

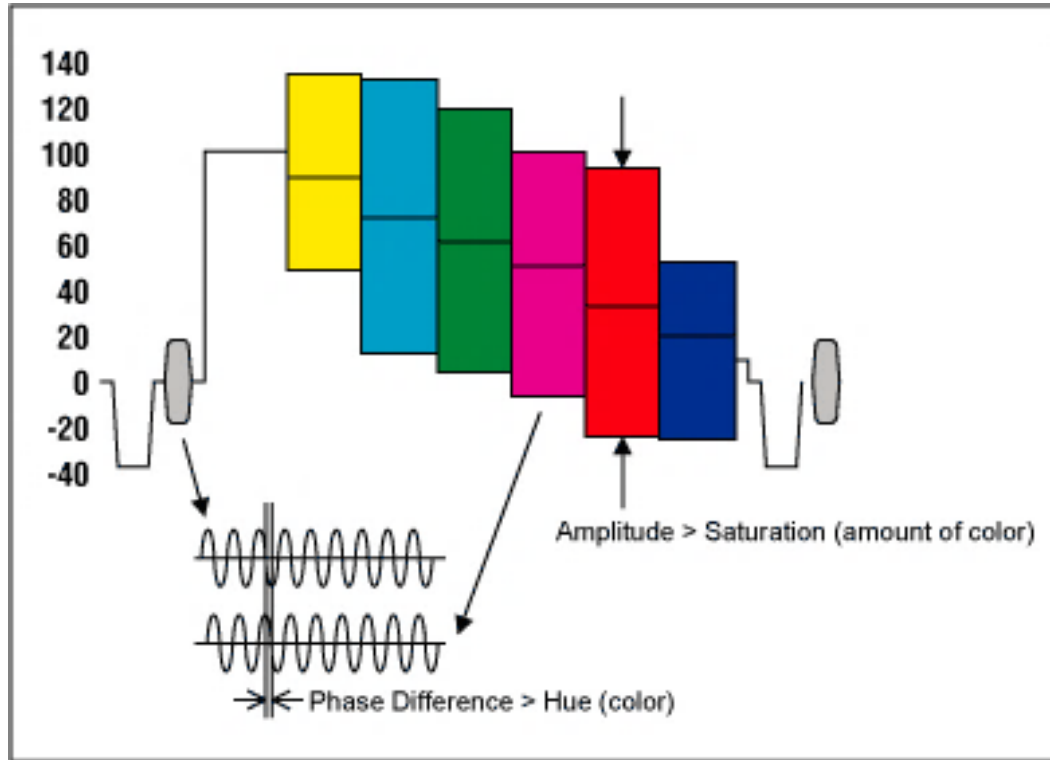
Migrating Live Production to IP Technology

