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SMPTE – Enabling Global Education

Exploring the Role of NMOS: Discovery and Connection in an IP World

Peter Brightwell, BBC R&D

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Guest Speaker

Peter Brightwell

Lead Engineer
BBC R&D

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Your Host

Joel E. Welch

Director of Education
SMPTE

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Contents

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- Transition to IP
- AMWA Networked Media Open Specifications
- Approach and model
- Discovery (IS-04)
- Connection (IS-05)
- Implementations
- Network Control (IS-06)
- Current activity

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Transition to IP

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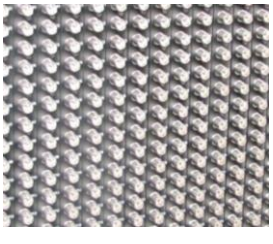

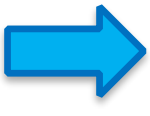

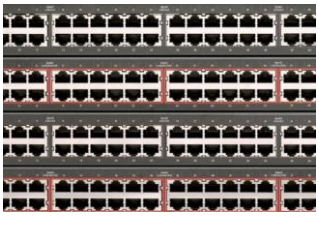

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Reasons to go IP?

- New facilities
- New formats and content types
- New distribution platforms
- Production flexibility
- New tools
- Simplified connectivity
- Joined-up operations
- Dynamic scaling (virtualisation / cloud)
- Cost reduction from COTS components
- Modern development techniques
- New market opportunities

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SDI and friends

AUDIO ES

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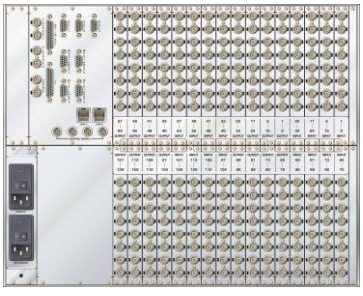
- Trusted solution for this industry
- Fully defined by SMPTE specs
  - ➢ physical, electrical, data packing, format…
- Point-to-point
- Unidirectional
- Specialist infrastructure
  - ➢ Connectivity
  - ➢ Cross-point matrix
  - ➢ Distribution amplifiers



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"IP" and friends

Add IEEE and IETF logos

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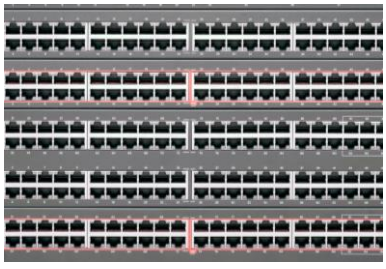
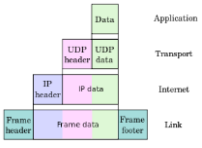
- Trusted solution elsewhere
- Defined by IEEE, IETF, and others
  - Layered specifications
- Flexible topology
- Routable
- Bidirectional
- Unicast or multicast
- Generic infrastructure





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SMPTE ST 2022 IP transport standards

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- ST 2022-1: Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks
- ST 2022-2: Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks
- ST 2022-3: Unidirectional Transport of Variable Bit Rate MPEG-2 Transport Streams on IP Networks
- ST 2022-4: Unidirectional Transport of Non-Piecewise Constant Variable Bit Rate MPEG-2 Streams on IP Networks
- ST 2022-5: Forward Error Correction for Transport of High Bit Rate Media Signals over IP Networks
- ST 2022-6: Transport of High Bit Rate Media Signals over IP Networks
- ST 2022-7: Seamless Protection Switching of SMPTE ST 2022 IP Datagrams

MPEG TS over IP

HBRMT (SDI over IP)

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SMPTE ST 2110
Professional Media over Managed IP Networks

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- Provides elemental approach more suitable for production use
  - Video, audio, ancillary data are separate RTP streams
  - Can be routed individually
  - Receivers just ask for/get what they need
  - Sync using RTP timestamps and PTP reference clock (ST 2059)

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SMPTE ST 2110
Professional Media over Managed IP Networks

- 2110-10: System timing and definitions
- 2110-20: Uncompressed active video
- 2110-21: Traffic shaping and delivery timing for video
- 2110-30: PCM audio
- *2110-31: AES-3 transparent transport*
- 2110-40: Ancillary data

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Transport 

Discovery 

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Timing 

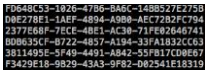
Connection 

Security 

Resilience 

Control 

Automation 

Identity 

Monitoring 

Composition 

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Networked Media Open Specifications

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AMWA NMOS

'…a growing family of specifications … available … at no cost … to support … an open industry framework … developed using Internet standards or Internet-friendly techniques…'

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Principles

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- Learn from how the Internet and Web have grown
- Open approach
- Use rather than invent
- Benefit from modern tooling
- Independent of infrastructure
- Guided by JT-NM RA

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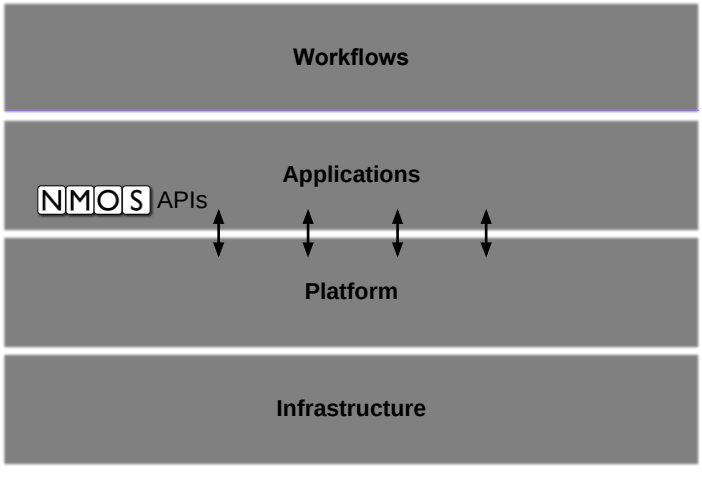
JT-NM Layered architecture

AMWA EBU SMPTE VSF



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AMWA Networked Media Incubator

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- Launched September 2015
- Umbrella group for projects developing specs
- “Hands on” approach to participation
  - Reference implementations
  - Workshops
- ~65 organisations, ~25 active
- 7 workshops so far
  - Plus input to other plugfests, NAB, IBC
  - Next workshop in July (Wuppertal, Germany)

