Migrating Live Production to IP Technology

It’s About Time!

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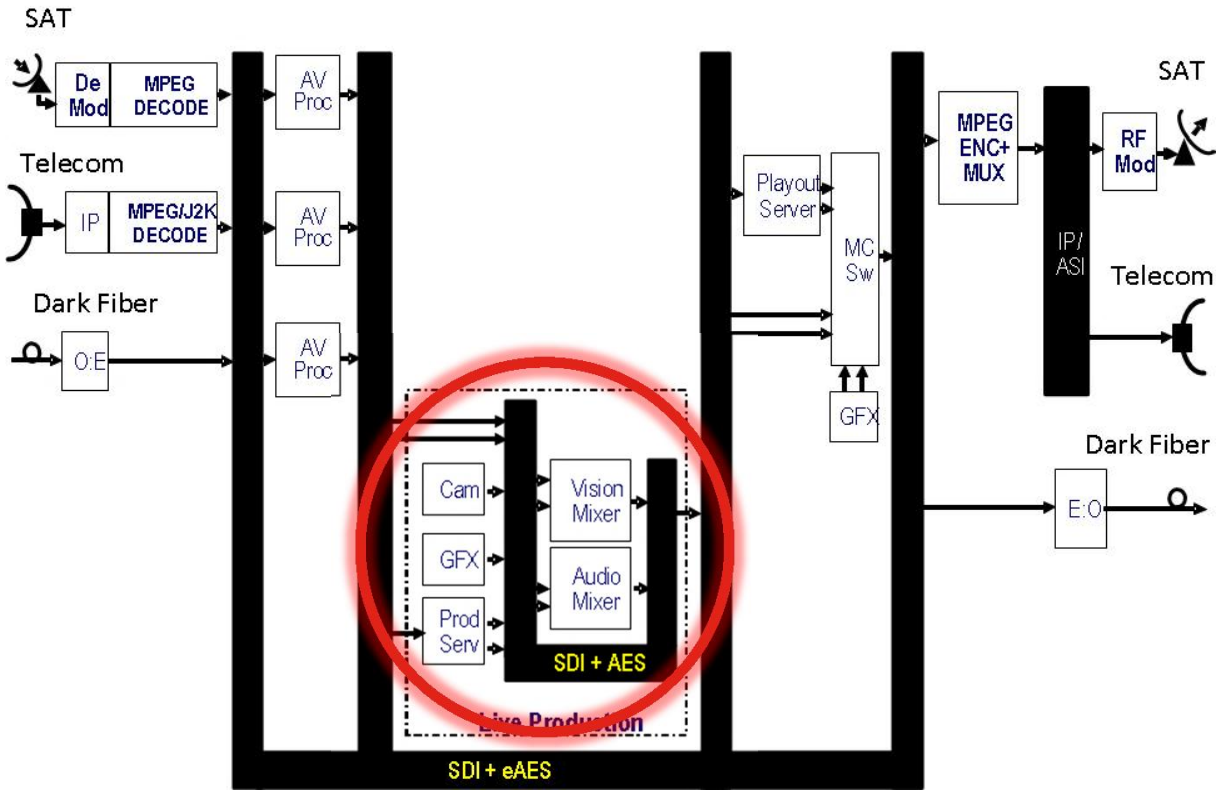
FUTURE-READY

The last piece of the jigsaw!

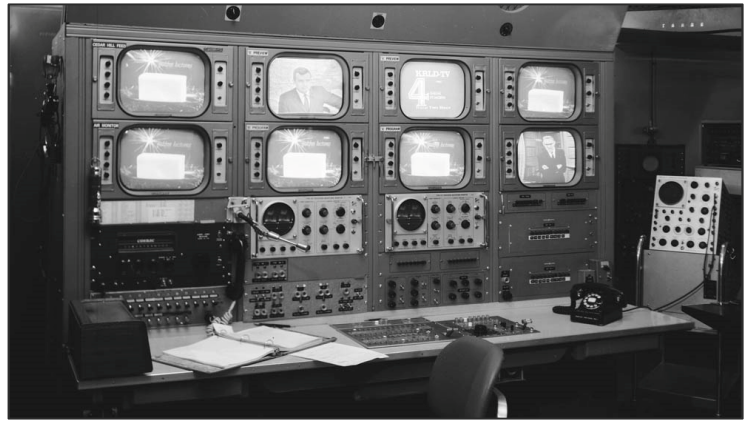
- Graphics - File
- NLE, DAW - File

- DVB, VOD - Packets
- Ingest - Packets
- IPTV - Packets
- OTT - Packets



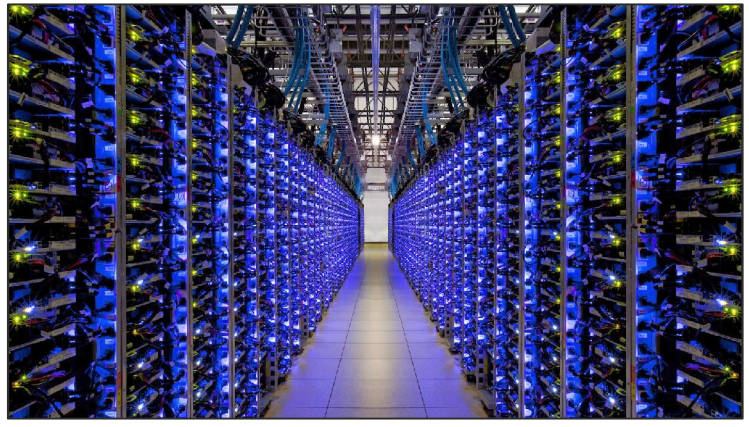
Where we have “been”

- Production was directly attached to the home TV
- Color television workflows embodied a brittle, camera-to-the-home stovepipe
  - Nanoseconds
- Every business model ROI was based on 1 to many



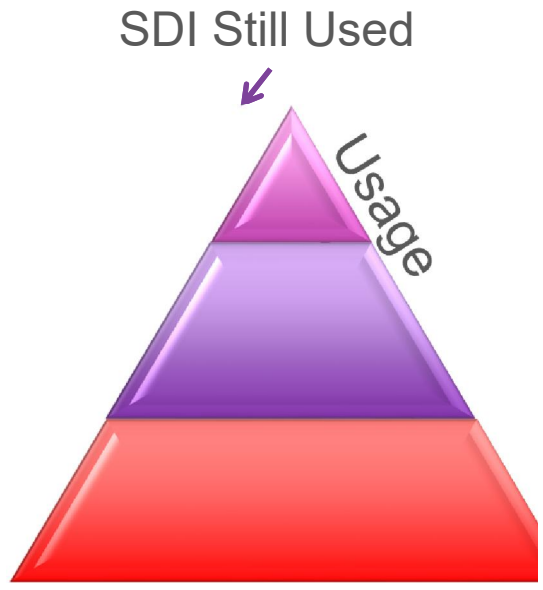
Where we are “now”

- Digital Television (HD) broke the strict connection between the camera and the home
- Video production became line based
  - 100 microseconds
- Many new ROI models are proposed, leveraging IP technology



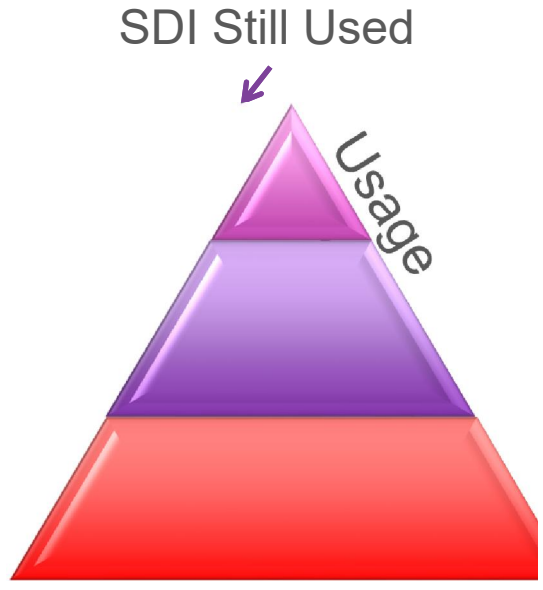
Workflow Timing Model

Latency Stratum	Network Latency	Human Factor
Absolute Real-Time	~10 us	**Imperceptible**
Pseudo Real-Time	< 1 ms	**Edge of Perceptible**
Fast Non-Real-Time	100 ms	**Noticeable**
Non-Real-Time	1 s	**Not Material**



Workflow Timing Model

Latency Stratum	Network Latency	Human Factor
Absolute Real-Time	~10 us	**Computation**
Pseudo Real-Time	< 1 ms	**Live Production**
Fast Non-Real-Time	100 ms	**Near On-Line/Streaming**
Non-Real-Time	10 s	**File Based**



Time Relationships

- Sampling time
  - Processing Samples and Pixels
  - Homogeneous flows
- Media Time
  - Relative relationship between media
  - Audio Image, 3D
  - Lip Sync
- Time of Day

Live Production Technology Inflection Point

- Wire Speed Routing
- High Bandwidth Transport
- Scalable Production Model
  - Transparent, low latency CODEC is a must!

Wire Speed Latency Update

Network Speed	Delay	Lines	2014	2017	2020
		2K/60	4K/60	4k/120	8K/120
Line Time	usec	14.8	7.4	3.7	1.9
1 GbE	37	2.5	5	10	20
10 GbE	3.7	0.25	0.5	1	2
25 GbE	***1.5***	***0.1***	***0.2***	***0.4***	***0.8***
40 GbE	0.9	0.06	0.12	0.24	0.5

