

SMPTE ST2110 – IP-Based Studios and the Path to Dematerialization

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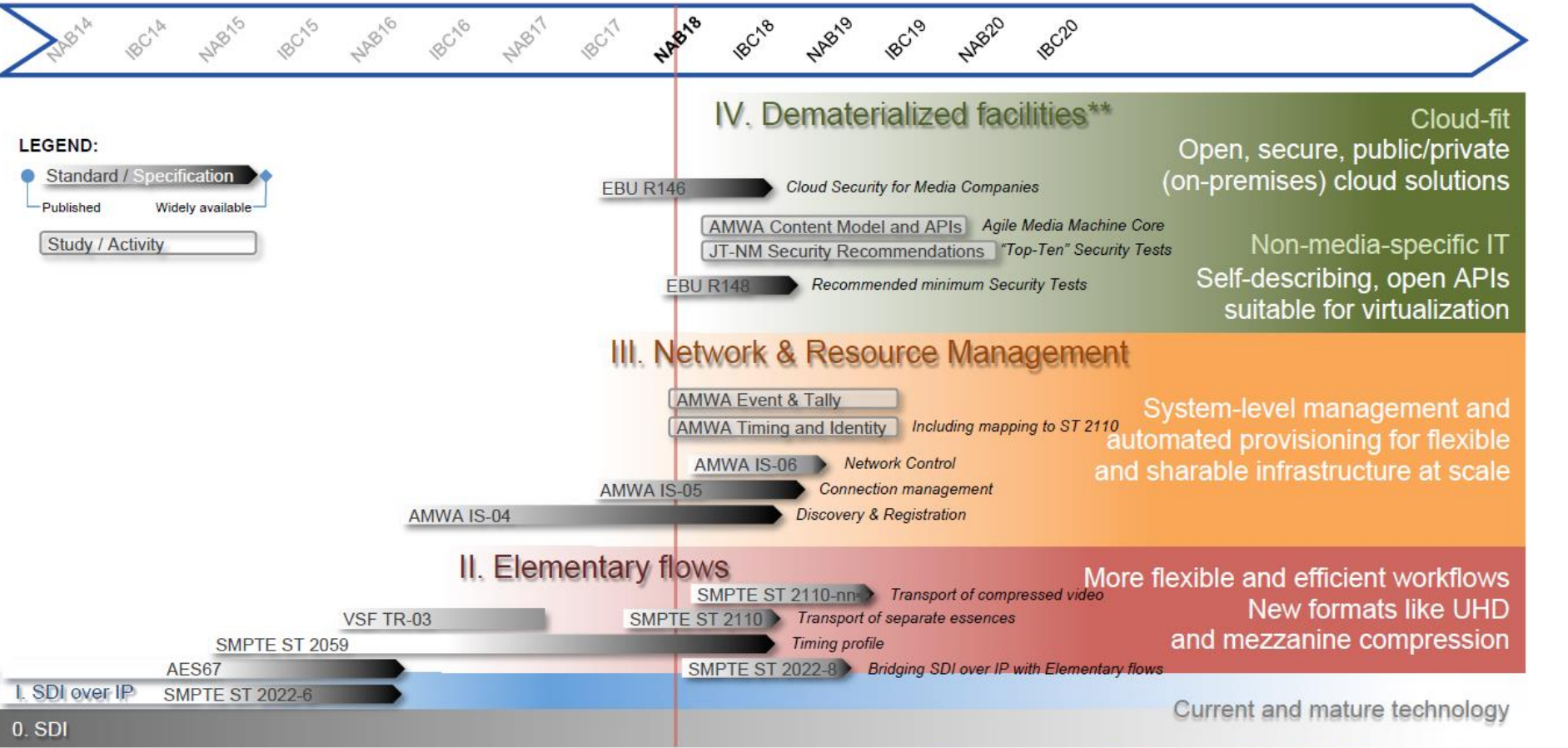
CTO, Networking, Imagine Communications

Drafting Group Editor, SMPTE ST2110

SMPTE 2110 is mostly finished and published !!!

