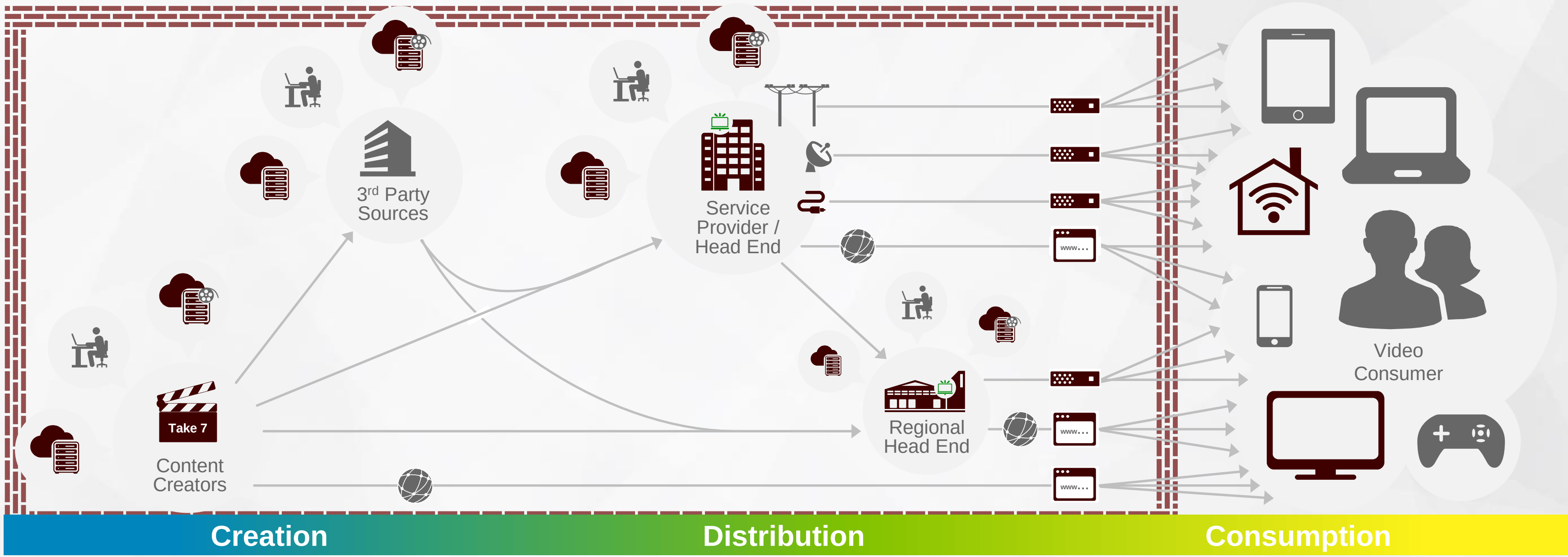
The perfect storm for change

- Consumer convenience and demand for personalization

- Unrestricted access to broadband data

- Technology enables agile, media publishing

Today, delivery methods are open with many options



Key: Corporate data centers | Employees & endpoints | Video content data centers | Satellite | Telecommunications | Cable | Content Delivery Network (CDN) | Set top box (STB) | IP

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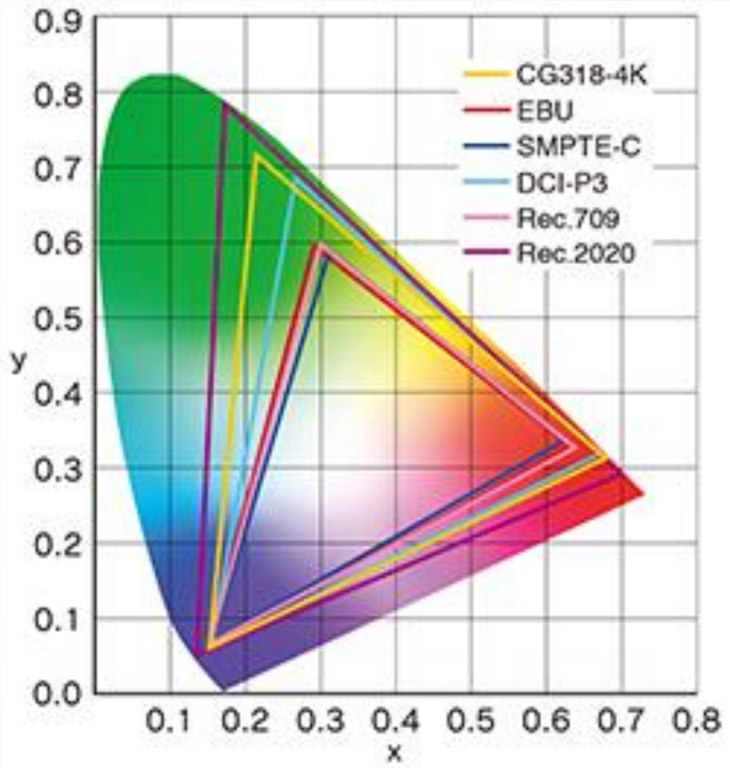
The format is not mandated

- Resolution has options
  - 2K, 4K and 8K

- Picture quality has options
  - HDR
    - HLG
    - PQ
    - others
  - WCG
    - Rec.709
    - Rec.2020
    - DCI-P3

- Frame rate has options
  - 25/30, 50/60, 100/120
  - Slo-Mo: 3x, 4x, 6x



Courtesy EIZO: https://www.eizo.com/news/2015/04/09/eizo-integrates-imagicas-3d-lut-data-into-4k

Any format delivered any way

- IP Technology provides flexibility and future scale

- Ethernet Transport scales
  - 1.5 Gbps for 2K 60 Fps.
    - HD-SDI today using commodity parts
  - 100 to 200 Gbps for 8K 120 Fps
    - There is no SDI chip set

- Ethernet/IP routers provide flexible scaling and expansion
  - CORE or Leaf/Spine
  - 3 Tbps and beyond

- PTP IEEE 1588: 2008 provides time
  - Everywhere
  - Frequency lock
  - Phase must be managed

Any format delivered any way

- Cloud Architecture provides flexibility and future scale
  - Off premise Cloud
    - Public or Leased
  - On premise Cloud
    - Private

- Compute acceleration enable virtualized processing
  - FPGA, GPU, CPU
  - Pixel processing
  - Image recognition
    - AI

- Micro-service approach
  - Devices can run on a platform which abstracts the infrastructure

DEMYSTIFYING IP TECHNOLOGY

Traditional

Connectivity

Copper

Video

BNC

HD-BNC

Audio

Multi-way
'D' type for
Analog & AES
Digital.
BNC for MADI

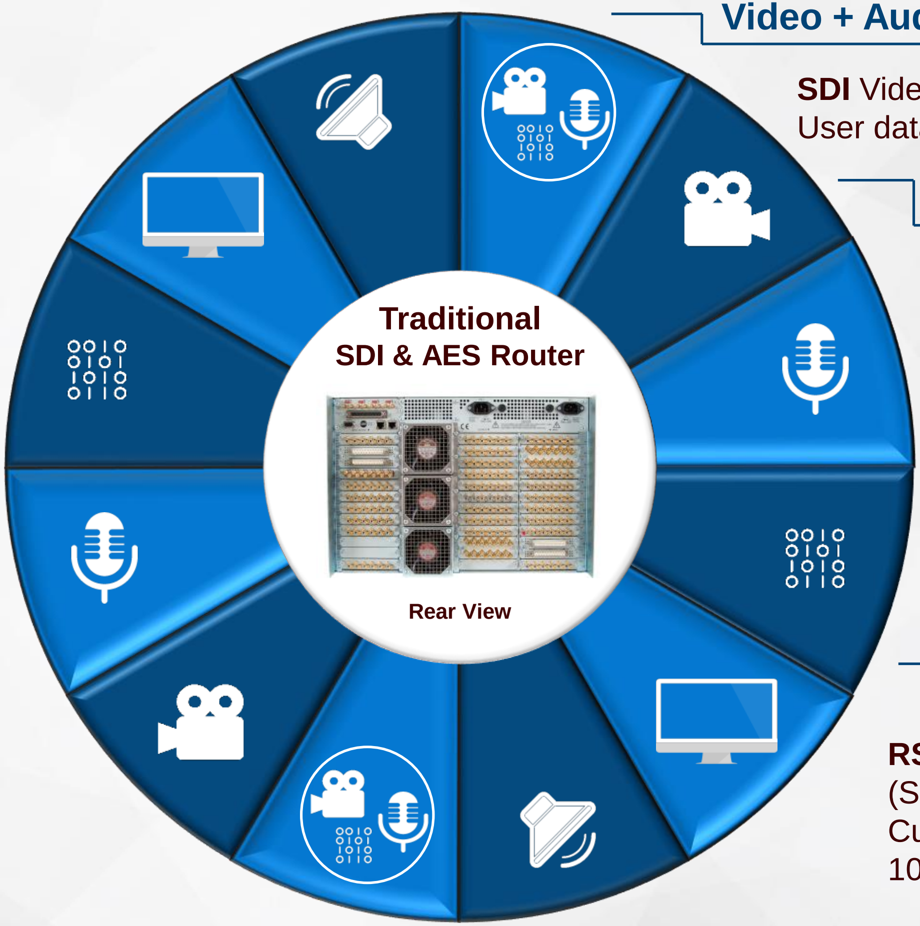
Fiber (SM/MM)

SFP*

3G/HD/SD-SDI

Dual Transmitters (2x Tx)
Dual Receiver (2x Rx)
Transceiver (Tx/Rx)

AES MADI 100Mb/s (Tx/Rx)



Video + Audio + Data

SDI Video + Embedded Audio (x16) +
User data (270Mb/s, 1.5/3Gb/s)

Video

SDI Video
(270Mb/s, 1.5/3Gb/s)

Audio

AES Digital Audio
(3Mb/s – 48kHz sampling)
Balanced - Differential
Unbalanced - Single Ended

Data

RS485 Serial - Older systems!
(Separate or integrated)
Currently more likely separate
100MbE or GbE IP Switch

SFP* – '**S**mall **F**orm-factor **P**luggable'