Latency Validation Data

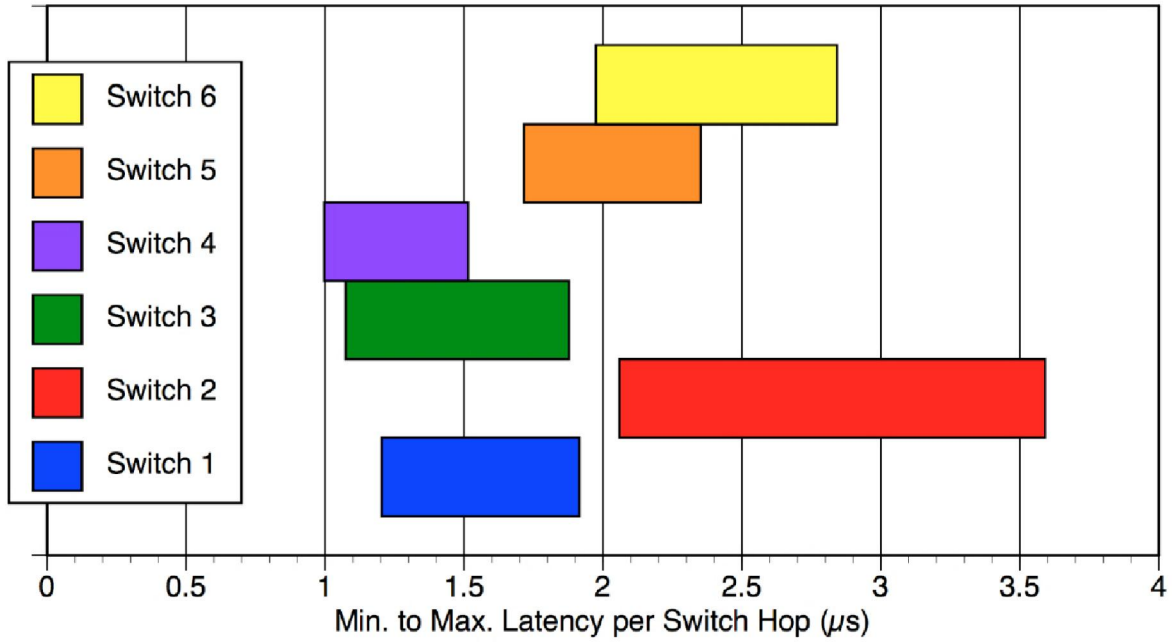


Figure 8. Latency per Switch Hop

Courtesy
Brian Keane
Aperi Corporation

Thomas Edwards
Fox Networks E&O

Jitter Validation Data

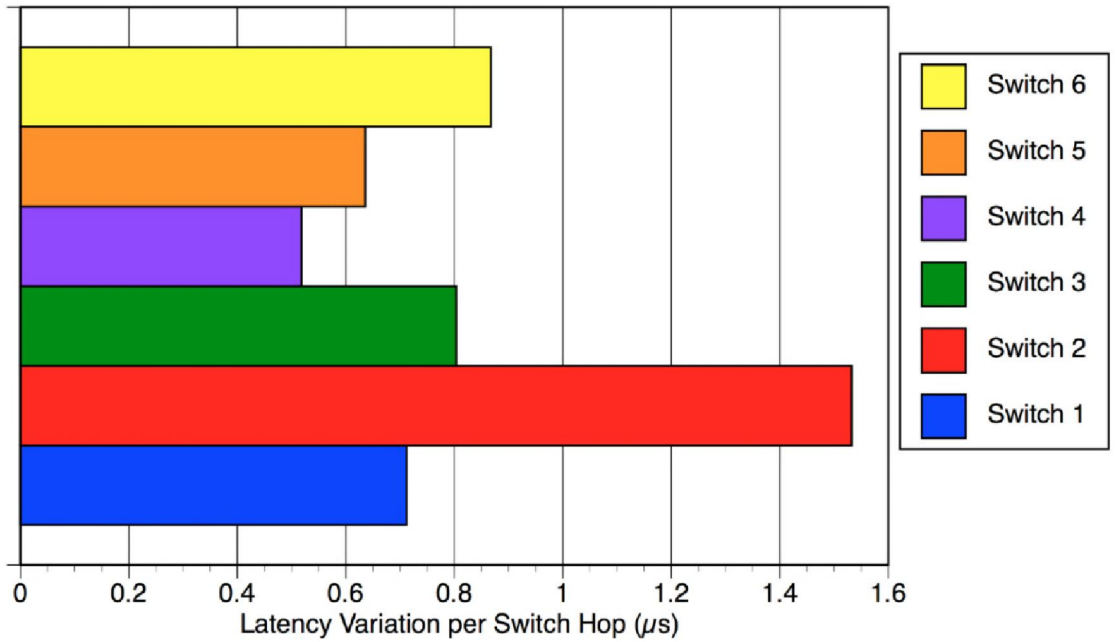


Figure 9. Variation of Latency

Courtesy
Brian Keane
Aperi Corporation

Thomas Edwards
Fox Networks E&O

What about faster pipes?

- 25 GbE is here!
  - IEEE 802.3by
  - 25/50/100 Standardised during 2016
  - QSFP28 as a package for 100Gbps with 4 fibers
  - Broad Industry Support

*Image and data courtesy of Arista

ARISTA BROADCOM CISCO DELL Google Mellanox TECHNOLOGIES Microsoft

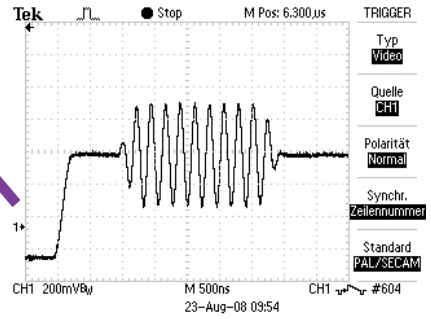
http://25gethernet.org/

Bound the Problem

- Time of Day – Only important to your PVR
- Sampling time – Too fast to perceive
  - Nanoseconds and Microseconds
- Media Time – Sets the constraint
  - Video: mutual to a line (~15 usec)
  - Audio Image: mutual to a sample (~20 usec)
  - Lip Sync: audio to video (-10 msec to + 30 msec)*

* Courtesy BBC ITU-R BT.1359

System Timing in Broadcast



Wire Speed
Multiple Paths
Delay Spread < 1 Line of Video

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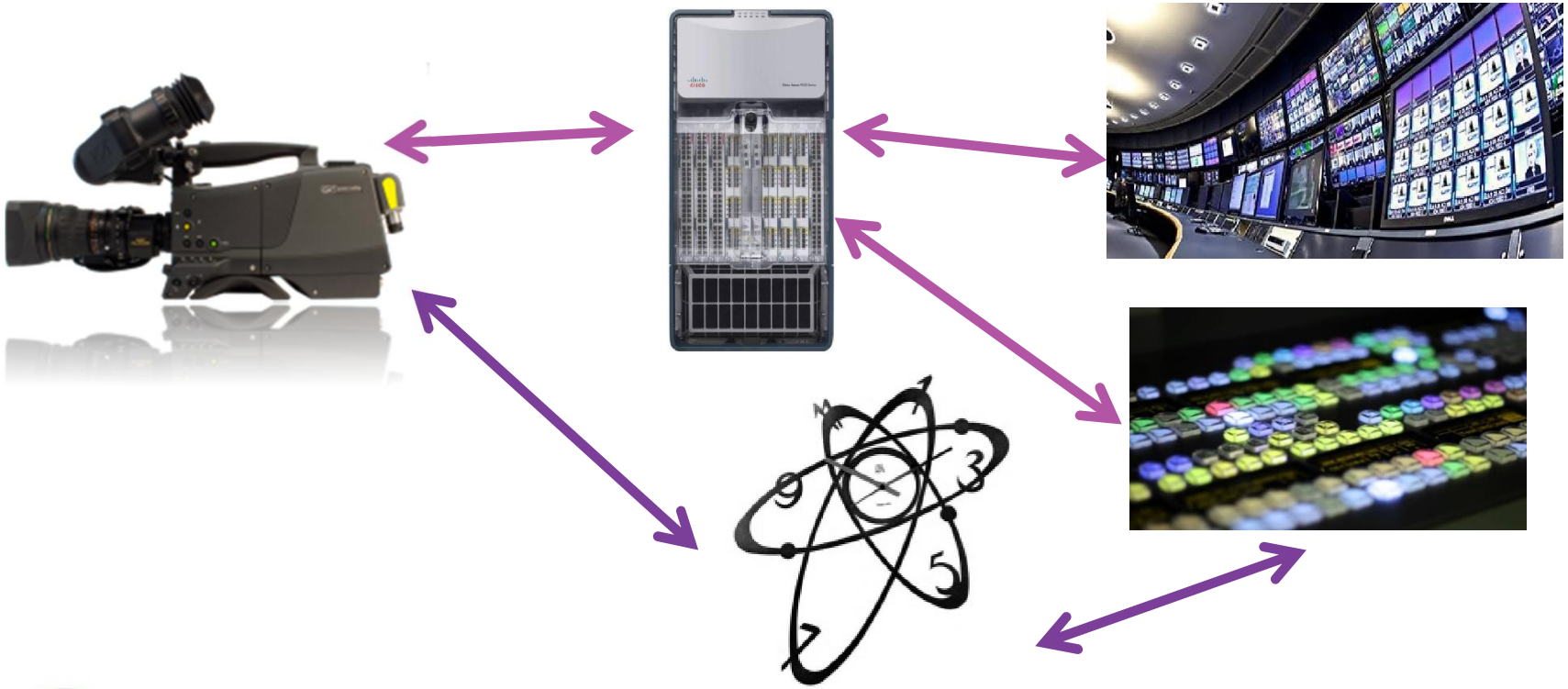
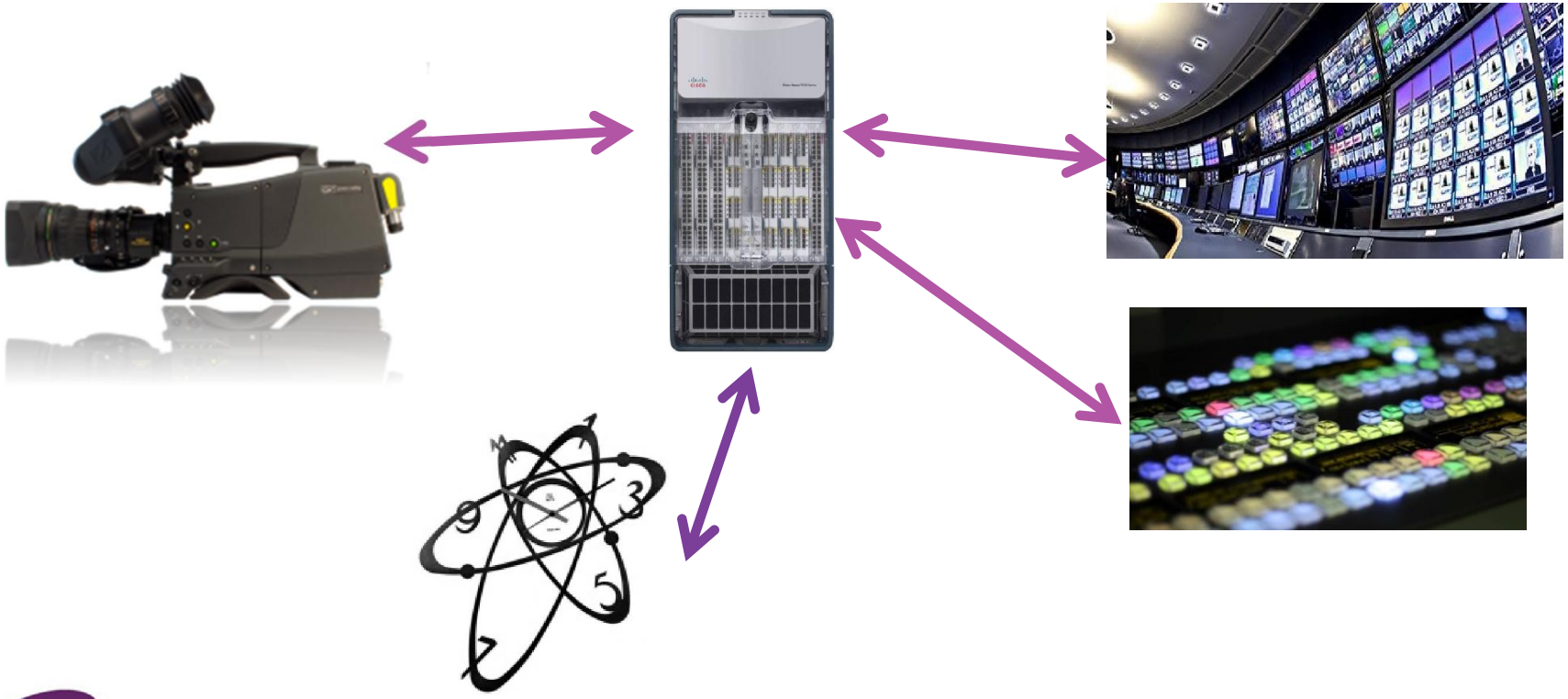
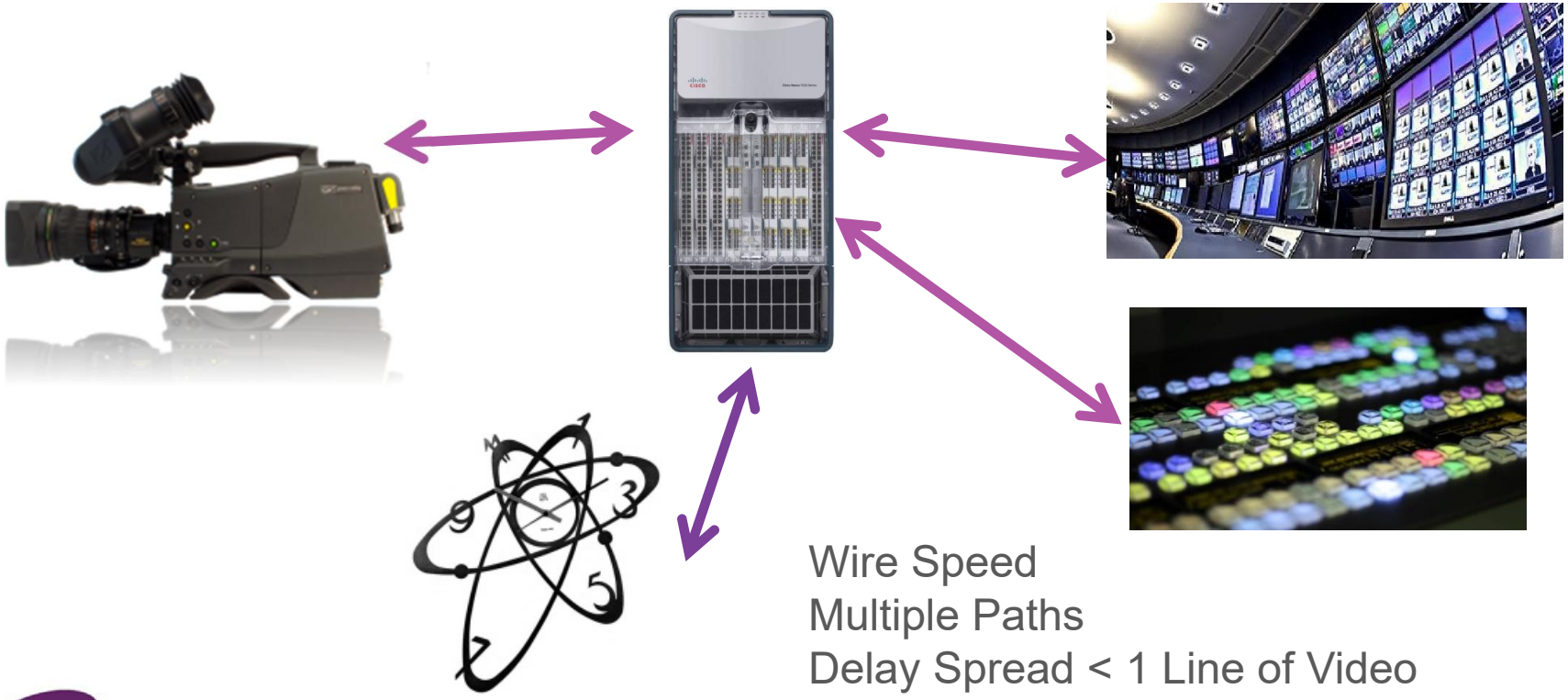
System Timing Using IP Reference