2110-10: System Timing	PUBLISHED
2110-20: Uncompressed Video	PUBLISHED
2110-21: Traffic Shaping Uncompressed Video	PUBLISHED
2110-22: Compressed Video Essence	(in progress)
2110-30: PCM Audio	PUBLISHED
2110-31: AES3 Transparent Transport	very soon
2110-40: Ancillary Data	PUBLISHED
2022-8: Integration with ST 2022-6	(in progress)

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

IP Transport Standards in SMPTE – The History

- ST 2022-1/2/3/4: MPEG-2 Transport Stream over IP
- ST 2022-5/6: SDI over IP
- Both of ***these are “multiplex” standards***, where the video, audio, and ancillary data signals (plus blanking and padding) are wrapped up into a single IP stream
- **ST 2110 puts each part** of the signal into a **different stream**
 - Video, Audio(s), and ANC(s) all separately routable
- Recipients can ask for exactly what they want, and get only that

2110-10: System Timing Model

2110-20: Uncompressed Video

2110-21: Traffic Shaping Uncompressed Video

2110-22: Compressed Video Essence

2110-30: PCM Audio

2110-31: AES3 Transparent Transport

2110-40: Ancillary Data

2022-8: Integration with ST 2022-6

ST 2110-10: How do the parts stay in sync?

SDI was good in this regard – the embedded audio and VANC were tightly bound to the video (from a timing perspective)

In ST2110, the separate streams have timestamps

- ST 2059 (PTP) is used to distribute time and timebase to every device in the system
- Senders mark each packet of video, audio, or ANC with an “RTP Timestamp” that indicates the “sampling time” (or equivalent)
- Receivers compare these timestamps in order to properly align the different essence parts to each other

Users can Mix-and-Match essence from any source !!!

ST2110-10: What's it About?

- Specifies how SMPTE 2059 PTP timing is used for ST2110
- Specifies how the RTP timestamps are calculated for Video, Audio, and ANC signals
- Specifies general requirements of the IP streams
- Specifies using the ***Session Description Protocol (SDP)***
- The actual stream formats are in the other parts of the standard

Each Stream has a set of metadata that tells the receiver how to interpret what is inside of it – the receiver needs this info!!

- The SDP (RFC4566) tells the Receiver what it needs to know
- Senders expose an SDP for every stream they make
- The control system (out of scope of 2110) conveys the SDP information to the receiver

An Example of an SDP

```
v=0
o=- 123456 11 IN IP4 192.168.100.2
s=Example of a SMPTE ST2110-20 signal
i=this example is for 720p video at 59.94
t=0 0
a=recvonly
a=group:DUP primary secondary
m=video 50000 RTP/AVP 112
c=IN IP4 239.100.9.10/32
a=rtpmap:112 raw/90000
a=fmtp:112 sampling=YCbCr-4:2:2; width=1280; height=720; exactframerate=60000/1001;
depth=10; TCS=SDR; colorimetry=BT709; PM=2110GPM; SSN="ST2110-20:2017";
a=ts-refclk:ptp=IEEE1588-2008:39-A7-94-FF-FE-07-CB-D0:37
a=mid:primary
m=video 50020 RTP/AVP 112
c=IN IP4 239.101.9.10/32
a=rtpmap:112 raw/90000
a=fmtp:112 sampling=YCbCr-4:2:2; width=1280; height=720; exactframerate=60000/1001;
depth=10; TCS=SDR; colorimetry=BT709; PM=2110GPM; SSN="ST2110-20:2017";
a=ts-refclk:ptp=IEEE1588-2008:39-A7-94-FF-FE-07-CB-D0:37
a=mid:secondary
```

