



NMOS Evolved - Beyond Routing Control

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Outline

- **What is NMOS?**
- **Required Components**
 - IS-04 (Registration & Discovery)
 - IS-05 (Connection Management)
 - IS-07 (Event & Tally)
 - IS-08 (Audio Mapping)
 - IS-09 (System Discovery)
- **Optional Components**
 - BCP-002 (Grouping/Naming)
 - BCP-006 (NMOS for JPEG-XS)
 - BCP-003/IS-10 (Security)
- **Under Development**
 - IS-11 (Stream Compatibility)
 - BCP-005-01 (EDID)
 - IS-12 (Operational Control)
 - MS-05-01/02/03 Modeling
 - Media Node Configuration
 - New Codecs
- **Why Should I Care?**
- **How is it Going?**
- **How Can I Try It?**



What is NMOS?

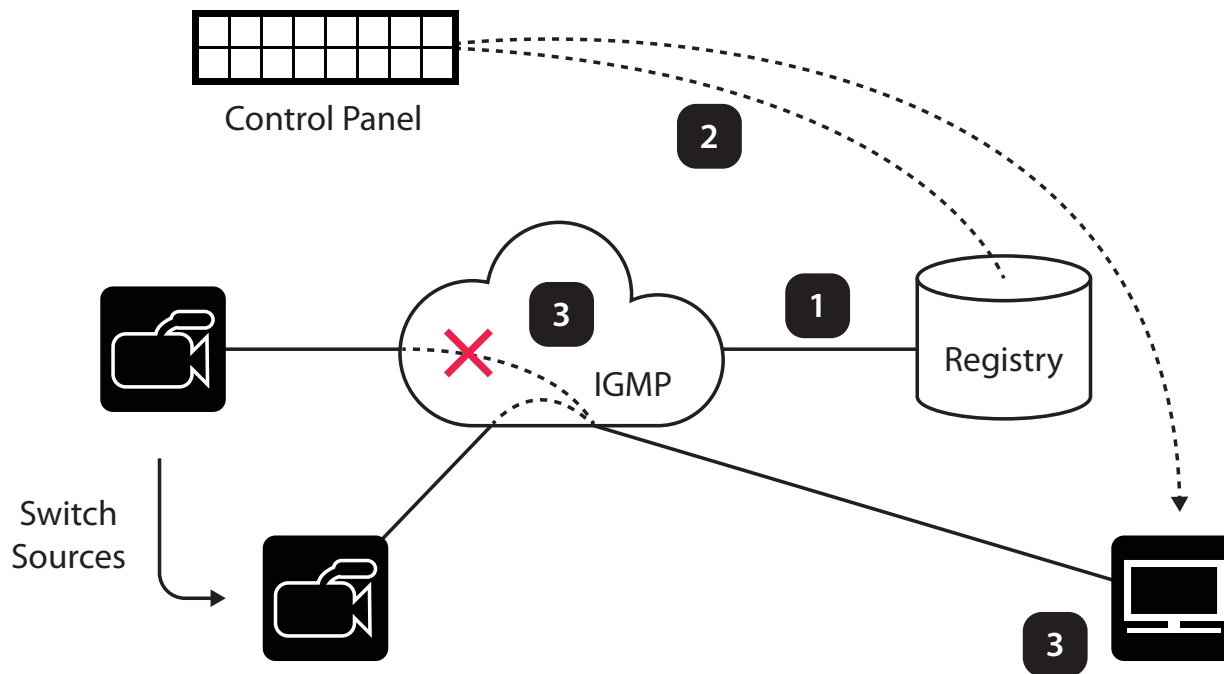
- NMOS is the Networked Media Open Specification, developed by the Advanced Media Workflow Association (AMWA)
- Delivered in the form of an open specification on the AMWA website
- Enables ST 2110 Controllers and Devices to seamlessly **interoperate** across multiple vendors
- Brings **Plug & Play** and **Push-Button** simplicity to Video over IP Routing



How does NMOS Work?