System Timing with Integrated IP



System Timing with Integrated IP



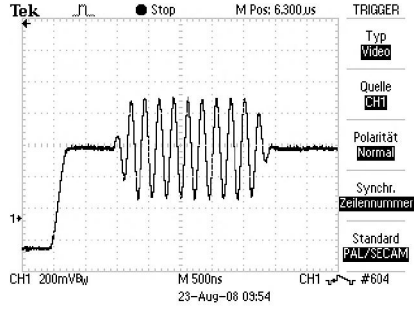
Wire Speed
Multiple Paths
Delay Spread < 1 Line of Video

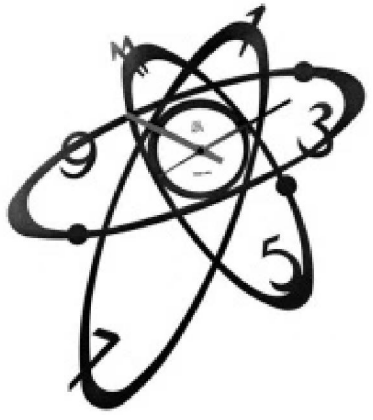
Strategy for Timing

- Source time cameras and mics
- Data buffers exist at end-points

- Digital SDI works this way today

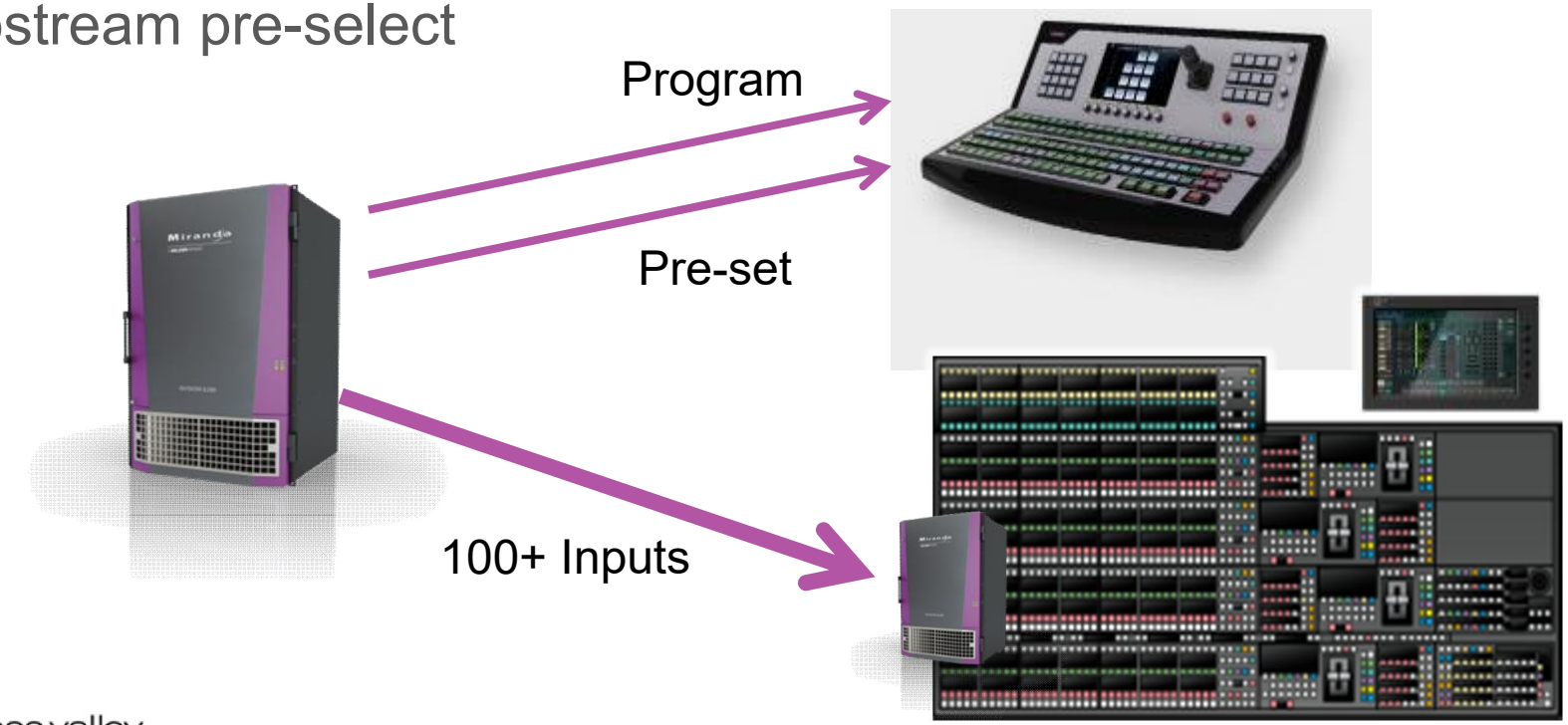
- Today's facilities are Time of Flight
- IP can be managed this way as well
  - And in the future PTP/IEEE-1588 enables more