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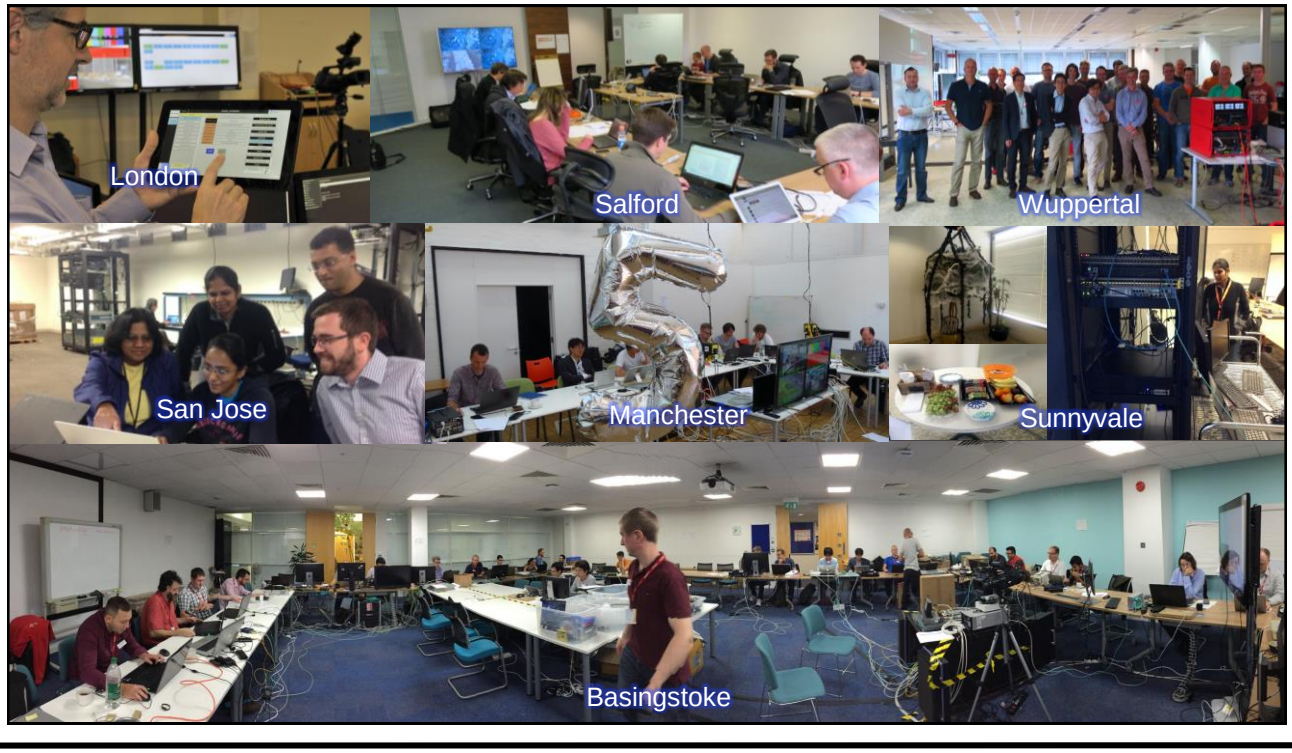
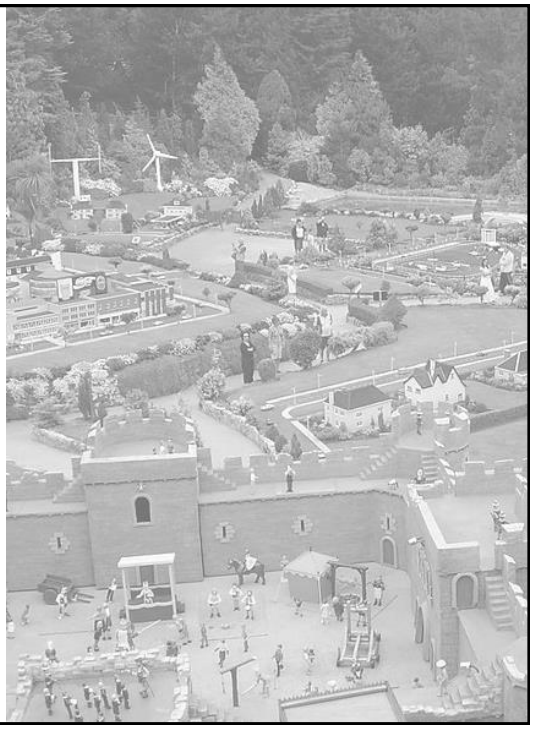


NMOS Model



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NMOS Model

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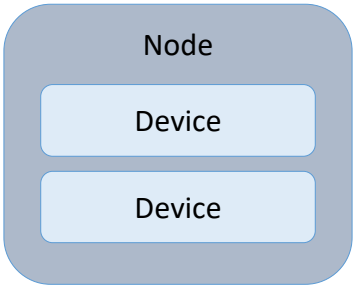
- **Devices** do things
  - Capture, transform, display, etc
- **Nodes** are their ***logical*** hosts
  - Physical or virtual



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NMOS Model

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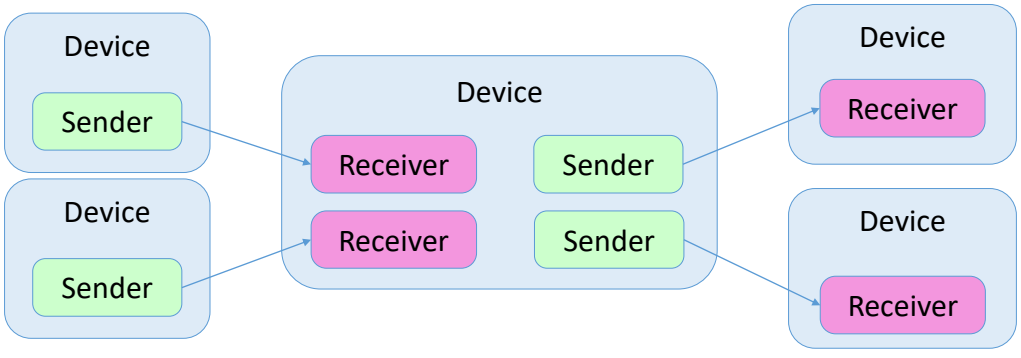
- Devices can have **Senders** and/or **Receivers**
  - These are ***logical*** outputs and inputs