IP World

Connectivity

Copper

Up to **10**GbE*

Fiber

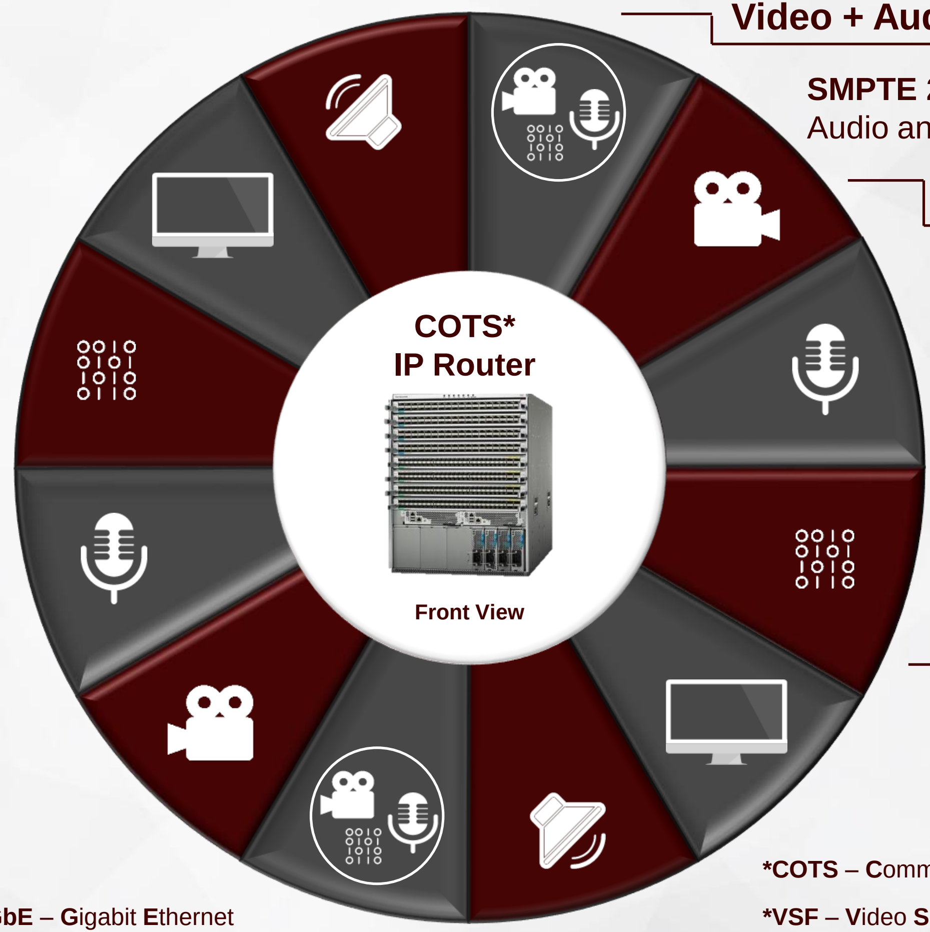
SFP*

10GbE **SFP+**

25GbE **SFP28**

QSFP+
QSFP28

40/100 GbE



Video + Audio + Data

SMPTE 2110 IP wrapper for SDI Video, Audio and Data

Before 2110

VSF* TR-04 Rasterized SDI and Audio
VSF TR-03 Essence over **RTP**

Audio

AES67 RTP Digital Audio
High-performance
IP streaming for Production

Data

TCP-IP Ancillary Data

***GbE** – **G**igabit **E**thernet

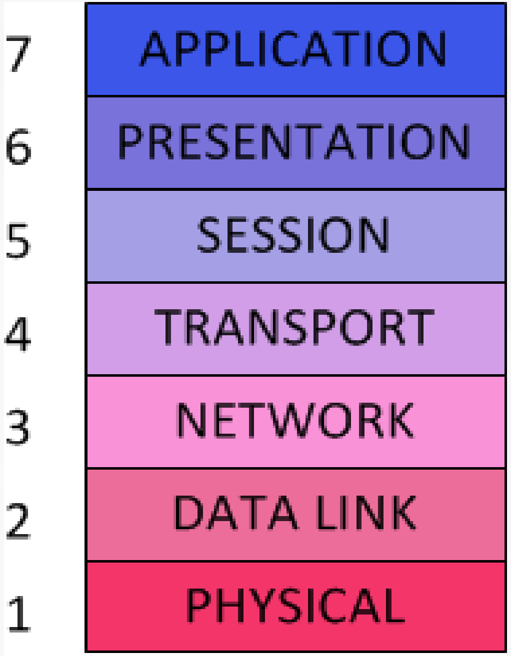
***SFP** – **S**mall **F**orm-factor **P**luggable

***COTS** – **C**ommercial **O**ff **T**he **S**helf

***VSF** – **V**ideo **S**ervices **F**orum

IETF – **I**nternet **E**ngineering **T**ask **F**orce

OSI Model



OSI Reference Model

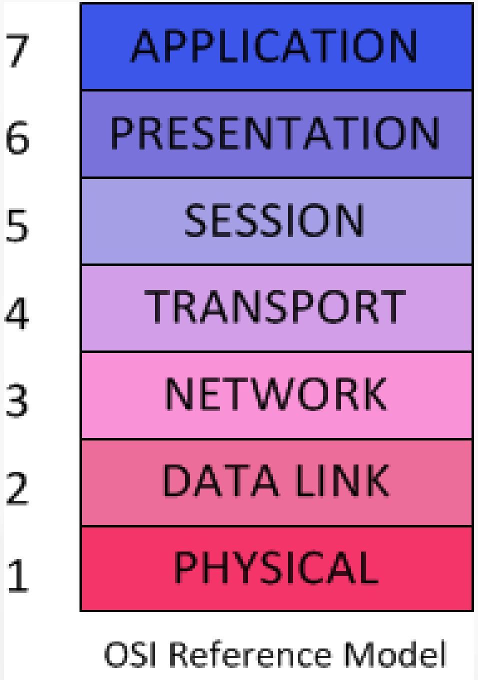
Applying this model in Media

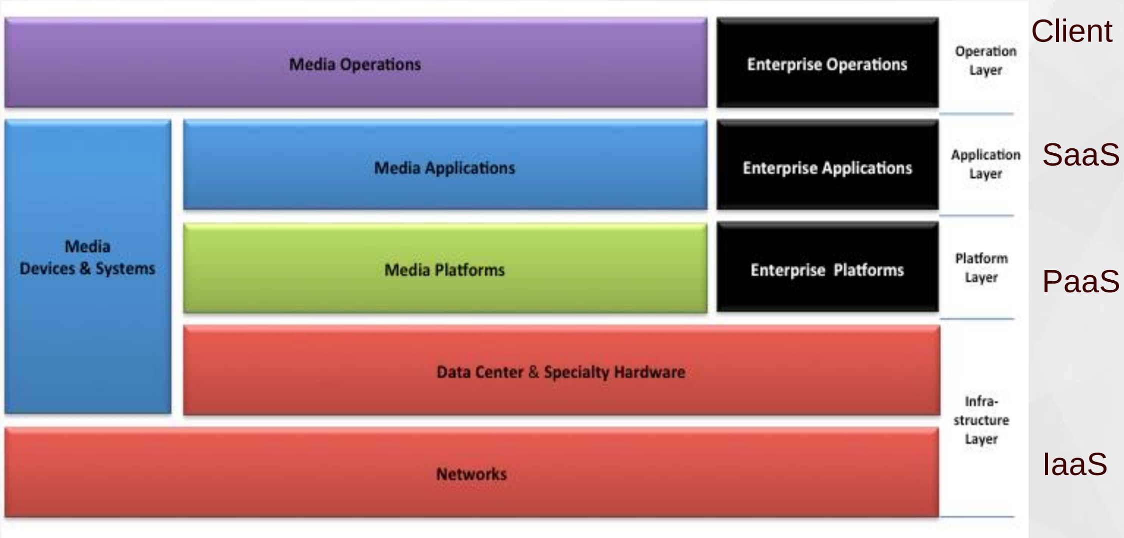
- JT-NM
  - Joint Task Force on Networked Media
- Made up of AMWA,EBU,SMPTE,VSF
- The work of the JT-NM shall be business driven
  - No science project
- The JT-NM effort shall be user-requirements driven
  - To derive business value, JT-NM must be focused on meeting user requirement

IP building blocks and terms

- Based on JT-NM layered architecture
  - Transport
  - Router
    - Redundancy
  - Registration and Discovery
  - Platform
    - Compute capabilities
  - Connection Management
    - SDP
  - Software as a service
  - Client facing applications

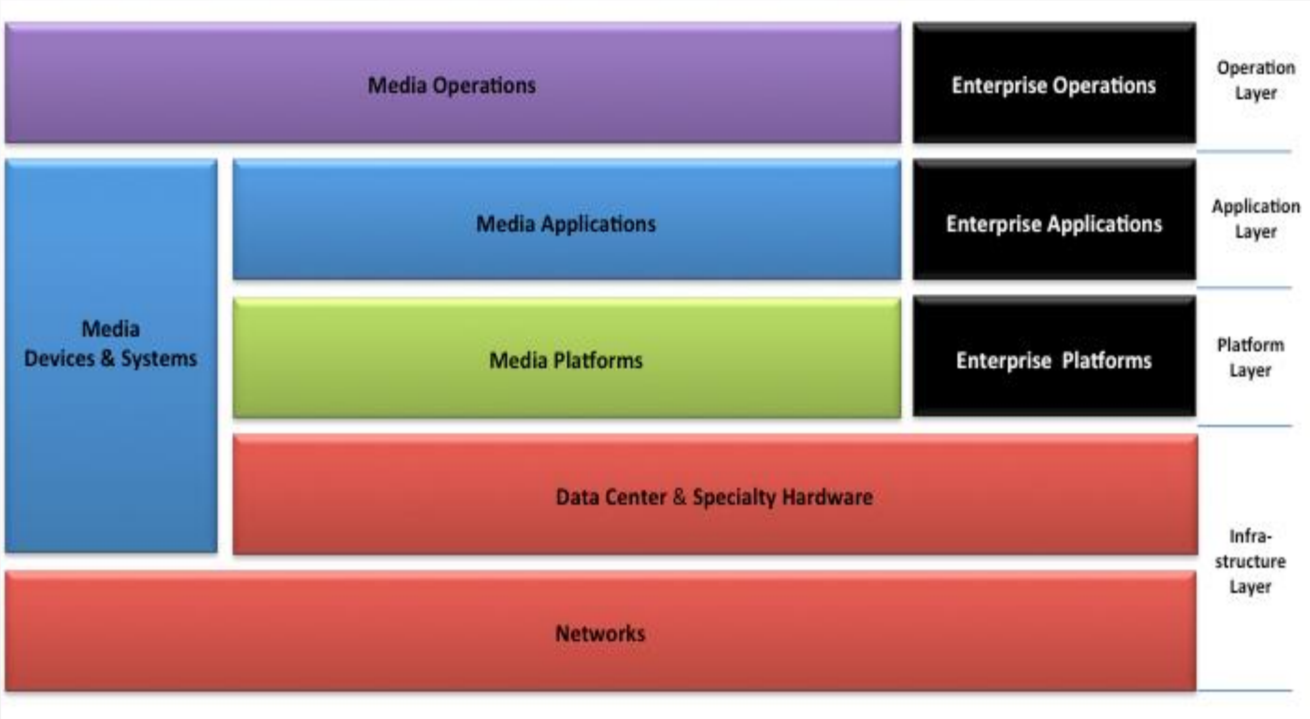
JT-NM cloud stack





- JT-NM RA 1.0 Published at IBC 2015
- http://www.jt-nm.org/

JT-NM Cloud Stack



Client

SaaS

PaaS

IaaS

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- http://www.jt-nm.org/

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Ethernet transport

- Ethernet is a suite of IEEE 803.XX standards
  - Defines the carriage of data as frames

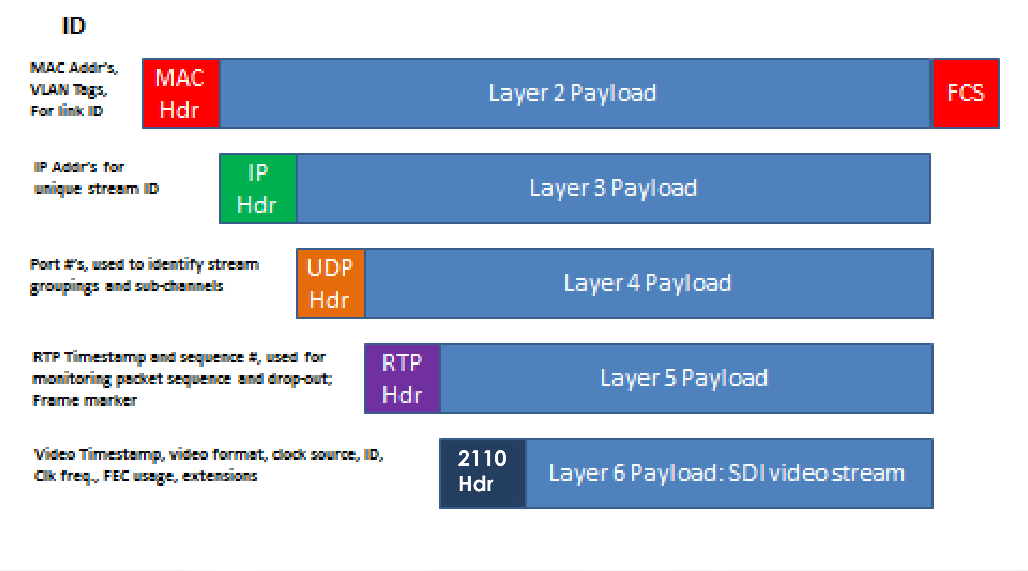
- Internet Protocol (IP)
  - Defines the carriage of data as packets, usually within an Ethernet frame

- Real Time Protocol (RTP)
  - Provides the ability to carry data, within IP packets and therefore Ethernet with indication of time