❖ It's About Time

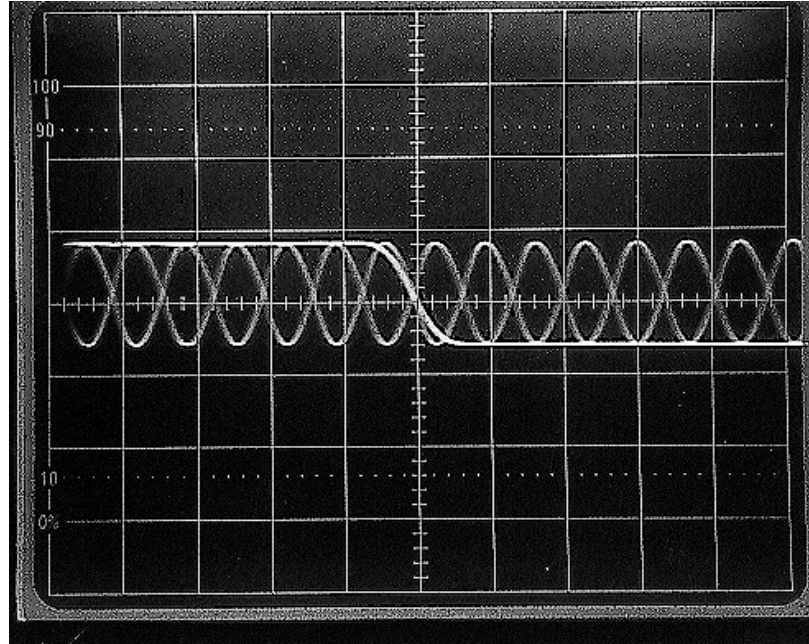
Where we have been

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

Color Television Time Domain

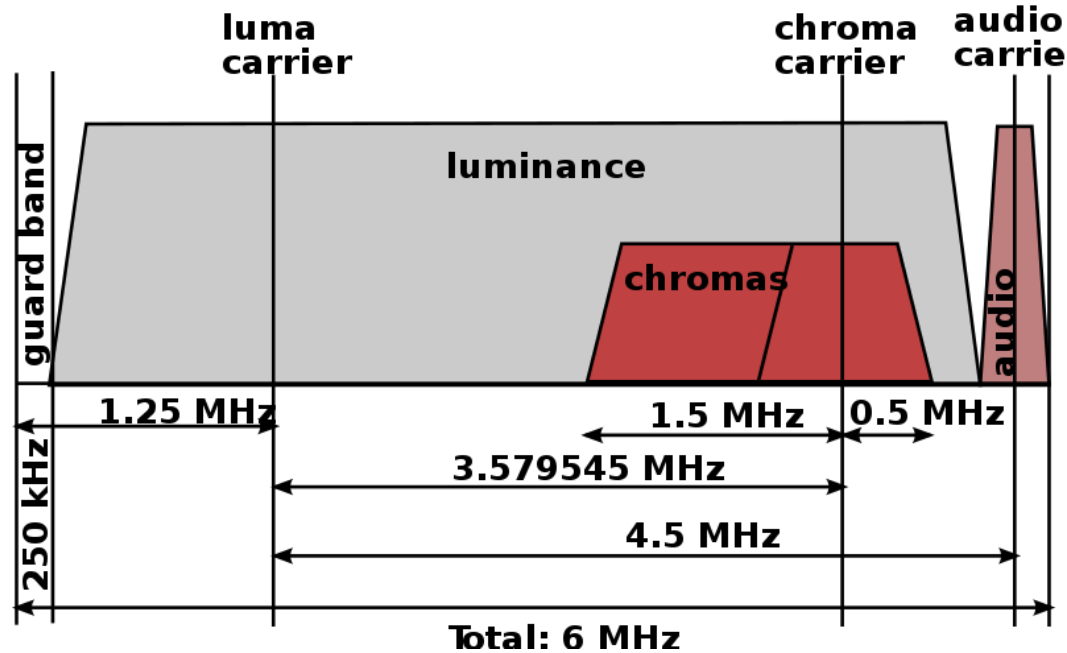


SC/H Phase



Leader, Teleproduction Test Volume 1 Number 10

Broadcast Spectrum



Strict Spectral Control
Tight Frequency Tolerance
Managed Signal Amplitude

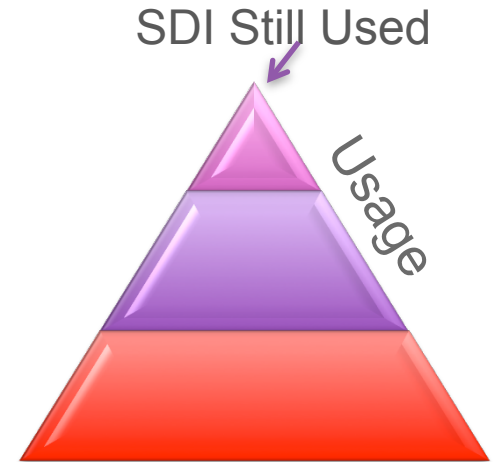
Where we are Now

- ❖ Digital television (HD) broke the strict connection between the camera and the home
- ❖ Video production became line based
- ❖ The requirement for nano-seconds is gone