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NMOS Model

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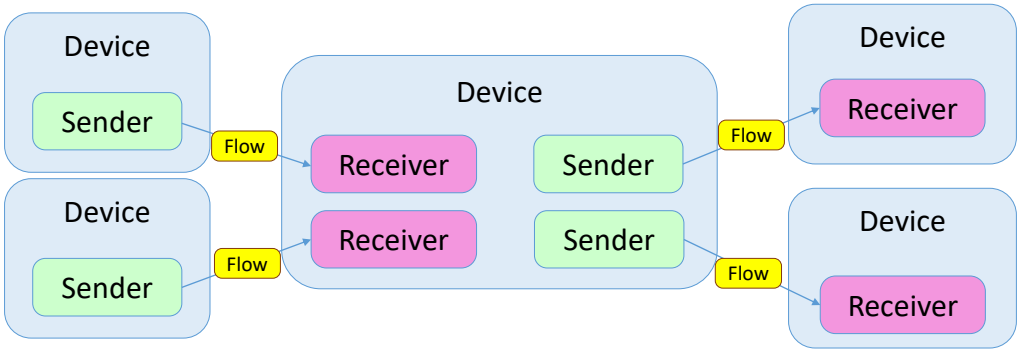
- **Flows** are ***logical*** sequences of video, audio or time-related data that can pass from a Sender to a Receiver



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NMOS Model

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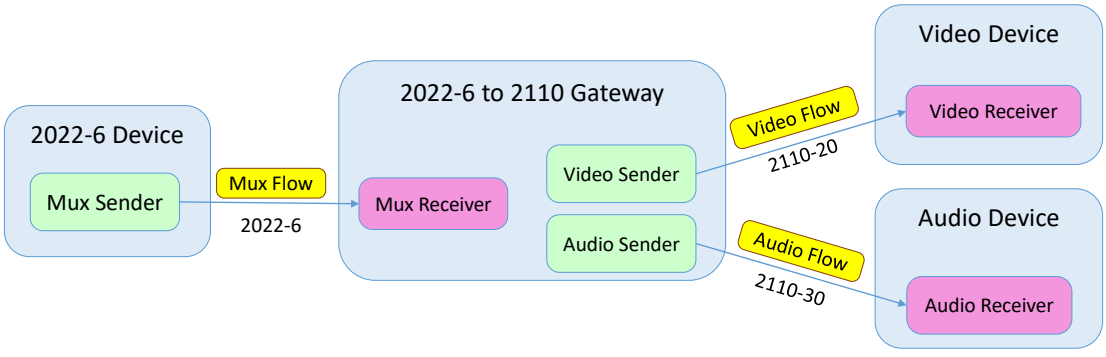
- Flows, Senders and Receivers can be elemental or multiplexed



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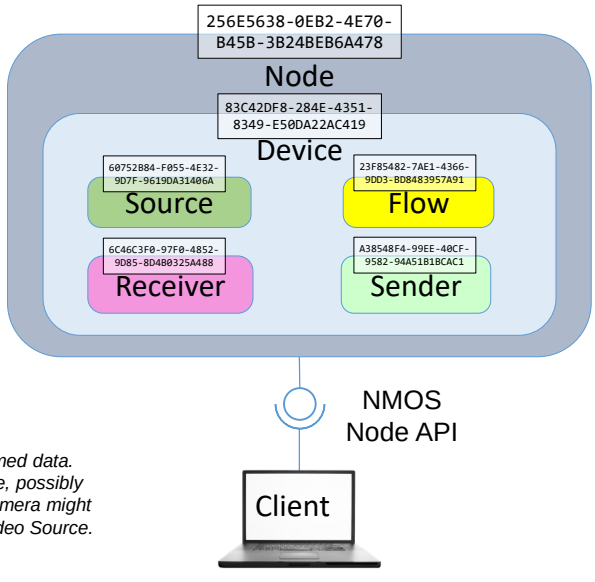
Resources

- Devices, Sources*, Flows, Senders, Receivers… are **Resources**
  - Uniquely identified and addressable parts of a networked system
  - A Node exposes its Resources through its **Node API**
  - NMOS Services act on Resources through other APIs



A Source provides a **logical identifier for media or timed data. There may be multiple Flows associated with a source, possibly using different formats or protocols. For example a camera might produce both full-res and proxy Video Flows for its Video Source.*

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APIs…

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…use web-friendly technologies, including

- HTTP(S)
- WebSockets
- JSON
- UUIDs

```
http(s)://<ip address or hostname>:<port>/x-nmos/<api type>/<api version>/
```

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(Simplified) JSON representation of an NMOS Device resource