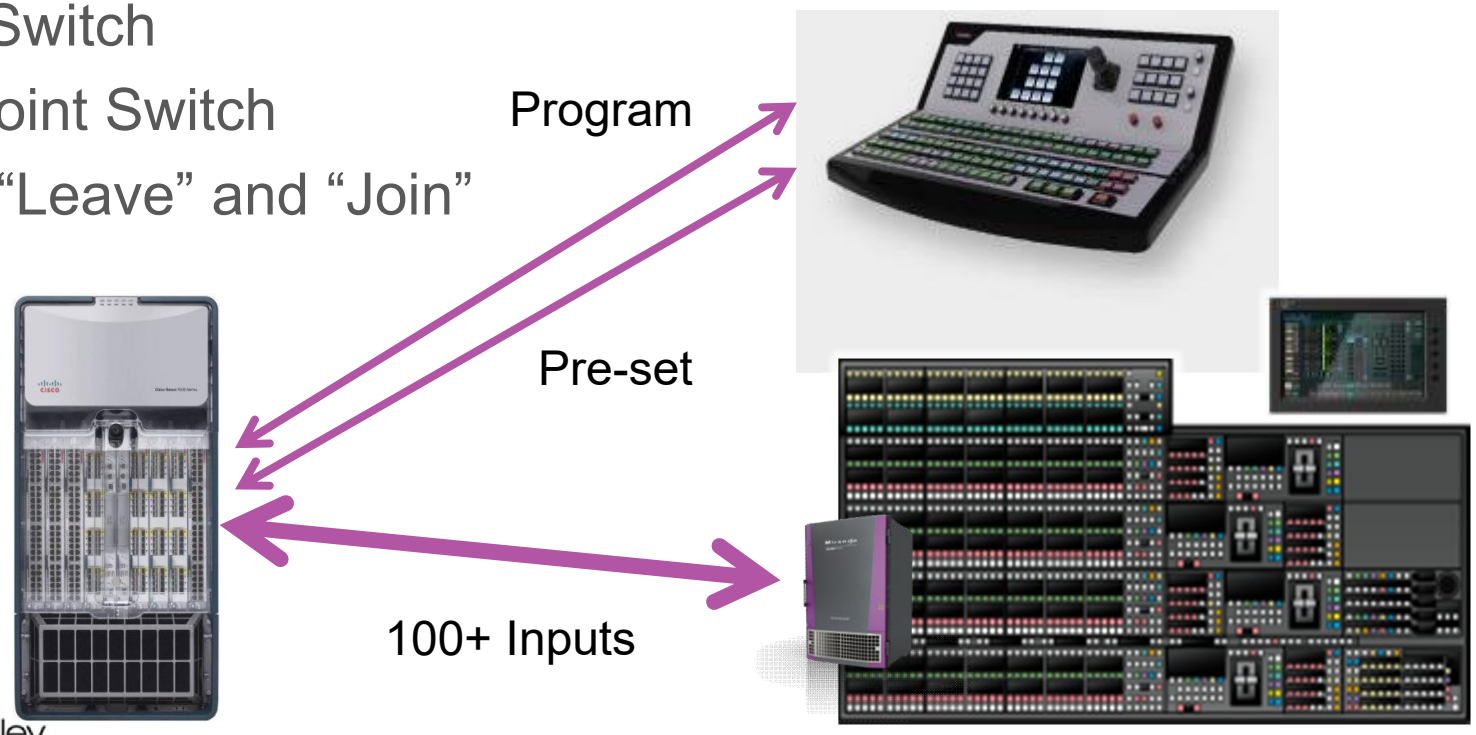
Clean On-Air Switch

- A/B Master Control
- Upstream pre-select



Clean On-Air Switch in IP

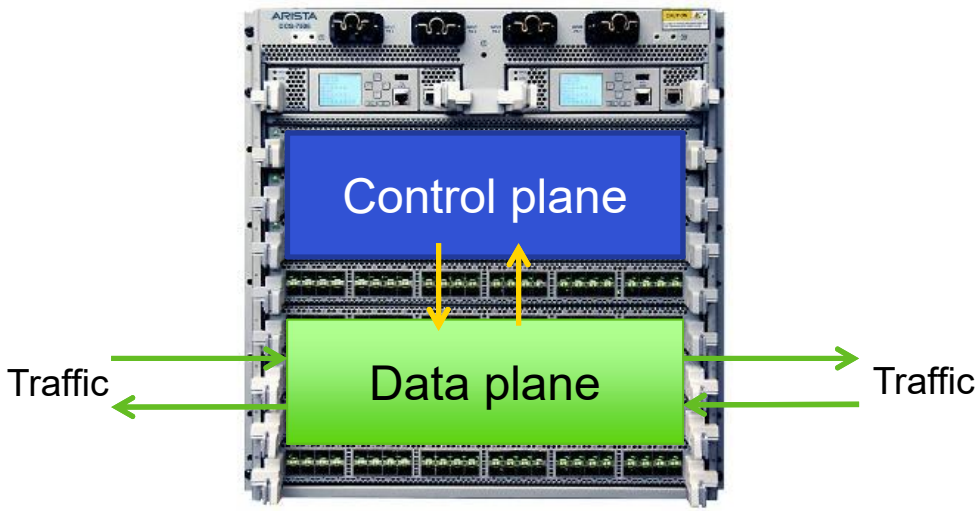
- Clean Switch
- Edge Switch
- End-Point Switch
- IGMP “Leave” and “Join”



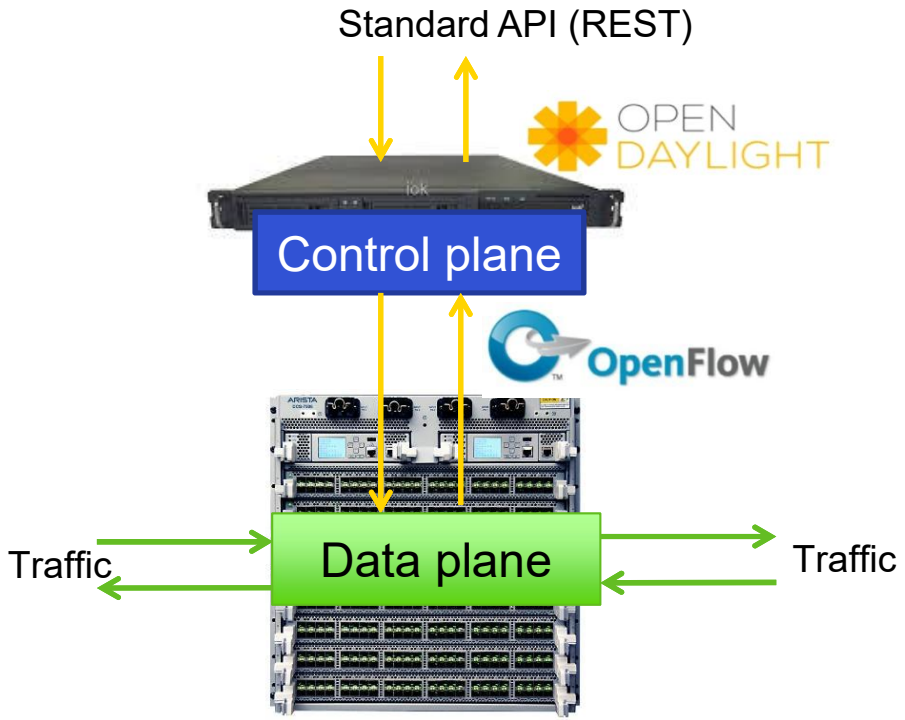
3 Possible Strategies to Switch

- Source
  - Changing source ports, or IP addresses is new control paradigm
- In the fabric
  - Mimics broadcast. Solutions will be coming to market
- End-Point
  - The easiest to implement
  - Replicates current up-stream pre-select model