2110-10: System Timing

2110-20: Uncompressed Video

2110-21: Traffic Shaping Uncompressed Video

2110-22: Compressed Video Essence

2110-30: PCM Audio

2110-31: AES3 Transparent Transport

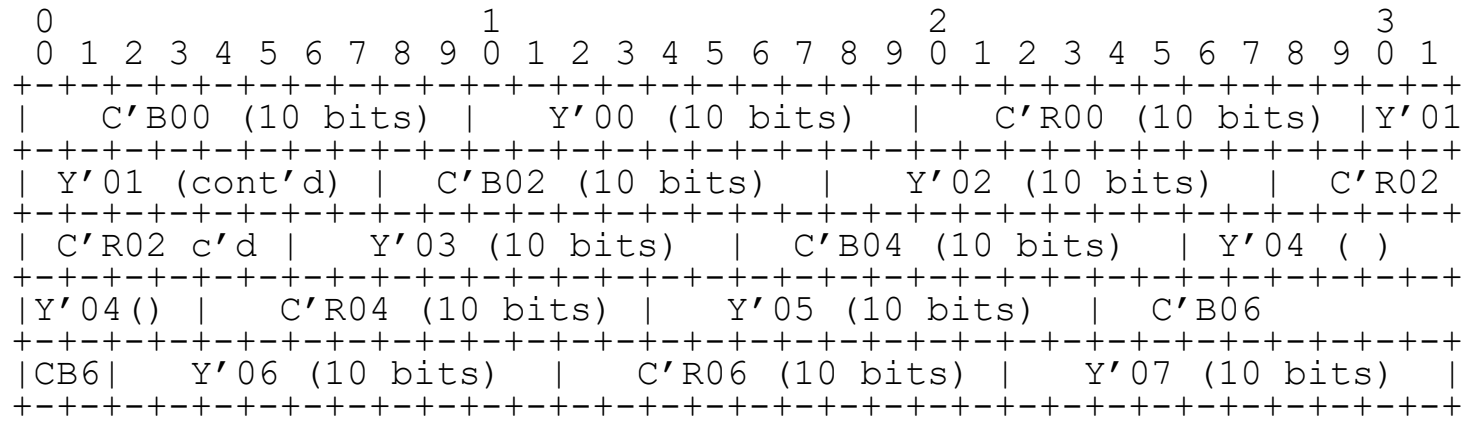
2110-40: Ancillary Data

2022-8: Integration with ST 2022-6

ST2110-20: Uncompressed Video

- Only the “Active” image area is sent – no blanking
- Supports image sizes up to 32k x 32k
- Supports Y’Cb’Cr’, RGB, XYZ, I’Ct’Cp’
- Supports 4:2:2/10, 4:2:2/12, 4:4:4/16, and more
- Supports HDR (PQ & HLG)

The Samples are Tightly Packed



4:2:2/10
example

How Much Bandwidth was Saved ?

<i>Scan Format</i>	<i>2022-6 (Gb/s)</i>	<i>2110-20 (Gb/s)</i>	<i>difference</i>
2160p @ 59.94	12282.2	10279.6	-16.3%
1080p @ 59.94	3070.7	2570.1	-16.3%
1080i @ 29.97	1535.4	1285.0	-16.3%
720p @ 59.94	1535.4	1142.5	-25.6%
2160p @ 50	12294.8	8754.9	-30.3%
1080p @ 50	3074.1	2143.9	-30.3%
1080i @ 25	1537.4	1071.9	-30.3%
720p @ 50	1537.4	953.0	-39.9%

Is ST2110-20 Ready for the Future?

- Image size can be up to 32K x 32K
- Frame Rate can be anything you want
- Can signal which HDR system (SDR, HLG, PQ, easy to add more)

2110-10: System Timing

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2110-22: Compressed Video

- Uncompressed HD is 1.2 (or 1.0) Gbits/sec
- Uncompressed UHD is 10.3 (or 8.8) Gbits/sec
- Can I use J2K / TICO / AVCI / JPEG-XS / MFC (MyFavoriteCodec) in 2110?
- YES, and 2110-22 says generically how to do it.
- 2110-22 defines the timing relationship between Compressed elementary stream video signals and the 2110 ecosystem

What about Audio?

How SMPTE 2110-30 makes it better

2110-10: System Timing

2110-20: Uncompressed Video

2110-21: Traffic Shaping Uncompressed Video

2110-22: Compressed Video Essence

2110-30: PCM Audio

2110-31: AES3 Transparent Transport

2110-40: Ancillary Data

2022-8: Integration with ST 2022-6

2110-30: Important Facts

Built On AES67 -- PCM Audio (only)

Many things **allowed** but only a few **required**

- **48kHz sampling** is required for all devices
- **1ms packet time** is required for all devices
- **1..8 channels per stream** is required for all devices
- **16 & 24 bit depth** required for all devices

Outside the **required**, must read specs carefully

IP Digital Audio for Video People



Word Clock & RTP Timestamp

Sampling Rate (44.1 kHz or 48 kHz)
Channels Per Packet (a choice)
Packet Time (1ms usually)



A little more about channels/stream

Send every channel separately?

- Lots of streams, more configuration, not typical

Send bigger streams (2, 4, or 8 channels per)

- Switching in IP will switch all (2/4/8) channels
- Downstream sub-selecting makes this a bit better

Giant “stems” up to 64 channels are possible

Different Devices make different trade-offs

- Ask about the number of streams, not just channels

How “big” is an audio stream?

Tiny (compared to the video)

A 2-channel stream is:

$$(2 \text{ channels}) * (24 \text{ bits}) * (48000 \text{ samples}) * (1.08 \text{ RTP}) \\ = 2.5 \text{ Mbits/sec}$$

An 8-channel stream is:

$$(8 \text{ channels}) * (24 \text{ bits}) * (48000 \text{ samples}) * (1.05 \text{ RTP}) \\ = 9.7 \text{ Mbits/sec}$$

What about Non-PCM Audio?