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```
{
  "id": "a370d258-69de-4422-860a-ee4cf32ee9f4",
  "node_id": "3a25a674-e6eb-4987-84ad-ef479fe4d527",
  "version": "1441723676:366608283",
  "type": "urn:x-nmos:device:mydevicetype",
  "description": "Multiviewer device",
  "label": "Multiviewer 1",
  "receivers": [
    "863532de-a97d-4597-989a-e79688f2d5f9",
    "632d7e6d-7357-44de-a425-a94fbe94974e",
    "95ef711b-564d-4655-a98b-5b9ccfb419d7",
    "9ee74607-f831-42f5-af08-a614ce0706df"
  ],
  "senders": [],
  ...
}
```

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Discovery

Ensure the parts of a networked system can find each other

➢ *If you can't find it, you can't control it*

- Traditionally manual and static
- Essential for dynamic provisioning
- Various proprietary approaches
- Some build on DNS-SD / uPNP

IS-04 Registration and Query APIs

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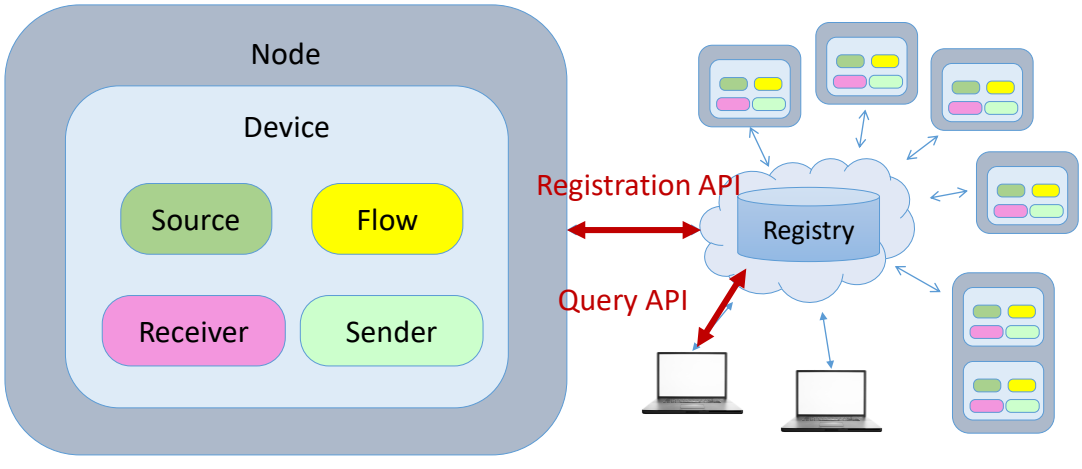

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IS-04 Registration and Query Services

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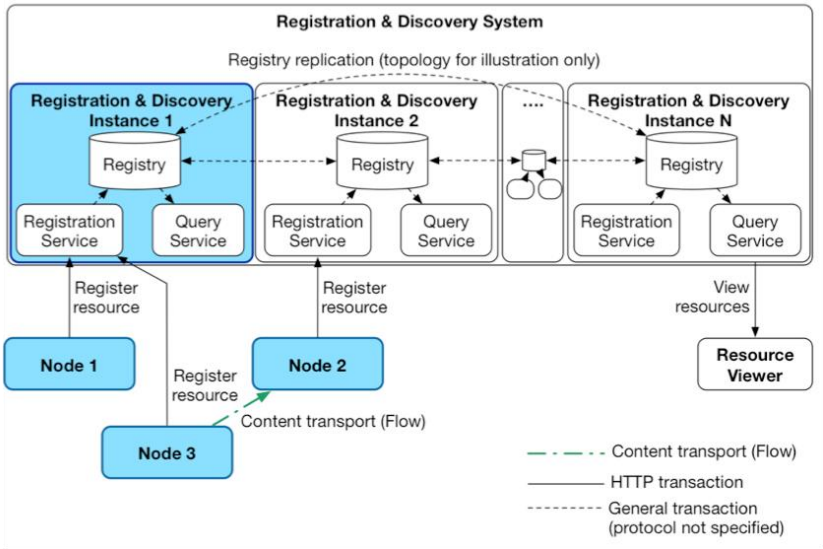

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Finding the IS-04 Services

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- Registration / Query implementations make announcements using DNS-SD
  - Aka Bonjour, Avahi
- Can use multicast or unicast DNS

Finding the endpoints is independent of how the APIs themselves are specified

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IS-04 Registration

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The Node

- Finds Registration endpoint via `_nmos-registration._tcp`
- Registers *itself* with POST to `/resource` (with `"type": "node"`)
  - Response include UUID
- Persists itself by POSTing time to `/health` every 5 seconds
- Registers its Resources with further POSTs to `/resource`
- De-registers resources with DELETE `/resource/<type>/<id>`

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IS-04 Query

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Client can…

- Get a one-off query e.g. HTTP GET `/devices`

Or can…

- Get ongoing updates via a `subscription` resource
  - ➢ which provides a WebSocket URL `ws://…`

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Peer-to-Peer operation

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- It's best to use a registry but sometimes that may not be possible:
  - E.g. for direct connection between camera and monitor for test purposes

- IF a Node doesn't find a `_nmos-registration._tcp`
  OR it can't access the registration service
  THEN
  the Node **announces itself** with `_nmos-node._tcp`
  clients find its resources directly through its Node API

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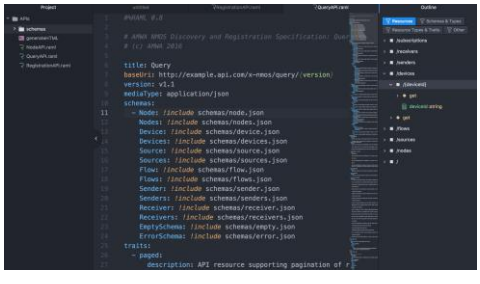
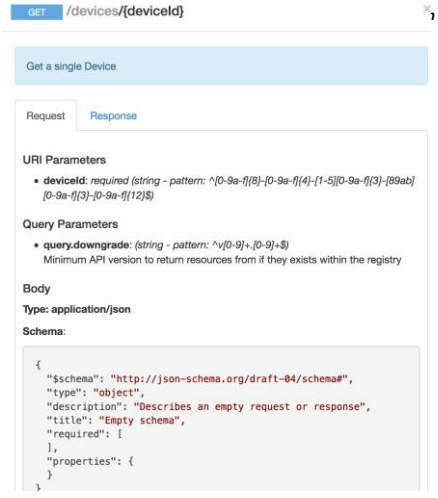
IS-04 Specification

Publicly available at AMWA's GitHub:

- Spec: github.com/AMWA-TV/nmos-discovery-registration
- Docs: amwa-tv.github.io/nmos-discovery-registration/

RAML & JSON Schema





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Semantic versioning of specifications

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Version identifiers included in API and DNS-SD messages

x.y.z

Major version	Minor version	Point version
• Breaking change	• Compatible change	• Fix/documention

IS-04 Registration and Query implementations MUST support requests Nodes using a later minor version

➢ Support for earlier versions is also recommended

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IS-04 versions

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Version	Status	Core functions	Peer-to-peer	Support HTTPS, WSS	Advanced queries	Paged queries	ST 2110 Flow atributes	Multiplexed Flows (ST 2022-6)	Support basic connections	Support IS-05 connections
1.0	AMWA Spec	✓	✓	✗	✗	✗	✗	✗	✓	✗
1.1	AMWA Spec	✓	✓	✓	✓	✓	✓	✓	✓	✗
1.2	Proposed Spec*	✓	✓	✓	✓	✓	✓	✓	(✓)	✓

**AMWA Proposed Specifications are stable and suitable for implementation.*
IS-04 v1.2 is expected to be raised to Specification in Summer 2018.

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Connection

Traditionally: cross-point routers with old control protocols e.g. SW-P-08

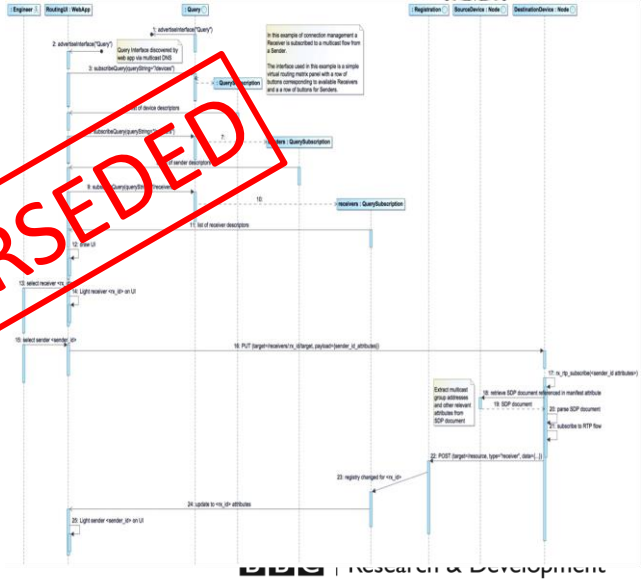
ST 2110 specifies stream description with SDP but does not specify connection mechanism

Various vendor-specific approaches available
- Integrations with broadcast control systems
- SDN controllers
- IGMP-based

Basic connections: IS-04 v1.0/v1.1

- Sender resource includes link to description of its Flow(s)
  - ➢E.g. a SDP file
- Receiver uses this info to access the Flow
  - ➢E.g. subscribe to multicast group for RTP stream
- Limited functionality and extensibilty
- Superseded by IS-05

SUPERSEDED



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IS-05 Device Connection Management API

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- Provides a *general* mechanism for connecting senders and receivers
  - Extensible beyond RTP to other protocols
  - Supports both multicast and unicast
  - Suitable for use with or without network (SDN) controller
  - Supports seamless protection e.g. ST 2022-7
  - Supports signalling of FEC info e.g. ST 2022-5
  - Provide feedback on success/failure
  - Supports “bulk” connections
  - Supports immediate or stage-and-activated connections
- Best used in conjunction with IS-04 (v1.2 or later)
  - Documentation provided assumes this is the case!

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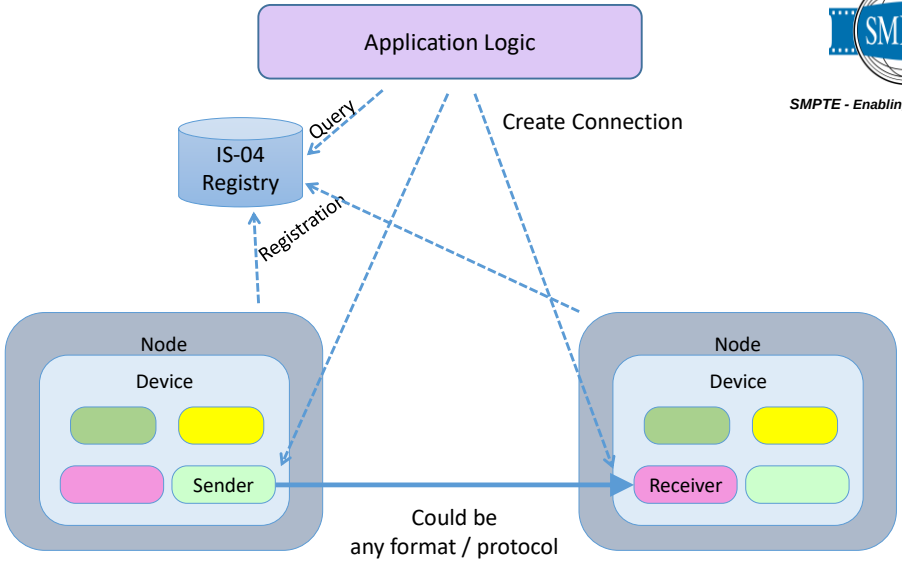

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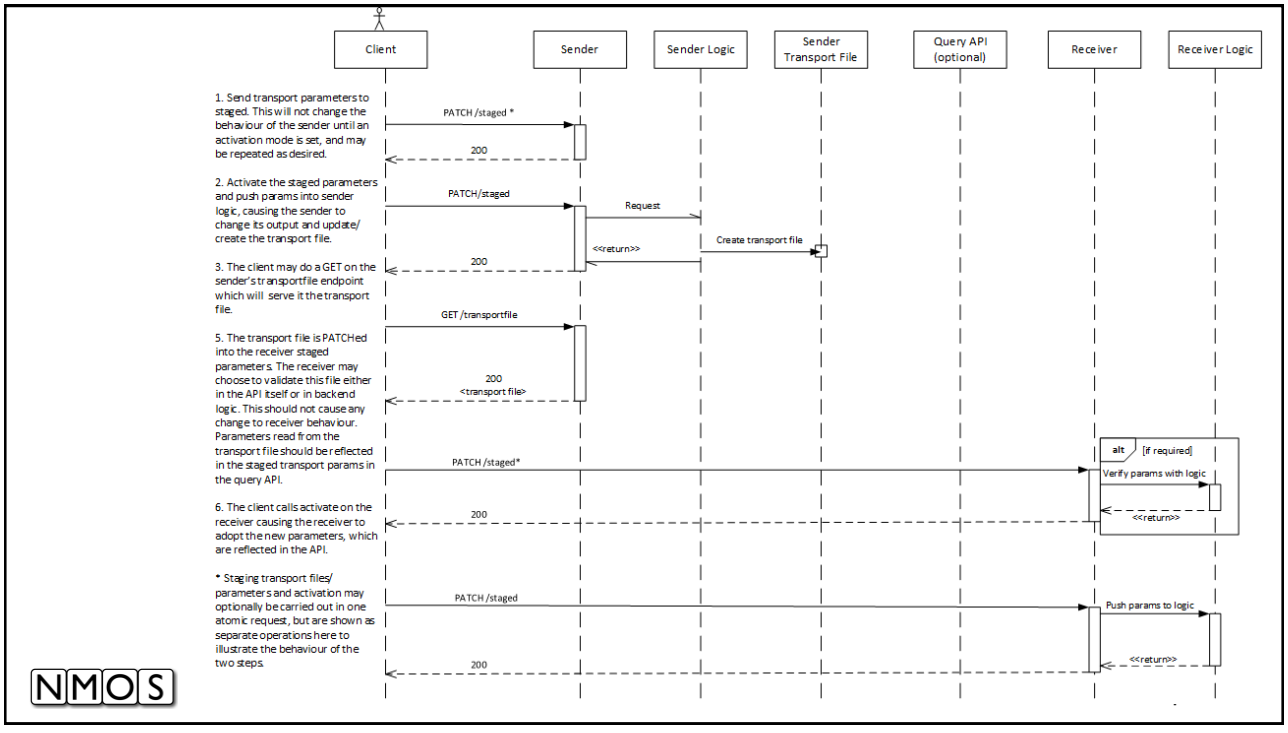

Connection control on NMOS Device

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```
...
"controls": [
  {
    "type": "urn:x-nmos:control:sr-ctrl/v1.0",
    "href": "http://192.168.10.3/x-nmos/connection/v1.0/"
  }
]
...
```

