



# Interoperable Intercom in an IP World

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# Interoperability Considerations



Payload

Timing

Control



## Interoperability

Payload



Interoperability

Payload

Standards

## Protocols for AoIP



**AES67**



ST 2110-30

## Commonalities and Interoperability



## ST 2110-30 (AES67 Constraints)

	AES67	ST 2110-30
<b>Media Payload</b>	PCM Uncompressed Audio	PCM Uncompressed Audio
<b>PTP version</b>	IEEE1588-2008 (PTPv2)	IEEE1588-2008 (PTPv2)
<b>PTP Profile</b>	AES67 Profile	SMPTE 2059-2 Profile
<b>PTP Leader/Follower</b>	Leader or Follower, selected by BMCA	Must be configurable for Follower Only Mode
<b>Connection Management</b>	SIP or Unicast	SDP can be used but manual configuration must be possible.  NMOS IS-04/IS-05
<b>Transport</b>	Unicast or Multicast	Multicast only
<b>Payload and Packet Time</b>	<ul style="list-style-type: none"> <li>1-8 Channels, 1ms, @48kHz mandatory</li> <li>all other possibilities allowed</li> </ul>	<ul style="list-style-type: none"> <li>Level A: 1-8 Channels, 1ms, @48 kHz</li> <li>Level B: 1-8 Channels, 0.125ms, @48 kHz</li> <li>Level C: 1-64 Channels, 0.125 ms, @48 kHz</li> </ul>

## Commonalities and Interoperability



ST 2110-30





## Dante AES67

	ST 2110-30	Dante – AES67	Dante - 2110
<b>Media Payload</b>	PCM Uncompressed Audio	PCM Uncompressed Audio	PCM Uncompressed Audio
<b>PTP version</b>	PTPv2 (ST-2059-2 Profile)	PTPv2 (AES67 Profile) AND PTPv1	PTPv2 (ST-2059-2 Profile, AES67 Profile) and PTPv1
<b>Multicast IP Address</b>	Any address from 239.0.0.1-239.255.255.255	Only addresses that are defined in the Scope in Dante controller.	Any address from 239.0.0.1-239.255.255.255
<b>PTP Leader/Follower</b>	Must be configurable for Follower Only Mode	Leader or Follower, selected by BMCA. Not configurable for Follower Only Mode	Same as “Dante AES67”
<b>Connection Management</b>	SDP can be used but manual configuration must be possible.  NMOS IS-04/IS-05	SAP Discovery. No manual subscription is possible	SAP Discovery. Manual subscription is possible.  No NMOS Support
<b>Payload and Packet Time</b>	<ul style="list-style-type: none"> <li>Level A: 1-8 Channels, 1ms, @48 kHz</li> <li>Level B: 1-8 Channels, 0.125ms, @48 kHz</li> <li>Level C: 1-64 Channels, 0.125 ms, @48 kHz</li> </ul>	<ul style="list-style-type: none"> <li>1-8 Channels, 1ms, @48kHz only</li> </ul>	<ul style="list-style-type: none"> <li>Level A: 1-8 Channels, 1ms, @48 kHz</li> <li>Level B: 1-8 Channels, 0.125ms, @48 kHz</li> <li>Level C: 1-64 Channels, 0.125 ms, @48 kHz</li> </ul>

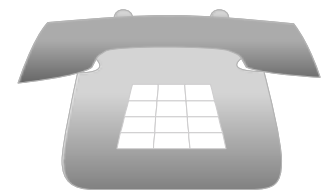
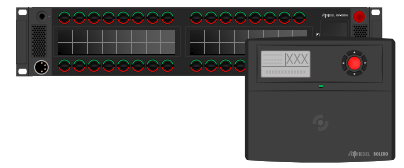
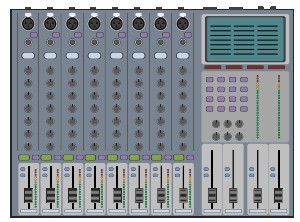
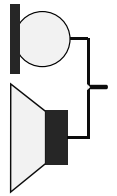


Interoperability

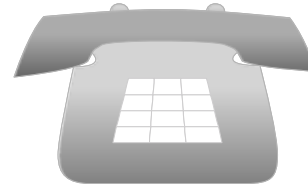
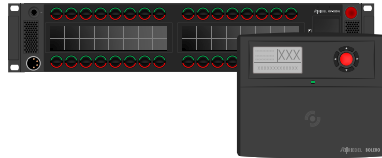
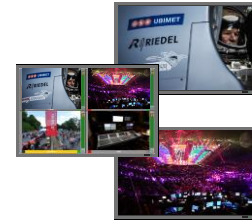
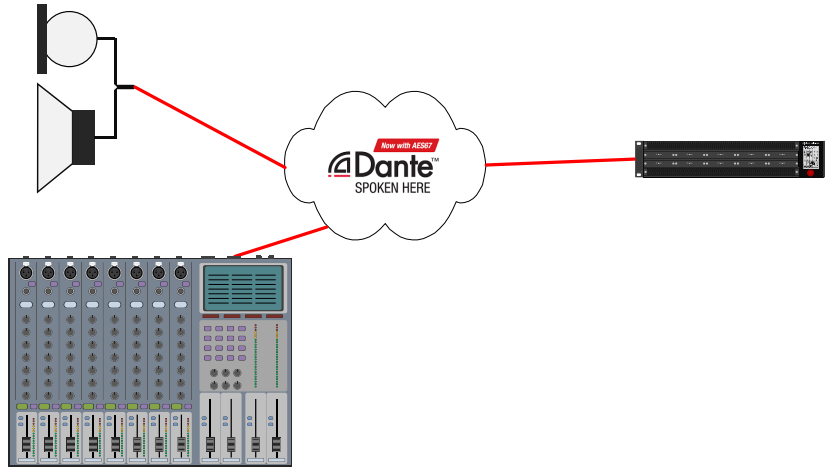
Payload