- RTP Datagram
  - The complete RTP packet, including its header and payload
  - These packets carry media essence as standardized by SMPTE and AES

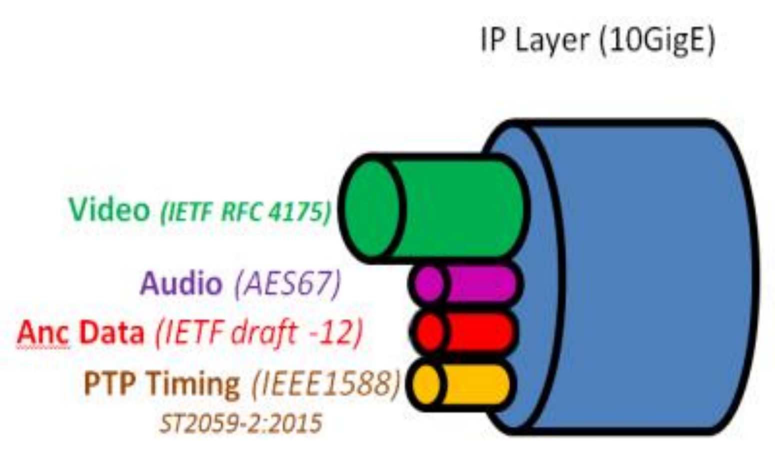
Ethernet transport

2110 Packet Structure



One Ethernet port multiple streams

- One Ethernet MAC
  - Unique data payload, or frame
- Multiple IP addresses
  - Unique data packets
- Each unique IP address
  - One media type per packet payload
- Media types are defined as Essence
  - Audio
  - Video
  - Meta Data
  - Timing



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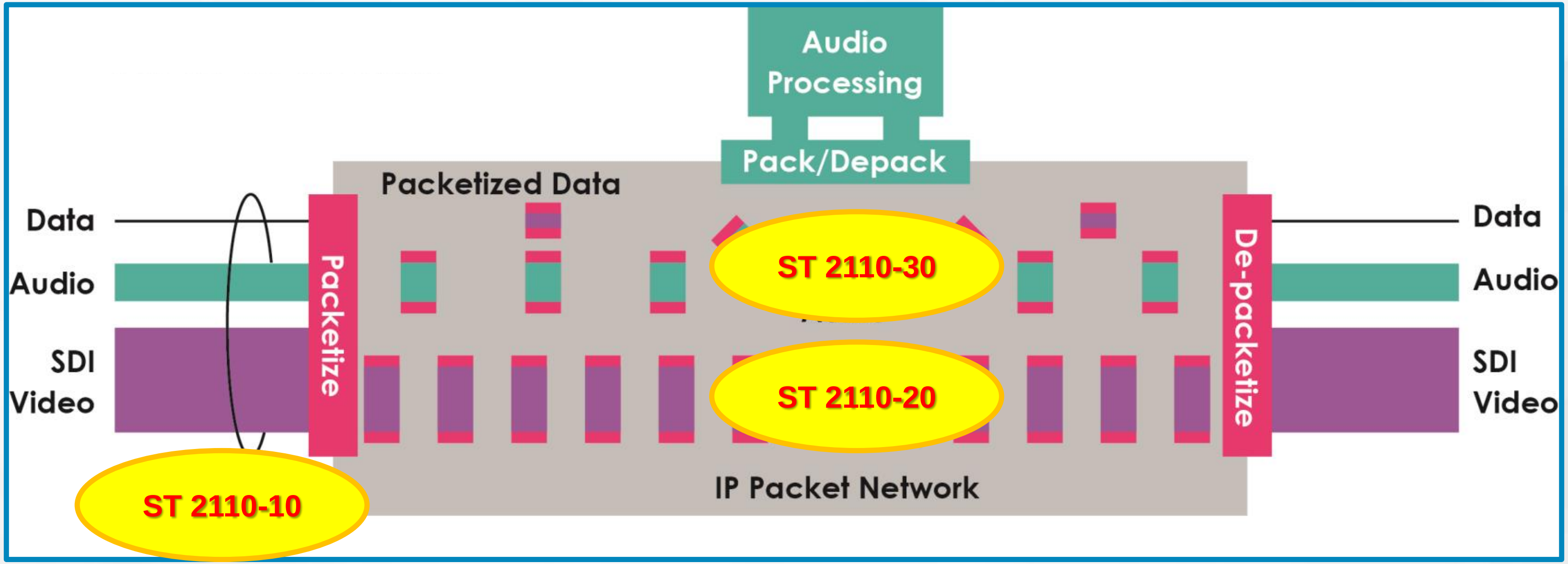
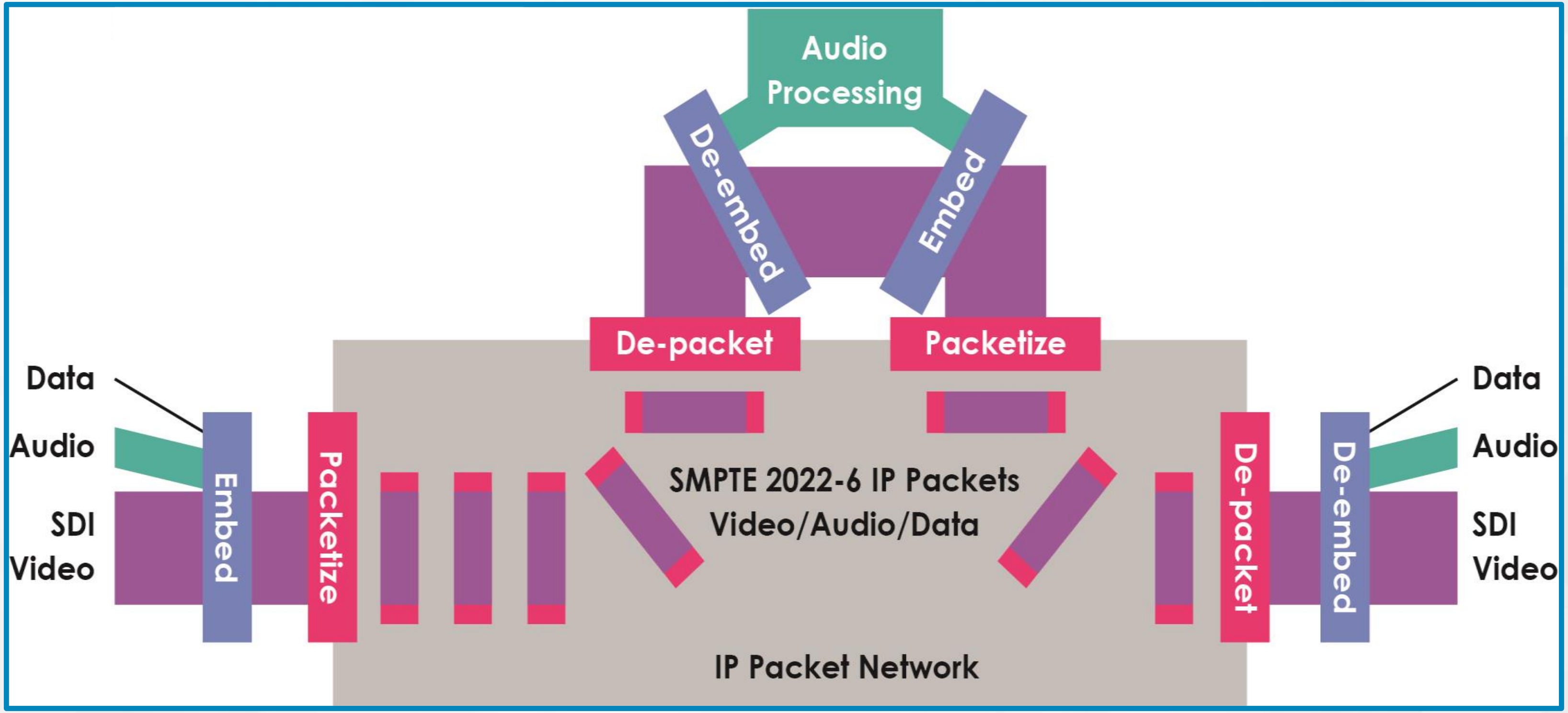
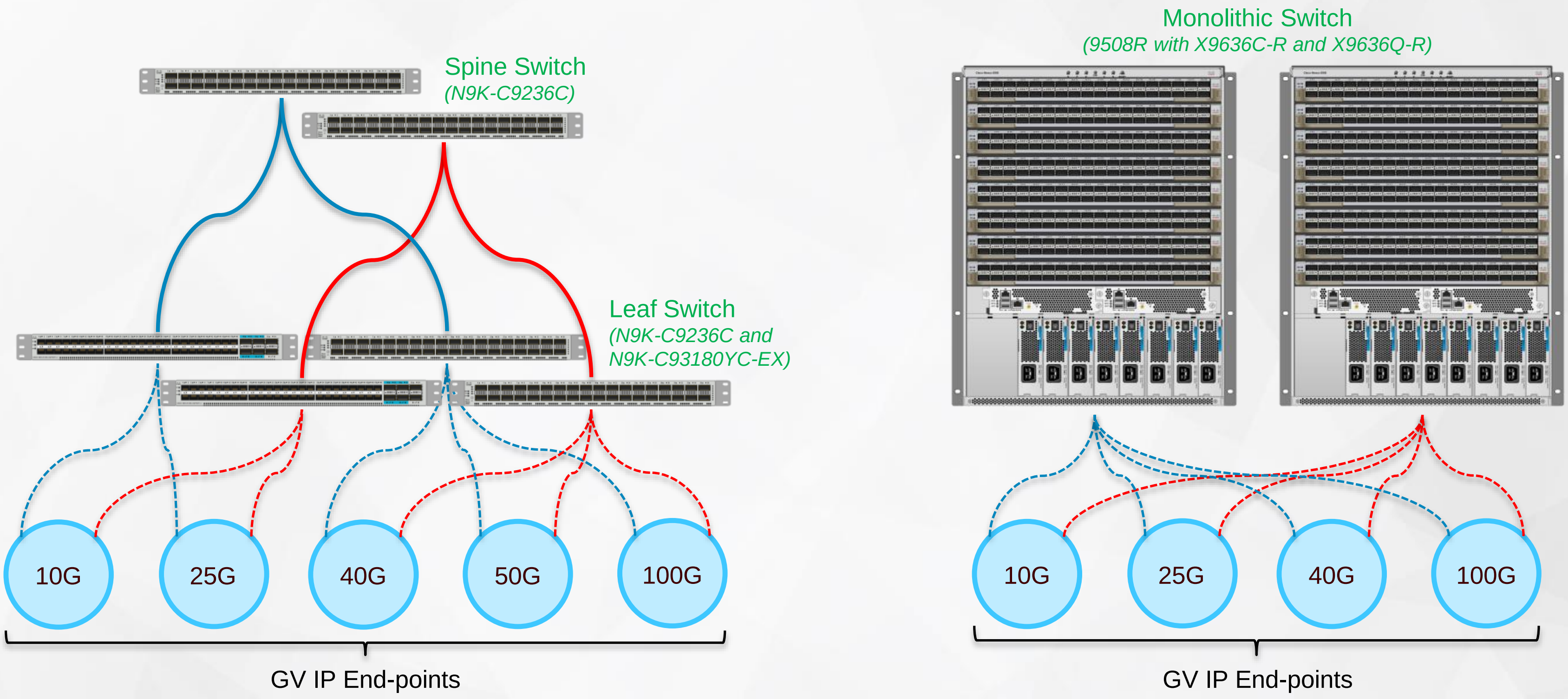
Essence (SMPTE ST 2110)