- ❖ Many new ROI models are proposed, leveraging IP technology

Workflow Timing Model

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



Time Relationships

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

Wire Speed Latency

Network Speed	Delay	Line Times			
	usec	2K/60	4K/60	4k/120	8K/120
		1.48E-05	7.41E-06	3.70E-06	1.85E-06
Gig E	36.96	2.5	5.0	10.0	20.0
10Gig E	3.70	0.2	0.5	1.0	2.0
100Gig E	0.37	0.0	0.0	0.1	0.2

Originally Presented by Meyer at Vid-Trans, March 2014

Latency Validation Data

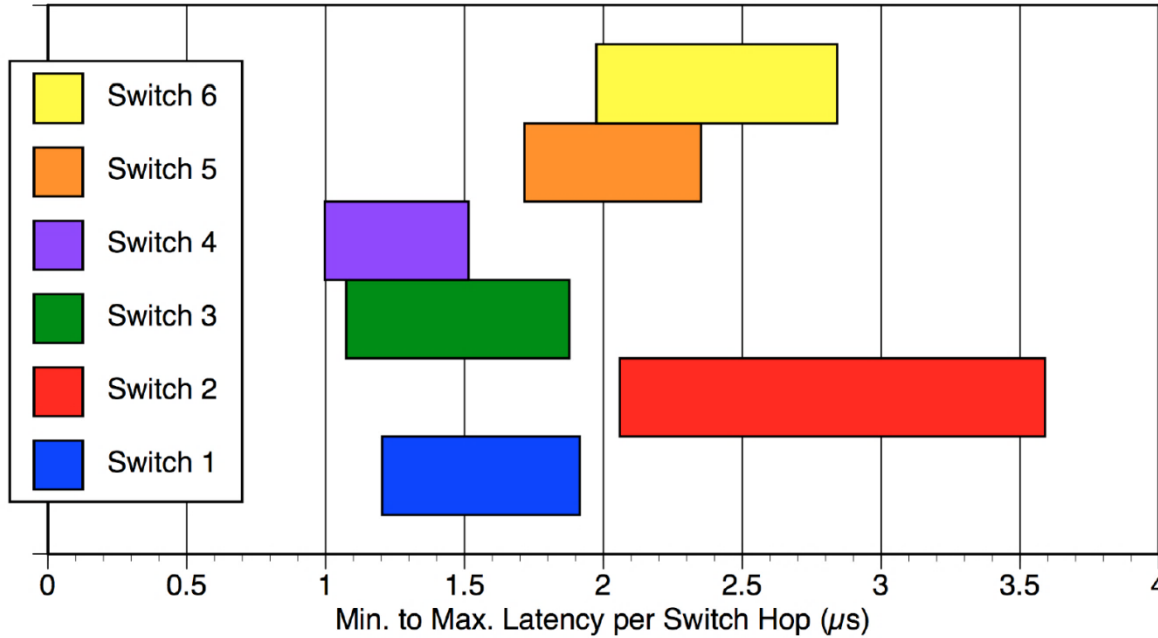


Figure 8. Latency per Switch Hop

Courtesy
Brian Keane
Aperi Corporation
Thomas Edwards
Fox Networks E&O

Jitter Validation Data