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Example with multicast RTP

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Staged transport parameters

```
transport_params:[
    {
        "source_ip": "172.29.226.24",
        "multicast_ip": "232.21.21.133",
        "interface_ip": "auto",
        "destination_port": 5000,
        "rtp_enabled": true
    }
]
```

Sender's `/transportfile`

```
v=0
o=- 1497010742 1497010742 IN IP4 172.29.226.24
s=SDP Example
t=2873397496 2873404696
m=video 5000 RTP/AVP 103
c=IN IP4 232.21.21.133/32
a=source-filter:incl IN IP4 232.21.21.133 172.29.226.24
a=rtpmap:103 raw/90000
```

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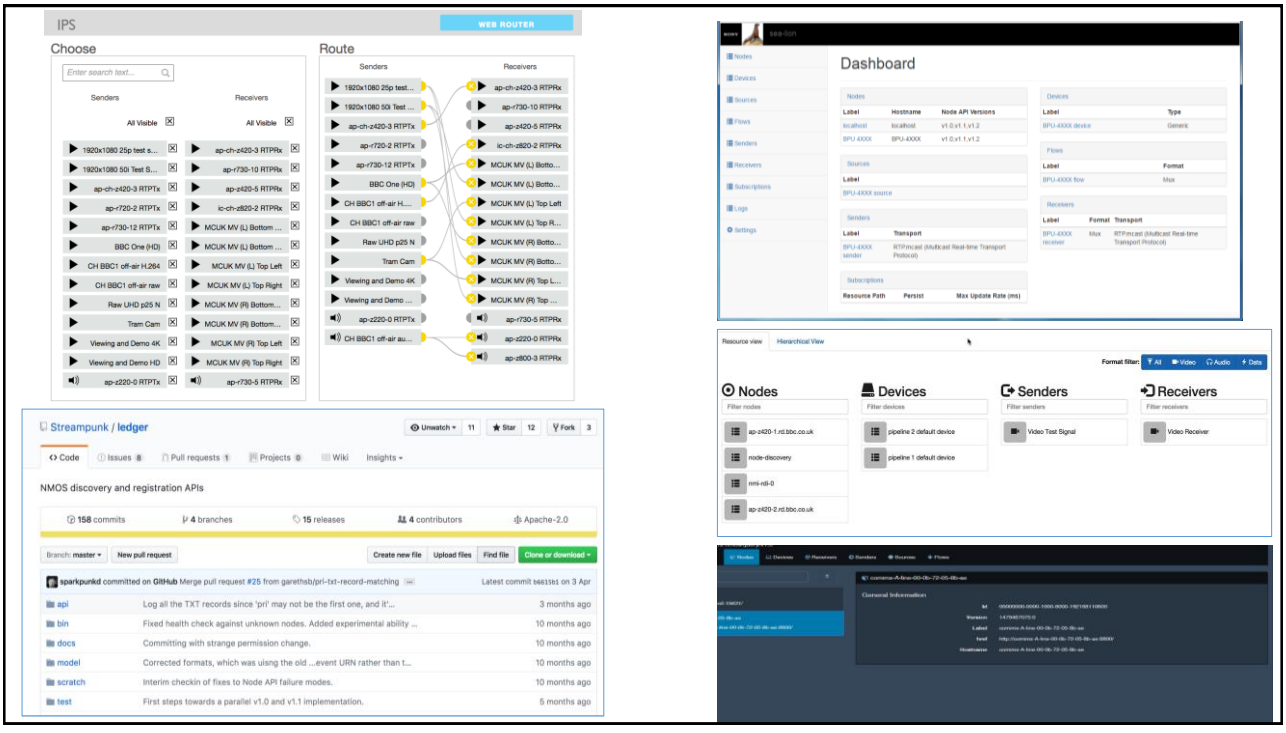
IS-04/05 Open source / Free Implementations

Creator	Language	License	URL	Description
BBC R&D	Python	Apache 2.0	https://github.com/bbc/nmos-joint-ri	IS-04 and IS-05 implementation used as reference in AMWA workshops
Riedel Comms	(executable)	EULA	https://myriedel.riedel.net/de/	Connection manager and resource explorer
Streampunk Media	Javascript (NodeJS)	Apache 2.0	https://github.com/Streampunk/ledger	IS-04 v1.0 APIs
Streampunk Media	Javascript (NodeJS)	Apache 2.0	https://github.com/Streampunk/zenmos	IS-04 automated testing
Sony	C++	Apache 2.0	https://github.com/sony/nmos-cpp	IS-04 and IS-05 registry, APIs
Sony	Javascript	Apache 2.0	https://github.com/sony/nmos-js	IS-04 and IS-05 partial client