Essence packet routing

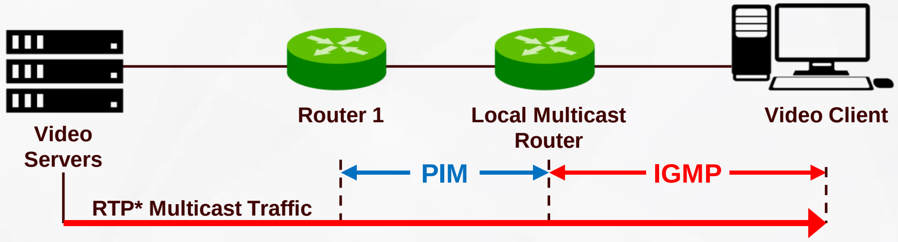


Basic topology options

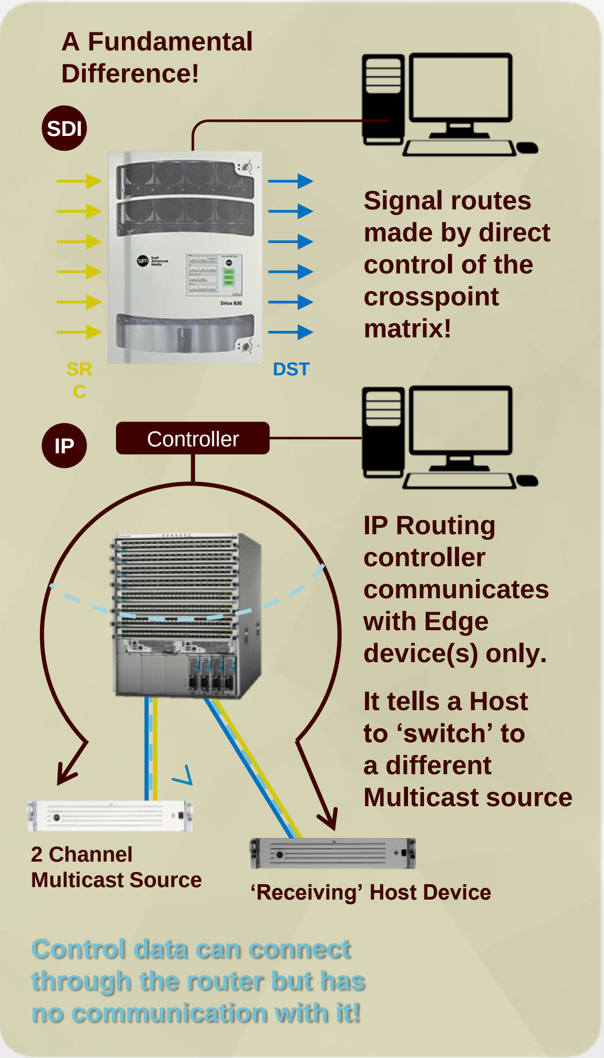


Modular CORE routers can also be used as a spine

How COTS* routers switch

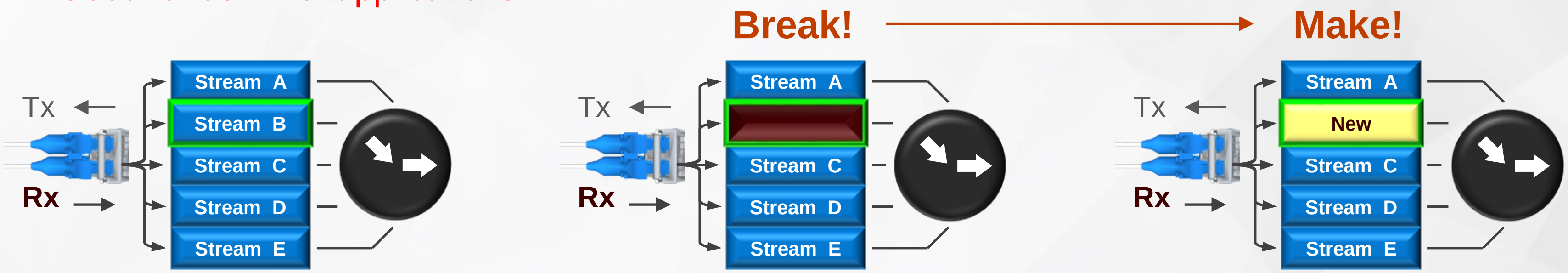


- Very large bandwidth
  - Up to 115 Tbits/s, Up to 51 Bpkts/s
- Non-Blocking
  - Router internal bandwidth can handle all the port bandwidths <u>at the same time</u> & <u>at full capacity</u>
- IGMPv3 (**I**nternet **G**roup **M**anagement **P**rotocol)
  - Communications protocol used by clients & adjacent routers establish multicast group memberships
- PIM-SSM (**P**rotocol **I**ndependent **M**ulticast - **S**ource **S**pecific **M**ulticast)
  - Between Routers. Allows a client to receive multicast traffic directly from the source



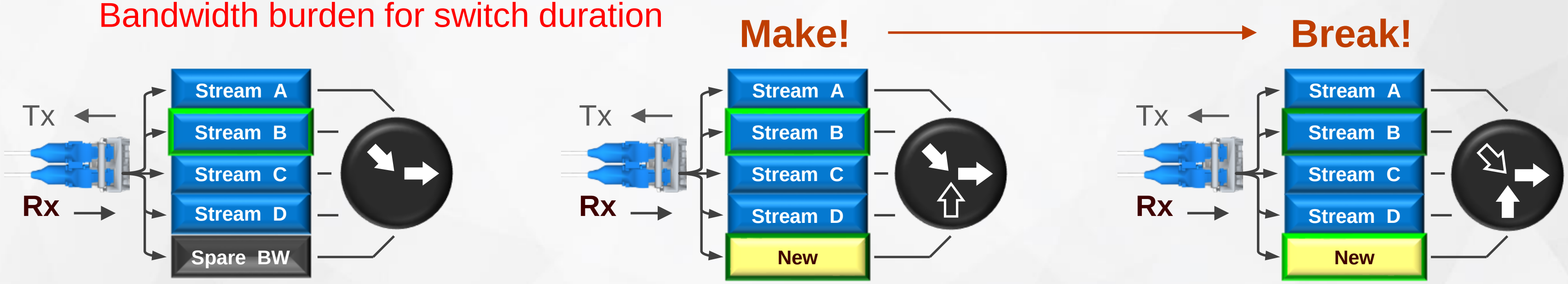
Break-before-Make (BBM) Clean, Very fast & Visibly undetectable (One frame repeat)

Good for 95%+ of applications!



Make-before-Break (MBB) Clean' (Switches on frame boundary)

Bandwidth burden for switch duration



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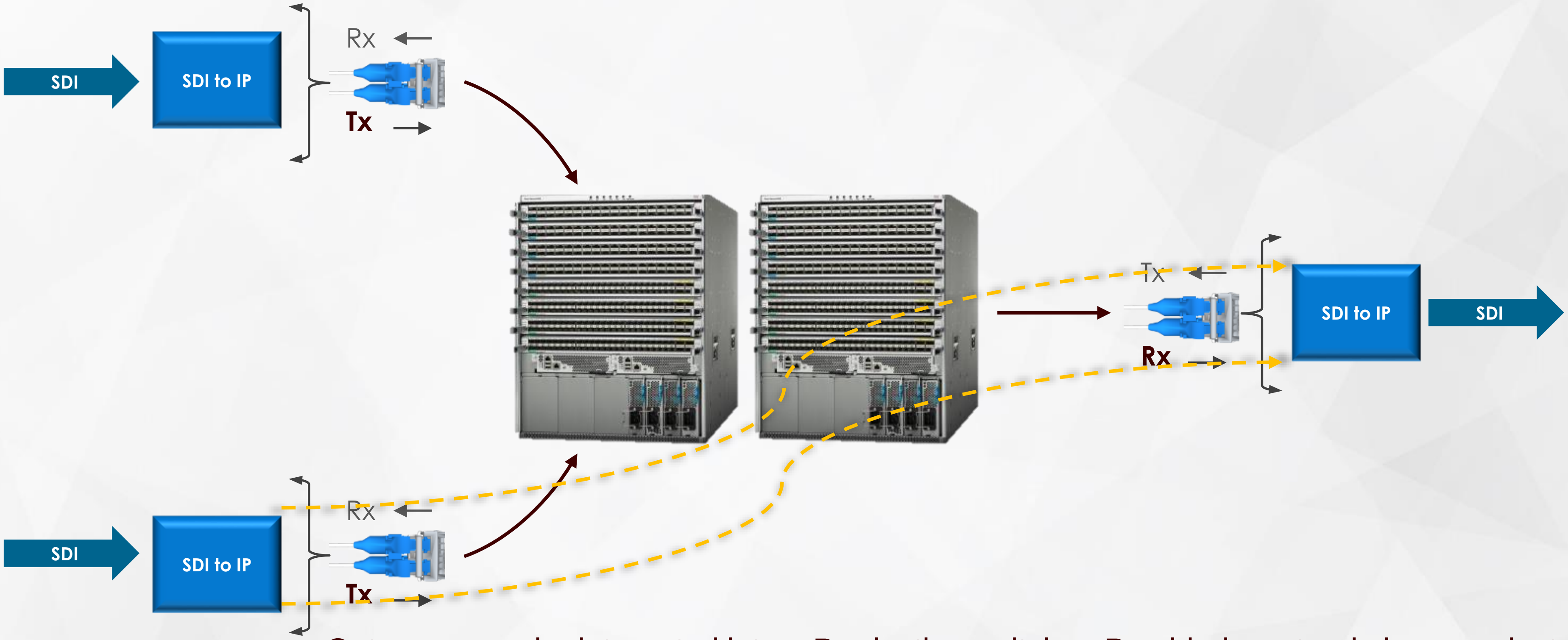
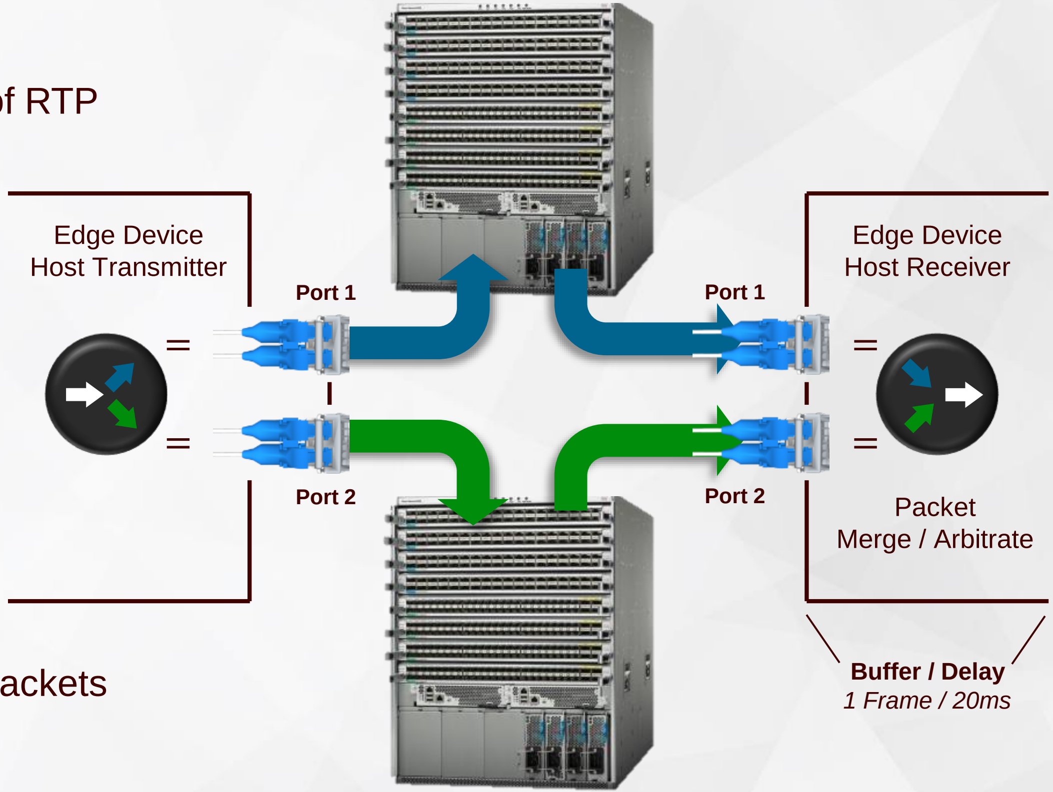
The role of gateways in switching