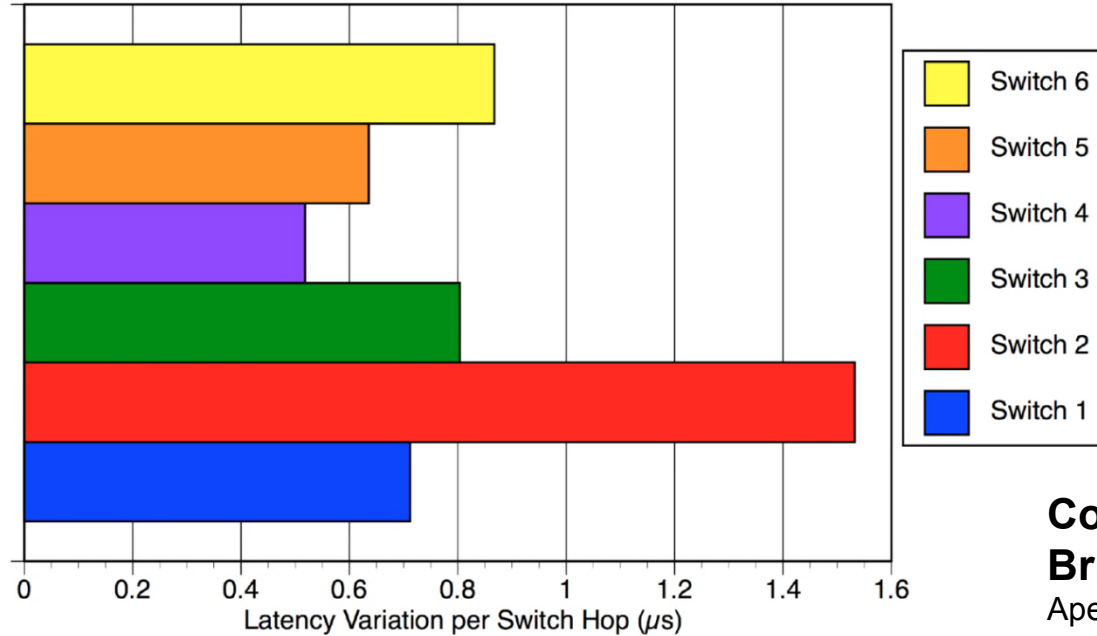


Figure 9. Variation of Latency

Courtesy
Brian Keane
Aperi Corporation
Thomas Edwards
Fox Networks E&O

Update on Ethernet

- ❖ 25 GbE is here.
 - IEEE 802.3by
 - 25/50/100 Standardized during 2016
 - QSFP28 as a package for 100 Gbps with 4 fibers
 - Broad Industry Support
 - Arista, Broadcom, CISCO, Mellanox



Image and data courtesy Arista

Wire Speed Latency Update

Network Speed	Delay	Lines			
		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

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
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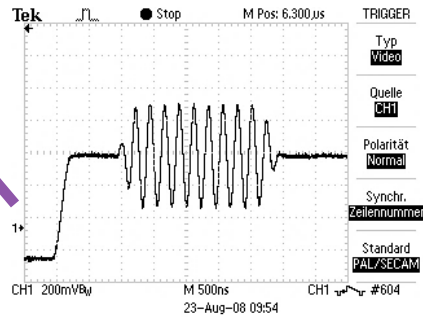
Bound the Problem