Islanding

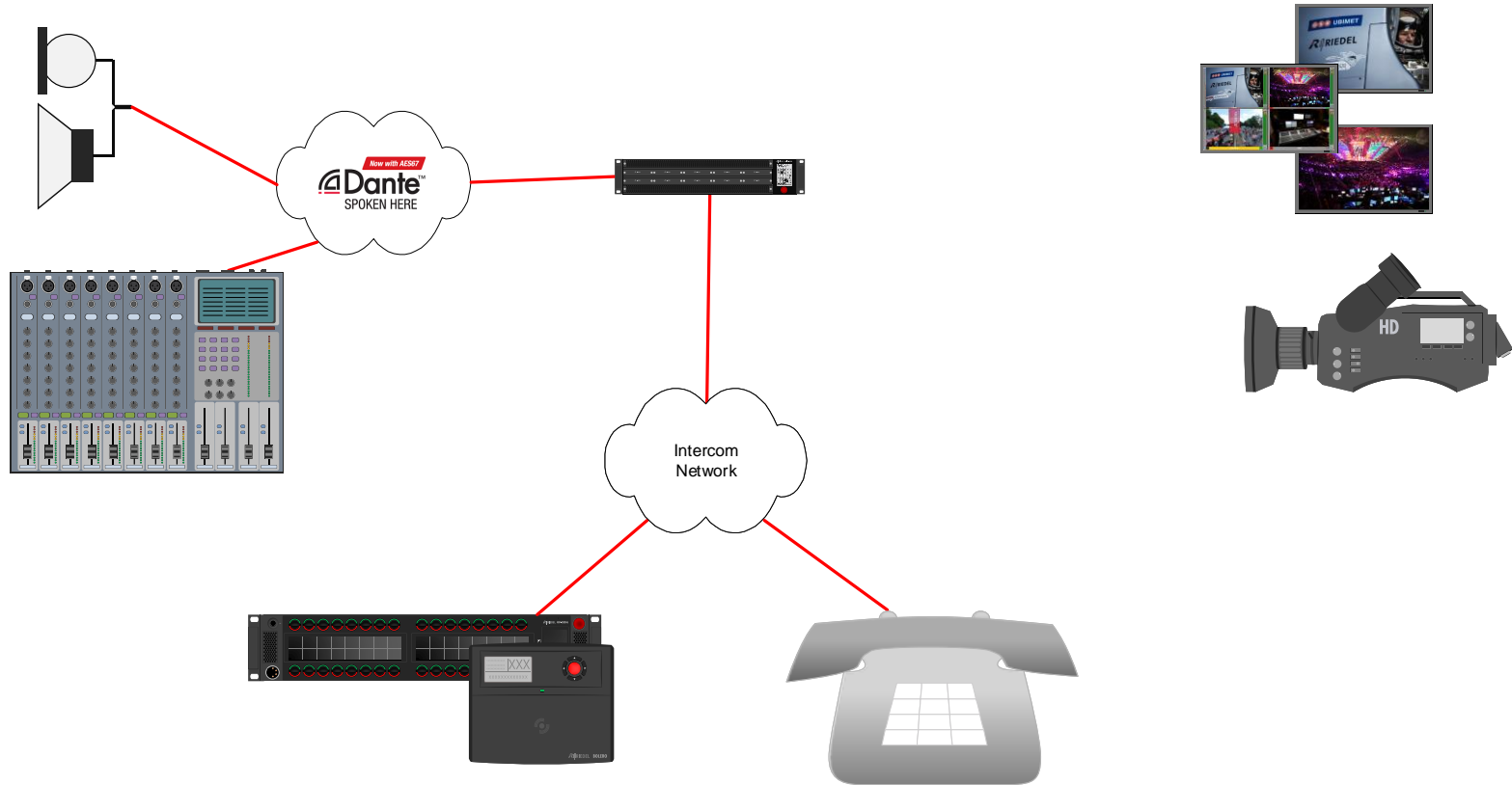
## Interoperability and Islanding



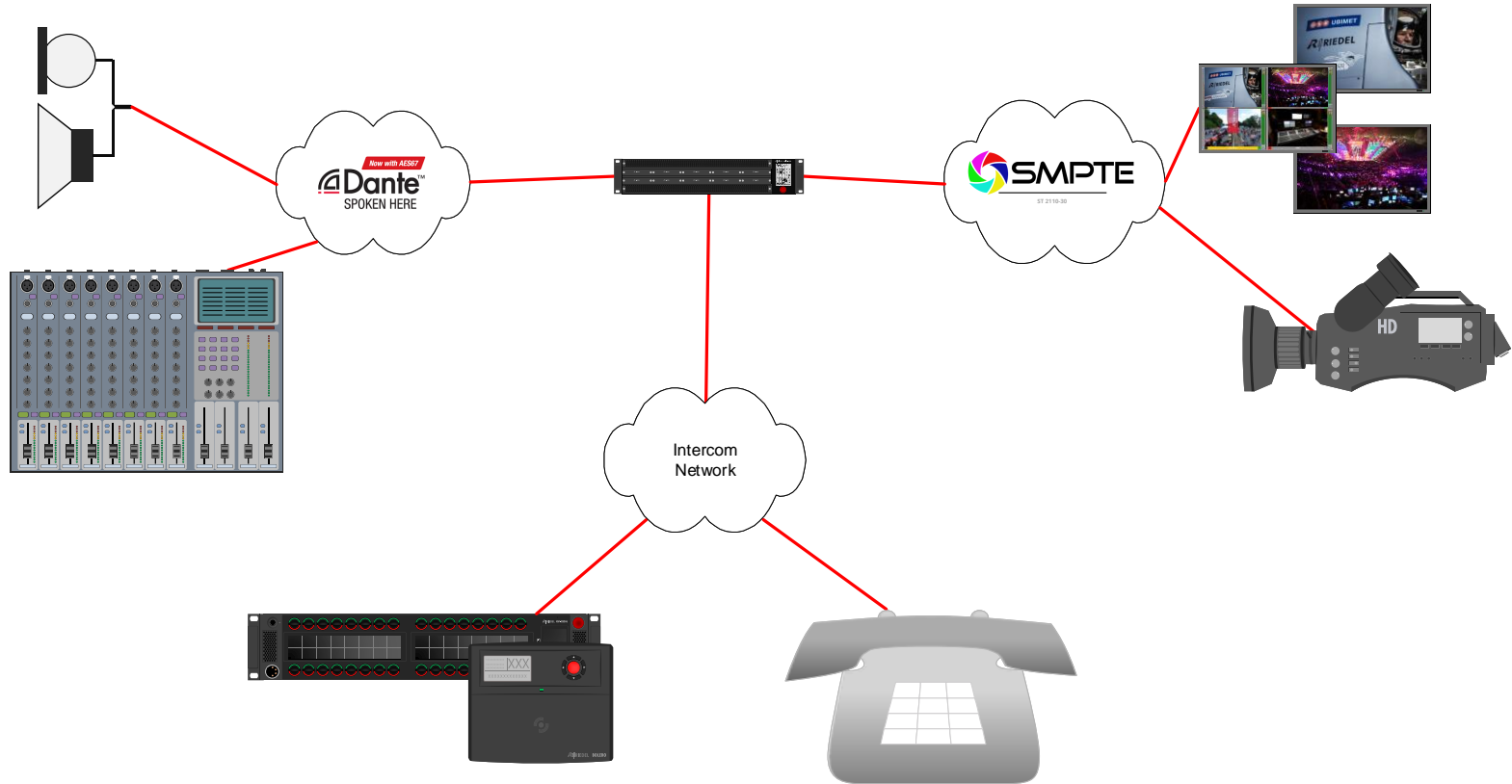
## Interoperability and Islanding



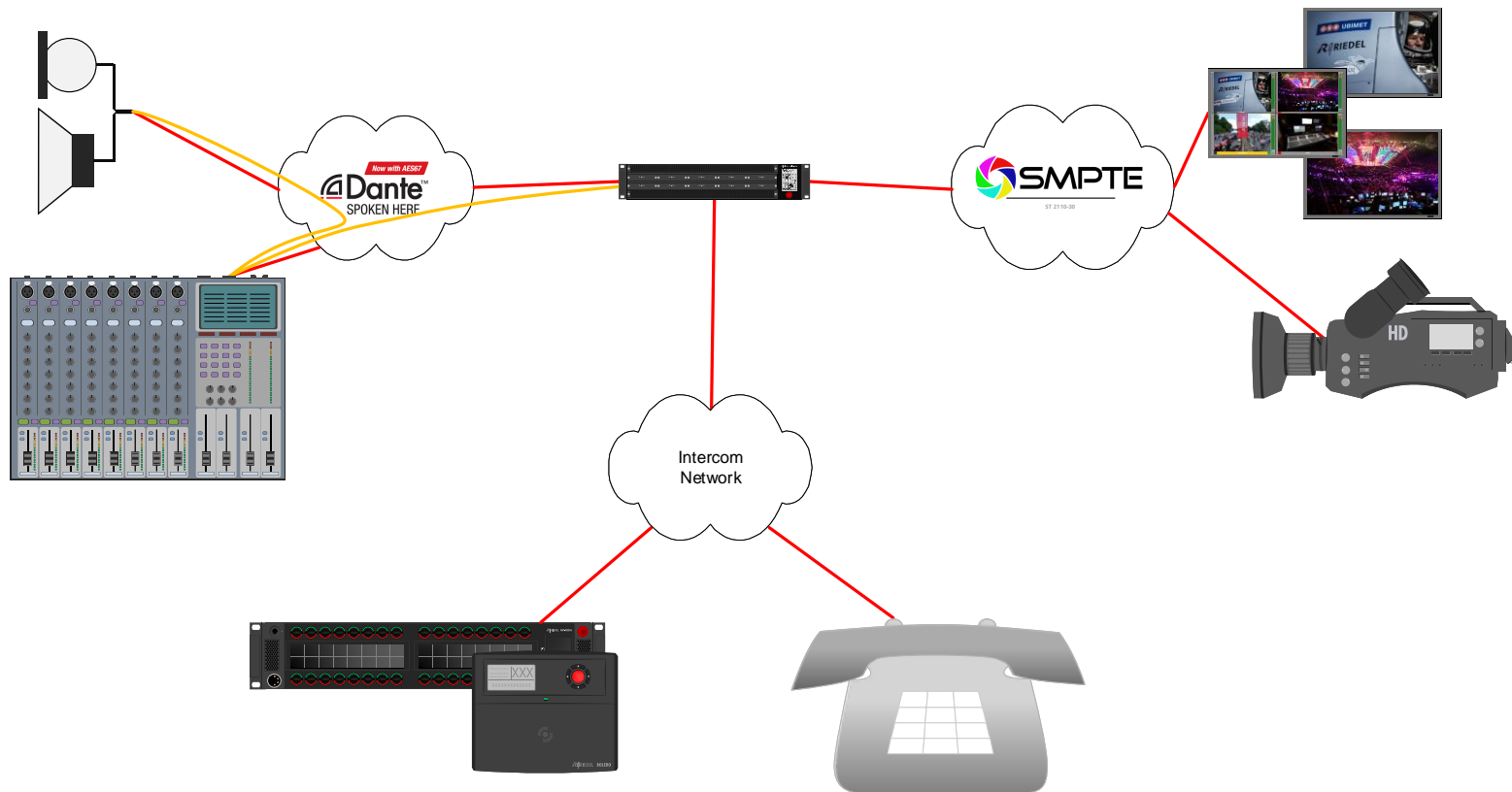
## Interoperability and Islanding



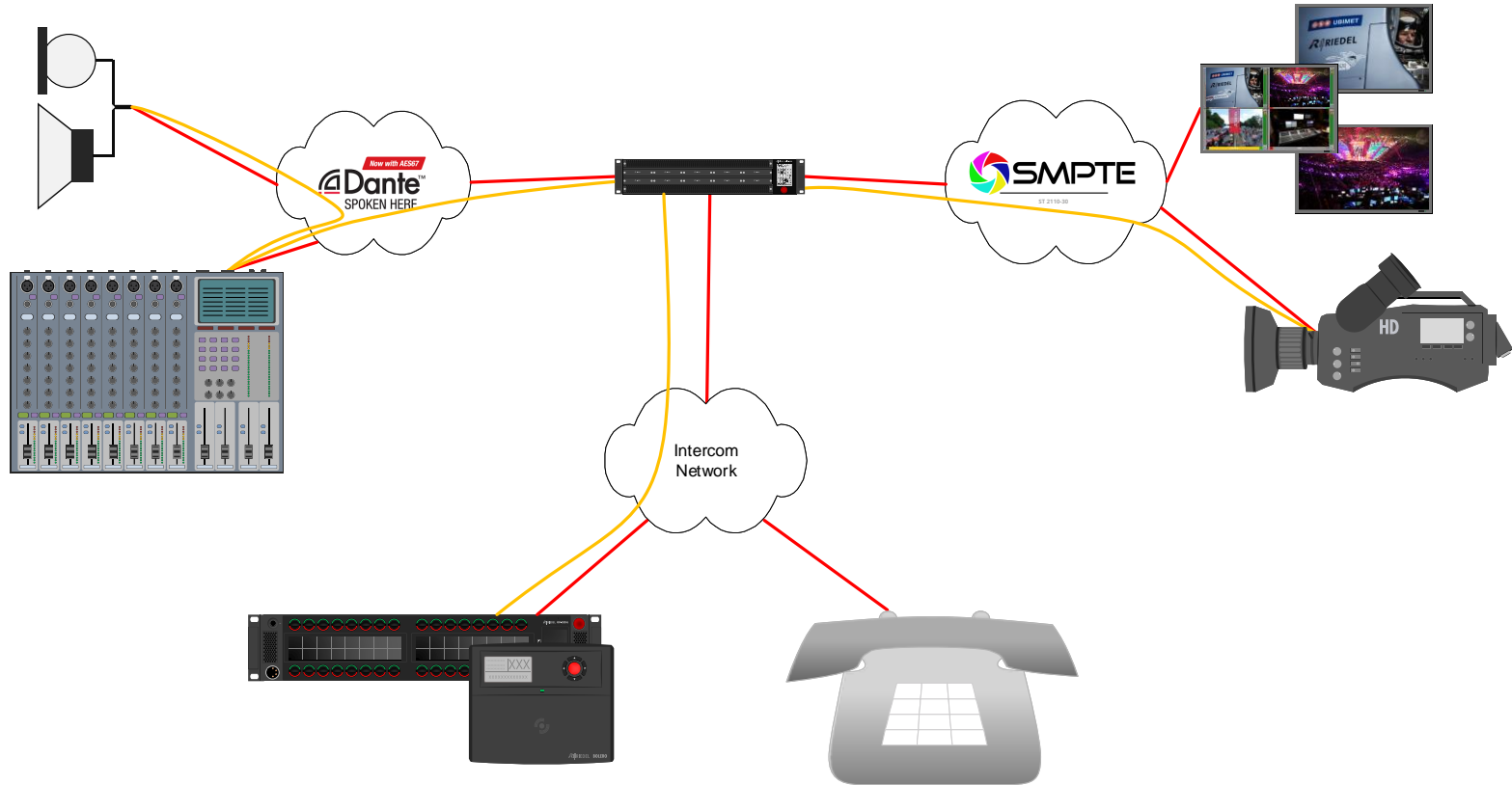
## Interoperability and Islanding



## Interoperability and Islanding

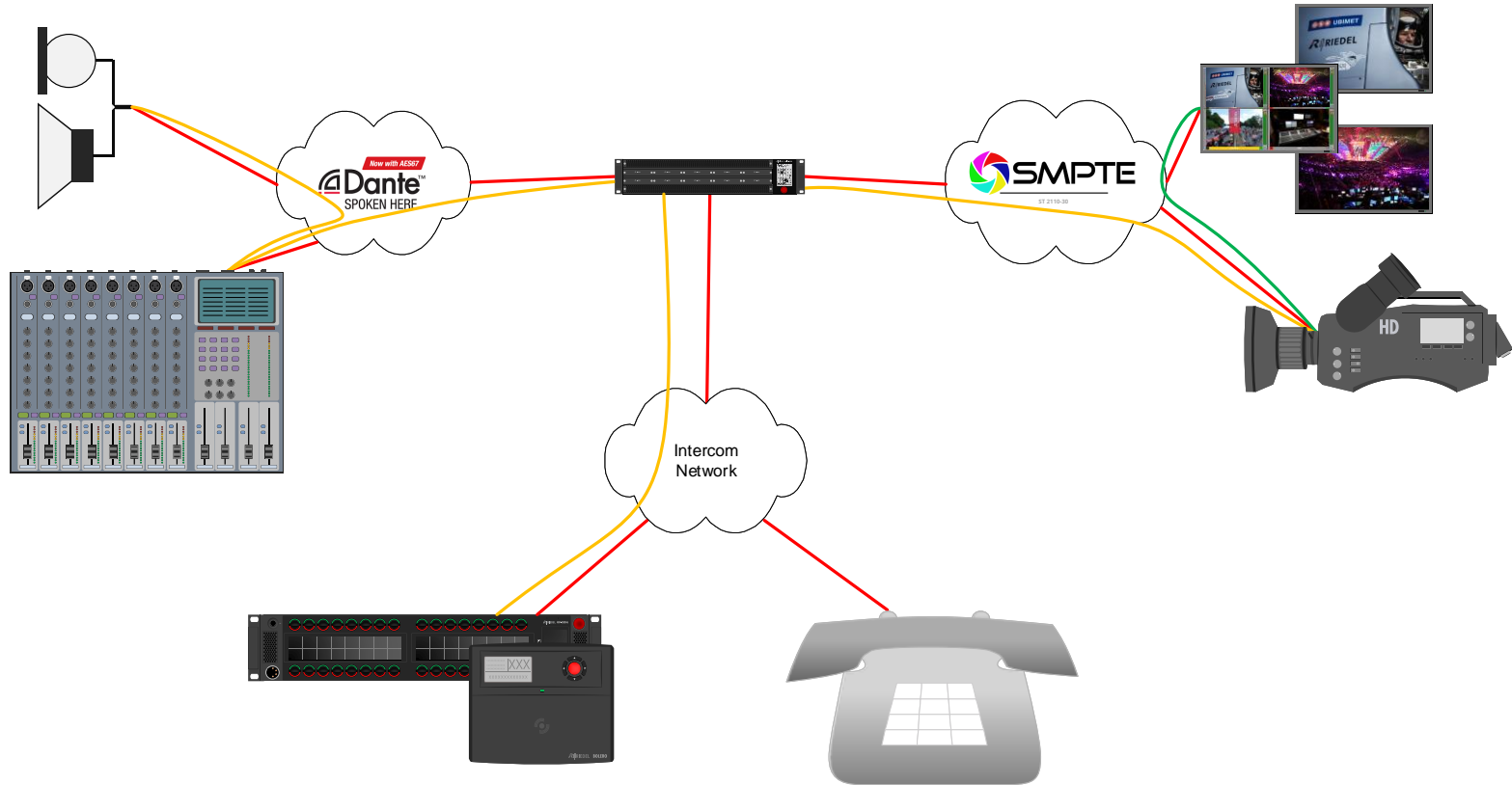


## Interoperability and Islanding

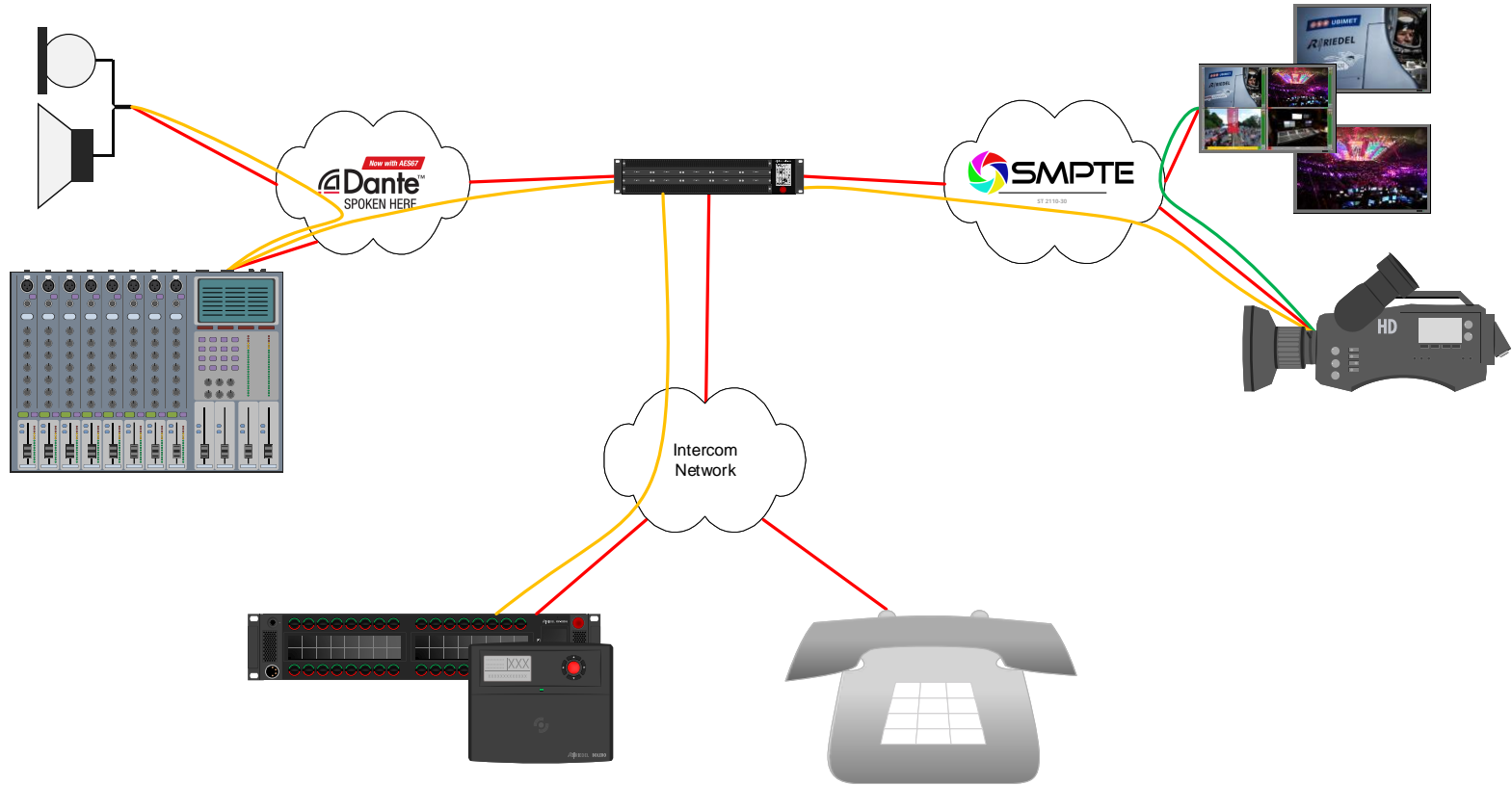




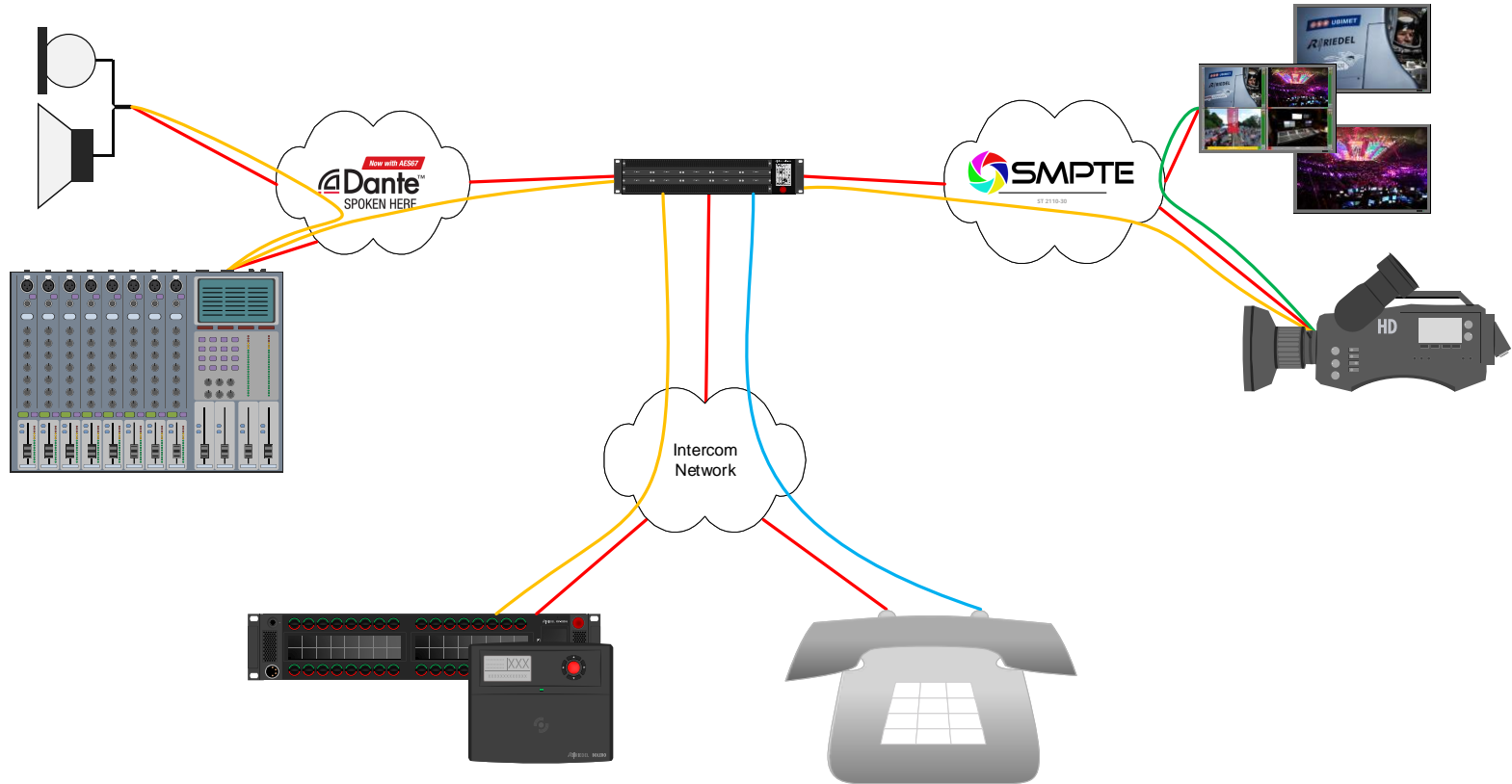
## Interoperability and Islanding



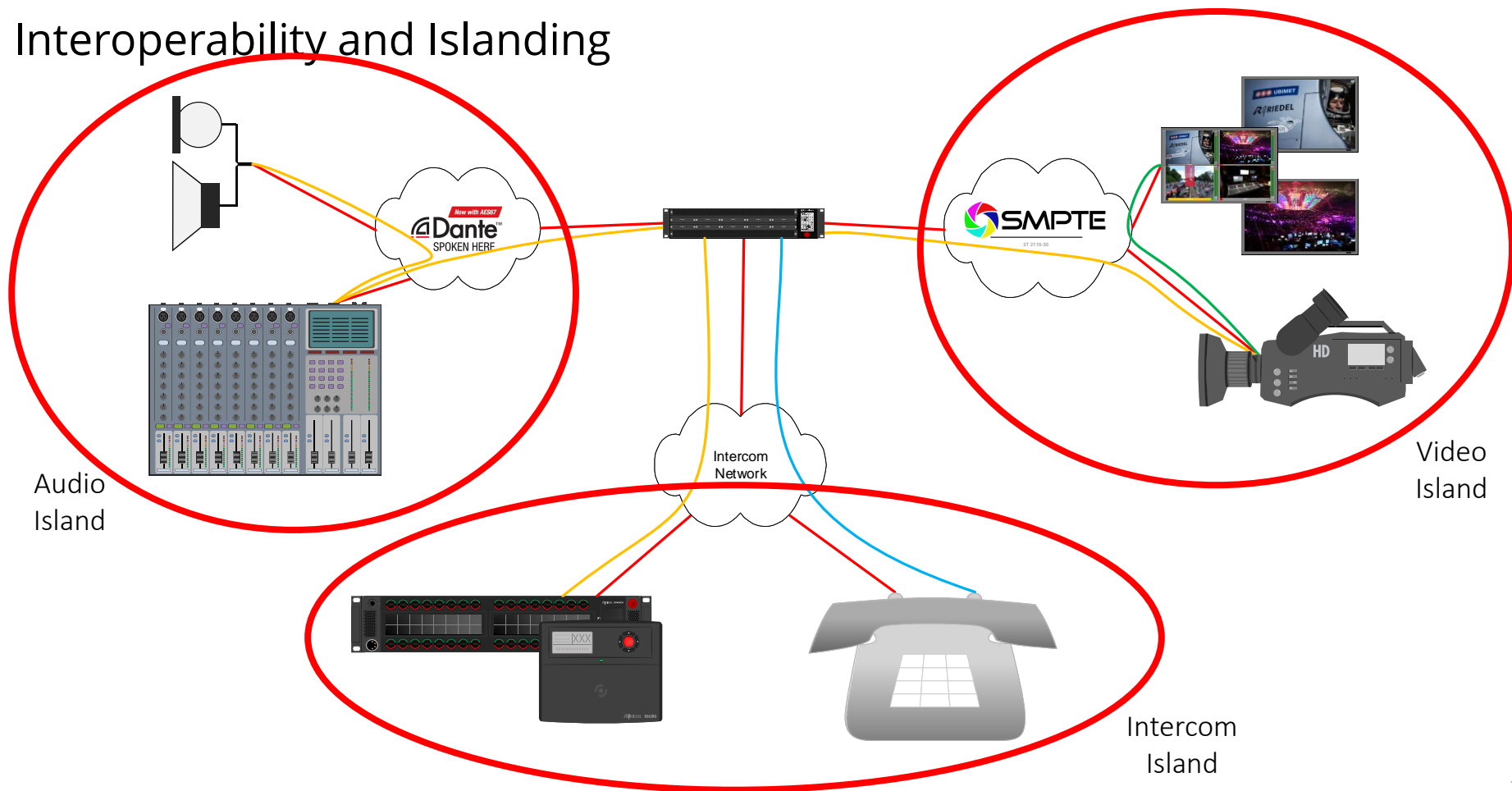