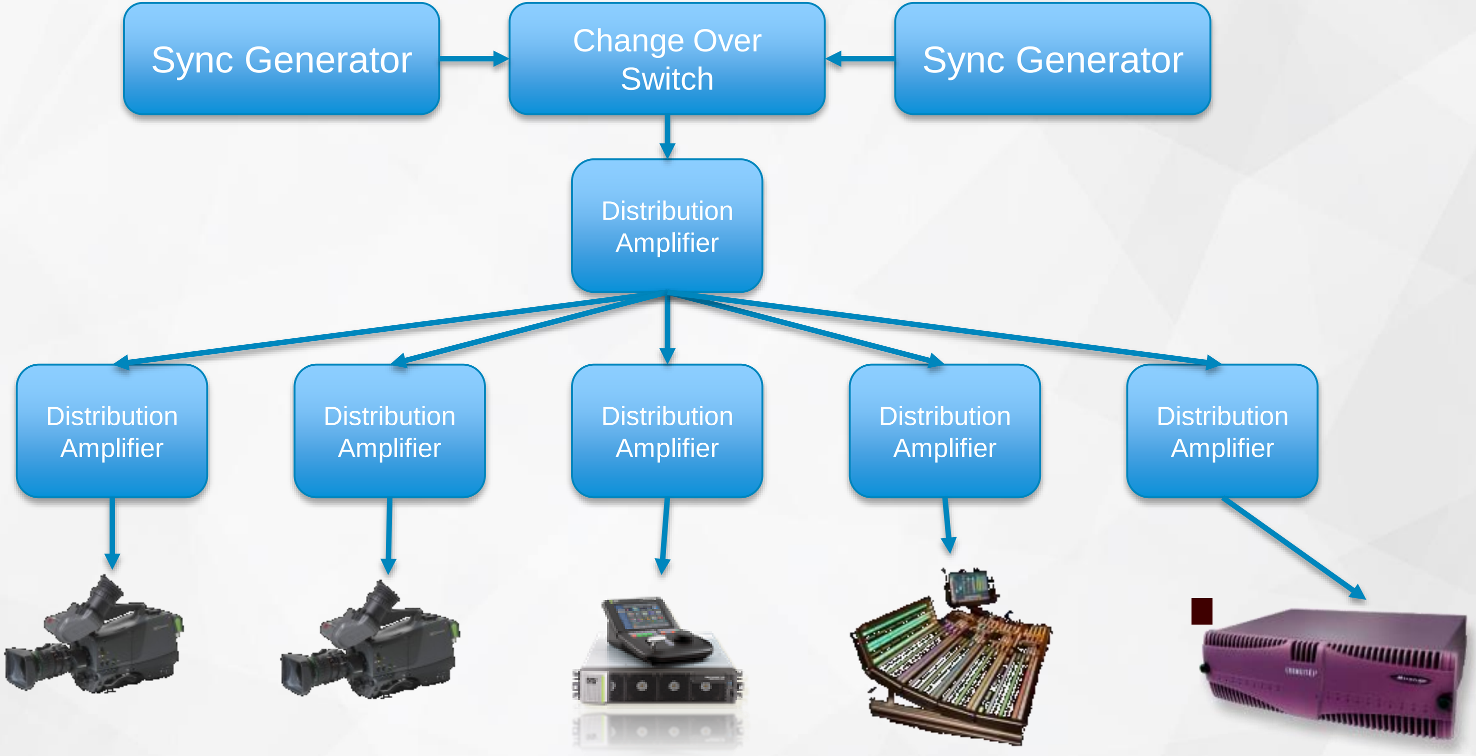
Gateways can be integrated into a Production switcher, Provided as stand alone products, or Integrated into products like GV Node, which provides aggregation and local vertical accurate switching

Redundancy

- **SMPTE ST 2022-7** Seamless protection of RTP Datagrams
- Requires copy of Multicast Source
- Two identical network interfaces
- Two IP Routers or two IP Router cards
- Packets received / joined at Host
- Packet-by-packet merging / arbitration
- Works for full stream loss and individual packets



Old way of doing system reference - Bi or Tri Level



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Precision time protocol

- IEEE 1588 PTP
  - Developed to provide very accurate frequency and phase

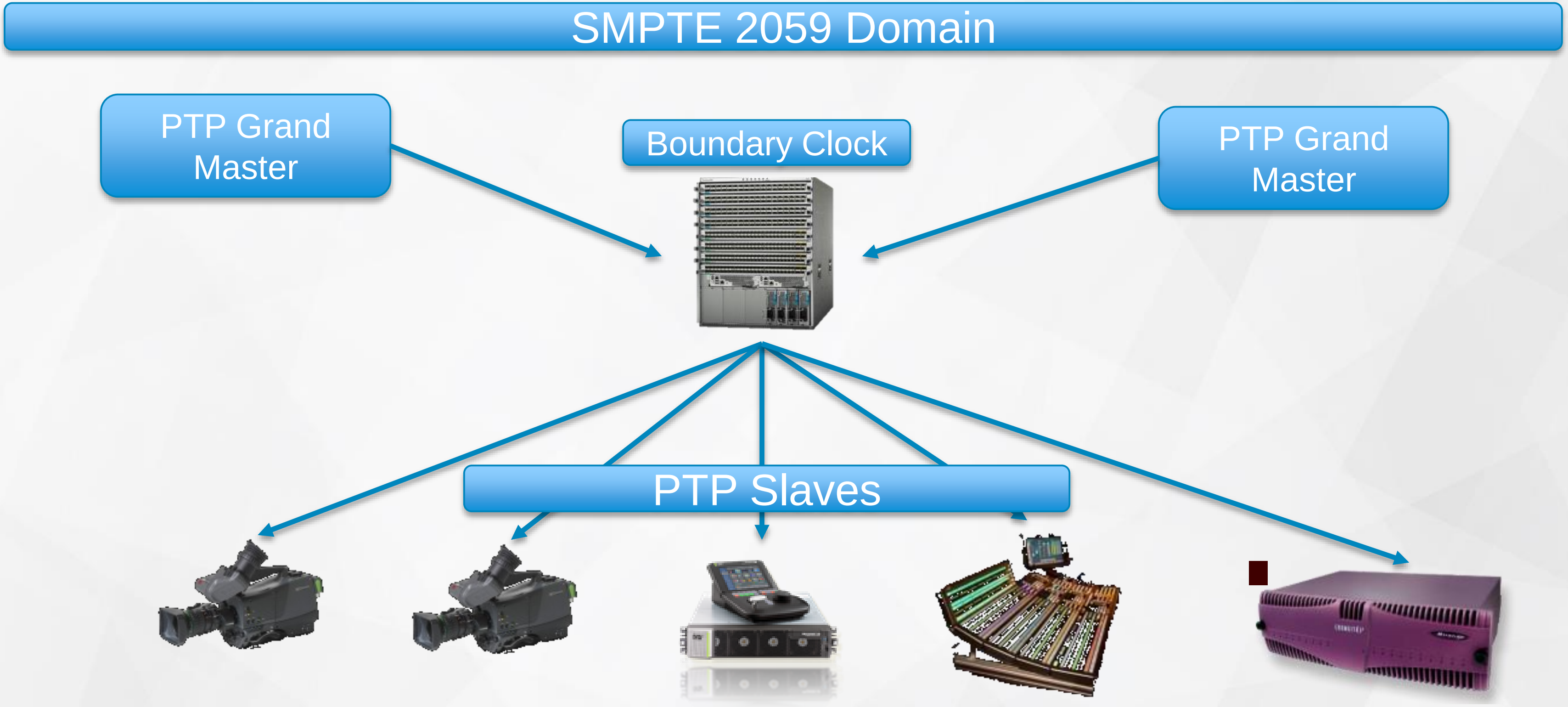
- Communicates Timestamps over Ethernet
  - Differential Timestamp values determine frequency
  - Timestamp messages determine propagation latency to adjust for phase

- Clock recovery of frequency and phase is enabled
  - Absolute Time may be traceable via GPS to TIA or UTC

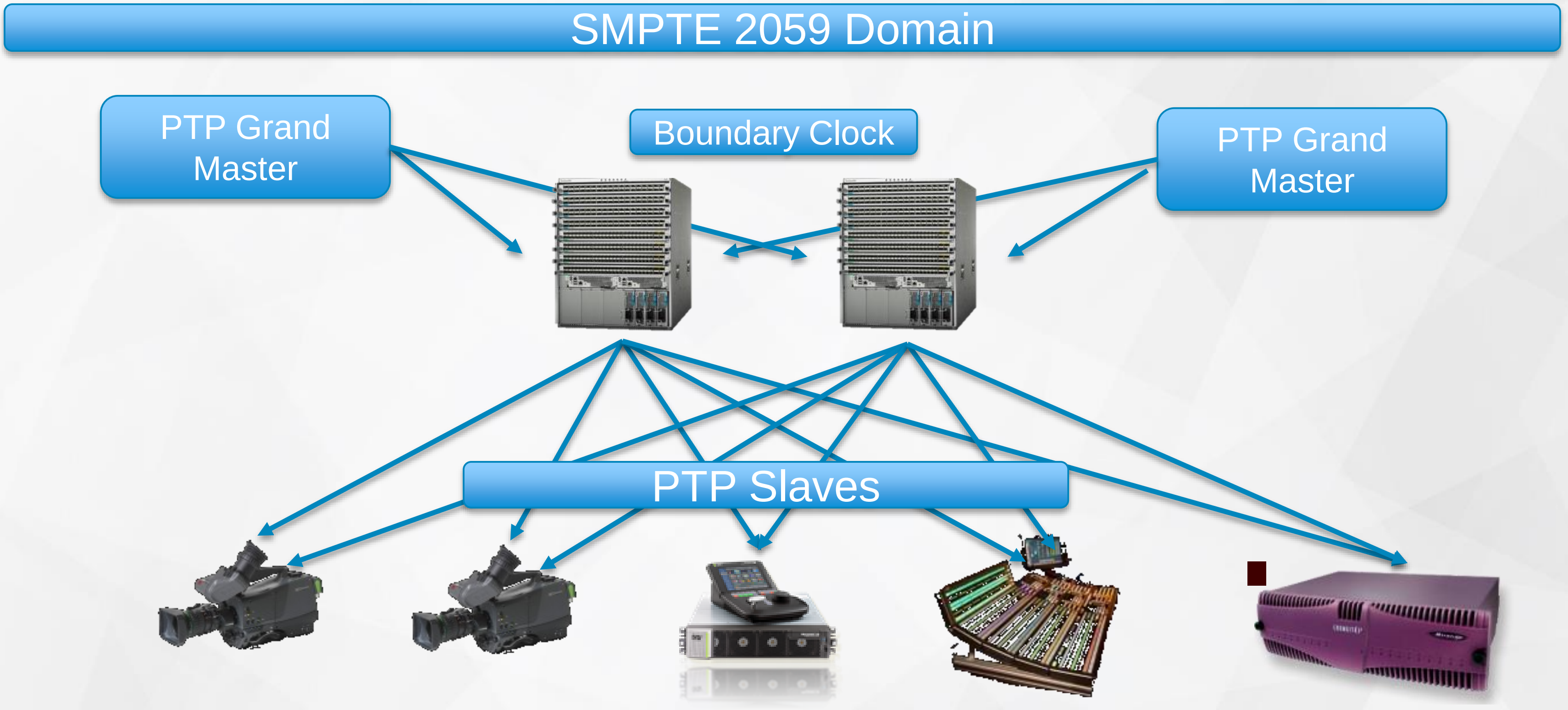
- Redundancy is provided with Best Master Clock Algorithm (BMCA)
  - 1+1 or 1+N

- Geographically distributed networks require phase management
  - A remote feed has may travel 1000's of km
  - The phase offset may require compensation