- ❖ 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)*

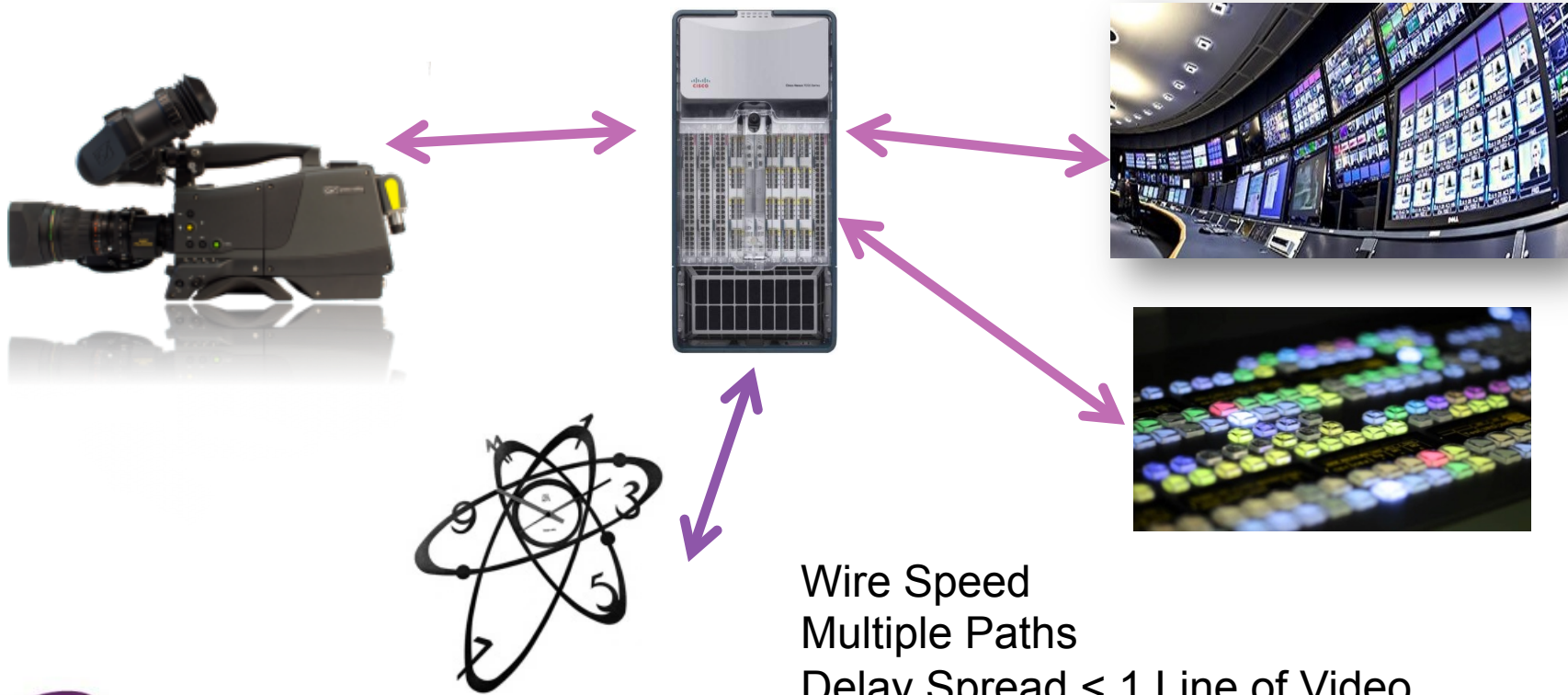
System Timing in Broadcast



Wire Speed
Multiple Paths
Delay Spread < 1 Line of Video

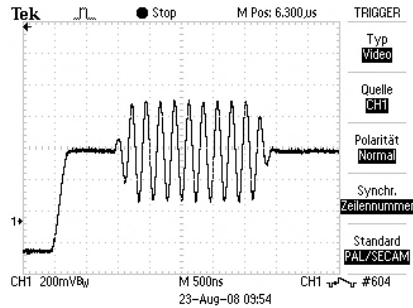
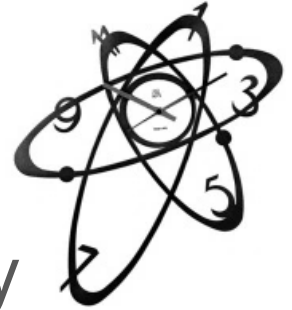


System Timing with Integrated IP



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 enables more



Strategy to Reduce Cabling

- ❖ Cost per signal per physical network segment
- ❖ UHDTV
 - Gamut, HDR, HFR
 - 4K, 8K, etc...
- ❖ Lite Compression