IBC 2017: IP Showcase

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Multiple layers of control

Project is investigating different topologies for adoption of IS-04 and IS-05

- Atos BNCS
- GV Convergent
- Cisco DCNM
- Network Hardware

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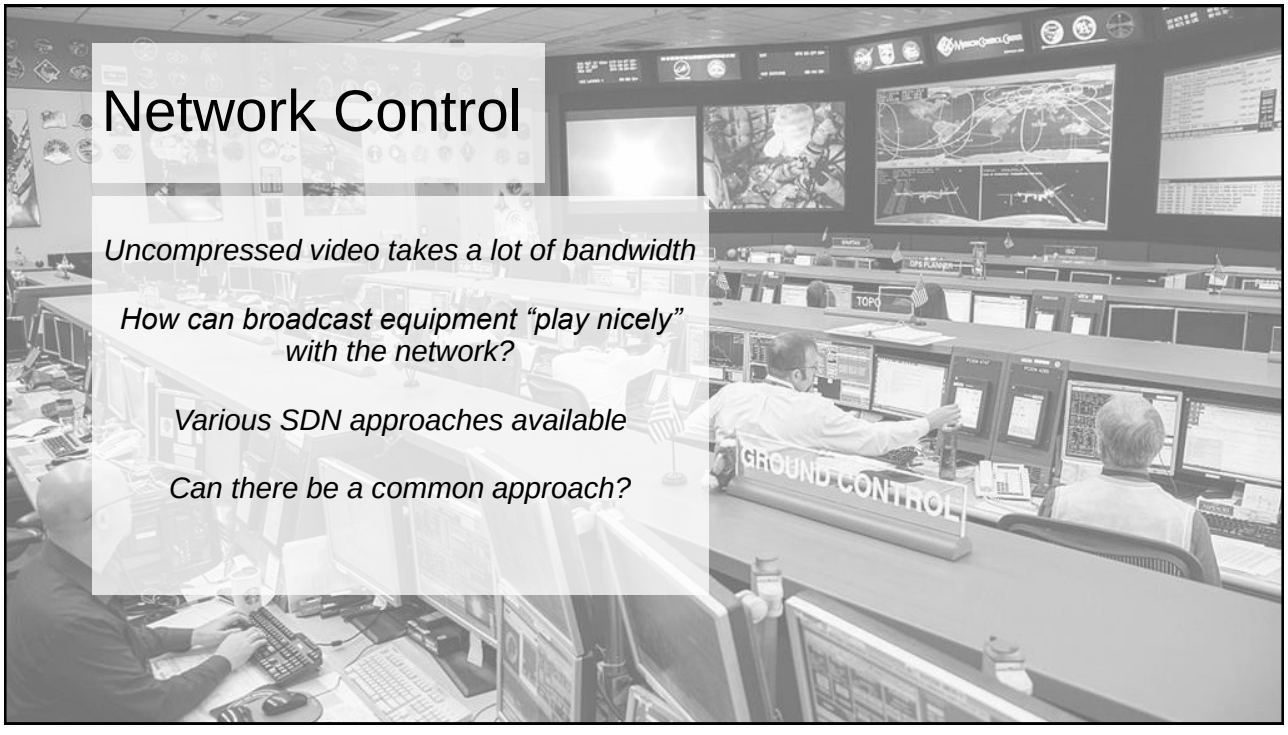

Network Control

Uncompressed video takes a lot of bandwidth

How can broadcast equipment "play nicely" with the network?

Various SDN approaches available

Can there be a common approach?

IS-06 Network Control API

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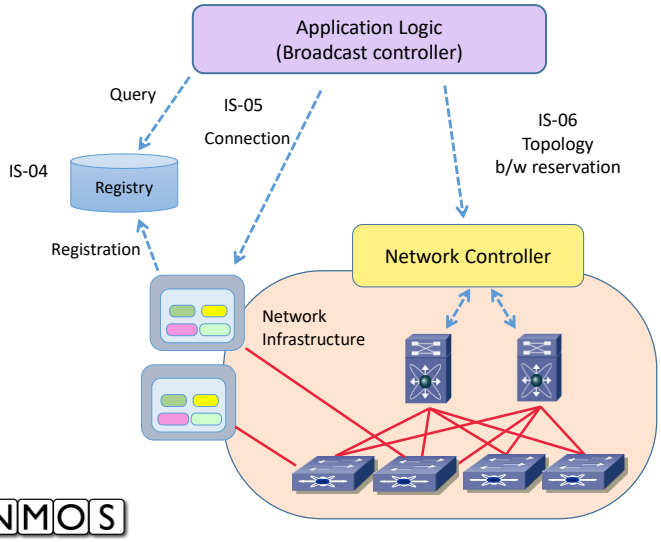


```
16 lines (15 sloc)  288 Bytes
{
  "id": "1650fbcc-d8a0-4bd2-8e61-c7abb38d78d2",
  "flow_label": "New video network-flow",
  "senders": [
    {
      "label": "Camera 1",
      "ip_address": "192.168.16.24"
    }
  ],
  "receivers": [
  ],
  "bandwidth": 2000000,
  "dscp": "AF11",
  "multicast_address": "227.1.1.1"
}
```

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IS-06 Network Control API

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- Discover network & endpoint topology
  - Including “endpoint matching” of IS-04 discovery
- Provide API support for low-level network functionality
  - authorization of senders, receivers and flows*
  - create, modify and delete flows
  - reserving network resource
  - establishing bandwidth limits
  - signalling flow priority

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IS-06 Network Control API

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- Currently Work In Progress
  - Release of v1.0 expected soon

https://github.com/AMWA-TV/nmos-network-control/blob/Phase-2-updates/APIs/NetworkControlAPI.raml