IS-04/05 System Diagram



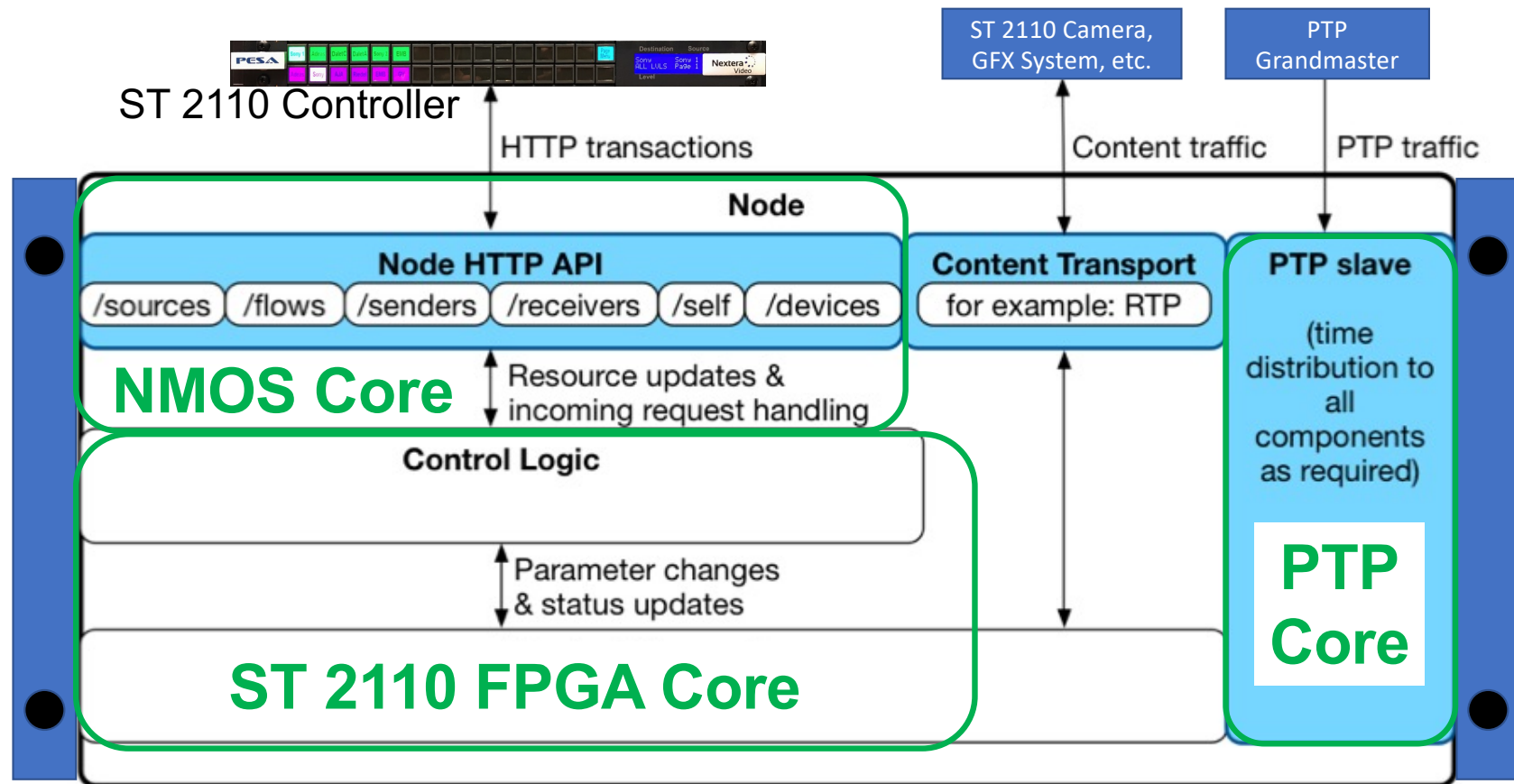
- 1 Sources automatically register with RDS
- 2 Control Panel gets list of devices from RDS
- 3 Upon button press, control system commands receiver to join the new multicast stream and leave the previous one

How is NMOS Accessed?



- Through a set of Application Program Interfaces (APIs)
 - In Plain English:
 - **http PUT/GET** => *http://<IP Address>/x-nmos /<API Name>/...*
- Examples (Viewable in Web Browser):
 - <http://192.168.10.2/x-nmos/node/v1.3/self>
 - <http://192.168.10.2/x-nmos/query/v1.3/senders>
 - <http://192.168.10.2/x-nmos/channelmapping/v1.0/map>
 - <http://192.168.10.2/x-nmos/channelmapping/v1.0/outputs>
 - <http://192.168.10.2/x-nmos/auth/v1.0/certs>

What is a Typical Implementation?



NMOS

Required
Components

EBU Mandate

EBU

OPERATING EUROVISION AND EURORADIO

Tech 3371

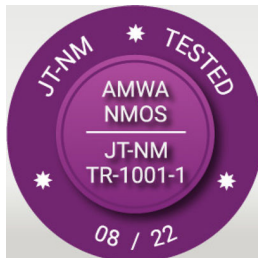
THE TECHNOLOGY PYRAMID FOR MEDIA NODES

MINIMUM USER REQUIREMENTS TO BUILD AND
MANAGE AN IP-BASED MEDIA FACILITY USING
OPEN STANDARDS & SPECIFICATIONS

Version 2.0

Geneva
July 2020

- III Operational Control**
 - III.1 Discovery and Registration: AMWA IS-04
 - III.2 Connection Management: AMWA IS-05
 - III.3 Device Control: Open Methods and AMWA IS-07
 - III.4 Audio Channel Mapping: AMWA IS-08
 - III.5 Topology discovery: LLDP
- IV Configuration and Monitoring**
 - IV.1 IP assignment and low-level configuration: DHCP, AMWA IS-09



➤ Validated via the “JT-NM Tested” Program

IS-04 (Registration & Discovery)



Consists of 3 API's
(Application Programming Interfaces)

Node API

Registration
API

Query API

<http://192.168.10.2/x-nmos/query/v1.3/senders>

Node
[Camera, Monitor]

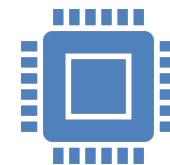
Registry
[PC running RDS SW or built into switch]

- Contains a database of all NMOS devices on the network

IS-05 (Connection Management)



- IS-05 is an API which provides the means to create a connection between Senders and Receivers
- Enables switching through “activations”
- Activations can be immediate, relative, or absolute