## Interoperability and Islanding



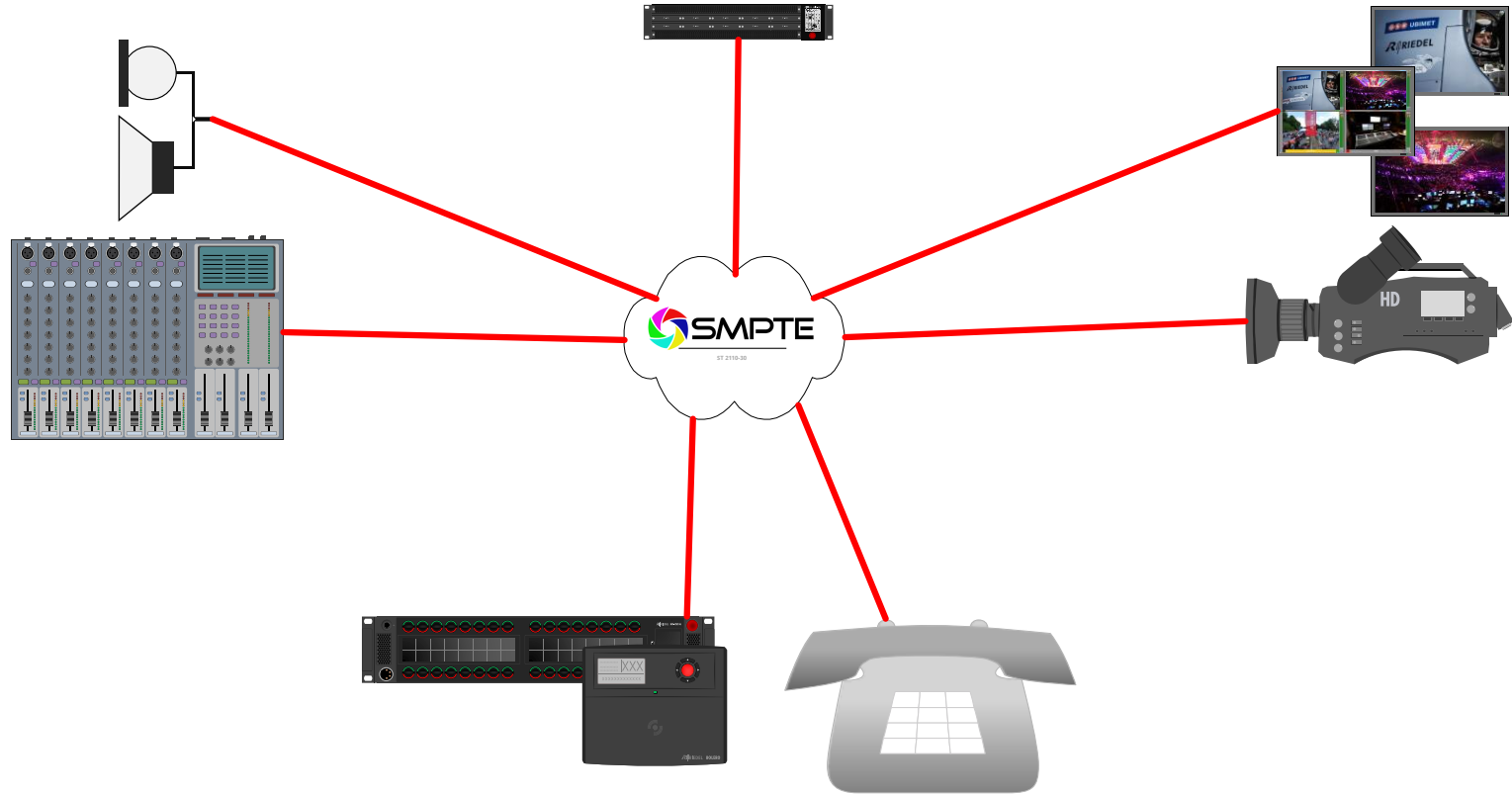
## Interoperability and Islanding



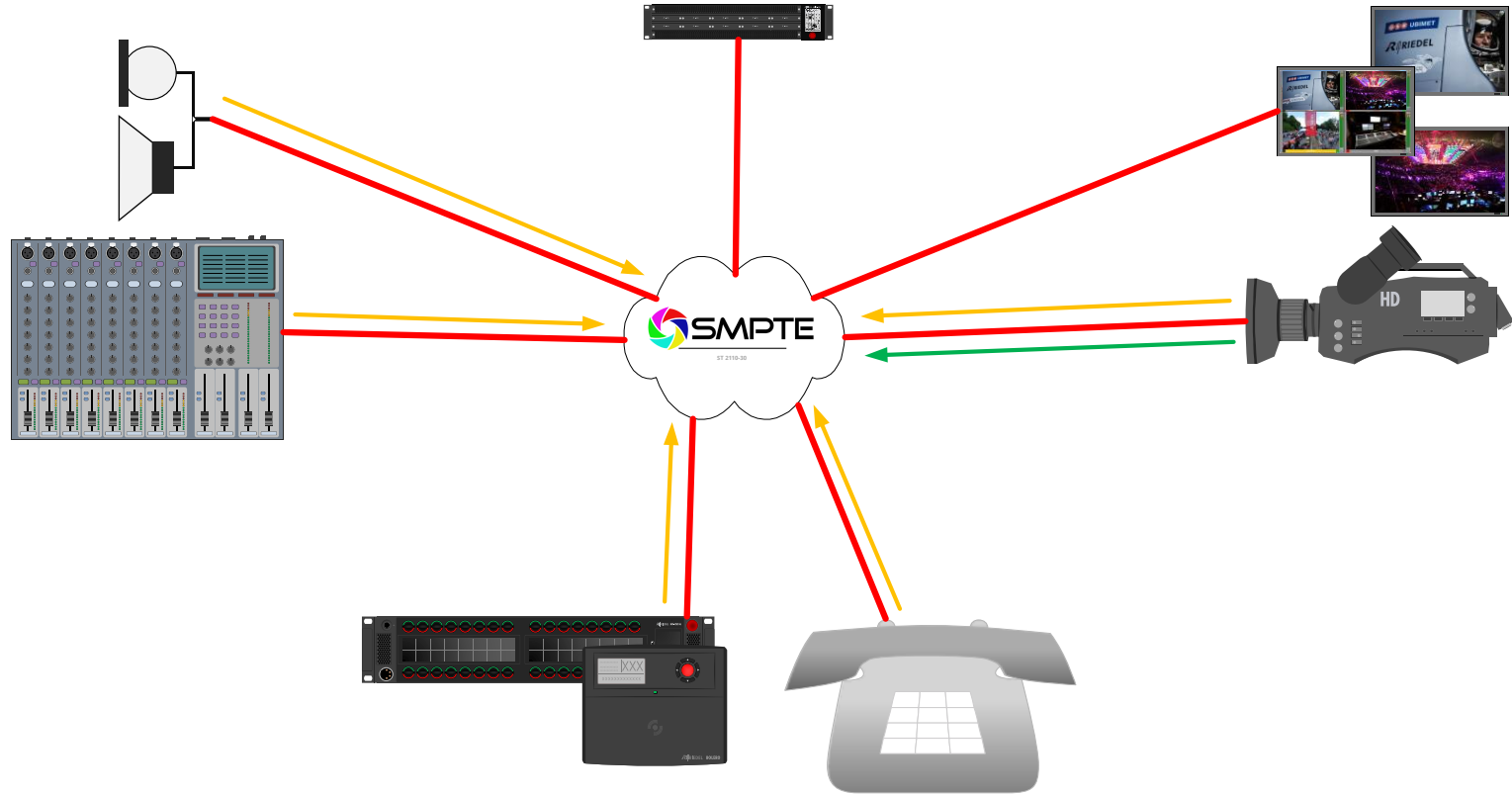
## Interoperability and Islanding



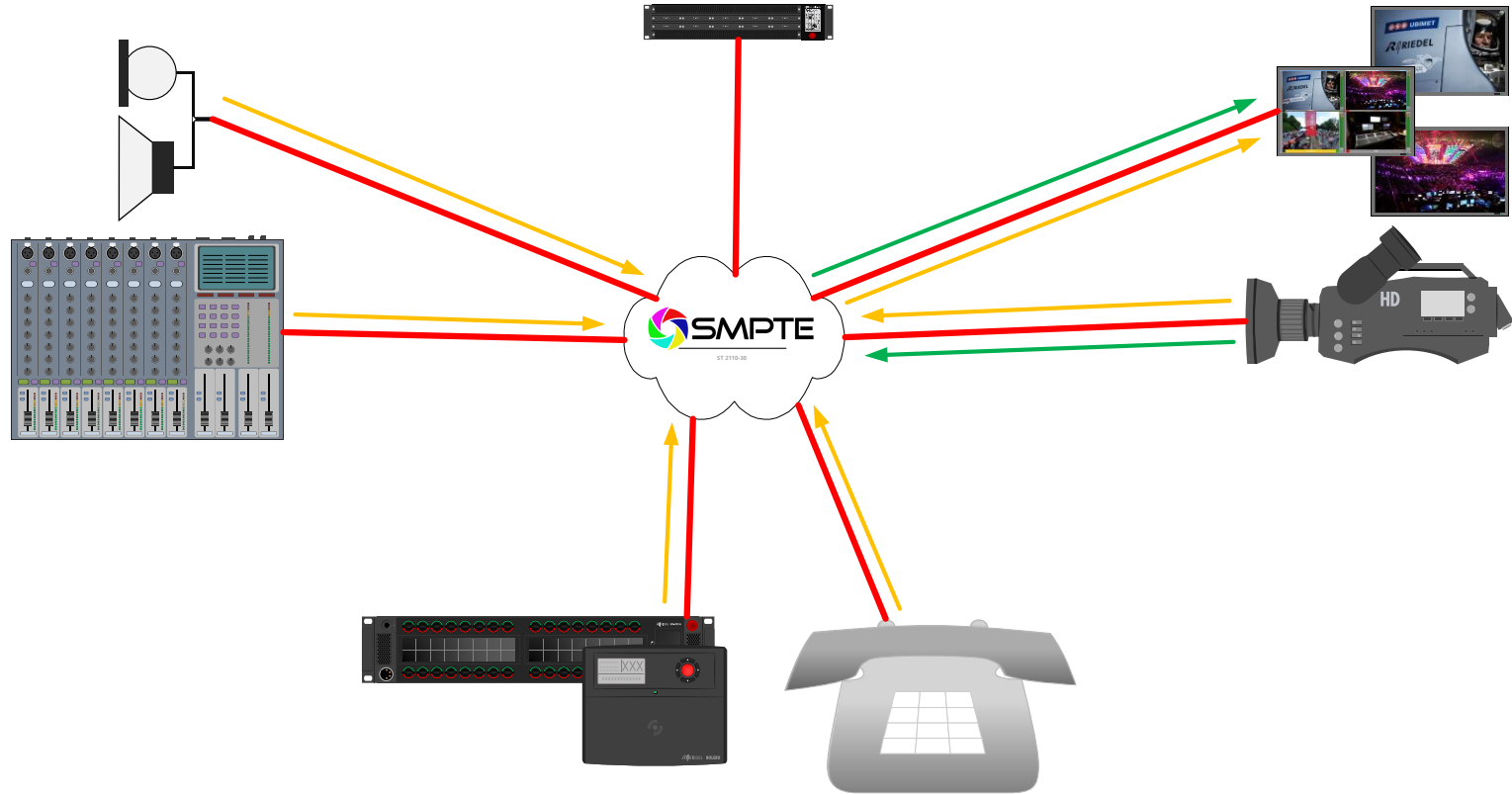
## Interoperability and Islanding



## Interoperability and Islanding



## Interoperability and Islanding





# Interoperability

Questions?





Interoperability

Timing



# Interoperability

Timing

PTP

## PTP – IEEE 1588

- Replaces Sync Pulse Generators
- Started in 2002
  - IEEE-1588-2002 or PTPv1
  - Created to synchronize financial transactions (i.e. wall street)