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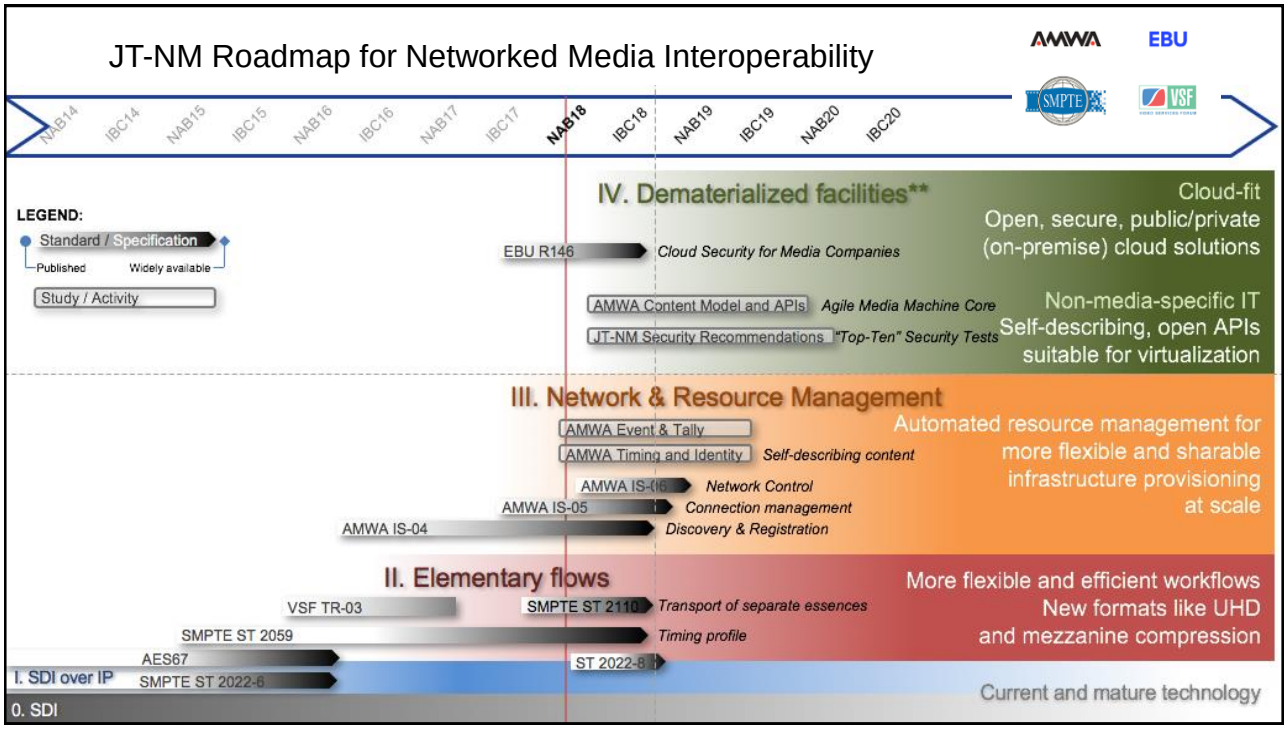

New work

NMOS

NMOS Scalability

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- Simulate network with thousands of Nodes
- Test registration and query performance
- Test recovery after network failures

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NMOS Resource Grouping

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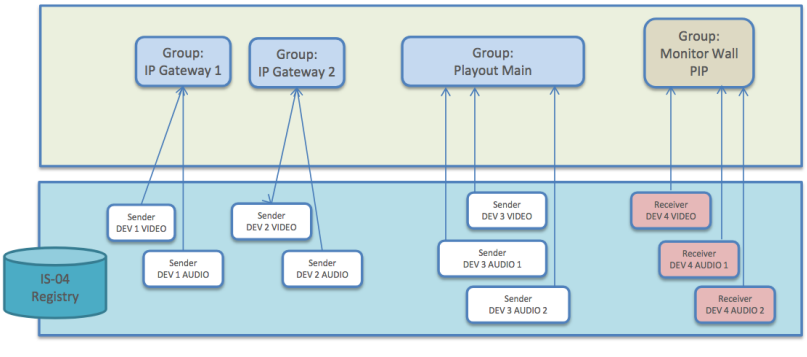
- IS-04/05 do not currently define way of representing related Resources together
- Current work: represent “natural groups” created by Device functionality
- Further work: represent human- or automation-created groups



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Identity & Timing

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- "Re-versioning" workflows becoming more commonplace and sophisticated
- Bring together parts as and when they are needed
- Requires robust approach to identifying media and data, and the time relationships between them
- ST 2110 only provides link-based timestamps
- AMWA model will provide a basis for mapping identity and timing information into specifications

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Event & Tally

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- Protocol for signalling of time-critical events over networks
  - ➢local or wide-area
- Will use NMOS Resource model and Identity & Timing model

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Security

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- Work starting on recommendations secure use of NMOS APIs
- Working with EBU on “top ten” security tests for workshops

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Beyond the facility

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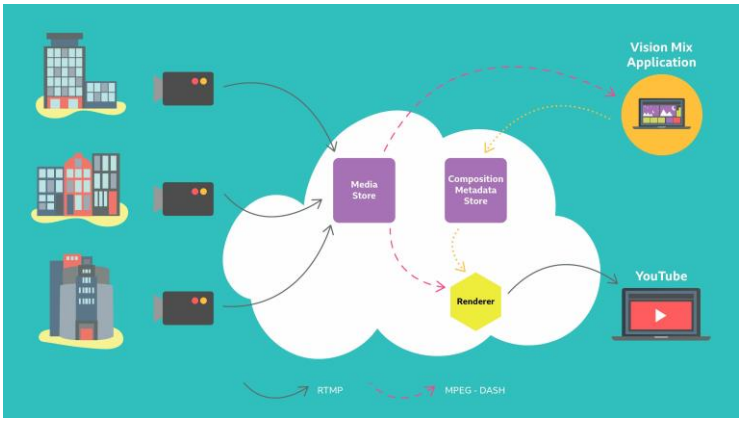
- NMOS Resources still make sense in the WAN/Cloud
- AMWA “Agile Media Machine” initiative



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Summary

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- ST 2110 and 2059 provide IP foundations within the facility
- Further “control plane” work is needed
- NMOS IS-04 provides modern approach for discovering resources
- IS-05 and -06 provide control mechanism for connections
- “Open-source” approach to NMOS specifications and versions
- Further work planned to build “up and out”

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More Information

AMWA

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- amwa.tv: AMWA’s official site
- nmos.tv: general information
- amwa-tv.github.io/nmos: technical documentation
  - amwa-tv.github.io/nmos/branches/master/NMOS%20Technical%20Overview.htm
  - amwa-tv.github.io/nmos/branches/master/FAQs.html
  - amwa-tv.github.io/nmos/branches/master/Implementations.html
- github.com/AMWA-TV/nmos*: specifications
  - github.com/AMWA-TV/nmos-discovery-registration (IS-04)
  - github.com/AMWA-TV/nmos-device-connection-management (IS-05)
  - github.com/AMWA-TV/nmos-network-control (IS-06)

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Questions?

Peter Brightwell

Lead Engineer
BBC R&D

Joel E. Welch

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