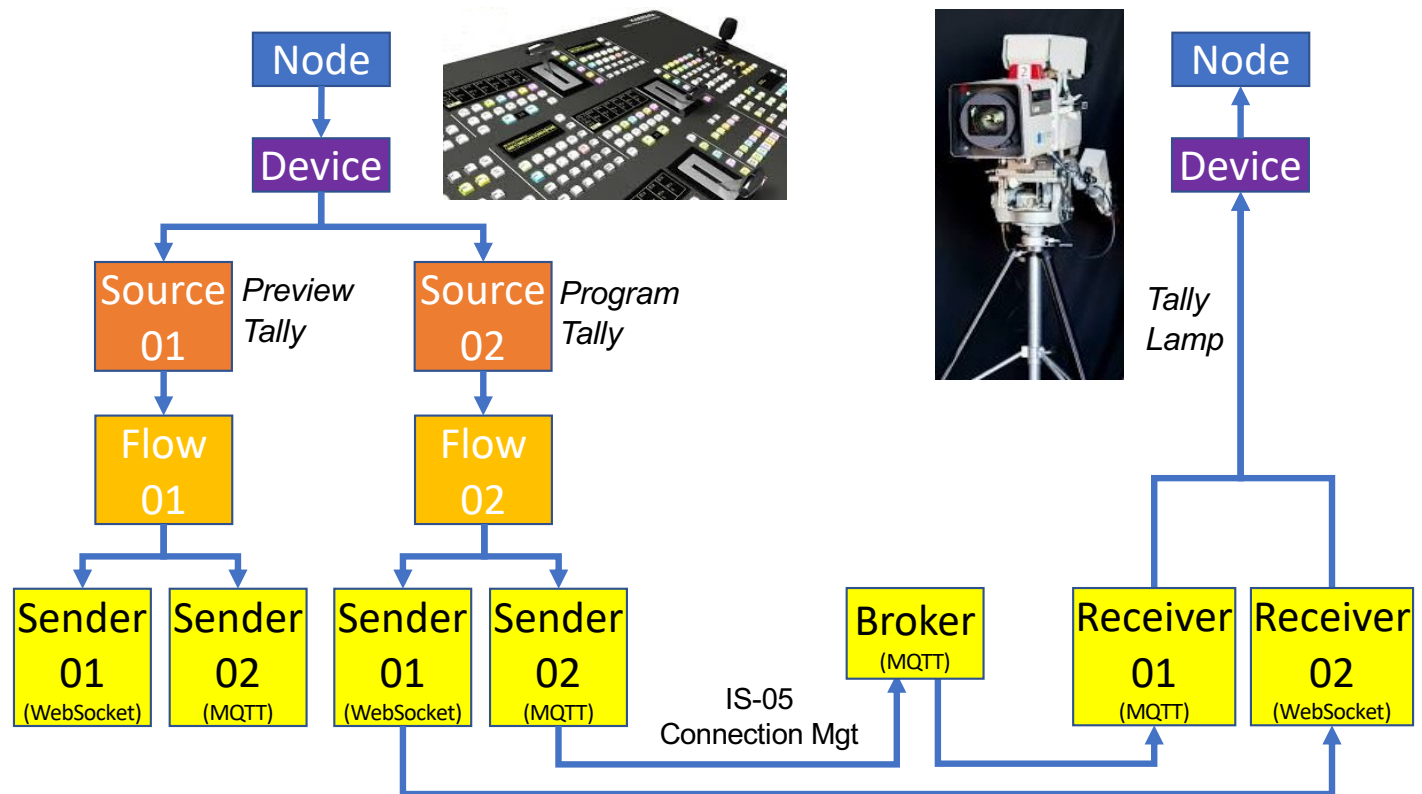


- Now
- In 5 seconds
- At 12:00 PM

IS-07 Event & Tally



- “GPIO over IP”
- Tally
- Dynamic Text (UMD)
- Etc.



IS-08 (Audio Mapping)



Provides SDI-router-like capabilities

- Combine individual channels from multiple sources into any output

Audio routing/shuffling facility with 4 APIs:

Inputs

Outputs

Map

I/O

- value is the
this specific
(receiver)
grouping
the device

IS-08 Demo Participants

 Adeas

 ARISTA

 Atos

 Imagine

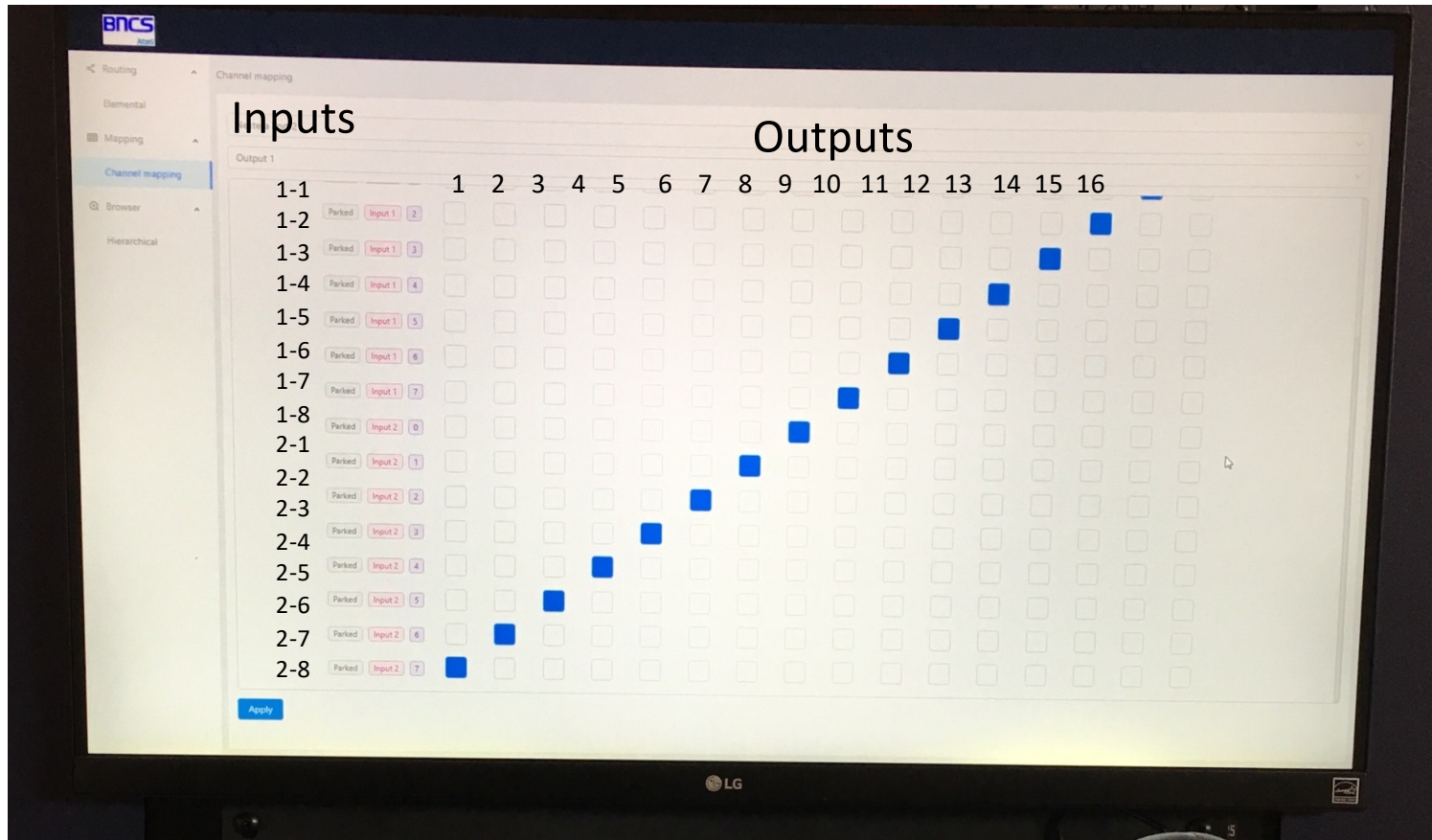
 Nextera
Video

 RIEDEL

 Trektronix



IS-08 Mapping Controls



IS-08 Demo – Audio Remapping



IS-09 (System Resource)



- Provides a global resource within the ST 2110 Environment
- Located using DNS Service Discovery (DNS-SD)
- Read by Media Nodes on Startup to determine:
 - System ID (assigned randomly at each facility)
 - Protocol (http or https)
 - NMOS API versions supported
 - PTP domain and announce interval
 - RDS Heartbeat Interval
 - Syslog hostname & port
- Implementation Guide
 - <https://specs.amwa.tv/info-004/>



*IS-09
DNS-SD
Server*

NMOS

Optional
Components

BCP-002-01 (Grouping)

- Best practices for grouping NMOS resources
- Uses the 'tags' resource in IS-04 in order to achieve 'natural grouping' of Senders and Receivers
- Ex) Video, Audio, and ANC from a specific device
- Uses “grouphint” tag & roles

Grouping Example



Playout server sender with 1 video & 2 audio flows

Video 1 group:
“Playout
Master”

Audio 1 group:
“Playout
Master”

Audio 2 group:
“Playout
Master”

Video 1 role:
“Primary”

Audio 1 role:
“Audio 1 –
2ch”

Audio 2 role:
“Audio 2 –
5.1ch”

BCP-002-02 (Asset Distinguishing Information)

- Node and Device resources MUST include exactly one value for each of the following tags, and the combination MUST be unique:
 - **Manufacturer** (e.g.: Vendor A)
 - **Product Name** (e.g.: Model A)
 - **Instance Identifier** (e.g.: 12345ABC)

- Device resources MUST also include at least one value for the following tag which MUST reflect the current state:
 - **Function** (e.g.: Decoder)

BCP-006 (NMOS for JPEG-XS)



- Enables ProAV applications to use NMOS
 - To be supplemented by VSF TR-10-8 (NMOS for IPMX)
- Refers to VSF TR-08 (Transport of JPEG-XS Video in ST 2110-22)
- Leverages IS-04 & IS-05
- Uses BCP-002-01 Natural Grouping
- Uses media_type ***video/jxsv***
- Specifies updates to Session Description Protocol (SDP) file

Goals:

Confidentiality - Data passing between client and the APIs is unreadable to third parties.

Identification - The client can check whether the API it is interacting with is owned by a trusted party.

Integrity - It must be clear if data travelling to or from the API been tampered with.

Authentication - The client can check if packets actually came from the API it is interacting with, and vice versa.

Control Security



BCP-003-01

Uses Transport Layer Security (TLS) to encrypt communications between NMOS controllers & devices (https)



BCP-003-02

Client authorization and user management in NMOS systems



BCP-003-03

Certificate Provisioning using Enrollment over Secure Transport (EST)

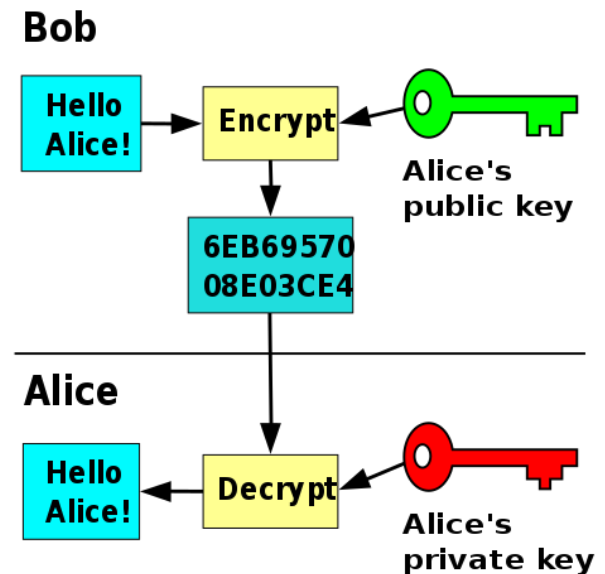
IS-10 (Authorization)