    - Mobile Phone Tower Transmissions
    - Basically networks that require precise timing but lack access to satellite navigation signals.
- IEEE-1588-2008 (PTPv2)
  - Improves accuracy, precision and robustness
  - Not backwards compatible with PTPv1

## PTP – IEEE 1588

- PTP Group      224.0.1.129
  - Sync
  - Follow up
  - Announce
  - Management
  - Delay Request
  - Delay Response
  
- Hybrid      Delay Request and Delay Response are sent via Unicast instead of Multicast

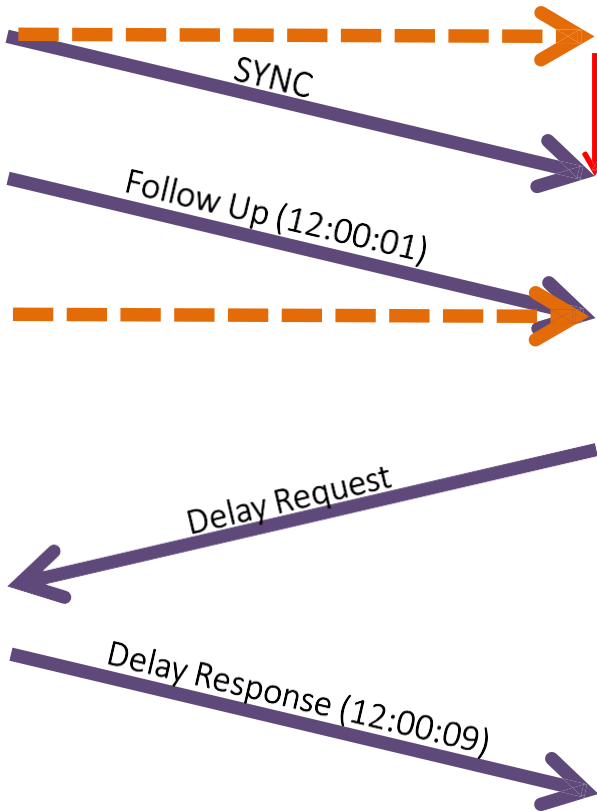
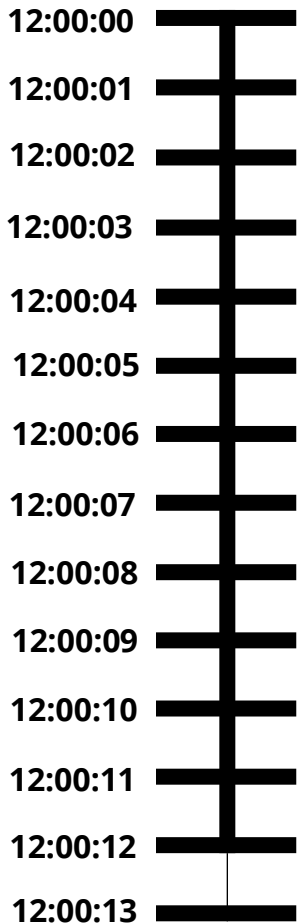
## PTP – IEEE 1588