Why SDN? Traditional vs SDN IP SW

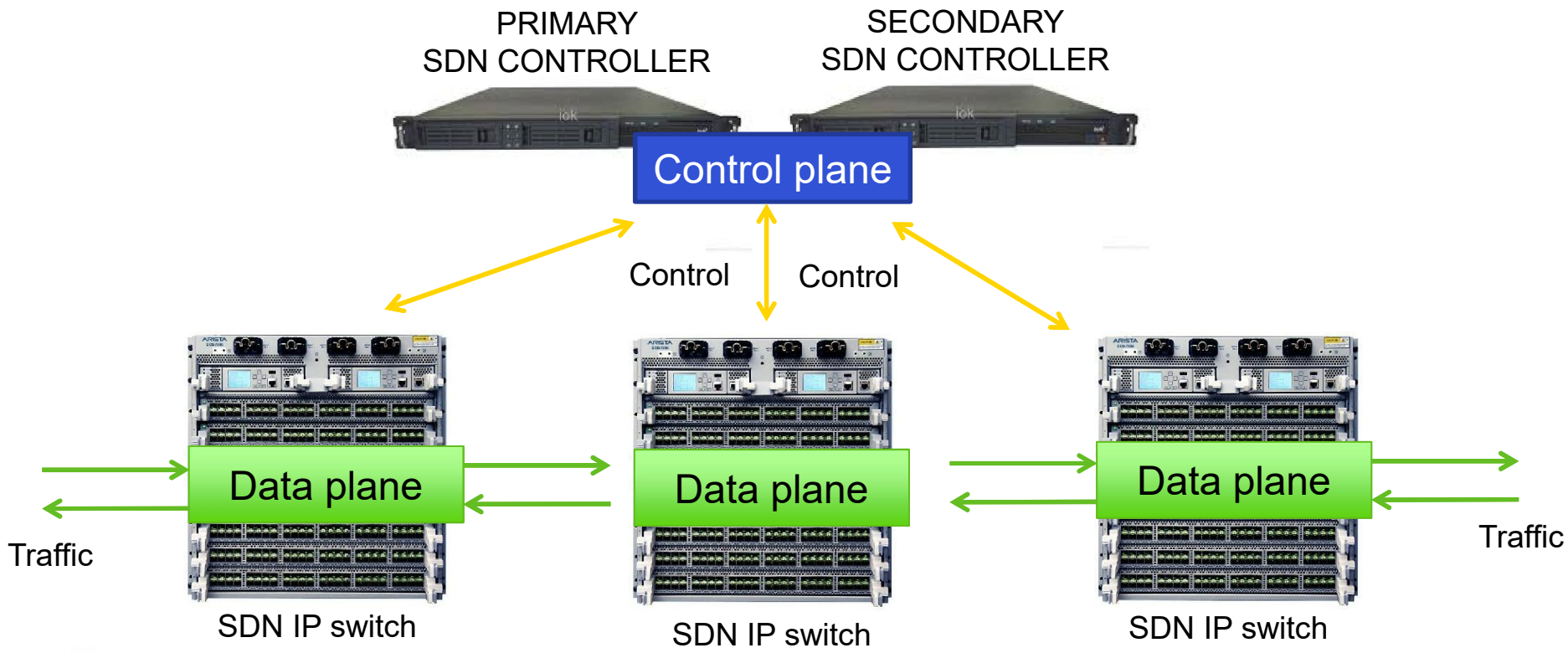


Traditional IP switch

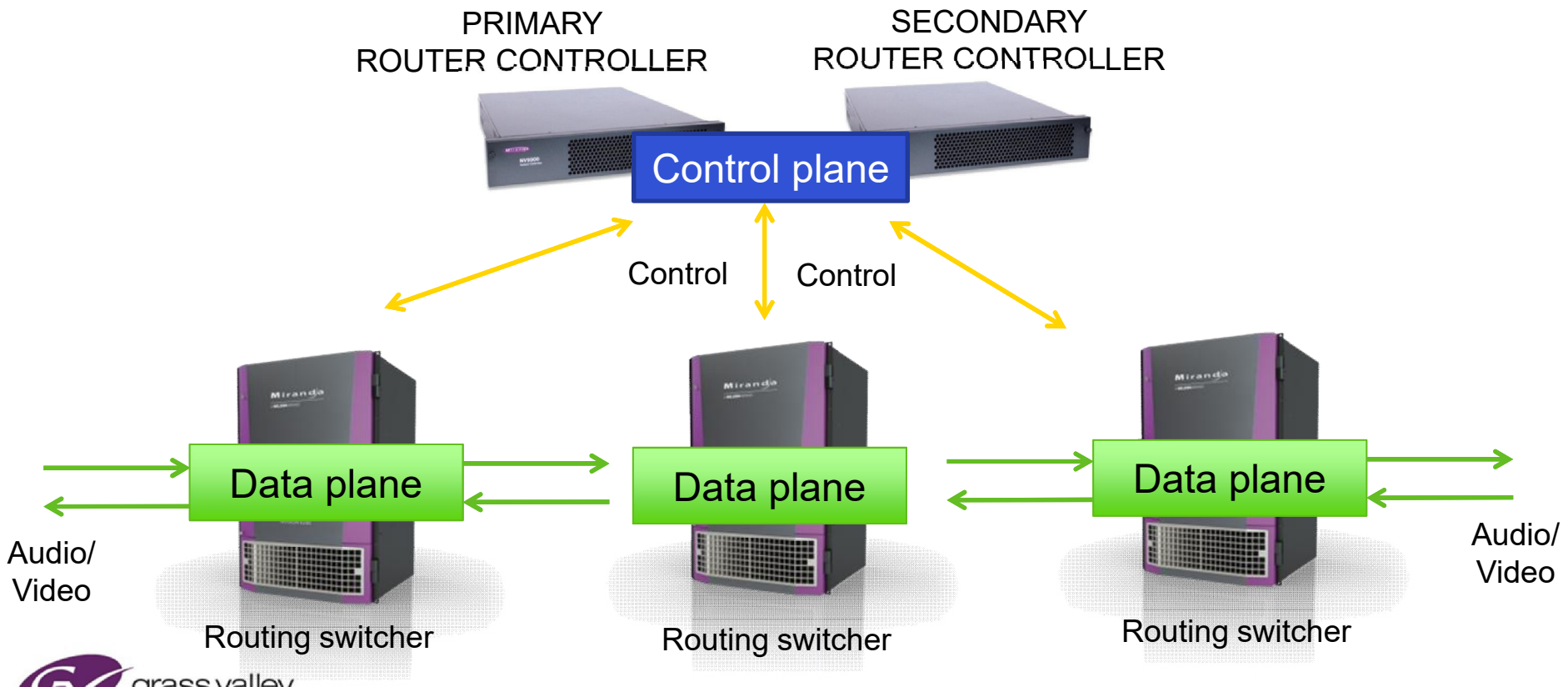


SDN IP switch

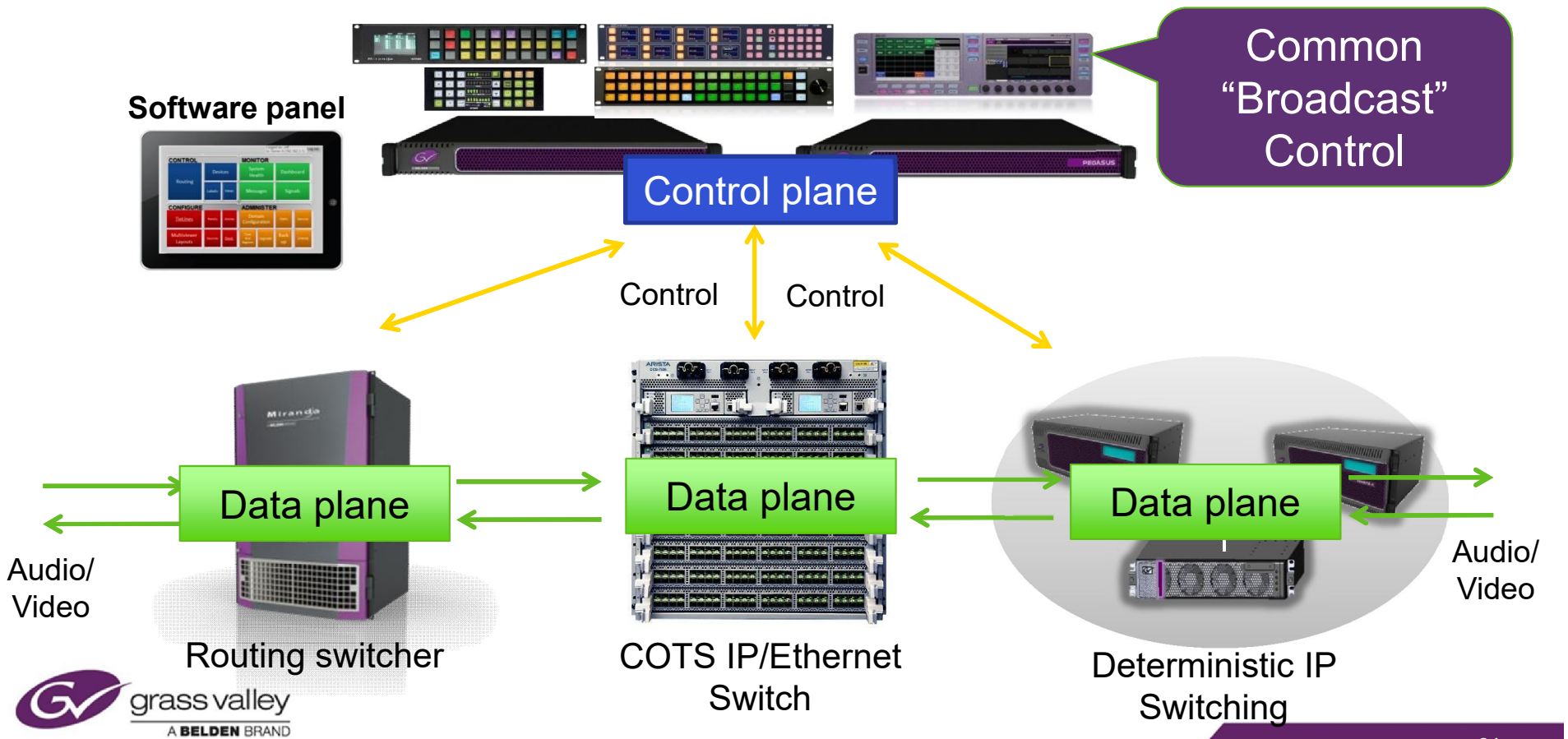
Why SDN? Optimal control of QoS



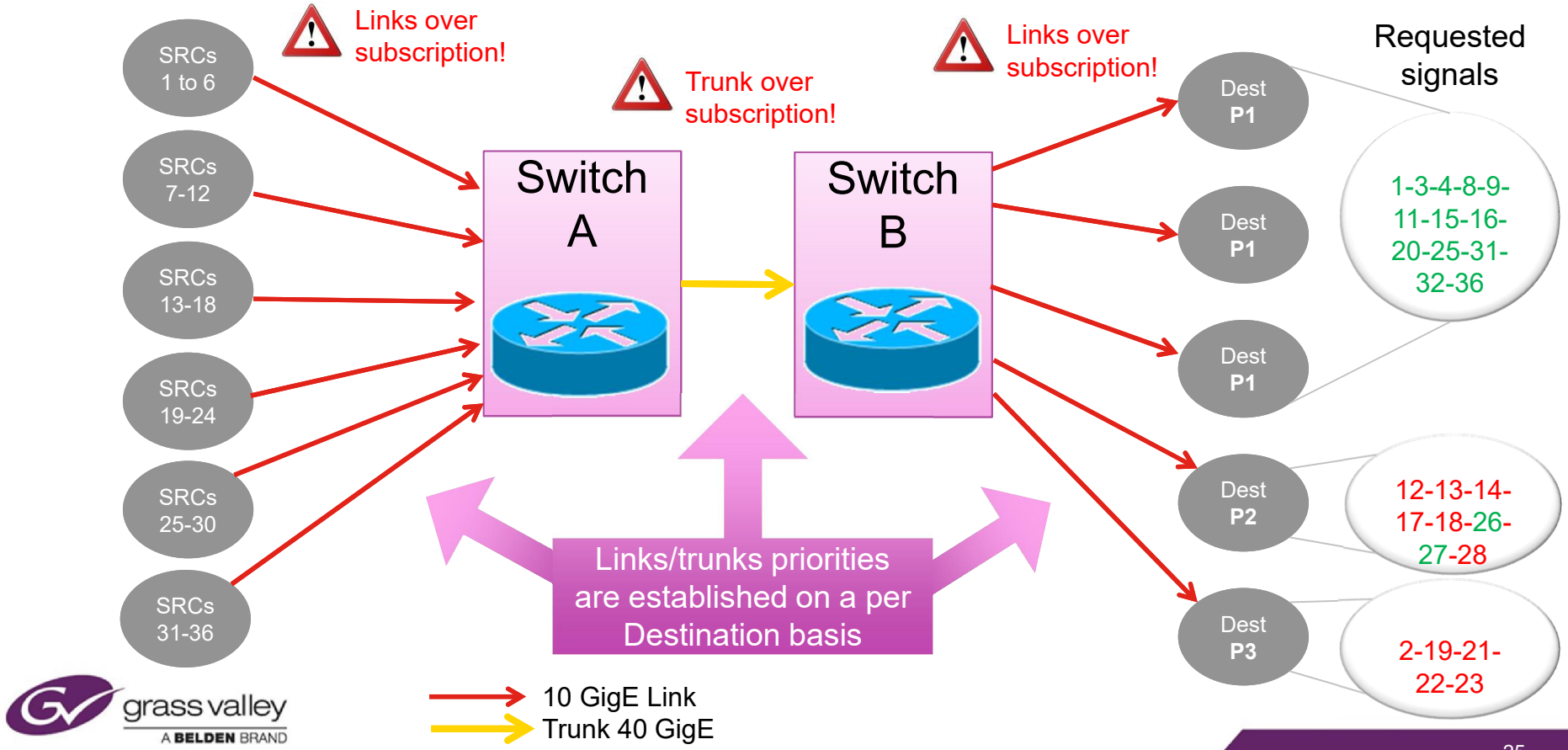
Why SDN? Broadcasters already using SDN!