- Accompanies the [BCP-003-02](#) specification to restrict what users are authorized to change in an NMOS system
- Based on JSON Web Tokens and OAuth 2.0

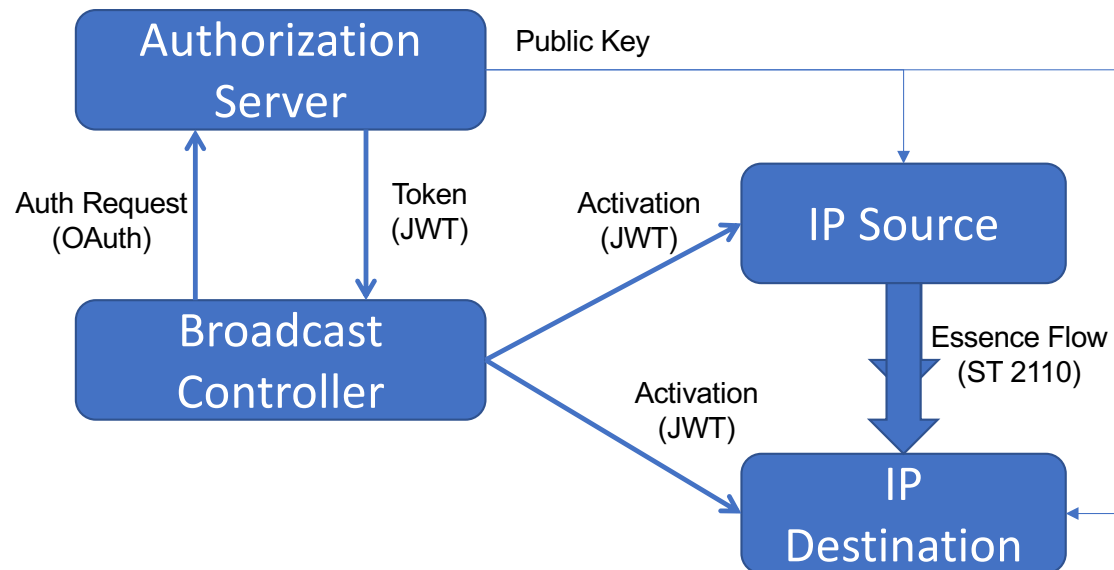
Public Key Infrastructure (PKI)



- A set of roles, policies, and procedures needed to create, manage, distribute, use, store & revoke digital certificates and manage public-key encryption



NMOS Security Example



Security Technologies - Acronyms



PKI

(Key Exchange)



HTTPS

(http over TLS)

Connection Security
(Encrypted Control
Interface)



REST

**(HTTPS PUT &
GET)**



JSON

**(Key-Value
Parameter sets)**



OAuth 2.0

**(Open
Authorization)**

Clients Authenticate
with Authentication
Server



JWT

**(JSON Web
Token)**

Client Authorization
(issue access tokens)
– RSA with SHA-256

NMOS Cipher Suite



- TLS ECDHE ECDSA WITH AES 128 GCM SHA256
- TLS ECDHE ECDSA WITH AES 256 GCM SHA384
- TLS ECDHE ECDSA WITH AES 128 CBC SHA256
- TLS ECDHE ECDSA WITH AES 256 CBC SHA384
- TLS ECDHE RSA WITH AES 128 GCM SHA256
- TLS ECDHE RSA WITH AES 256 GCM SHA384
- TLS DHE RSA WITH AES 128 GCM SHA256
- TLS DHE RSA WITH AES 256 GCM SHA384
- TLS ECDHE RSA WITH AES 128 CBC SHA256
- TLS ECDHE RSA WITH AES 256 CBC SHA384
- TLS DHE RSA WITH AES 128 CBC SHA256
- TLS DHE RSA WITH AES 256 CBC SHA256
- TLS ECDHE ECDSA WITH AES 128 CCM 8

Johnny Quest Decoder Ring:

TLS = Transport Layer Security

ECDHE = Elliptic Curve Diffie-Hellman Ephemeral KE

ECDSA = Elliptic Curve Digital Signature Algorithm

AES = Advanced Encryption Standard (#bits)

GCM = Galois/Counter Mode

CBC = Cipher Block Chaining (XOR)

SHA = Secure Hash Algorithm (#bits)

CCM = Counter with CBC-MAC (Cyber Block Chaining Message Authentication Code)

←===== Minimum Requirement

The Evolution of NMOS (Under Development)

IS-11 (Stream Compatibility Management)



- Formerly EDID (Extended Display Identification Data)
- State of a Sender can be tuned to be compatible with a corresponding Receiver or many compatible Receivers
- Example:
 - Sender & Receiver support 2160p59 or 1080p59
 - Sender set to 2160p59
 - Second receiver subscribes but only supports 1080p59
 - Sender TX Format is adjusted to 1080p59
- See BCP-004-01 Receiver Capabilities
 - Senders & Receivers advertise their constraints
 - Video Format: Frame Size, Frame Rate, Color Sampling, SDR/HDR, etc.
 - Audio Format: # Channels, Packet Time, Sample Rate, etc.
- See BCP-005-01 NMOS EDID to Receiver Capabilities Mapping

IS-12 (Operational Control)