PTP v2 / SMPTE 2059



PTP v2 / SMPTE 2059



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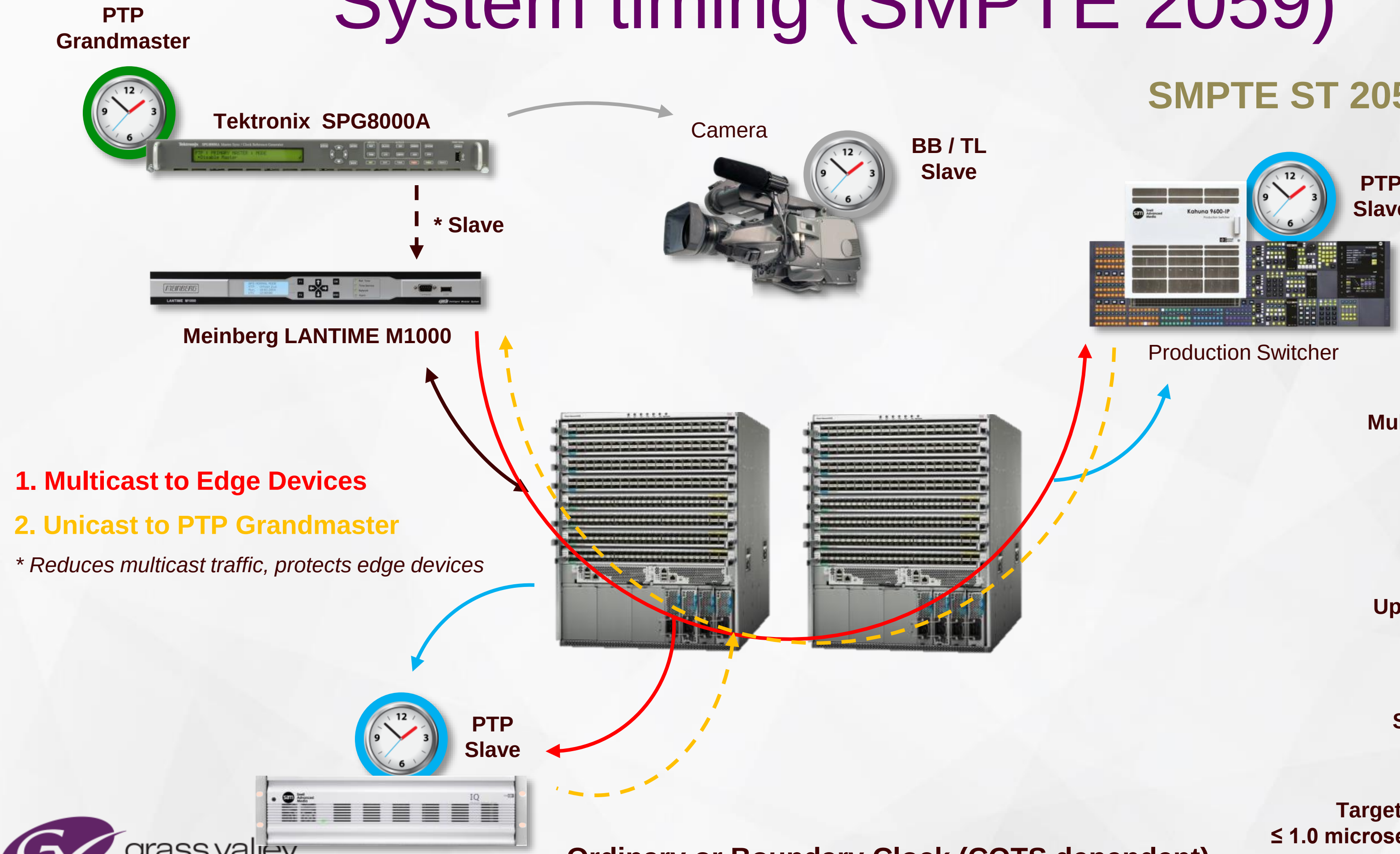
System timing (SMPTE 2059)

SMPTE ST 2059-1 and -2



Multi-format SDI references
1 x PTP (RJ45), 1 x PTP(SFP)
Free-run or Genlock
GPS option

Modular (No SDI)
Up to 4 PTP ports/modules
Free-run or Genlock
GPS option

*M1000 can be slaved to SPG8000A to circumvent high client count issues

Target ΔT between all devices:
≤ 1.0 microsecond (Lock time < 5s)

Ordinary or Boundary Clock (COTS dependent)

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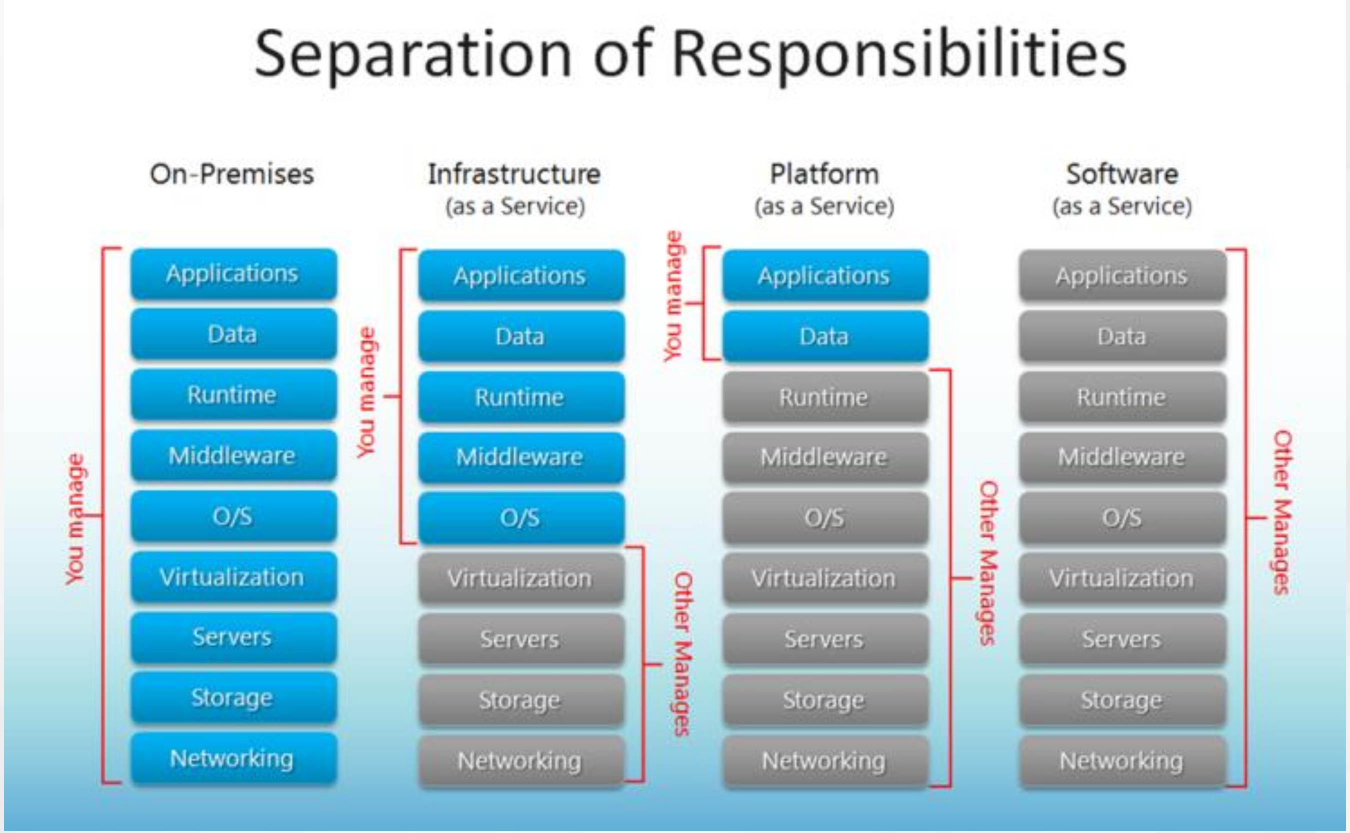
The platform



http://robertgreiner.com/2014/03/windows-azure-iaas-paas-saas-overview/

The platform

- Abstracting the infrastructure

- Managing virtual devices

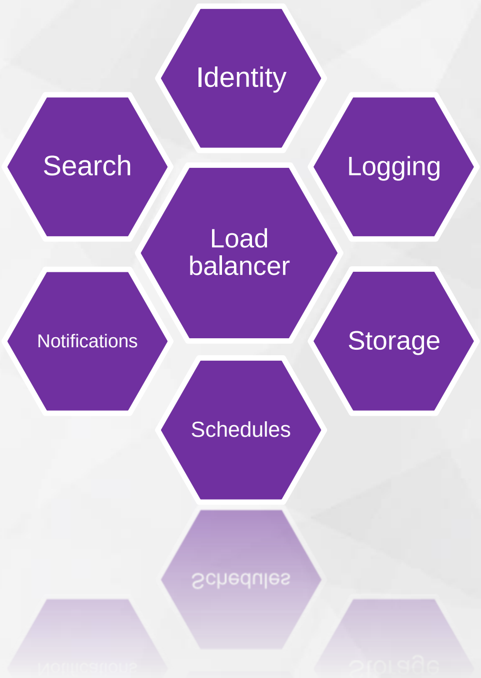
- Managing compute and storage capacities to meet operational goals
  - The device must meet performance criteria
  - The infrastructure must contain sufficient CPU cycles
  - The infrastructure must meet memory access criteria
  - Network bandwidth must be available

- Monitoring
  - Available resources
  - Correct operations

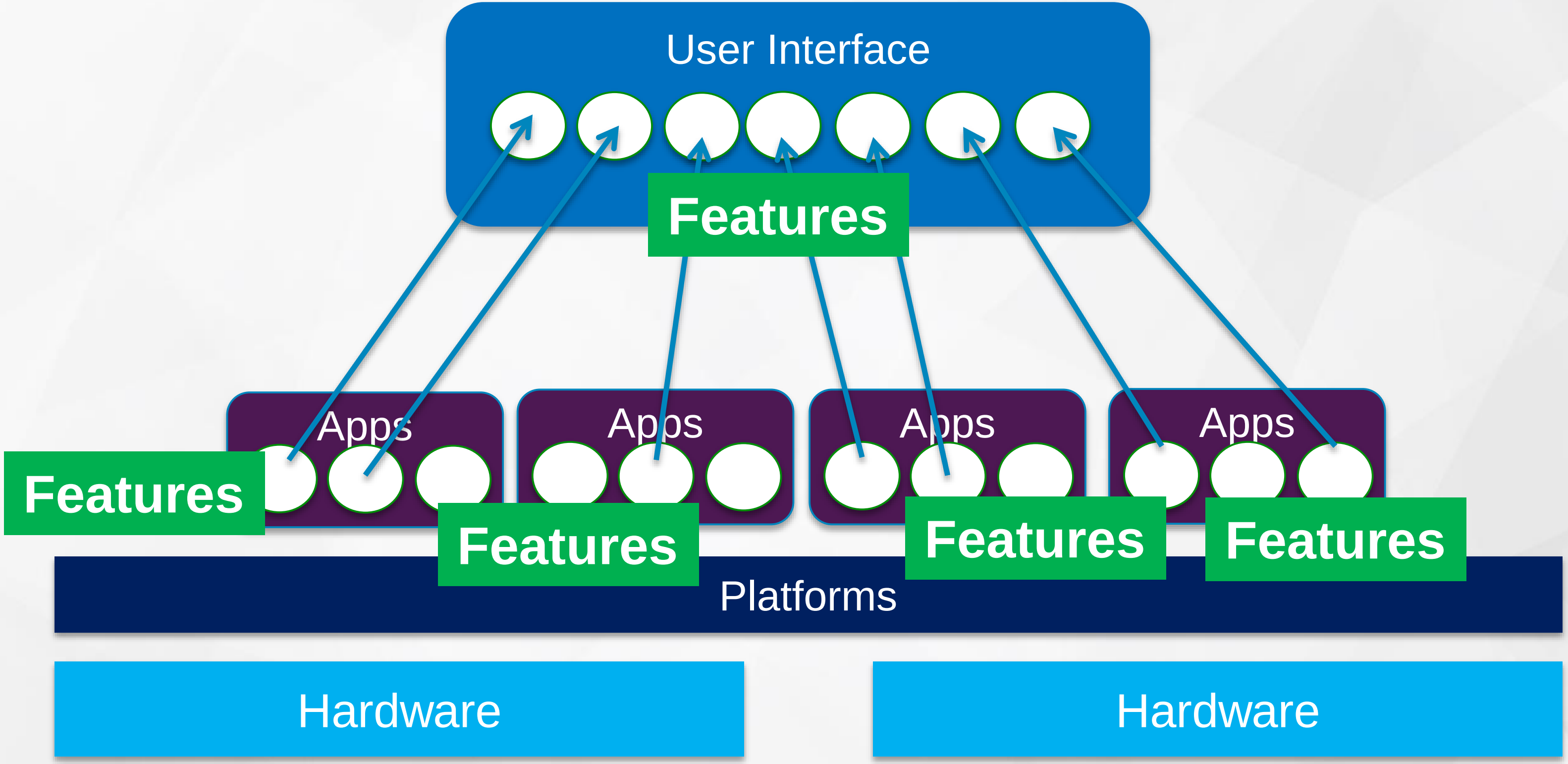
SaaS

- GV.Platform
  - Provides common software services
    - Useful for multiple applications
    - Provides enhanced system operations