Providing TV Centric control for Hybrid IP/SDI

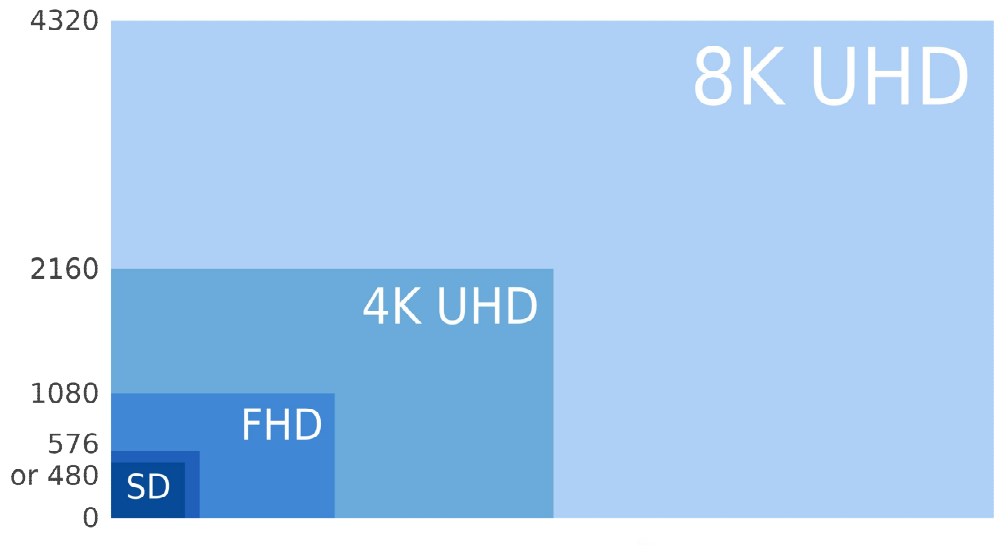


Strategy to Manage Bandwidth

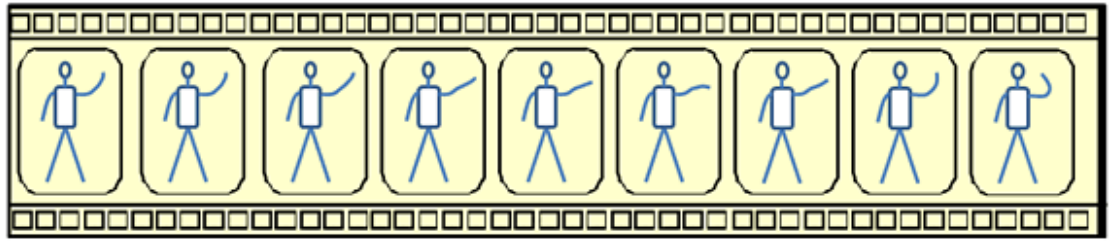


Strategy to Manage Bandwidth

- Cost per flow per physical network segment
- UHDTV
  - Gamut, HDR, HFR
  - 4K, 8K, etc…
- Lite Compression

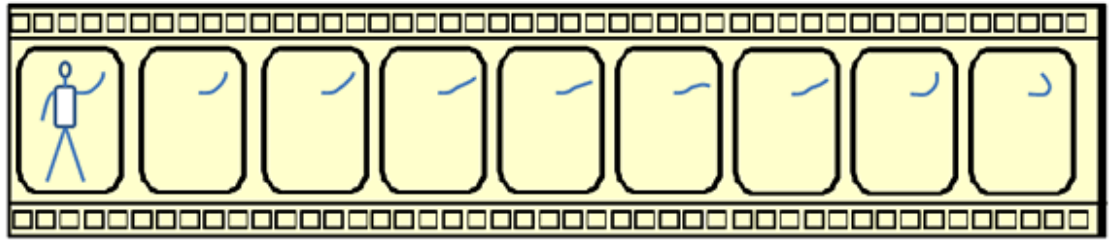


Types of compression



Intraframe compression

Every frame is encoded individually



Interframe compression

Only the differences between frames are encoded
for each group of frames

Lite Compression Defined

- Visually lossless and multi-pass performance
- Latency measured in lines, not frames
- Low cost hardware platform
- Low power consumption

What Codec's are available?

	Application	Delay (Frames)	Resources	Power	Standard
J2K	Contribution	2-3+	Large	Large	ITU 800
LLVC	4K Mezzanine	~1	ASIC	X	SMPTE RDD
J2K ULL	4K Contribution	~1	Large	Large	VSF (WG)
VC-2 (Dirac)	HD Mezzanine	Variable, ~2-4%	Small	Small	SMPTE
TICO*	***4K Production***	***<2%, Fixed***	***Small***	***Small***	***SMPTE RDD***
	****Software!!!***				

4:1 Ratio – 25GbE is a sweet spot!

Network Speed	Delay		2014	2017	2020
	8 Lines	2K/60	4K/60	4k/120	8K/120
		3 Gbps	12 Gbps	24 Gbps	96 Gbps
			3 Gbps	6 Gbps	24 Gbps
10 GbE		3	3	1	
25GbE		***8***	***8***	***4***	***1***
40 GbE		13	13	6	1

Who is in front?

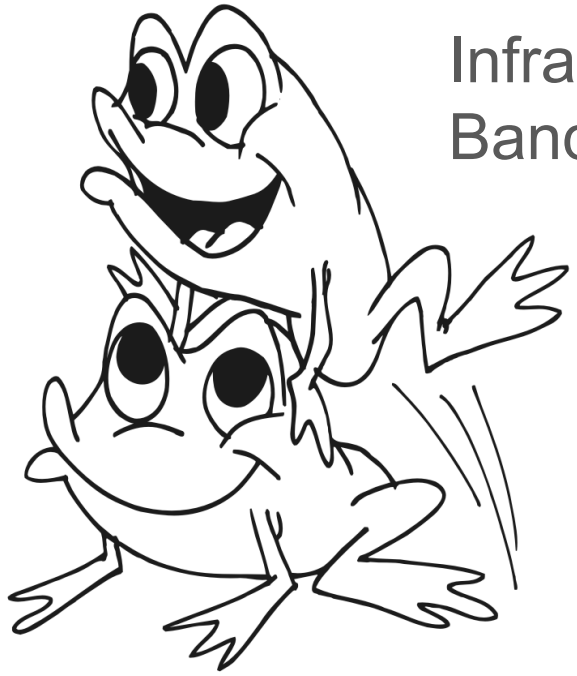
Image Format

Infrastructure
Bandwidth

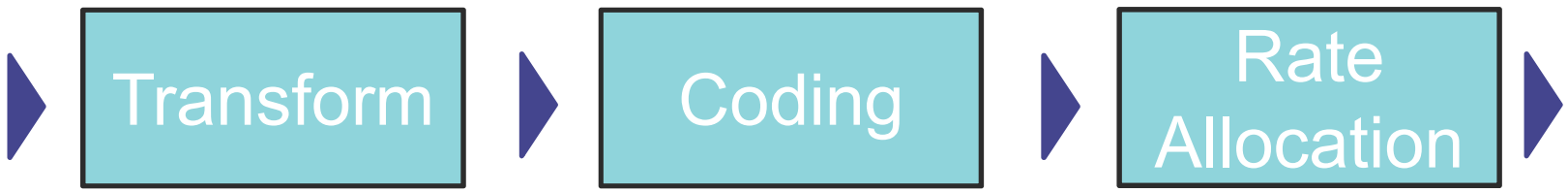
Who is in front?

Infrastructure
Bandwidth

Image Format



TICO: High level description



Decorrelation of information

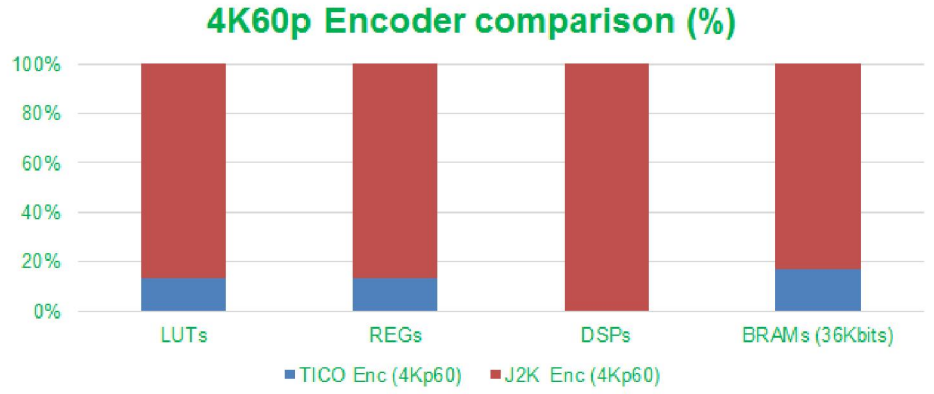
to apply coding efficiently

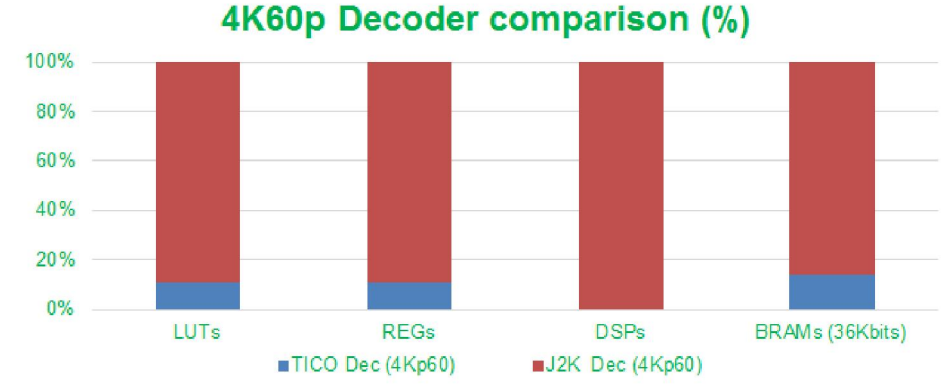
at a determined bit-rate

TICO features

Feature	Description
Image features	• Color modes : 422 and 444, RGB, YCbCr • Bit Depth: 8,10,12 • Resolutions: Any up to UHD2 (8K)
Compression	• (Sub) Intra-frame • Real-time operation guaranteed • Fixed Latency (few pixel lines)
Quality and Bit rate	• Adjustable compression rate (Visually Lossless/Lossless) • Full Constant Bit rate (CBR)
FPGA	• Low cost implementation due to very low logic and no external RAM requirement. • Fit in the smallest devices • Synchronized design with the video clock