LEADER

FOLLOWER

Time Stamps

12:00:01  
12:00:09



Time Stamps

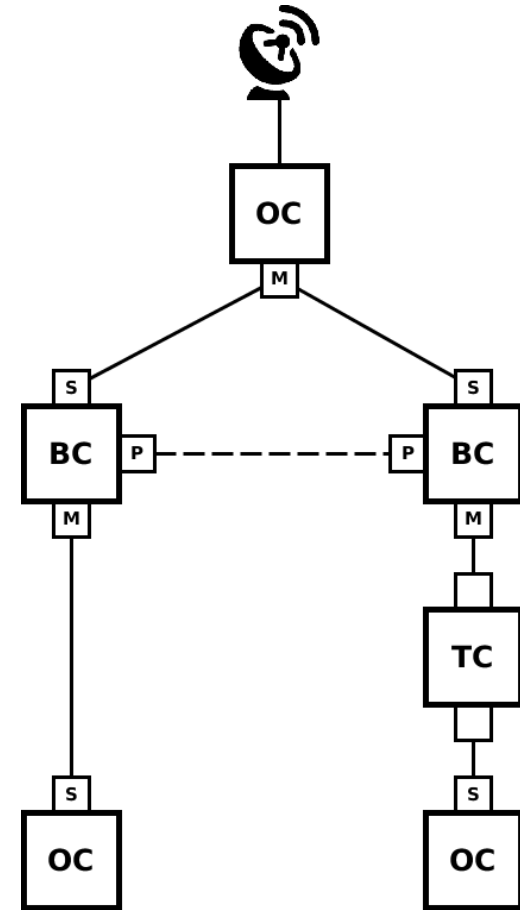
11:59:43  
- 12:00:01  
-----  
00:00:18  
00:00:18  
+ 11:59:45  
-----  
12:00:03

12:00:05  
- 12:00:09  
-----  
00:00:04  
/2  
-----  
2

## PTP – IEEE 1588

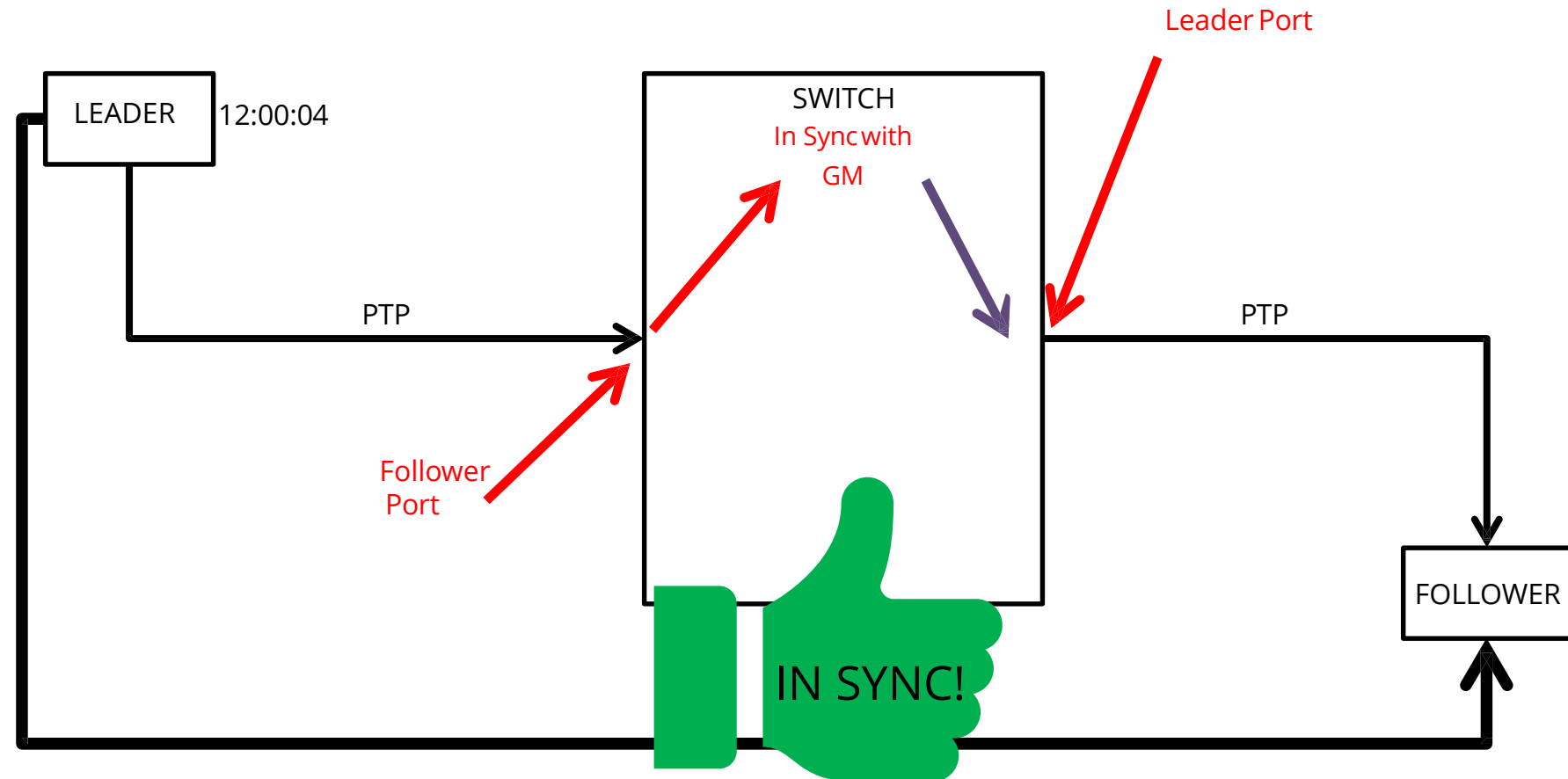
### BMCA Algorithm

- Best Master Algorithm for the Leader / Follower decision
  - Priority 1
  - ClockClass
  - ClockAccuracy
  - Variance
  - Priority 2
  - ClockIdentity (Based on MAC Address)



## PTP – IEEE 1588

Boundary Clock



## PTP – IEEE 1588

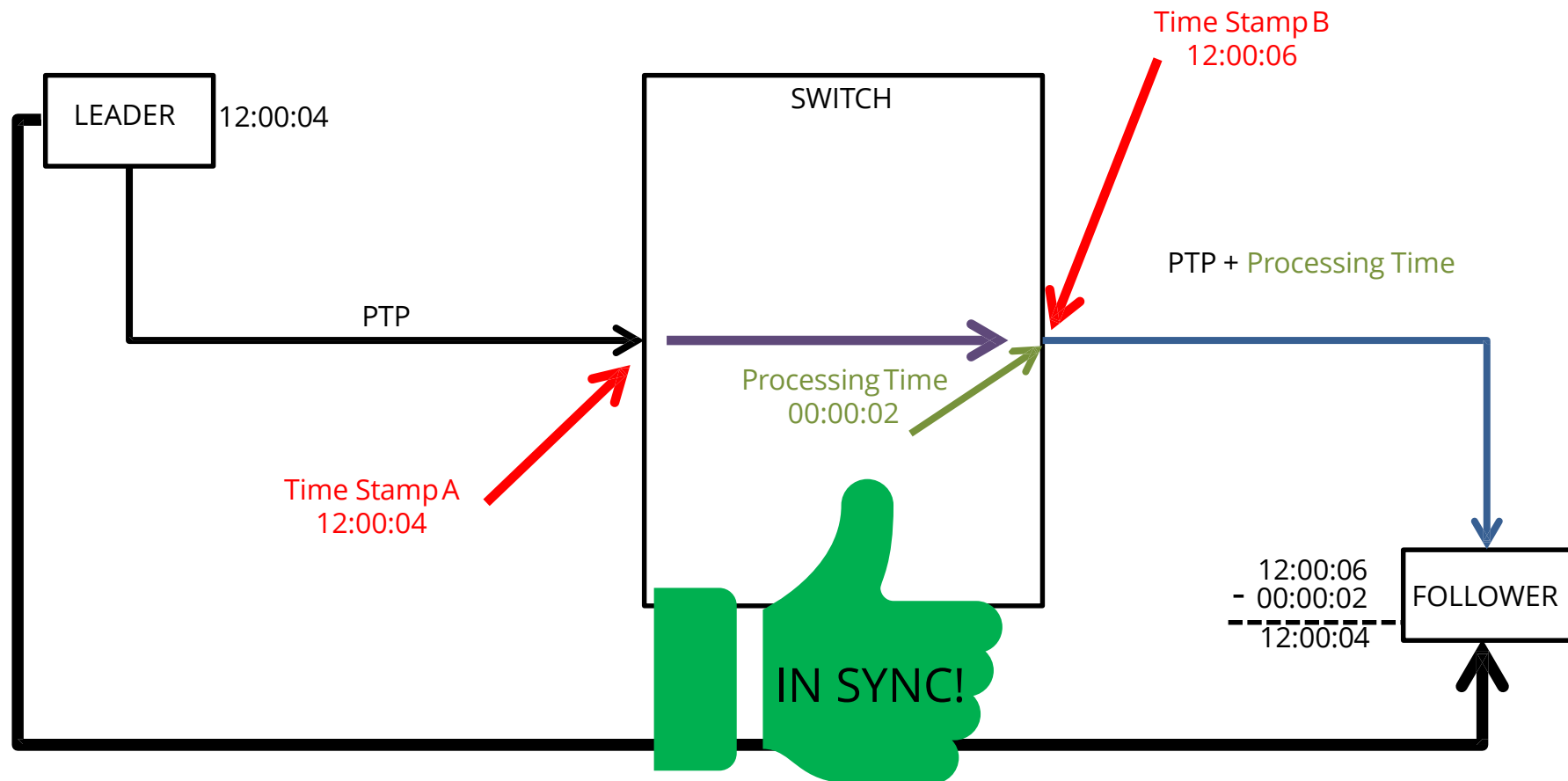
### ST2110-20/30 via PTP Aware Boundary Clock Switch

- Boundary Clock (BC) switch terminates the PTP connection from the Leader and creates a NEW PTP connection towards the Follower
- BC removes Packet Delay Variations (PDV) between itself and the next upstream clock
- BC's may be installed in every network element for the highest level of performance at the Follower device
- Allows for significantly larger networks