- Cluster Manager
  - Optimizes the use of Platform resources
  - Leverages GV.Platform services
  - Coordinates operation of numerous software services within platform constraints



Software virtualization



Client facing applications

- GV STRATUS
  - A complete set of production tools
  - With human interface

- GV UX
  - Services for MAM
  - Traditional playout operations
    - Timelines, rundowns

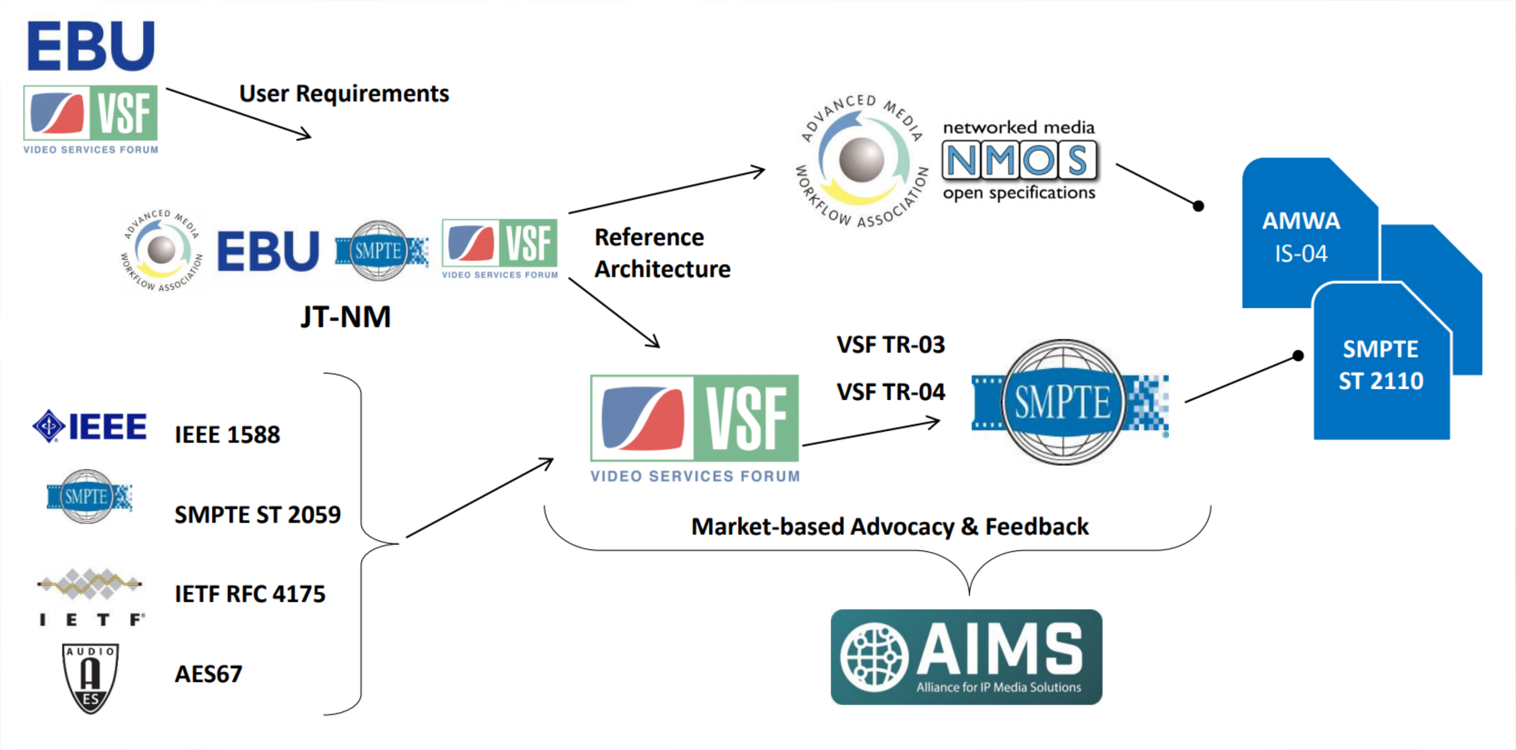
- Both leveraging other services beneath them in the cloud stack
  - GV.Engine

Design considerations for IP

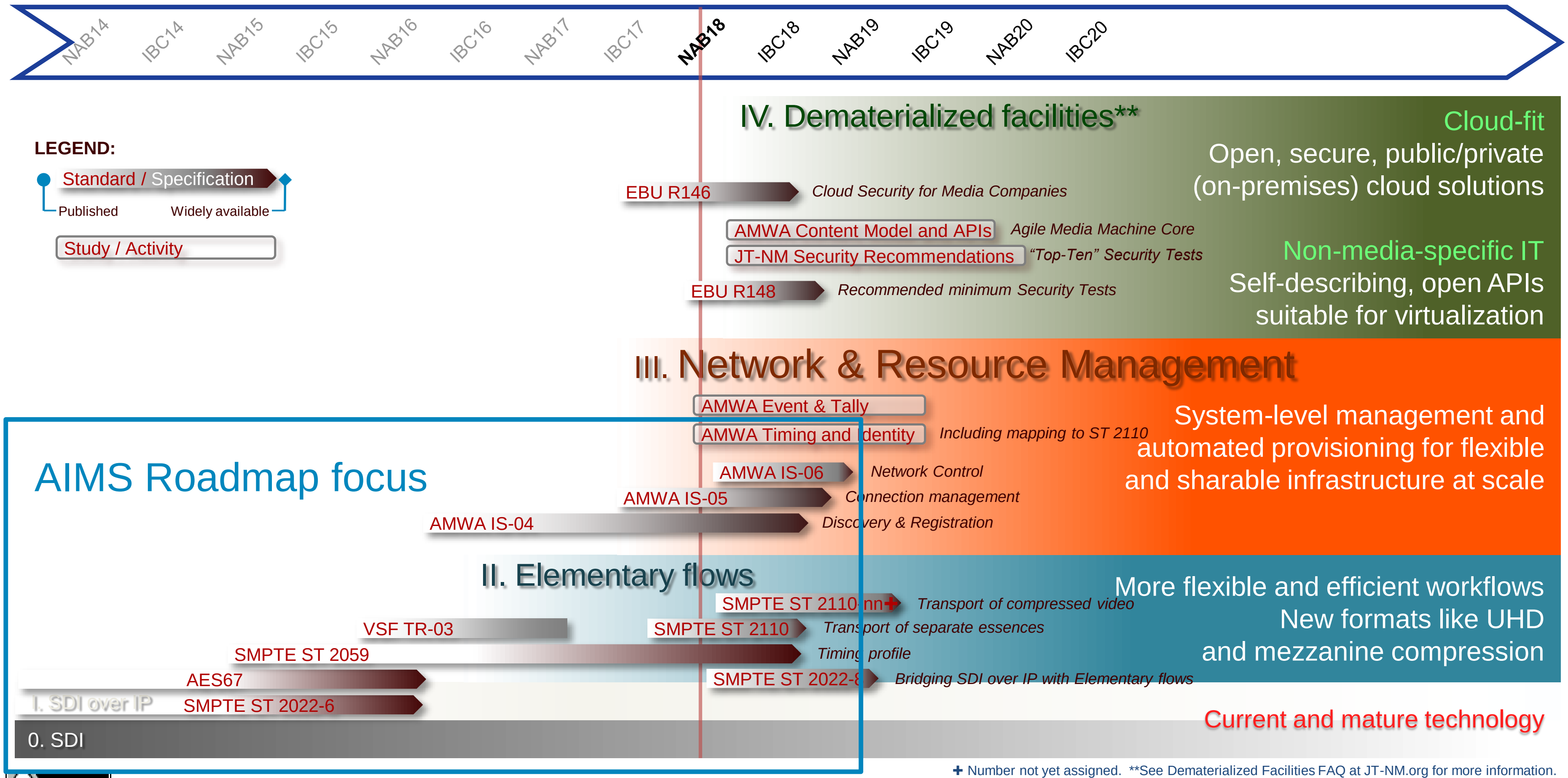
- **Standards** – Which ones ? Do we care ?
- **IP Conversion (to/from SDI)** – Amount ? **Formats** ?
- **IP Conversion (to/from MADI)** - Amount ? Formats ? Processing ?
- **Native IP Devices** – Amount ? Format ? Control ?
- **Signal Processing** – **Video** ? **Audio** ? **Transportation** ?
- **Multi-viewers** – 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 ?
- **Timing** – Legacy BB/TL ? PTP ? Ordinary ? Boundary ?
- **System redundancy** – All or Core Components ?

IP STANDARDS UP-DATE

Heritage of current standards



JT-NM Roadmap of Networked Media Open Interoperability *



✚ Number not yet assigned. **See Dematerialized Facilities FAQ at JT-NM.org for more information.

* JT-NM assumption as of March 2018 and will evolve over time. Visit JT-NM.org for the latest update. Feedback to jt-nm-info@videoservicesforum.org

AIMS Roadmap

- Provides recommendations to the relevant organizations

*Fostering the **adoption** of IP interoperability specifications and standards developed by these organizations*