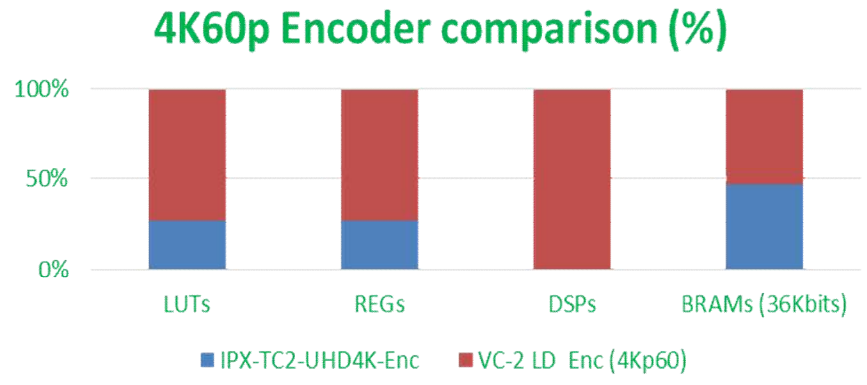
TICO FPGA and J2K

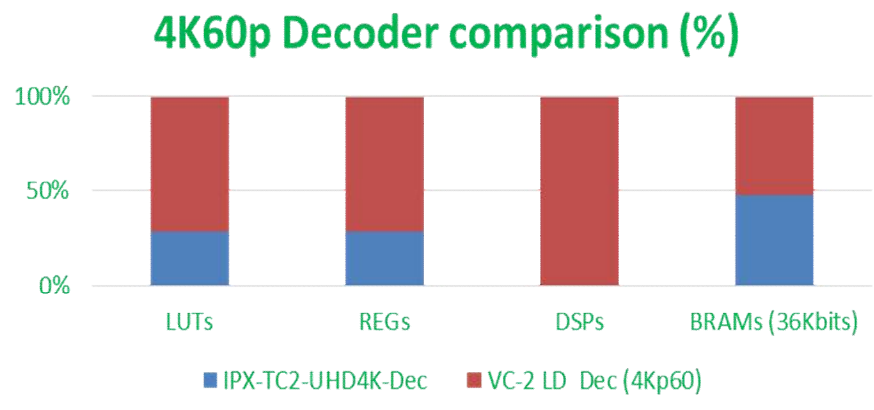




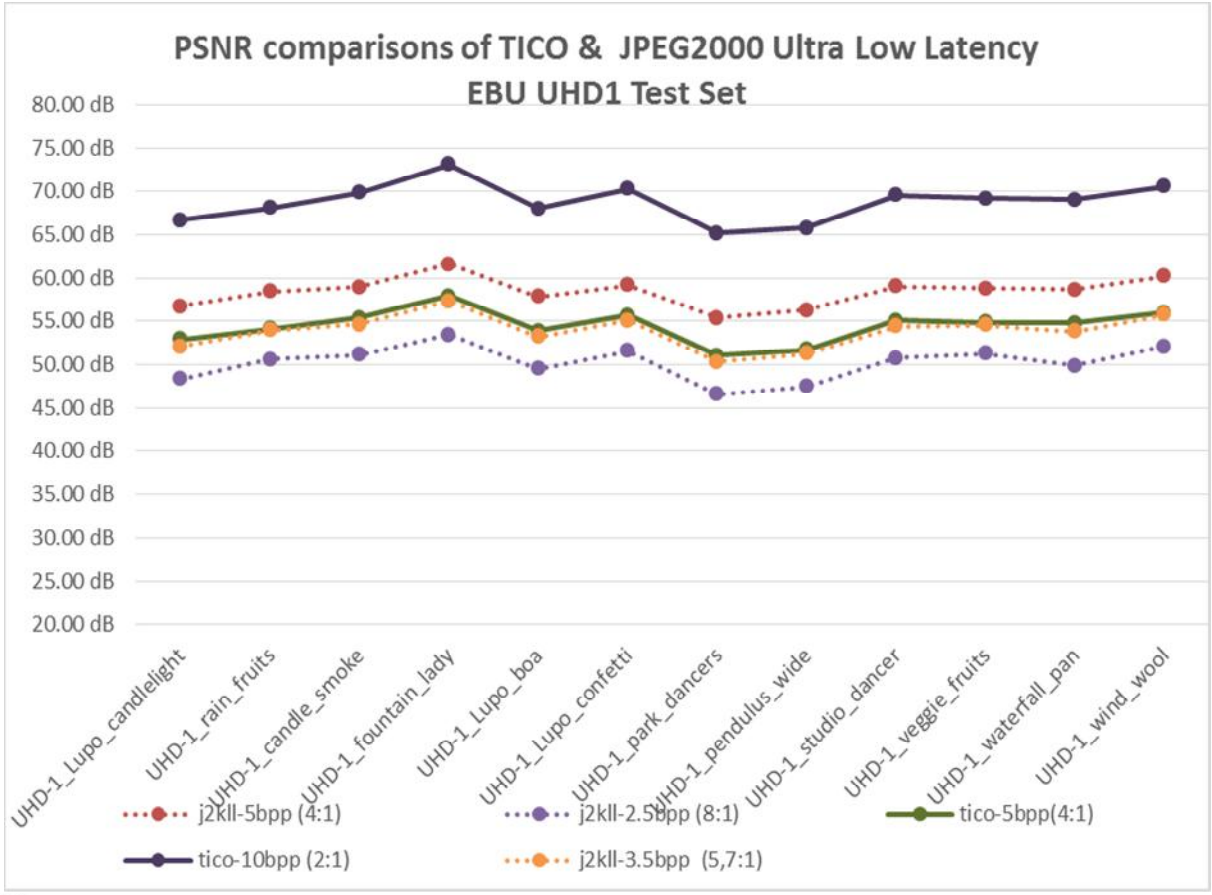
TICO is much smaller than J2K
No External DDR3

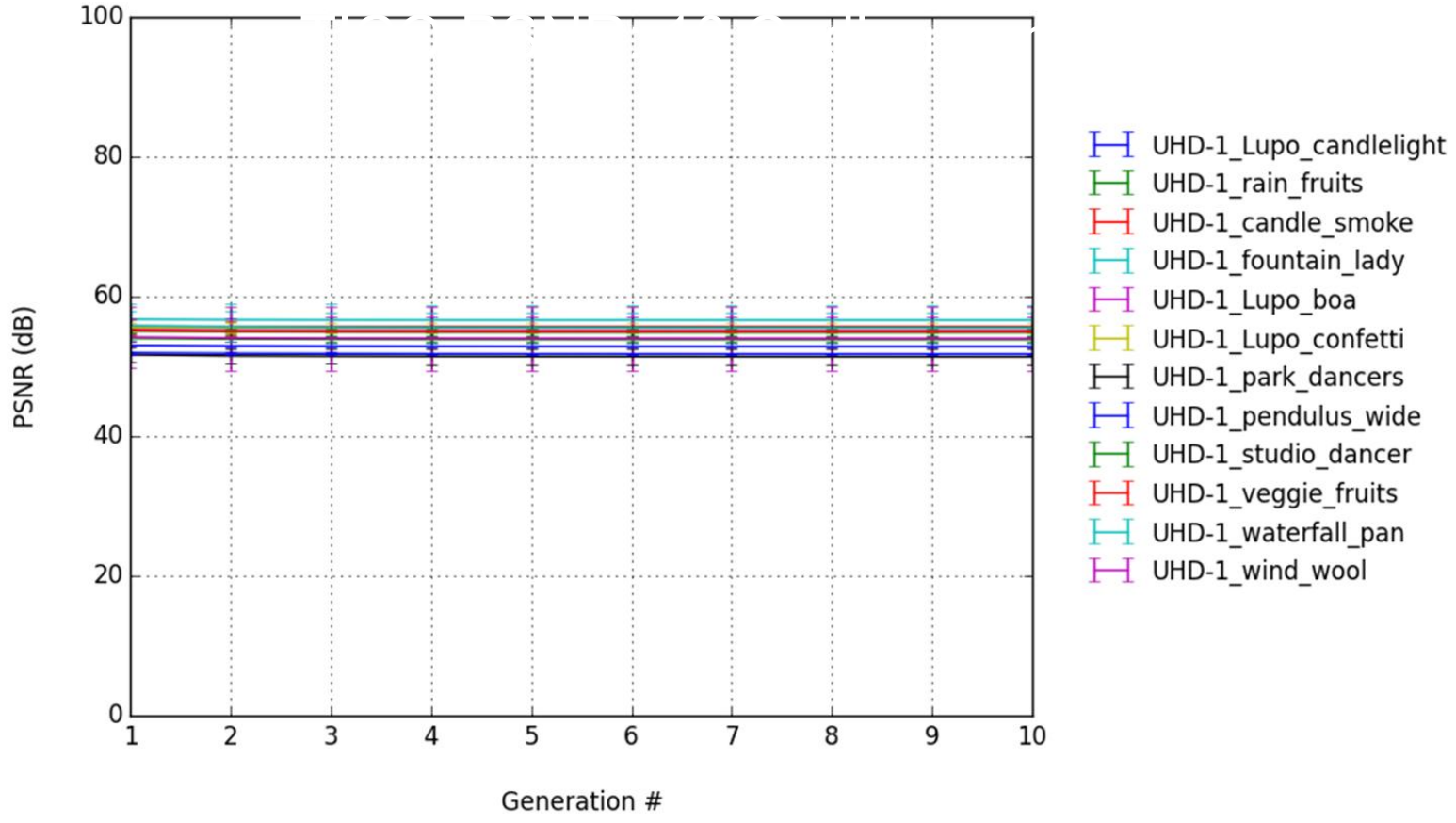
TICO FPGA and VC-2





TICO is much smaller than VC-2


PSNR comparisons of TICO & JPEG2000 Ultra Low Latency
EBU UHD1 Test Set
80.00 dB
75.00 dB
70.00 dB
65.00 dB
60.00 dB
55.00 dB
50.00 dB
45.00 dB
40.00 dB
35.00 dB
30.00 dB
25.00 dB
20.00 dB
UHD-1_Lupo_candlelight
UHD-1_rain_fruits
UHD-1_candle_smoke
UHD-1_fountain_lady
UHD-1_Lupo_boa
UHD-1_Lupo_confetti
UHD-1_park_dancers
UHD-1_pendulus_wide
UHD-1_studio_dancer
UHD-1_veggie_fruits
UHD-1_waterfall_pan
UHD-1_wind_wool
j2kll-5bpp (4:1)
j2kll-2.5bpp (8:1)
tico-5bpp(4:1)
tico-10bpp (2:1)
j2kll-3.5bpp (5,7:1)


100
80
60
40
20
0
PSNR (dB)
1
2
3
4
5
6
7
8
9
10
Generation #
UHD-1_Lupo_candlelight
UHD-1_rain_fruits
UHD-1_candle_smoke
UHD-1_fountain_lady
UHD-1_Lupo_boa
UHD-1_Lupo_confetti
UHD-1_park_dancers
UHD-1_pendulus_wide
UHD-1_studio_dancer
UHD-1_veggie_fruits
UHD-1_waterfall_pan
UHD-1_wind_wool

Relative Performance Summary

- J2K is typically used at 5.7 to 1
  - HD into 300 Mbps
- TICO at 4:1 is the same PSNR as J2K
- Lighter Compression ratio provides better multi-pass
- TICO offers performance greater than, or equal performance