2110-30 deals only with PCM audio

2110-31 provides bit-transparent AES3 over IP

- Can handle non-PCM audio
- Can handle AES3 applications that use the user bits
- Can handle AES3 applications that use the C or V bits

2110-31 is always “stereo” (like AES3), can contain multiple AES3 in the same IP stream.

What about Ancillary Data?

How SMPTE 2110-40 makes it work

SMPTE 2110-X: Parts

2110-10: System Timing

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2110-40: Important Facts

Over the years, lots of things have been put into the SDI “Ancillary Data” system

- Some are tightly related to the video signal
- Some are really separate essence
- Some are just along for the ride

Audio is handled a better way – don’t use this method for audio

IETF just published RFC 8331, which says how to wrap ANC in IP

2110-40 says how to use RFC 8331 in an ST2110 system

Break-Away Routing Ancillary Data?

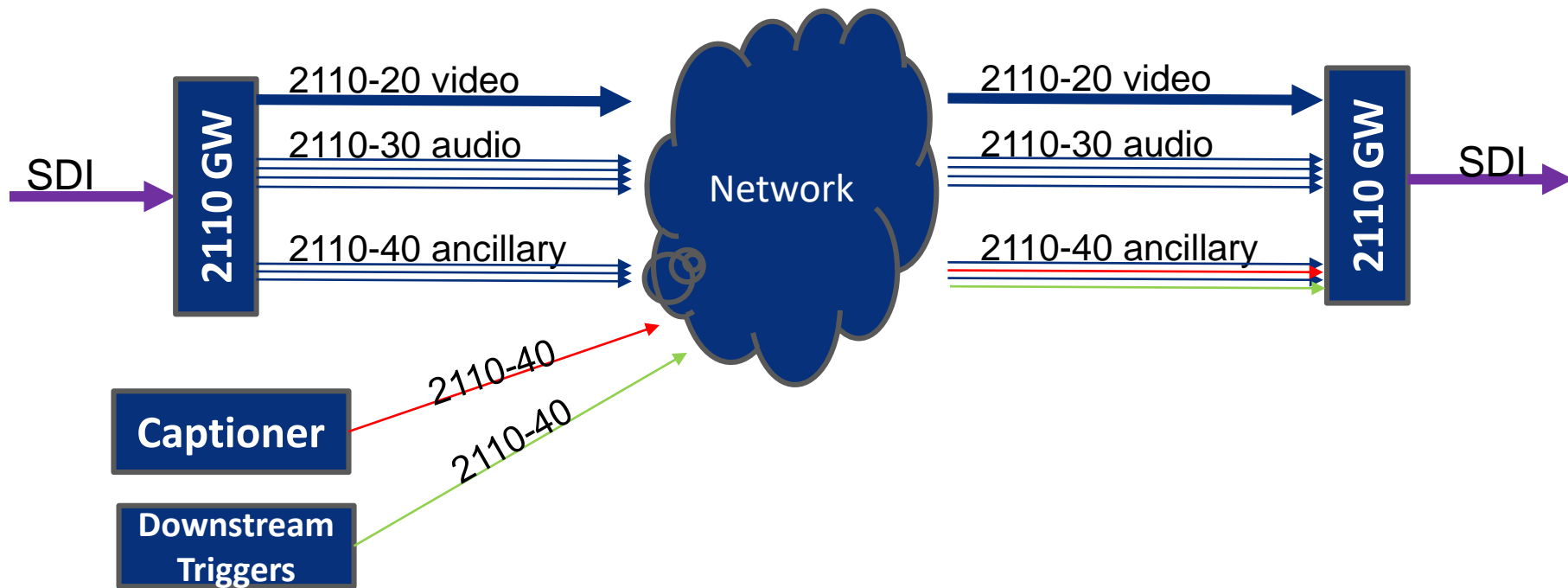
This is a capability we've never had before...

What could you do with this kind of ability ?

Today – we loop through a lot of VANC inserters

Future – the SDI (if you need it) is “composed” from the parts

VANC Data Routing – Just Like Audio?





Is ST 2110 the universal perfect solution for all situations?

No, silly, of course not...

Is 2110 perfect for every situation?