The Role of AIMS

Technical Recommendations

AMWA

nmi

VSF VIDEO SERVICES FORUM

Standards

SMPTE

EBU

AUDIO AES

Reference Architecture

SMPTE

EBU

VSF VIDEO SERVICES FORUM

AIMS Roadmap

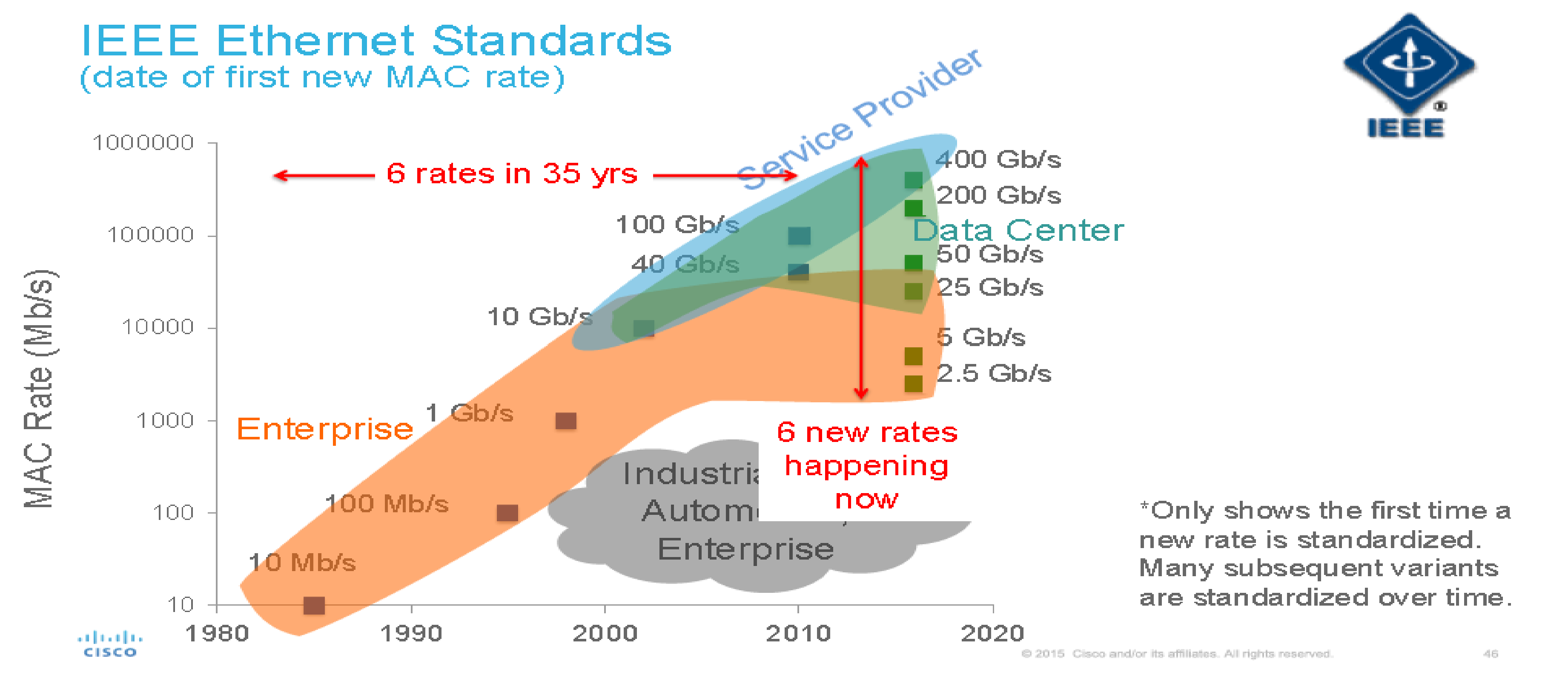
Baseline for Interoperability	Enable IP Streaming of Audio	Support Split Video and Audio Routing	Add Video Bandwidth Efficiency to Split Video, Audio and ANC Data Routing	Enable Discovery and Registration of Compliant Streams
SMPTE 2022-6	AES67	VSF TR-04 - SMPTE 2022-6 - AES67 SMPTE 2059	VSF TR-03 - IETC RFC 4175 - AES67 - IETF draft ANC291 SMPTE 2059	AMWA IS-04
SMPTE 2022-6	AES67	SMPTE 2110		IS-04

AIMS Alliance for IP Media Solutions

***AIMS** – **A**lliance for **I**P **M**edia **S**olutions

***AMWA** – **A**dvanced **M**edia **W**orkflow **A**ssociation

Ethernet technologies



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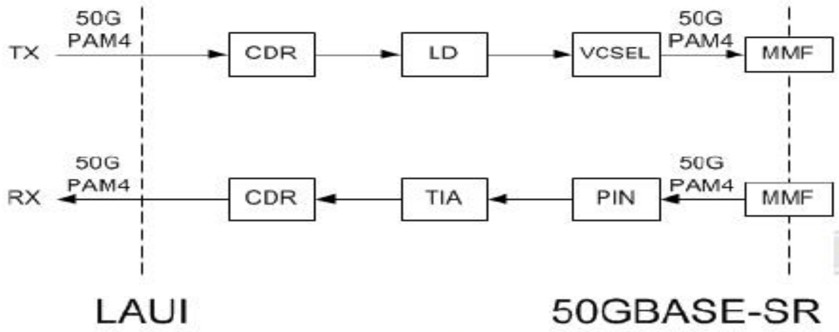
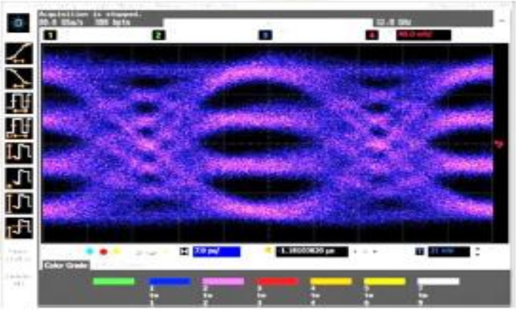
Ethernet technologies

50G 850nm MMF Optics



56Gb/s PAM4 optical eye



Form Factor: SFP56 w/ LC

Lane Rate	No. of Lanes		Data Rate
Gb/s	fiber pairs	λ	Gb/s
50	1	1	50

Ethernet roadmap

- The Ethernet Alliance roadmap is based on input from users
- It represents current capability and future expectations
- Component manufacturers target the roadmap, working hard to deliver the necessary router chips and optical components
- NIC cards, IP Routers and Optics are developed in parallel
- The entire eco-system moves forward in unison

Existing Media standards

- SMPTE 2110-10 The RTP System
- SMPTE 2110-20 Video Essence
- SMPTE 2110-21 Video Traffic Shaping
- SMPTE 2110-30 Audio Essence
- SMPTE 2059-1 Generating PTP Signals
- SMPTE 2059-2 SMPTE PTP Profile
- SMPTE 2022-7 Hitless Switching

More standards and specifications

AES67	Professional Audio over RTP
IEEE 1588	Precision Time Protocol
RFC 8331	RTP transport for SMPTE ANC DATA
IS-04	Registration and Discovery
IS-05	Connection Management

SMPTE ST 2110-10: System

SMPTE ST 2110 – 10 (System – RTP, SMPTE ST 2059, SDP)

Engineering criteria that defines an extensible system of RTP-based essence streams referenced to a common reference clock, in a manner which specifies their timing relationships. This standard specifies the system timing model and the requirements common to of all of the essence streams

- RTP (Real-time Transport Protocol – RFC 3550) ➔ proven technology for transporting time-critical data over UDP packets (RFC 768)
- SMPTE ST 2059 ➔ based on IEEE 1588 standard, greater technology maturity
- PTP utilised in many other mission critical applications ➔ high frequency trading, energy infrastructure and robotics to name a few
- SDP (Session Description Protocol – RFC 4566) ➔ metadata exposed by the senders, tells the receiver what it needs to know – distributed by the control system (not covered in ST 2110-10)
- **Published**

SMPTE ST 2110-10 (Session Description Protocol)

```
v=0
o=- 243362948900865 0 IN IP4 192.168.20.112
s=GV IQMIX
t=0 0
a=ts-refclk:ptp=IEEE1588-2008:ec-46-70-ff-fe-00-bf-60:0
a=mediaclk:direct=0
a=clock-domain:PTPv2 0
m=audio 50000 RTP/AVP 97
i=RAVENNA Audio-strm0/0,RAVENNA Audio-strm0/1
c=IN IP4 239.31.112.1/31
a=source-filter: incl IN IP4 239.31.112.1 192.168.20.112
a=rtpmap:97 L24/48000/2
a=framecount:48
a=ptime:1
a=recvonly
a=sync-time:0
```

Flow Metadata

Should include the following metadata:

- Sender description
- Video and/or audio essence
- Raster size (in pixels)
- Frame-rate (video)
- Channel count (audio)
- Sampling structure (audio/video)
- Bit depth (audio/video)
- Colourimetry
- Source IP address and port
- RTP payload ID (audio/video)
- PTP grandmaster source and domain

SMPTE ST 2110-20: Video

SMPTE ST 2110 – 20 (Uncompressed Video – RFC 4175)

Specifies the real-time, RTP-based transport of uncompressed active video essence over IP networks. An SDP-based signalling method is defined for image technical metadata necessary to receive and interpret the stream

- Raster size independent ➔ up to 32K x 32K pixels
- Agnostic
  - Colour sampling ➔ 4:1:1 to 4:4:4+
  - Bit depth ➔ 8 to 16-Bit+
  - Frame-rate ➔ 23.98 to 120 fps+
- Support for HDR ➔ PQ & HLG
- Significant bandwidth efficiency ➔ 1080p50 @ ST 2022-6 = 3,074 Gbps vs 1080p50 @ ST 2110-20 = <u>2,143 Gbps</u>

- **Published**

SMPTE ST 2110-21: Traffic

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: Audio

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**

SMPTE ST 2110-30: Audio Levels

SMPTE ST 2110 – 30 (Uncompressed Audio – RFC 3190)

Level(s)	Supported by the Receiver
A	Reception of 48 kHz streams with from 1 to 8 channels at packet times of 1 ms
AX	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
B	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
BX	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
C	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
CX	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

SMPTE Standards coming soon

Standards in final ballot draft / in progress – coming soon !

SMPTE ST 2110 – 40 (Ancillary Data – VANC based on IETF ANC 291)

Based on IETF RFC 8331 which is based on SMPTE ST 2038

SMPTE ST 2110 – 31 (Compressed Audio – non-PCM/AES3, Guardband aware, stereo)

Tunnel for AES3

SMPTE ST 2022 – 8 (Support for legacy ST 2022-6 infrastructure in ST 2110 systems)

Modifies 2022-6 by using a 90 kHz media clock, SDP and consistent RTP timestamp practice as defined in SMPTE ST 2110-10

SMPTE ST 2110 – XX (Generic Compressed Video Transport) Effort just started

An RTP transport supporting self-identified CODECs. This generic transport could support any number of CODECs, such as VC-2 or JPEG-XS (TICO)

AMWA Specifications

Specifications continually evolving

NMOS IS-04 - (Device Discovery and Registration) Specification by AMWA
Currently version 1.2

NMOS IS-05 - (Connection Management) Specification by AMWA
Currently version 1.0

NMOS IS-06 - (Network Control) Specification by AMWA
Currently under development

Registration and discovery

- Knowing what is connected
- AMWA IS-04 v1.2
- Devices have unique identity shared during Discovery
  - mDNS (multi-cast Domain Name System) for example
  - MAC addresses are constant
  - IP addresses will change
  - Unique Identify is essential for plant operation
    - IETF Style Unique Resource Identifiers are used
- Identities are Registered for use across the system
  - HTTP based queries
- Dynamic devices must also comply

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Connection management and SDP

- AMWA IS-05
- Sharing information about streams
  - The source may have more than one essence stream
  - Video with 4 channels of audio is one example
  - The bandwidth and other stream relationships are shared

- Session Description Protocol (SDP)

- RFC 4566
  - Provides details about the essence stream
    - Video essence format, frame rate
    - a=fmtp:112 sampling=YCbCr-4:2:2; width=1280; height=720; exactframerate=60000/1001; depth=10; TCS=SDR; colorimetry=BT709

- IS-05 works together with SDP

IS-06 Northbound router API

Work in progress

- Provides internal router control and monitoring
  - Open SDN functionality
  - Control flow and stream connections
  - View connection status
  - View internal router performance

- Enable richer system control
  - Closer coupling with IGMP
  - More flexible routing
    - Always on Devices
    - Event pre-queue

BRING IT BACK TOGETHER

Future considerations

- Future cost modeling
  - Build the facility based on the highest bandwidth
    - Potentially more expensive
    - Are you sure you won't need more?

  - Use aggregation
    - Can you use islands of higher bandwidth?

  - What happens when the native network segment bandwidth is exceeded?
    - "Lite" CODECs
    - Single Essence decomposed into multiple streams

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Common design constraints

- Capex vs Opex applies to every aspect

- Infrastructure
  - CAPEX
  - Cost per stream per time is key metric
  - Cost per compute cycle
    - Includes time
- Operational
  - Lease bandwidth
  - Lease Compute resource
    - Both on a per unit time basis

- Design Challenge Question
  - ***Do you need continuous 100% resource availability for 100% peak capacity?***
  - ***Do you need to support every stream at 8K 100 Fps, 24/7?***

Review the business case

- Flexibility: Upgradeability and future expansion
- Format Agnostic: 1080p, UHD, HDR, WCG, HFR and more
- Agility: Build a platform capable of virtualized services
- Reliability: Native support of 1+1 or 1+N redundancy
- Interoperability: Open to any vendor
- Empowerment: Capitalize on your expertise in content creation and delivery.

Join the Conversation

Questions ?

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Create [Control] Connect [Content Your Way.

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Thank You !

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