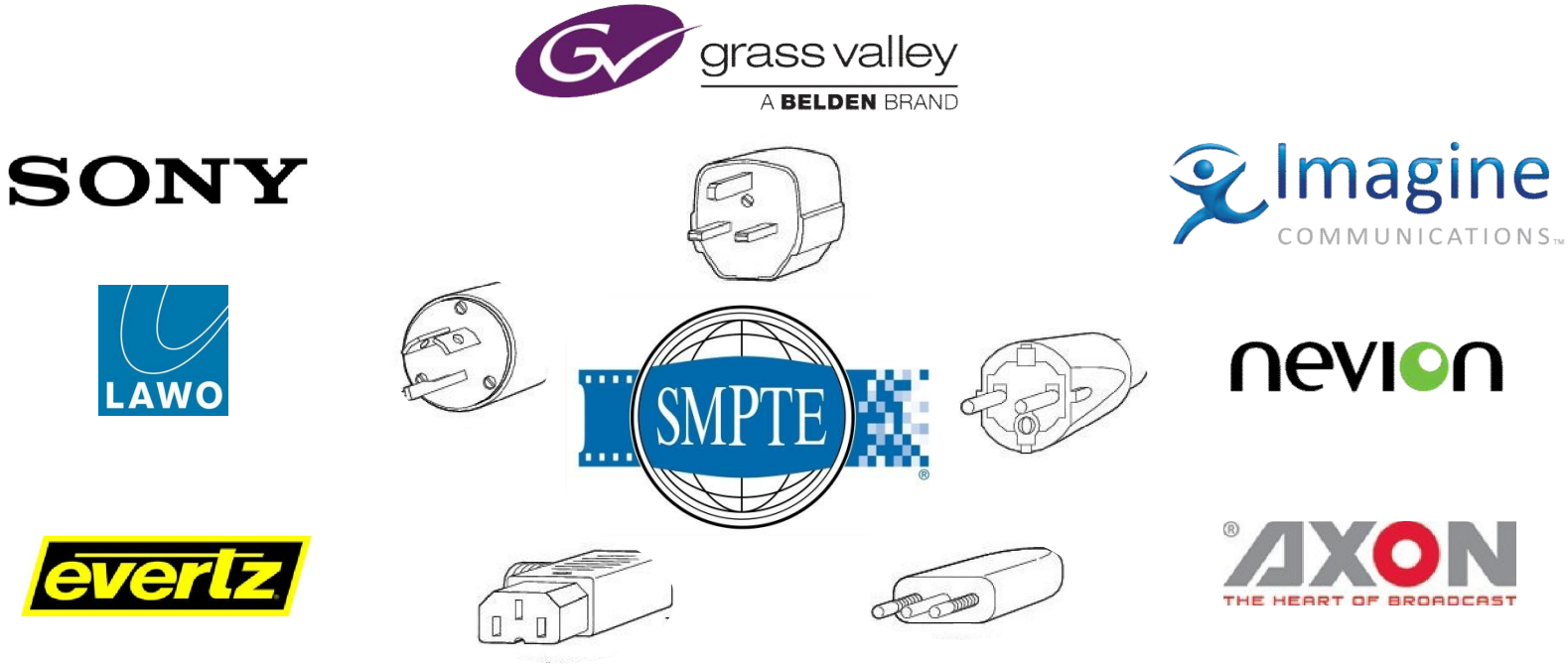
What is the current status?

- **TICO SMPTE RDD Draft**
  - Completed October 2015
  - Is shared with industrial partners & broadcasters to enable interoperability
  - Mapping over 3G-SDI & SMPTE 2022-6
  - Mapping over RTP

Benefits of TICO for Broadcasters

- Works in today's infrastructures - and tomorrow's.
  - COAX – SDI, IEEE 802.xxxx
- Common adaptive workflow
- Lightweight in terms of power, computation, memory
- Suited for Virtualisation
- Excellent long term CAPEX and OPEX

Interoperability - the reality



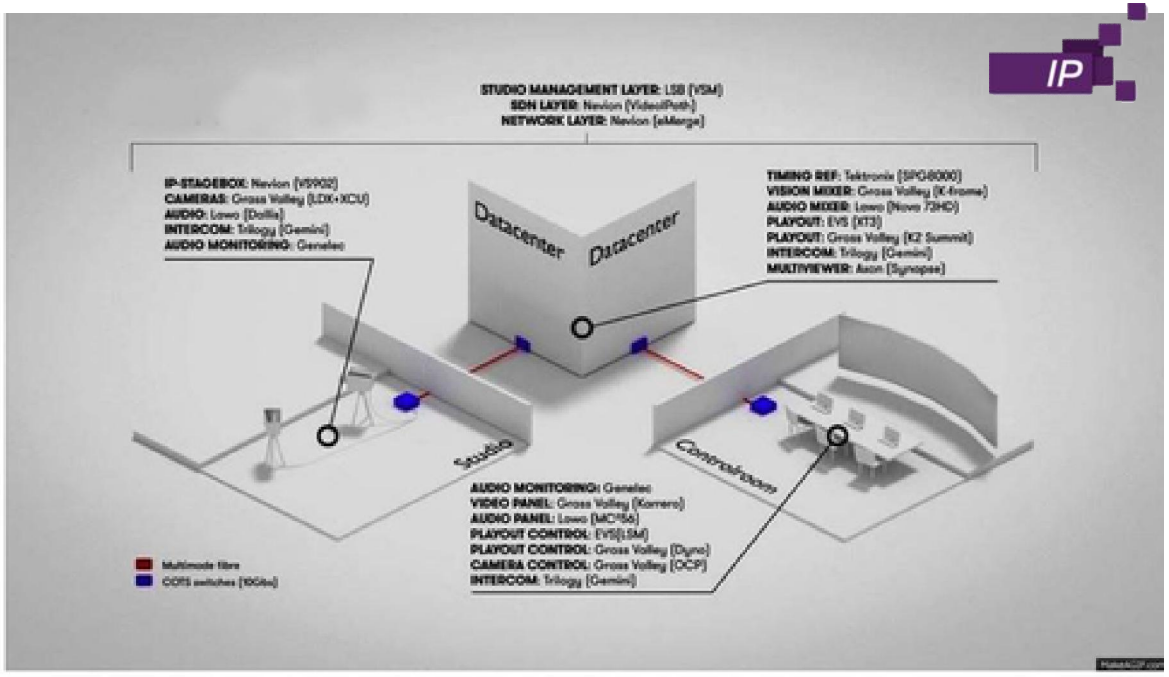
- Standards are critical to assure customer value and adoption
- Grass Valley is, and has always been, dedicated to driving and supporting open, standards based solutions

So what did we learn from customer PoC's?

- SMPTE 2022-6 is a robust starting point for interoperability
  - Well adopted by most broadcast manufacturers, some via "reverse gateways"
- SMPTE 2022-7 is seen as a must for core broadcast infrastructure
  - Although, many broadcast manufacturers are still adding this functionality today - whilst customers work through the ROI for the additional port cost
- PTP/IEEE-1588 support is a requirement, but traditional Genlock sources need to be facilitated in any design (i.e. legacy devices)

So what did we learn from customer PoC's?

- SMPTE 2022-5 (FEC) is linked to specific broadcast devices and flows due to the increase in overall latency
- Audio should be treated as an equal, not as a second class citizen
  - Required for discrete audio (transportation and shuffling) and intercoms
- "Clean" and/or "Vertically accurate" switching should be facilitated in specific core broadcast areas (same as we have today)
- Finally, bring your own LC cables and SFP+ modules to PoC's ☺



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trilogy · Tektronix · GENELEC · DWESAM · vrt · EBU

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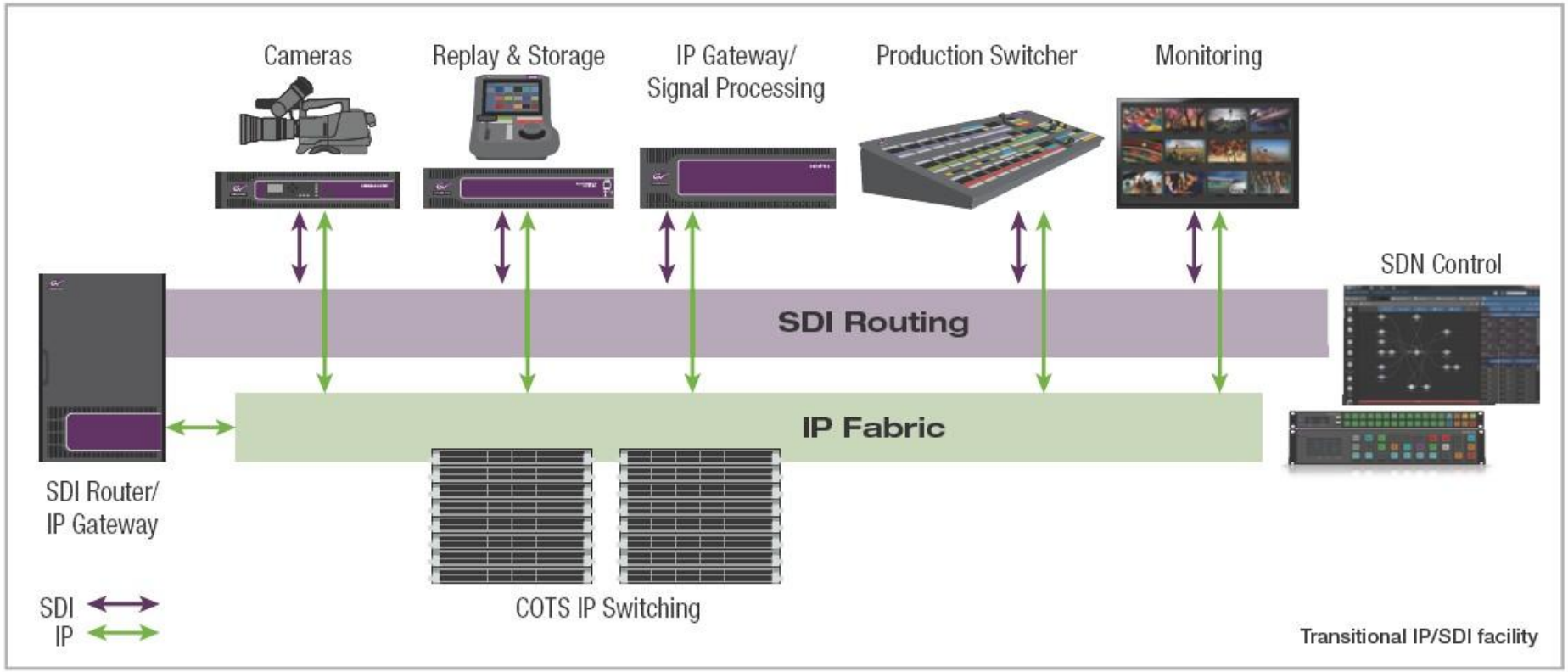
http://sandbox.vrt.be/liveip/

So what's "next"?

- Separate Elementary Streams without Encapsulation (TR03)?
- Lower latency recommendation for SMPTE 2022-7 (2022-7 Lite)?
- Greater interoperability AES67 support alongside SMPTE 2022-6?
- Industry wide support of a Device Control & Discovery protocol?
- Adoption of additional mezzanine codecs?

One final comment… we do have products today!



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'Glass-to-Glass Production over IP' Solution

Phil.Myers@grassvalley.com

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FUTURE-READY