- 2110 is a great solution for:
 - Large-Scale OB Trucks that need to support UHD
 - Large-Scale audio/video routing systems with studios
 - Distributed (Venue/Campus) Production Environments
 - Where there is one PTP domain and an integrated Management System

- 2110 is probably NOT the ideal solution for:
 - Getting to and from “the cloud”
 - Cost-sensitive Long-Haul contribution links
 - Distribution (network-to-affiliate, etc)
 - Interchange between arms-length unrelated parties

2110 Defines Transport, but What About Control?

How is IP Television Routing Different from SDI ?

- In SDI Routing, all the action happens in the SDI crosspoint frame
 - The Control System tells the crosspoint what to switch where
 - The Crosspoint Router switches everything internally
 - The **Receivers just eat whatever bits show up**

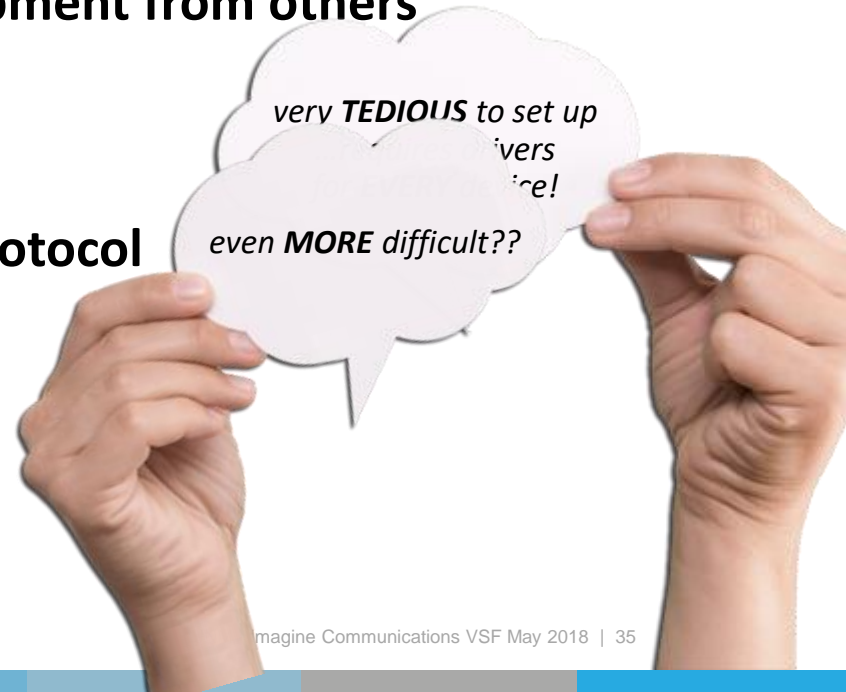
- In IP Television Routing, the **Receiver is involved in the switching**
 - The Control System tells the Receiver
 - What Multicast Group & Port# to switch to (Main and Protect)
 - The Technical Metadata of the new stream
 - The **Receiver is responsible for how** it switches/transitions to it
 - The **Receiver asks the network** for the new signal
 - The network provides the new signal through packet forwarding logic

HOW DID YOU DO IT IN AN SDI SYSTEM??

- Automated discovery maybe within the same vendor
- Manual entries when integrating equipment from others

HOW WILL IT WORK IN AN IP ENVIRONMENT?

- Automated Discovery by a Standard Protocol
- Stream Switching requests, too
- Let's talk about **AMWA-NMOS**



ADVANCED MEDIA WORKFLOW ASSOCIATION



Devices: things that make or eat signals

- Look in DNS (or mDNS) to find the “registry”
- Tell the “registrar” who they are and what they have
- Keep the “registrar” informed as things change