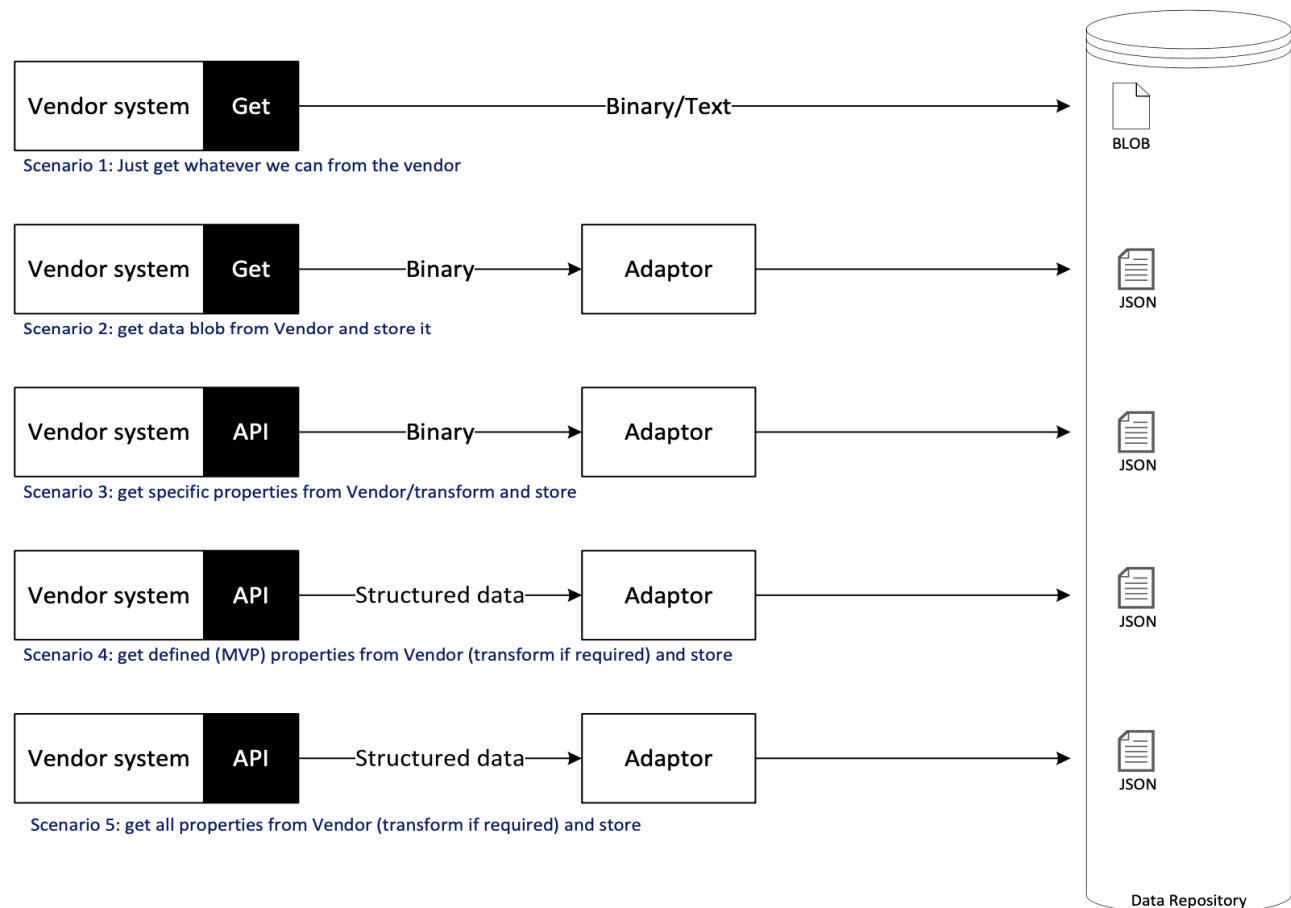


- Goal is to create a Universal Control Protocol
- Exposes a common, but vendor-extensible API
- Replacement for:
 - SNMP – Too difficult to add standard MIBs
 - OpenConfig – Scope too narrow
 - Ember+ – Great approach, but not 100% open
- Device Model provides a structured view of the controls and statuses of the parameters inside the device
- Uses WebSockets & JSON
- References MS-005-01/02/03 Frameworks/Block Specs
- Next steps are to publish standardized blocks and functions
 - Can be customized, would require control system driver

Media Node Configuration



- Ability to download and archive the complete configuration of a device (and a system)
- Goal is to have Readable/Editable configurations
- Crucial with thousands of devices
- Functionality likely will be added to MS-05



New Codecs & Transports




The following activity groups are just beginning:

- H.264 (AVC) – BCP-006-02 draft on GitHub
- H.265 (HEVC) – BCP-006-03 draft on GitHub
- NDI
- MPEG-TS

Why Should I Care?



- During system provisioning, manually entering a sea of cryptic configuration options such as IP Addresses, Ports, PTP Parameters, etc. is *time consuming, costly, and error prone*
- **Plug and Play is Fun!** A red circular icon with a black border and the word 'easy' in white lowercase letters.
- Most all new facility build tenders are specifying NMOS
- Most Control System Providers have fully embraced NMOS
 - Need to encourage the 1 or 2 who still have not...

How is it going?



- Early facilities adopting NMOS control had some issues (teething pains)
 - Not all devices supported NMOS
 - Some new NMOS devices didn't get JT-NM testing (Covid)
 - **Controller specs not clear and Interop testing for controllers didn't exist**
- Mitigation
 - Most all new ST 2110 devices are support NMOS
 - JT-NM Testing is back!
 - Face2Face Interop August 19-23 @ Riedel (Germany), very promising
 - **AMWA INFO-005 Implementation Guide for NMOS Controllers**
 - Automated self-test suites NOW AVAILABLE for Devices & Controllers

NMOS Testing

Selecting a test to run

NMOS Test

This test suite is under active development and does not yet provide 100% coverage of specifications. We recommend regularly re-testing implementations as new tests are developed.