## PTP – IEEE 1588

## Transparent Clock

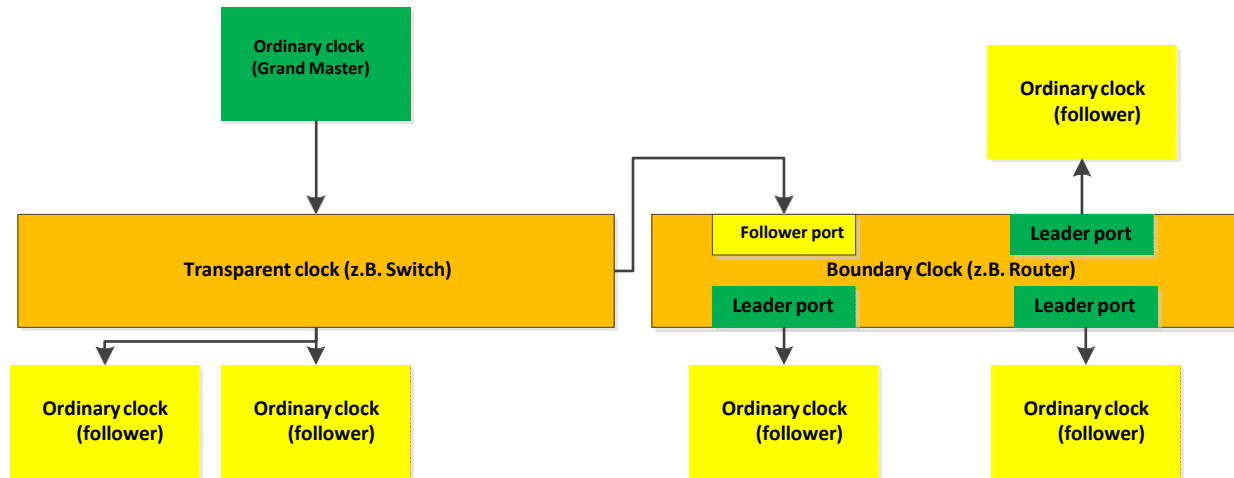


## PTP – IEEE 1588

### PTP Aware Transparent Clock Switch

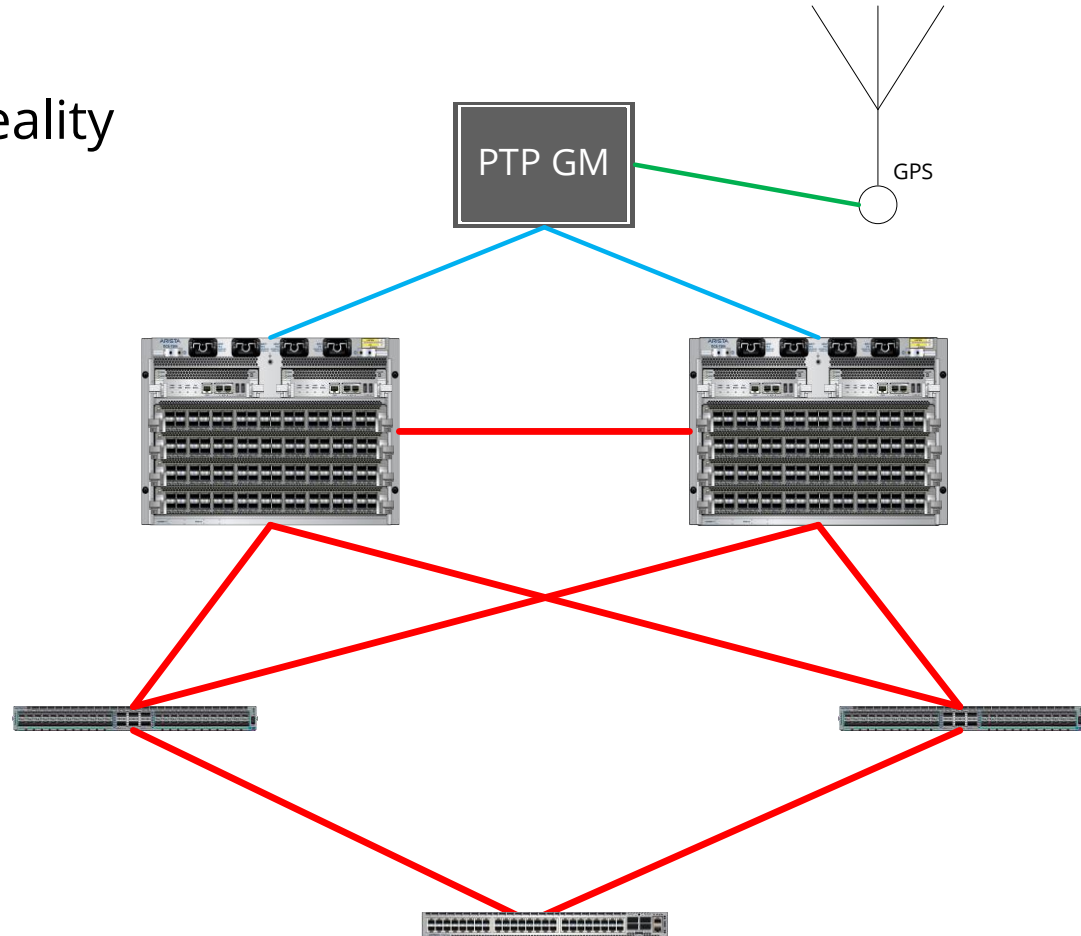
- Takes into consideration processing time incurred within the switch
- TC modifies the PTP packet as it flows through the switch
  - TC removes only its own processing time (end-to-end operation)
- Does not terminate the PTP connection as in BC enabled Switches
- Not scalable to a limitless size
- Good for small to medium size networks

## PTP – IEEE 1588



# PTP - IEEE 1588

## Network Topology In Reality





# Interoperability

Questions?



# Interoperability

Control



Interoperability

Control

SDP

(Session Description Protocol)

# Traditional Approach

Properties of Port 'Test Talk to GV Cam' (Type Split Input AES67)

General Details Trunking Gain Virt. Keys AES67 Input Usage Rights

AES67 Stream and Connection Settings

Mode: Port 8

Connection settings

Protocol: Manual Supported: Manual (RTP only), RTSP

Import SDP File Renegotiate RTSP will cause interrupt in audio

Multicast IP: 239 . 32 . 37 . 1 RTP Multicast IP (IPv4, 239.0.0.1 - 239.255.255.254)

Multicast Port: 50030 RTP Multicast Port (Default: 5004, Range 1024-65535)

RTSP URI:

Stream settings

Bit Depth: L24 Default: 'L24', Bits per Sample

Packet Time: 1.000 ms Audio content per packet

Receive Buffer: 3.000 ms Buffer size in milliseconds (Default: 3 x Packet Time)

Payload Type: 97 Default: 96, Range 96-127

SSRC: 0 Default: 0, Range 32bit

Time Stamp Offset: 0 Default: 0, Range 32bit

Samplerate: 48 KHz

Channels: 8 Channels per stream

Port Settings

Selection: 8 Audio channel from the stream to be used



# Session Description Protocol SDP

## Example AES67

**v=0**

**o=- 1311738121 1311738121 IN IP4 192.168.1.1**

**s=Stage left I/O**

**c=IN IP4 239.0.0.1/32**

**t=0 0**

**m=audio 5004 RTP/AVP 96**

**i=Channels 1-8**

**a=rtpmap:96 L24/48000/8**

**a=recvonly**

**a=ptime:1**

**a=ts-refclk:ptp=IEEE1588-2008:39-A7-94-FF-FE-07-CB-D0:domain-nmbr=0**

**a=mediaclk:direct=963214424**

# Session Description Protocol SDP

## Example 2110

```
v=0
o=- 123456 11 IN IP4 192.168.1.1
s=Professional Networked Media Test i=A test of video, audio, and ANC
t=0 0
a=group:LS V1 A1 M1 a=recvonly
m=video 50000 RTP/AVP 96 c=IN IP4 239.0.0.1/32
a=rtpmap:96 raw/90000
a=fmtp:96 sampling=YCbCr-4:2:2; width=1280; height=720; depth=10; colorimetry=BT.2020;EOTF=SMPTE2084
a=ts-refclk:ptp=IEEE1588-2008:39-A7-94-FF-FE-07-CB-D0:0
a=mediaclock:direct=2216659908 a=mid:V1
m=audio 50010 RTP/AVP 97 c=IN IP4 239.0.0.2/32
a=rtpmap:97 L24/48000/6 a=ptime:0.250
a=ts-refclk:ptp=IEEE1588-2008:39-A7-94-FF-FE-07-CB-D0:0
a=mediaclock:direct=963214424
a=fmtp:97 channel-order=SVIP.(L,C,R,Lrs,Rrs,LFE) a=mid:A1
m=video 50020 RTP/AVP 98 c=IN IP4 239.0.0.3/32
a=rtpmap:98 smpte291/90000
a=ts-refclk:ptp=IEEE1588-2008:39-A7-94-FF-FE-07-CB-D0:0
a=mediaclock:direct=2216659908 a=mid:M1
```

SDP

REST Client

RESTNBAPI

Device IP Address:10.41.5.34

GETRefreshPUTPUT Preset

2

1000000a-990d-11e5-8994-feff819cdc9f1001000a-990d-11e5-8994-feff819cdc9f

1002000a-990d-11e5-8994-feff819cdc9f1003000a-990d-11e5-8994-feff819cdc9f

1004000a-990d-11e5-8994-feff819cdc9f1005000a-990d-11e5-8994-feff819cdc9f

```
v=0
o=- 1443716955 1443716955 IN IP4 10.41.5.34
s=Fusion 3B.4_0-0-0
t=0 0
a=group:DUP primary secondary
m=video 20000 RTP/AVP 97
c=IN IP4 239.20.1.34/64
a=source-filter: incl IN IP4 239.20.1.34 10.41.5.34
a=rtpmap:97 raw/90000
a=fmtp:97 sampling=YCbCr-4:2:2; width=1920; height=1080; exactframerate=60; depth=10; TCS=SDR;
colorimetry=BT709; PM=2110GPM; SSN=ST2110-20:2017; TP=2110TPN;
a=mediaclk:direct=0
a=ts-refclk:ptp=IEEE1588-2008:00-19-7C-FF-FE-02-57-12:0
a=mid:primary
m=video 20000 RTP/AVP 97
c=IN IP4 239.0.1.3/64
a=source-filter: incl IN IP4 239.0.1.3 192.168.0.1
a=rtpmap:97 raw/90000
a=fmtp:97 sampling=YCbCr-4:2:2; width=1920; height=1080; exactframerate=60; depth=10; TCS=SDR;
colorimetry=BT709; PM=2110GPM; SSN=ST2110-20:2017; TP=2110TPN;
a=mediaclk:direct=0
a=ts-refclk:ptp=IEEE1588-2008:00-19-7C-FF-FE-02-57-12:0
a=inactive
a=mid:secondary
```

And enter into here....

Properties of Port 'Test Talk to GV Cam' (Type Split Input AES67)

General Details Trunking Gain Virt. Keys AES67 Input Usage Rights

AES67 Stream and Connection Settings

Mode: Port 8

Connection settings

Protocol: Manual Supported: Manual (RTP only), RTSP

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Stream settings

Bit Depth: L24 Default: 'L24', Bits per Sample

Packet Time: 1.000 ms Audio content per packet

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Payload Type: 97 Default: 96, Range 96-127

SSRC: 0 Default: 0, Range 32bit

Time Stamp Offset: 0 Default: 0, Range 32bit

Samplerate: 48 KHz

Channels: 8 Channels per stream

Port Settings

Selection: 8 Audio channel from the stream to be used

**click here!**



Interoperability

Control

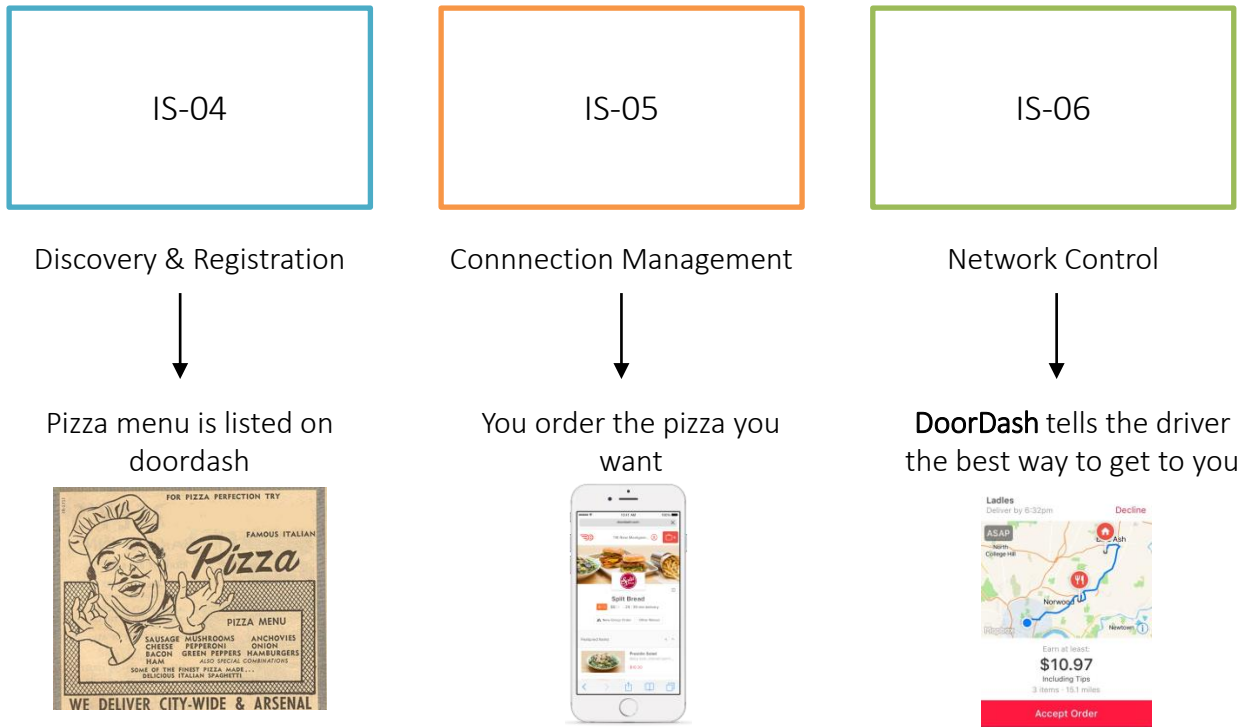
NMOS

# Interoperability

- AMWA NMOS Interface Specifications
  - IS-04 – Discovery & Registration
  - IS-05 – Device Connection Management
  - IS-06 – Network Control
  - IS-07 – Event & Tally
  - IS-08 – Audio Channel Mapping
  - IS-09 – System Parameters
  - IS-10 – Authorization
  - IS-11 – Sink Metadata Processing (WIP)