Lite Compression Defined

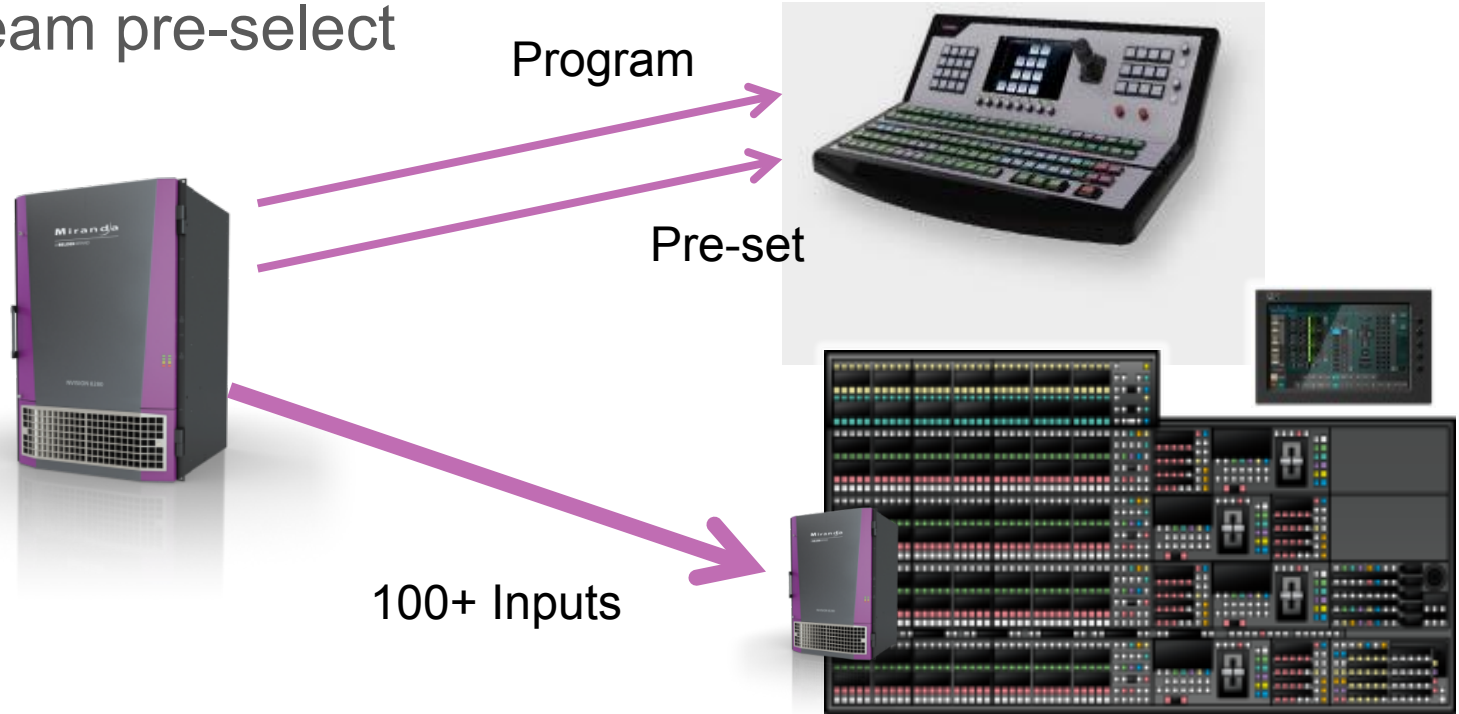
- ❖ Visually lossless and multi-pass
- ❖ Latency measured in lines
- ❖ Low cost hardware
- ❖ Low power