Test Suite: **BCP-003-01 Secure API Communications**

IP/Hostname: Port: API Version: **v1.0**

Protocol: **HTTP**

Discovery Mode: **Multicast DNS**

Test Selection:

all: Runs all tests in the suite
auto: Basic API tests derived directly from the specification RAML
test_01: TLS Protocols
test_02: TLS Ciphers

Run

Examining the results

NMOS Test

[Download JSON](#) - [More Options](#)

Result for test suite IS-04 Registry APIs on: <http://172.29.80.65:80/x-nmos/registration/v1.2/>, <http://172.29.80.65:80/x-nmos/query/v1.2/>

Failed Tests

Run

Test	Pass	Description	Reason	Completion Time	Time Elapsed
__init__	Not Applicable	Test initialisation		16:19:13.352	1.308s
run_tests	Not Applicable	Test setup		16:19:13.363	0.003s
auto_query_1	Pass	GET /x-nmos		16:19:13.369	0.006s
auto_query_2	Pass	GET /x-nmos/query		16:19:13.375	0.006s
auto_query_3	Pass	GET /x-nmos/query/v1.2		16:19:13.382	0.006s
auto_query_4	Pass	GET /x-nmos/query/v1.2/devices		16:19:13.395	0.013s
auto_query_5	Could Not Test	GET /x-nmos/query/v1.2/devices/{deviceId}	No resources found to perform this test	16:19:13.395	0.000s
				16:19:13.436	0.041s
			No resources found to perform this test	16:19:13.436	0.000s

The following test suites are currently supported.

Test Suite ID	Suite	Node	Registry	Controller	Other/Notes
IS-04-01	IS-04 Node API	X			
IS-04-02	IS-04 Registry APIs		X		
IS-04-03	IS-04 Node API (Peer to Peer)	X			
IS-04-04	IS-04 Controller			X	See Testing Controllers
IS-05-01	IS-05 Connection Management API	X			
IS-05-02	IS-05 Interaction with IS-04	X			
IS-05-03	IS-05 Controller			X	See Testing Controllers
IS-06-01	IS-06 Network Control API				Network Controller
IS-07-01	IS-07 Event & Tally API	X			
IS-07-02	IS-07 Interaction with IS-04 and IS-05	X			
IS-08-01	IS-08 Channel Mapping API	X			
IS-08-02	IS-08 Interaction with IS-04	X			
IS-09-01	IS-09 System API		(X)		System Parameters Server
IS-09-02	IS-09 System API Discovery	X			
IS-10-01	IS-10 Authorization API				Authorization Server
-	BCP-002-01 Natural Grouping	X			Included in IS-04 Node API suite
BCP-003-01	BCP-003-01 Secure Communication	X	X		See Testing TLS
-	BCP-003-02 Authorization	X	X		See Testing Authorization
-	BCP-004-01 Receiver Capabilities	X			Included in IS-04 Node API and IS-05 Interaction with IS-04 suites

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

Easy-NMOS Docker Compose Solution

This starter kit allows the user to launch a simple NMOS setup with minimal installation steps. It is composed of three Docker containers:

- an NMOS Registry (from [nmos-cpp](#))
- a virtual NMOS Node (from [nmos-cpp](#)) which should automatically register
- the [AMWA NMOS Testing Tool](#)

<https://github.com/rhastie/easy-nmos>

How Can I try NMOS? - Riedel NMOS Explorer

(IP SHOWCASE™)

Nodes

Type to filter...
MN Vasili (190) 10.30.6.190:3000
Micro IP 1 (links 196) 10.30.6.196:3000
MN Arne (199) 10.30.6.199:3000
Micro IP 2 (rechts 197) 10.30.6.197:3000
MN Max (200) 10.30.6.200:3000

Devices

Type to filter...
MN Vasili (190) Device
Micro IP 1 (links 196) Device
MN Arne (199) Device
Micro IP 2 (rechts 197) Device
MN Max (200) Device