# NMOS – Networked Media Open Specification

- ST2110's Search Engine
- Three Main Components



# **IS-04**

# **Discovery and Registration**



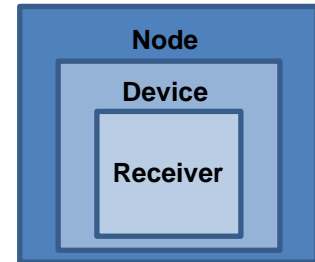
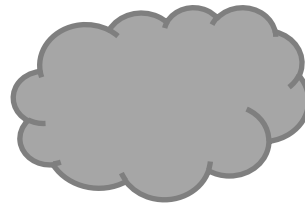
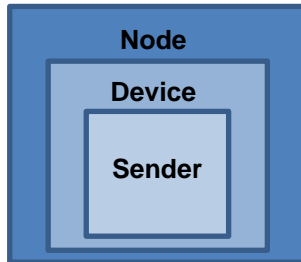
## IS-04

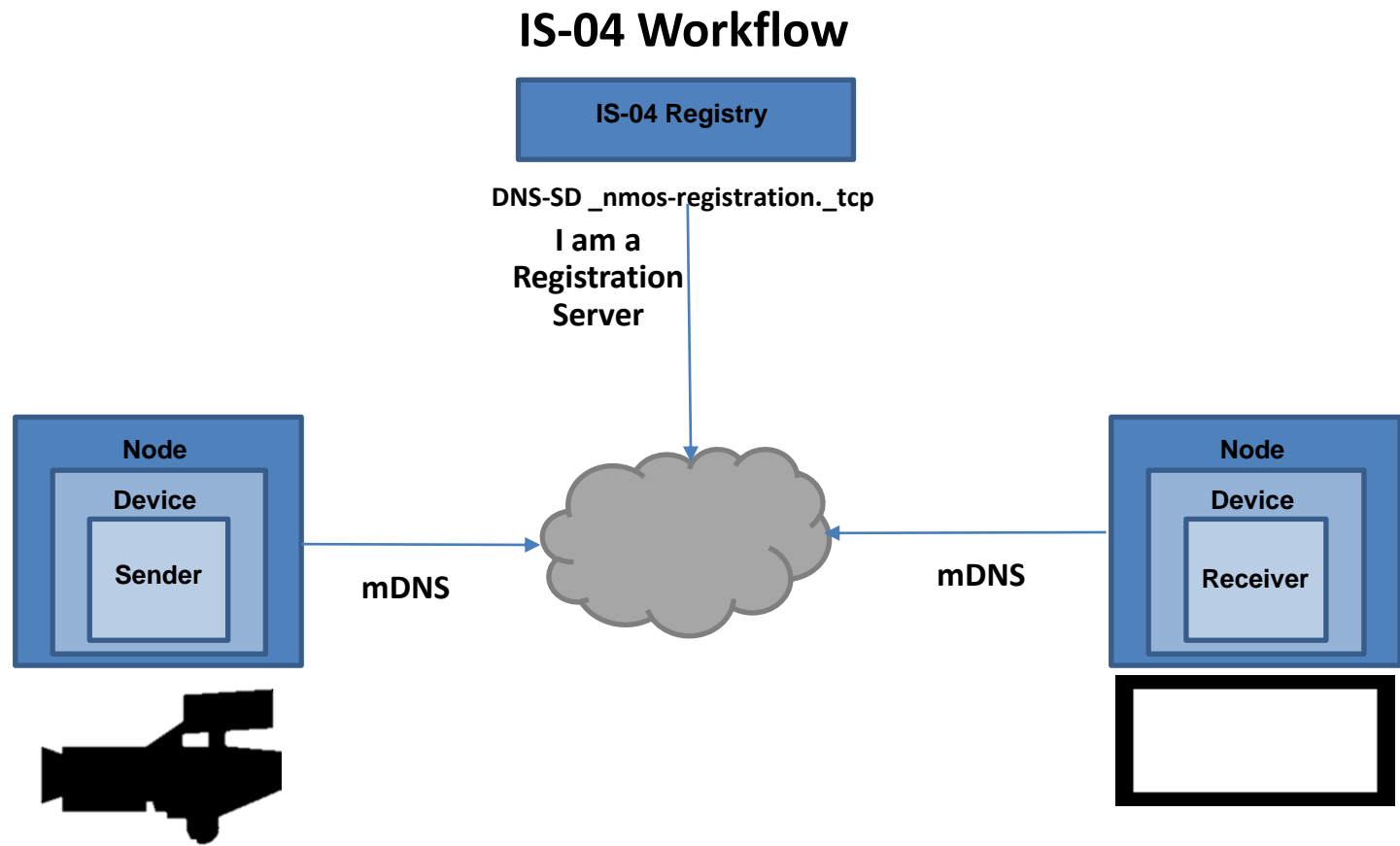
## IS-04 Workflow

A blue rectangular box with a black border containing the text "IS-04 Registry".

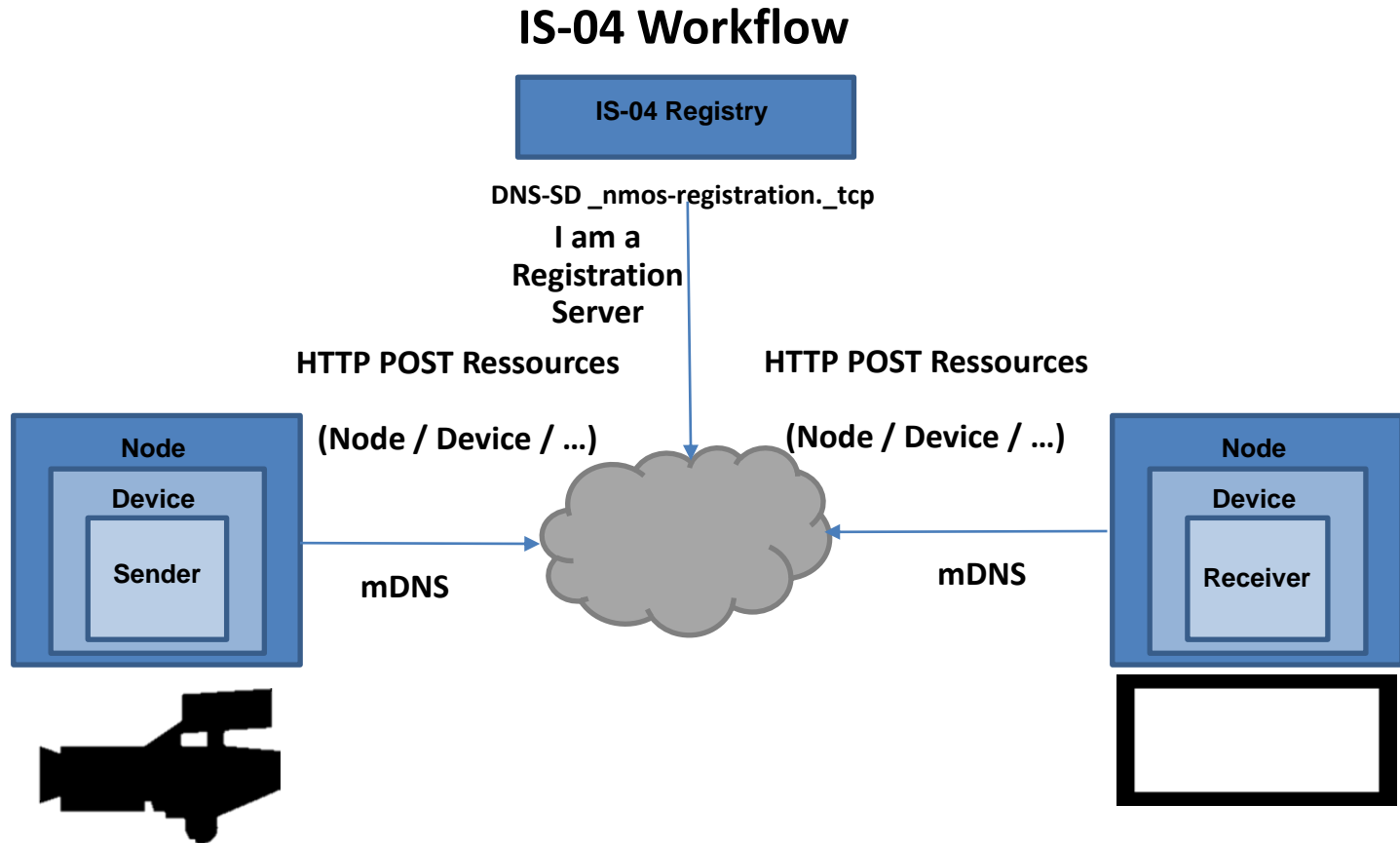
IS-04 Registry

DNS-SD \_nmos-registration.\_tcp





## IS-04



The screenshot shows the NVIDIA NMOS Commissioning Controller web interface. The interface has a dark gray background with a green header bar. On the left, there is a sidebar menu with icons and labels for Settings, Nodes, Devices, Sources, Flows, Senders, Receivers, Subscriptions, and Logs. The main content area features the title "NVIDIA NMOS Commissioning Controller" in large white text. Below the title is the NVIDIA logo, which consists of a green eye-like icon and the word "NVIDIA" in bold black letters. Underneath the logo, a line of text states: "Built using open-source code from projects [nmos.js](#) and [nmos.js](#)". Below this, the "Settings" section is visible, containing four configuration fields: "Query API" with the value "http://nmos.mnip.net/x-nmos/query/v1.3", "Logging API" with "http://nmos.mnip.net/log/v1.0", "DNS-SD API" with "http://nmos.mnip.net/x-dns-sd/v1.1", and "Paging Limit" with a dropdown menu set to "10".

Settings

- Query API: `http://nmos.mnip.net/x-nmos/query/v1.3`
- Logging API: `http://nmos.mnip.net/log/v1.0`
- DNS-SD API: `http://nmos.mnip.net/x-dns-sd/v1.1`
- Paging Limit: 10

## IS-04

Monitor

Configure

Device


Signals

Logs

Device Name: MouN B25 RT #2

IP Address: 10.42.20.66

Status: NOT\_RESPONDING



Chassis: 1c:34:da:8e:2c:00  
Port: Eth1/49/4

Device

PTP

Location

DNS

NMOS

Status: CONNECTED

Uptime: 556

Connection Count: 111

MDNS Mode: ☐

Registry Mode: ☐ Auto  
☒ Manual

Registry Address: 10.42.10.20:80

Manual DNS Server: 0.0.0.0

Apply

Refresh

## IS-04

Properties of SIC AES 67, bay 1 'Config. #1' - UIC frame: Artist 1024, Node 20

General Media 1 Media 2 PTP NMOS

☒ Enable NMOS

Network Settings

Interface: Media 2

Port: 8989 TCP Port the Node API listens on (Default: 8989 Range: 1024-65535)

IS-04 supported versions

☒ v1.1 ☒ v1.2 ☒ v1.3 API versions that shall be supported

Registration Service

Mode: Manual

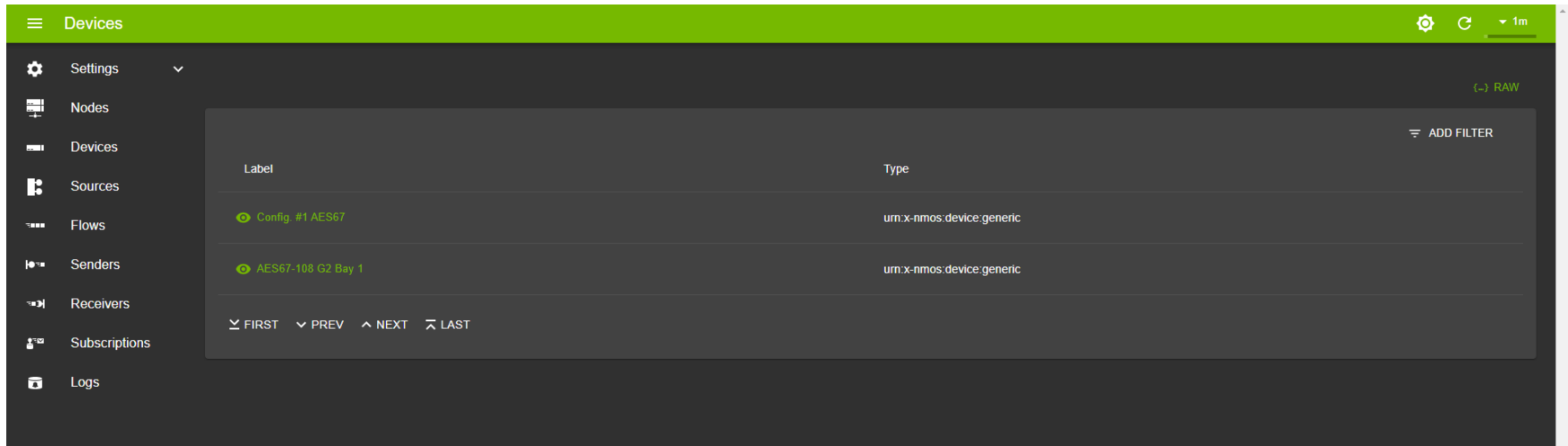
Address: 10 . 42 . 10 . 20

Port: 80 TCP Port the Registration Service listens on (Range: 1-65535)

Version: v1.3 API version to register against

OK Cancel Apply

## IS-04



The screenshot displays the RIEDEL IS-04 control interface. The top navigation bar is green and contains a menu icon, the text "Devices", and icons for settings, refresh, and a time filter set to "1m". On the left, a dark sidebar lists navigation options: Settings, Nodes, Devices, Sources, Flows, Senders, Receivers, Subscriptions, and Logs. The main content area has a dark background and shows a table of devices. The table has two columns: "Label" and "Type". It lists two entries: "Config. #1 AES67" and "AES67-108 G2 Bay 1", both with the type "urn:x-nmos:device:generic". A "RAW" link is visible in the top right of the table area. At the bottom of the table, there are navigation controls: "FIRST", "PREV", "NEXT", and "LAST".