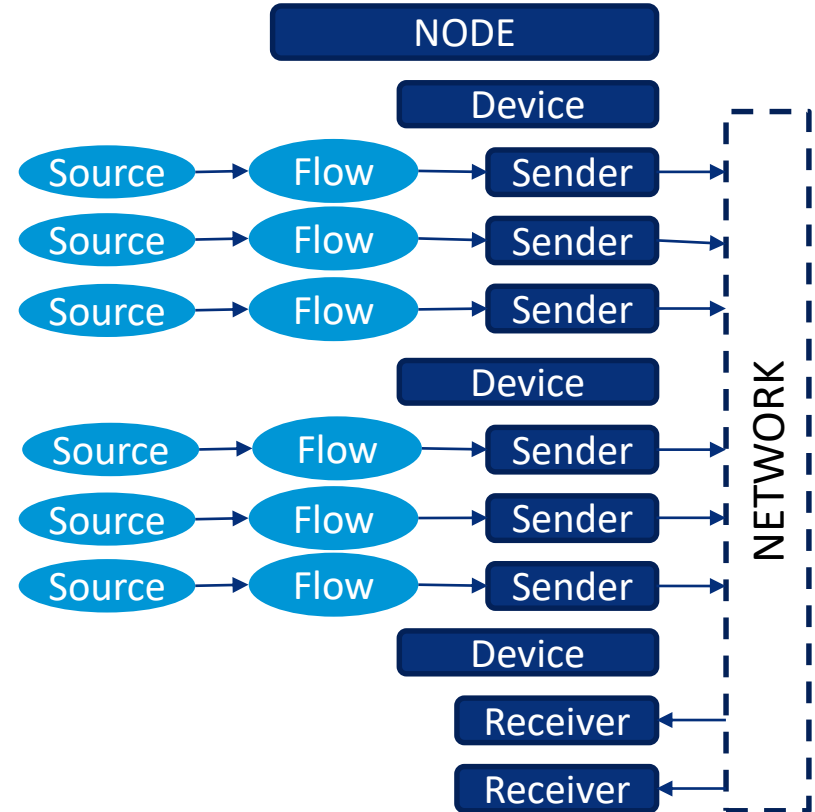
*Anybody, who cares to, can **query** this registry...*

- About the Devices and their Streams
- Subscribe to Updates as things change



What is in the Registry?

- Nodes (controllable entities)
- Devices (sub-entities)
- Senders (make stream on network)
- Receivers (eat streams from network)
- Flows (representation of the content)
- Sources (original content)



Controllers: things that make routing happen

- Know about the streams from the registration service
- Maintain the names and meanings of those streams
- Tell the Receivers what stream to take
- Act like a “routing system” to everything in the plant

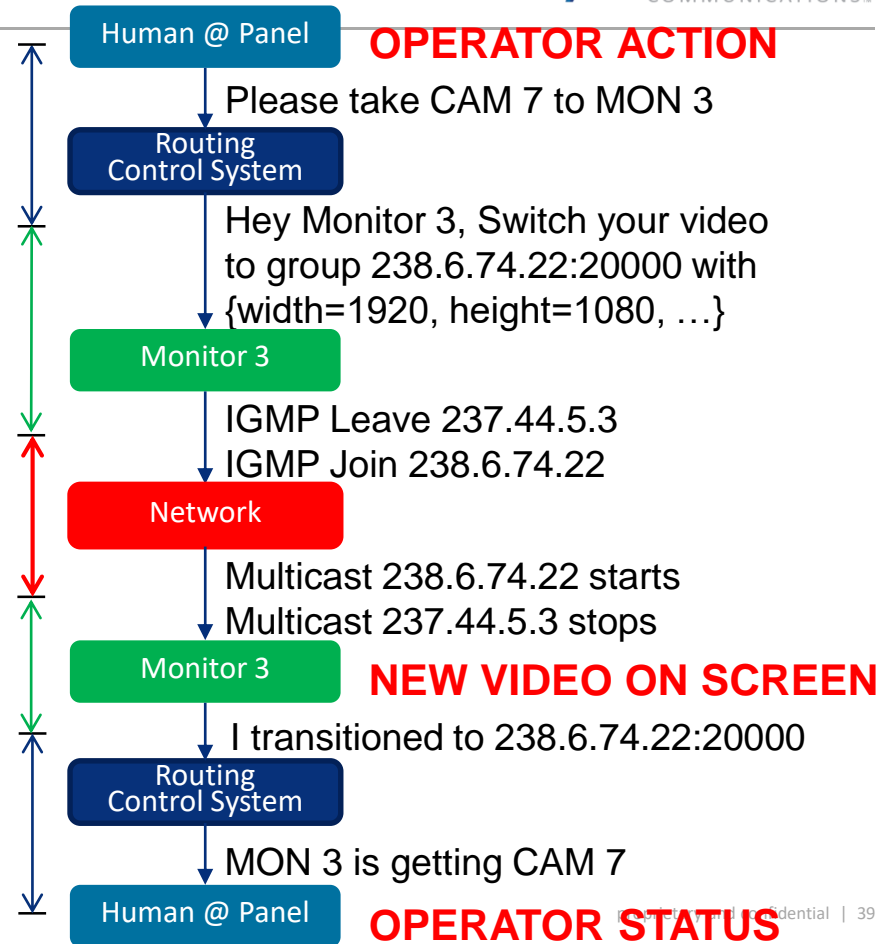


Senders and Receivers: things that make or eat streams

- Register themselves and keep the registration service informed of changes
- ***Respond to IS-05 Connection Management API***

What is involved in Switching a Signal?