Senders

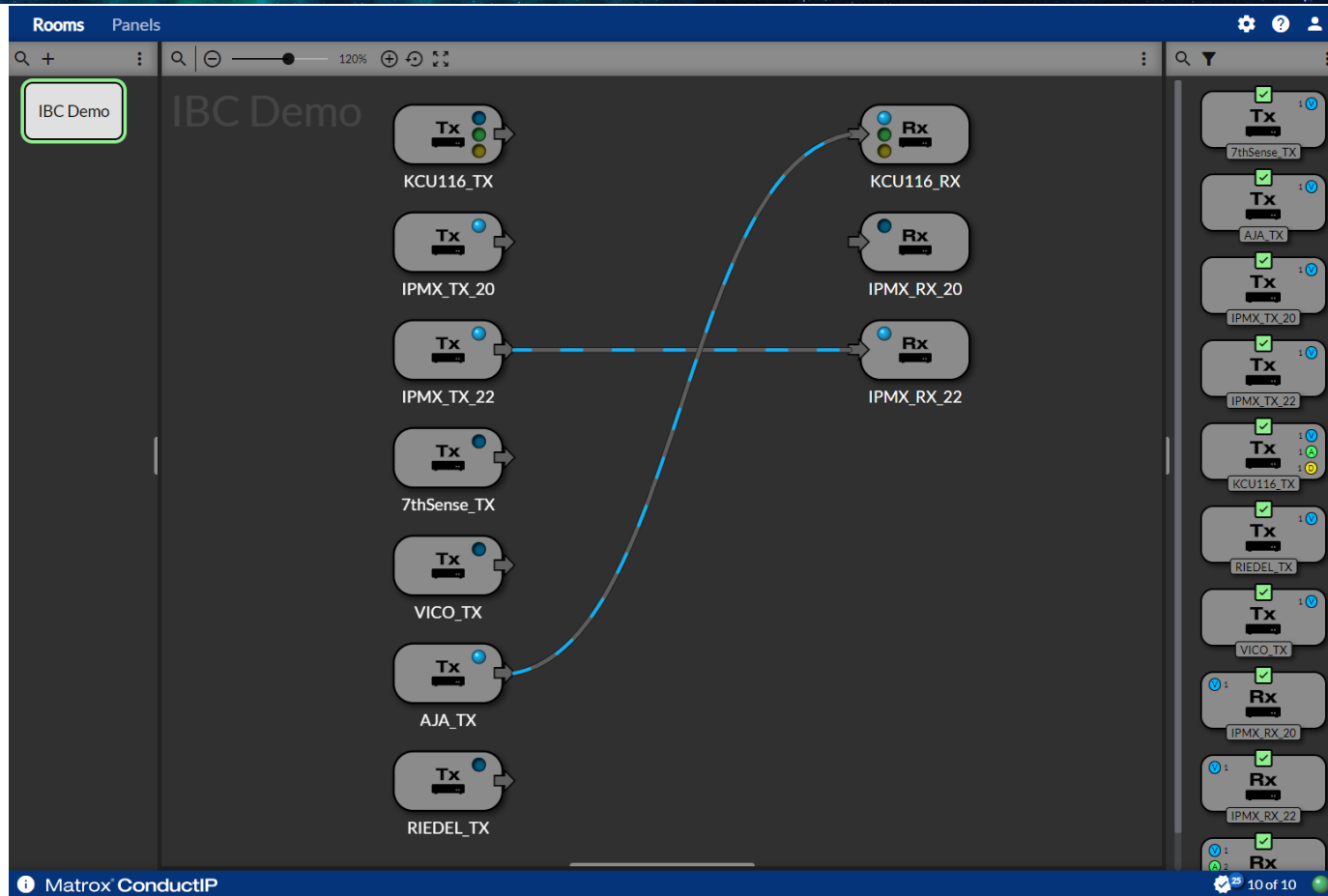
Type to filter...
Out 8 unix-nmos:format:video
Out 7 unix-nmos:format:video
Out 9 unix-nmos:format:video
Out 10 unix-nmos:format:video
Out 10 unix-nmos:format:video
Stream 1 unix-nmos:format:audio
Out 7 unix-nmos:format:video
Out 8 unix-nmos:format:video
Out 9 unix-nmos:format:video
Out 9 unix-nmos:format:video
Out 10 unix-nmos:format:video
Out 8 unix-nmos:format:video
Out 7 unix-nmos:format:video
Out 10 unix-nmos:format:video
Out 9 unix-nmos:format:video
Out 7 unix-nmos:format:video
Out 8 unix-nmos:format:video
Out 7 no active flow

Receivers

Type to filter...
In 2 unix-nmos:format:video
In 1 unix-nmos:format:video
In 4 unix-nmos:format:video
In 3 unix-nmos:format:video
In 2 unix-nmos:format:video
In 4 unix-nmos:format:video
In 3 unix-nmos:format:video
In 1 unix-nmos:format:video
In 4 unix-nmos:format:video
In 3 unix-nmos:format:video
In 2 unix-nmos:format:video
In 1 unix-nmos:format:video
In 2 unix-nmos:format:video
In 3 unix-nmos:format:video
In 1 unix-nmos:format:video
In 4 unix-nmos:format:video
Stream 1 unix-nmos:format:audio

<https://www.riedel.net/downloads/firmware-software/>

NMOS Control GUI (Matrox ConductIP)



NMOS Control GUI (Matrox ConductIP)



The screenshot displays the NMOS Control GUI (Matrox ConductIP) interface. The top bar is dark blue with the 'Rooms' and 'Panels' tabs, a search icon, and a zoom slider set to 145%. The main area is divided into a left sidebar and a central workspace. The sidebar contains a 'Receivers' list with items like 'IPMX_TX_20', 'IPMX_RX_20', 'IPMX_RX_22', and '*IPMX_TX_20 KCU116_RX'. The central workspace shows a grid of 'Senders' (7thSense_TX, AJA_TX, IPMX_TX_20, IPMX_TX_22, KCU116_TX, RIEDEL_TX, VICO_TX) and 'Receivers' (IPMX_TX_20, IPMX_RX_20, IPMX_RX_22, *IPMX_TX_20 KCU116_RX). A bottom control bar includes a 'Direct' toggle, 'Queue', 'Reset', 'Disconnect', and 'Take' buttons. The bottom status bar shows 'Matrix ConductIP' and '10 of 10'.

Take-aways



NMOS IS-04 and 05 are solid, stable, and mature & offered in most all new ST 2110 products



NMOS Control Systems are greatly improved thanks to spec clarifications and interop testing



Features like IS-08 (Audio Mapping), IS-09 (System Discovery), and BCP-002 (Grouping/Naming) take NMOS to a new level, far surpassing the level of control provided in SDI



BCP-003 (Security) adds a layer of security that has been sorely needed in control systems for quite some time



NMOS is being extended to go far beyond that with stream mapping, and ultimately full device configuration.

Any Questions?

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One API to
Rule them All

Please see our Live Demo in Central Hall 2630 (South of GV)