Mezzanine Compression 4:1

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

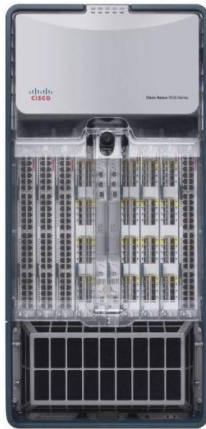
Clean On-Air Switch

- A/B Master Control
- Upstream pre-select



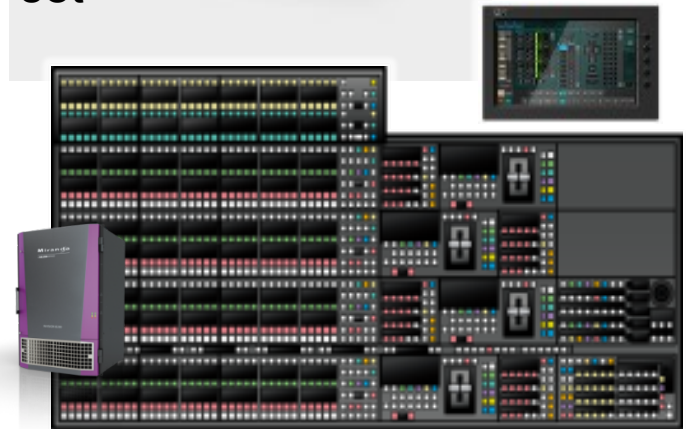
Clean On-Air Switch in IP

- ❖ Clean Switch
- ❖ Edge Switch
- ❖ End-Point Switch
- ❖ IGMP Leave and Join



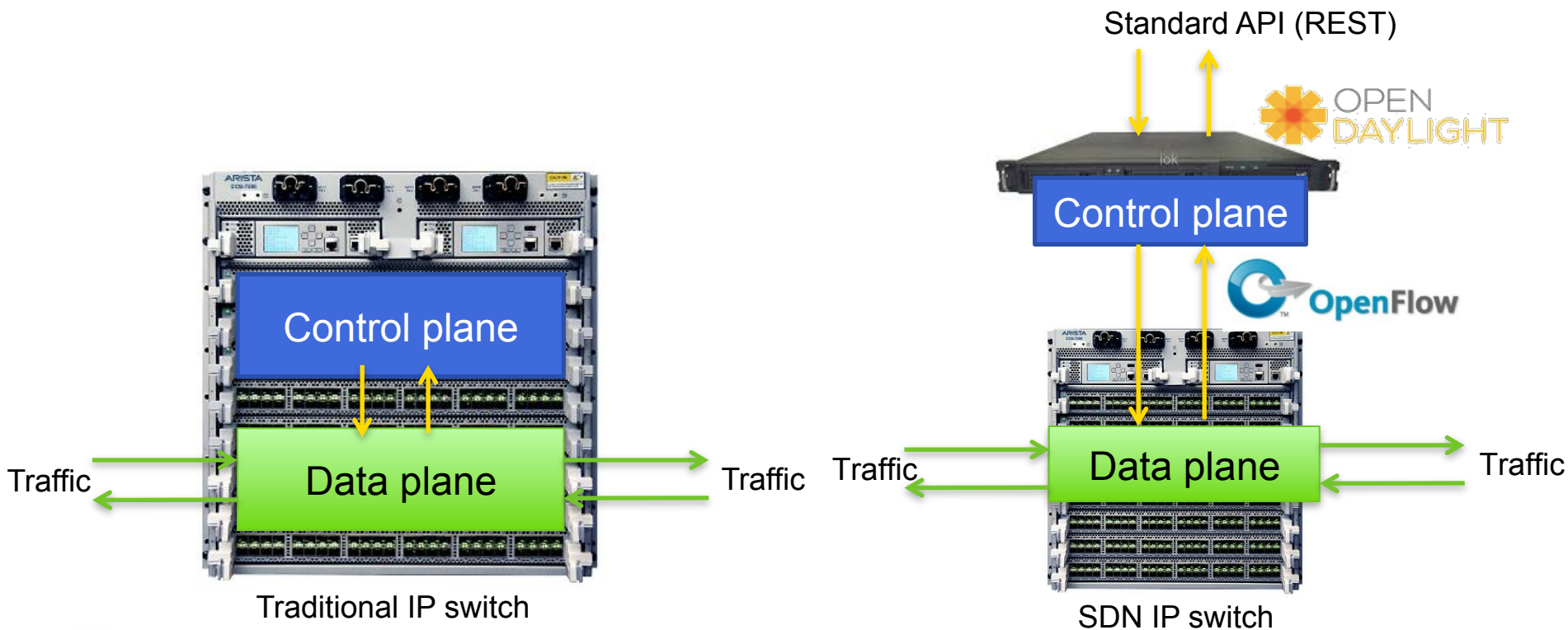
Program

Pre-set

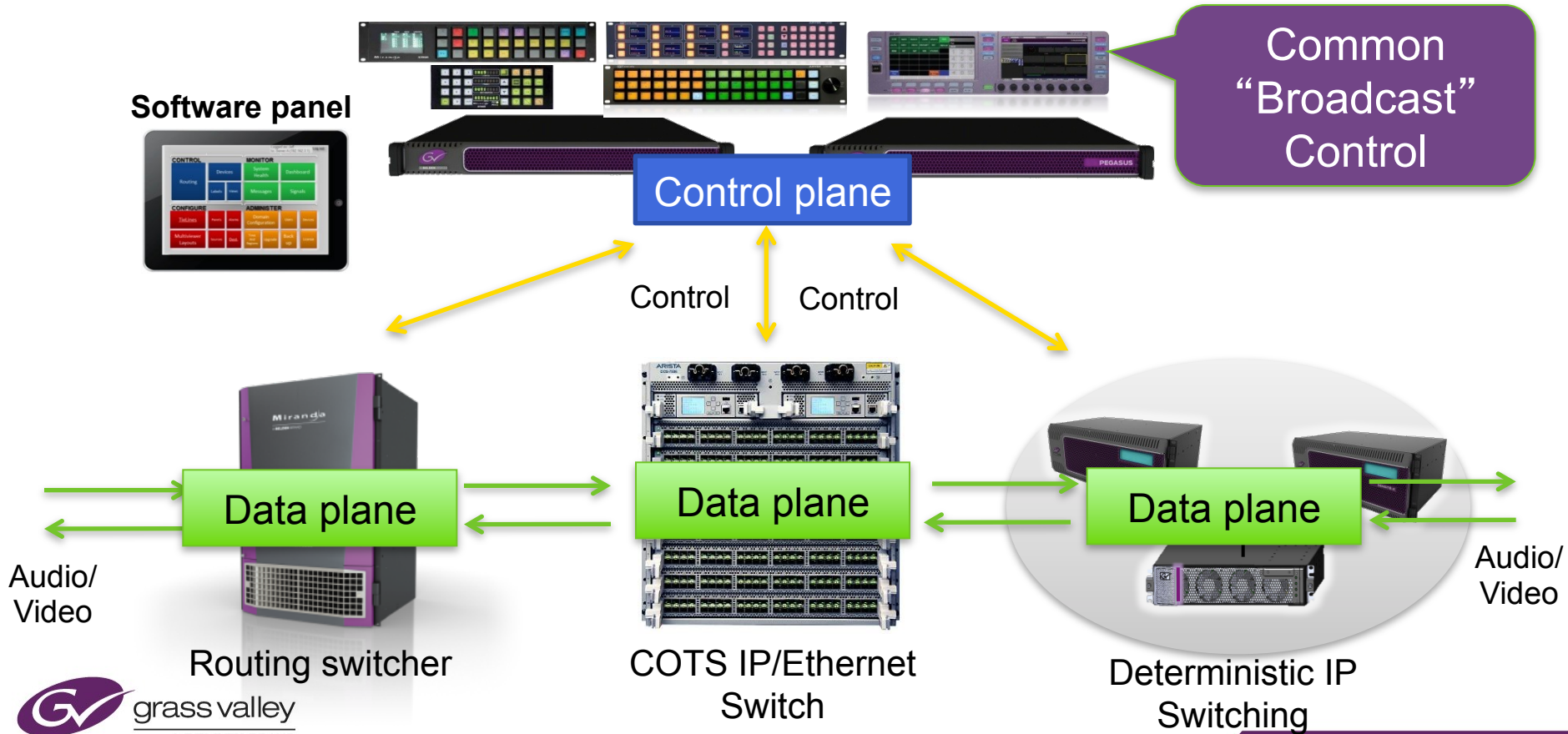


100+ Inputs

Why SDN? Traditional vs SDN IP Switch



SDN: Providing TV Centric control for Hybrid IP/SDI



10 GbE Enables Live

- ❖ Fabric delay with jitter is bounded: $< \frac{1}{2}$ Video Line
- ❖ Source timed, deterministic systems perform equally with today's SDI
- ❖ Time of flight design still works just like SDI
- ❖ Upstream pre-select models stay the same
- ❖ Familiar control surfaces still manage the facility

10 GbE Empowers the Future

- ❖ Intelligent process flows
- ❖ Multiple ROI models
- ❖ Bandwidth scalability easily adapts to new formats
- ❖ Sophisticated timing models
- ❖ Location independence
 - Control Room, Sources, or both



Thank You

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 FUTURE-READY



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