- Routing Control Systems
 - Manage GROUPING of element signals
 - Manage NAMES for groups of elementary signals (SOURCES)
 - Manage NAMES for groups of elementary receivers (DESTINATIONS)
- Routing is:
 - Connect SOURCE (group) to a DESTINATION (group)
 - Confirm with a positive status (or not)
- But under the hood a lot is happening



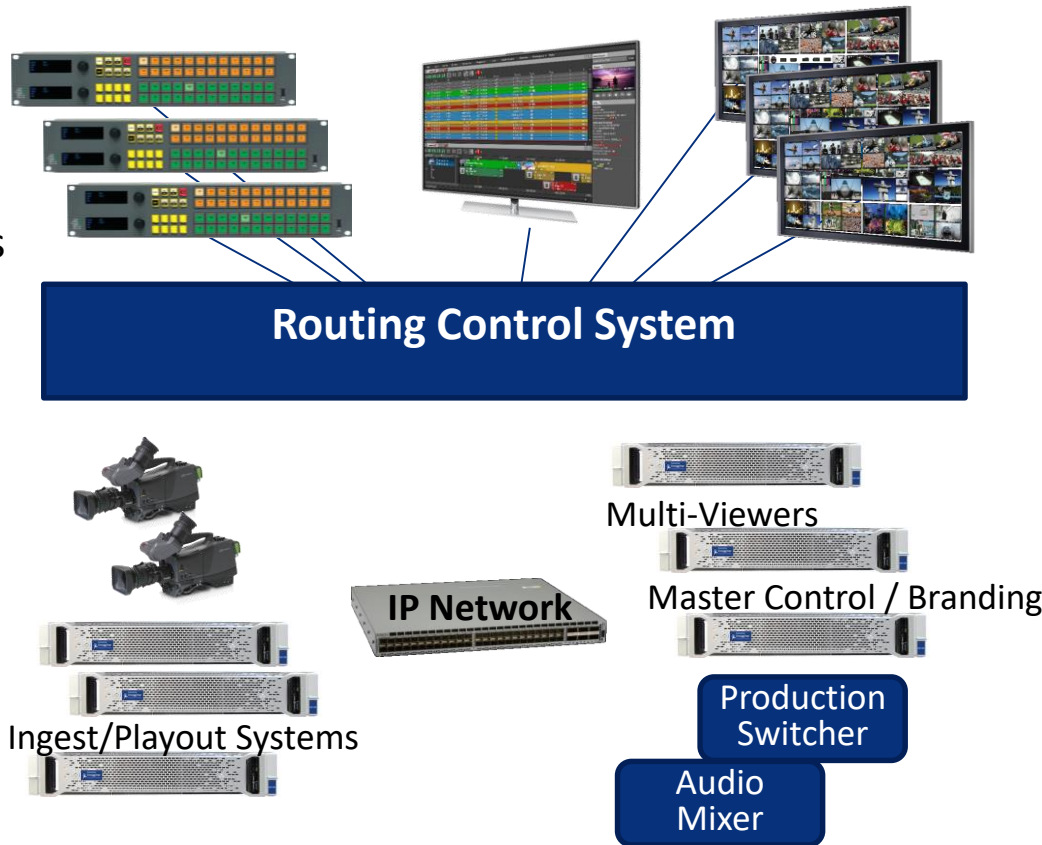
Can ST2110 Systems work without NMOS ?

- Of course they can – and do – today
 - The Control Systems have “drivers” for every different device they control
 - Identifying any required new drivers, and writing them, is part of the project
 - Always a danger of vendors updating a protocol and invalidating the driver

- Any Practical IP-Routing-Control System must handle all of:
 - Non-NMOS devices (any 2110 RX or TX that doesn't support NMOS)
 - Non-Managed streams (streams created from un-managed sources)
 - Integration with Adjacent SDI routing
 - Integration with other parts of the environment through “routing protocols”

The “Routing Environment” view of the facility

- The Routing System is controlled from many sources
 - Human Control Panels
 - Automation Systems
 - Master Control & Production Switchers
 - Multi-viewers
- Many parts of the facility track the status of the router
 - Tally Systems
 - Multi-viewers
 - Under-Mount Displays (UMD)
 - Redundancy Systems
- These Systems integrate using many different (existing) protocols to do it



Routing Control Bridges the Gap

- Operations is based on NAMES
 - CAMERA 1 → MON 5
 - PLAYOUT 3 → MCR 12
 - REMOTE 2 → PSW 7
- IP Networks use Addresses
 - 239.4.8.172:20000 → [...]
- Routing Control Systems use many different protocols up and down
 - AMWA NMOS will be a big help



How “Open” is AMWA NMOS?



Technologies that are already fully implemented in all major OS's and Platforms
Dozens of companies have tested NMOS in lab environments and interop events with success!

THE SPEC *free* - unlike SMPTE



<https://github.com/AMWA-TV/nmos>

OPEN SOURCE IMPLEMENTATIONS



<https://github.com/sony/nmos-cpp>
<https://github.com/Streampunk/ledger>

there are others reported to be WIP

IT SOLVES TWO KEY PROBLEMS WE CARE A LOT ABOUT



REGISTRATION & DISCOVERY (IS-04)

- Finding the parts of the system in a vendor-neutral way
- Cataloguing the streams being generated



MINIMAL END-POINT CONTROL (IS-05)

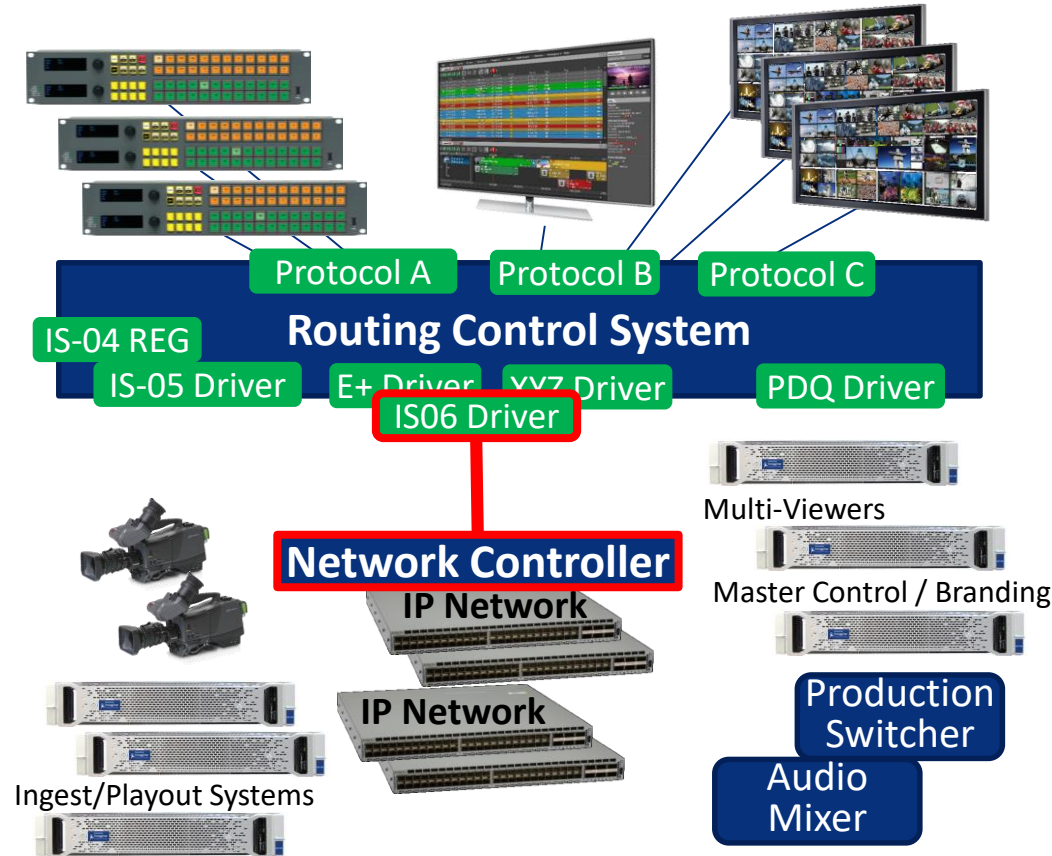
- Telling a Receiver to switch to a new stream
- Reducing the need for proprietary driver development



I Heard Something about ISO6 – what is that?

Routing Control Bridges the Gap

- IS04/05 are built assuming the network will just deliver the streams when they are asked for (maybe using IGMP)
- IS06 allows the Routing Control System to tell the network more exactly about the streams, and to manage bandwidth when needed
 - Blocking Networks
 - Input Policing & QOS





Thank You

John Mailhot