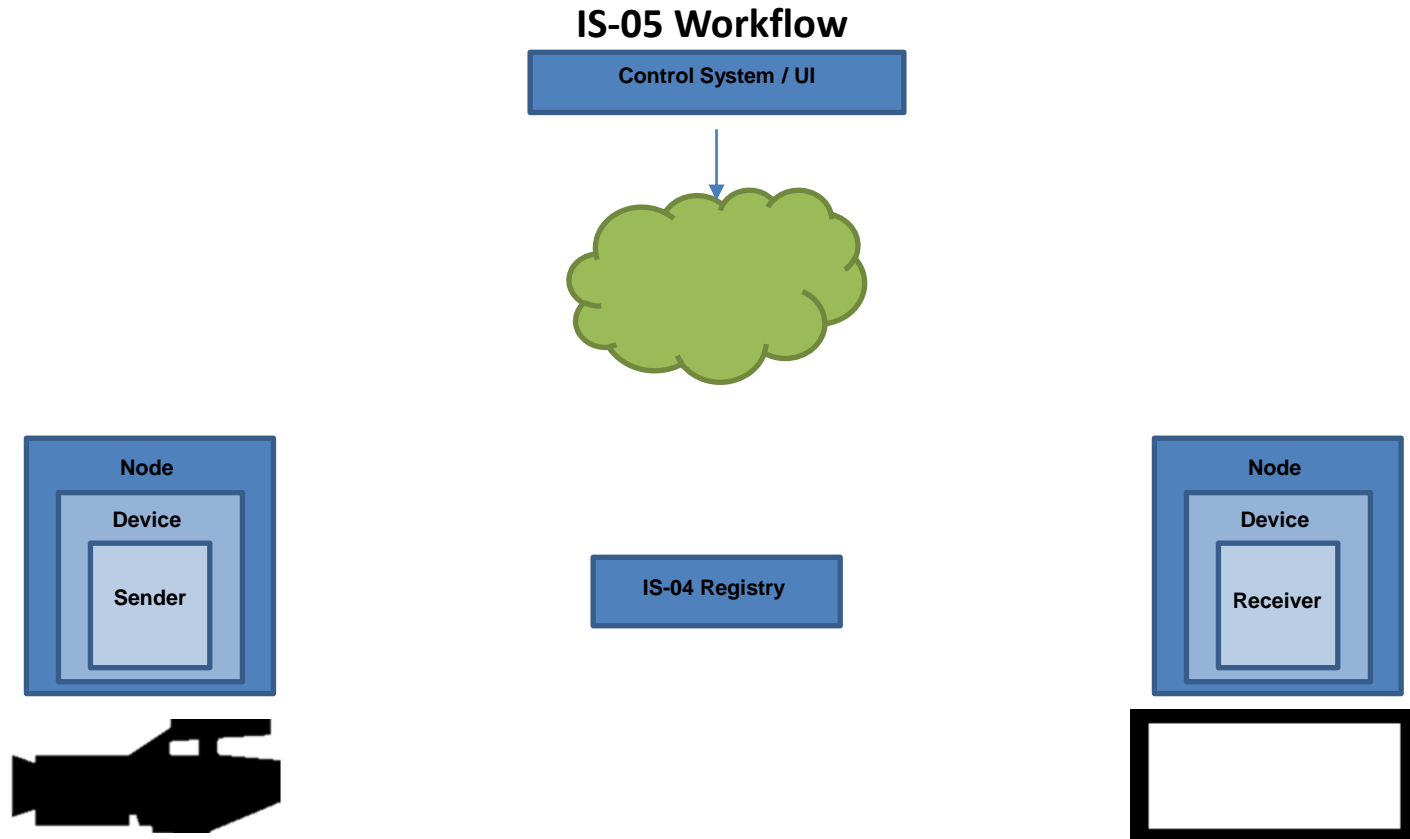
Label	Type
Config. #1 AES67	urn:x-nmos:device:generic
AES67-108 G2 Bay 1	urn:x-nmos:device:generic

# **IS-05**

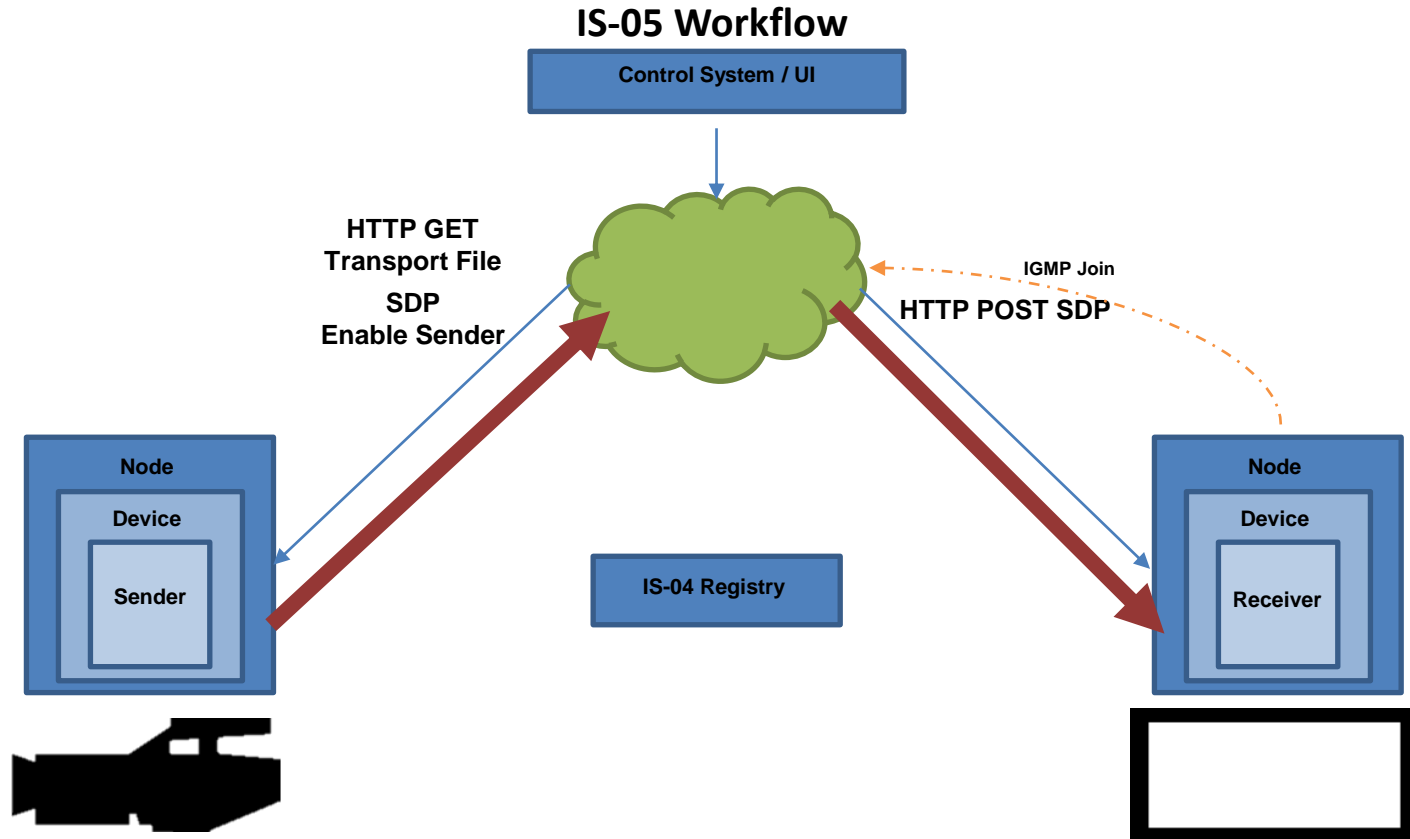
# **Connection Management**



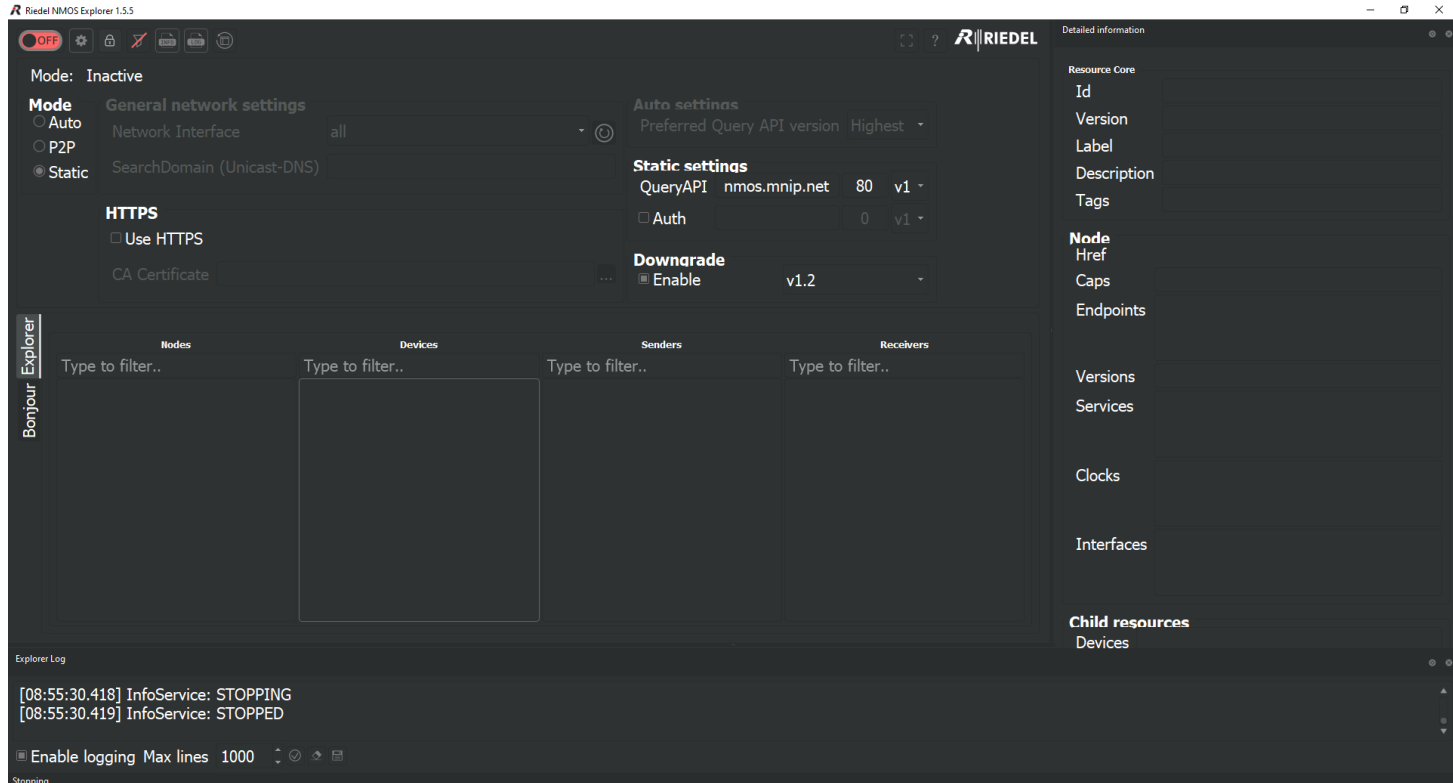
## IS-04 & IS-05



## IS-04 &amp; IS-05



## IS-04 &amp; IS-05



The screenshot displays the Riedel NMOS Explorer 1.5.5 application window. The interface is dark-themed and includes a top toolbar with icons for power, settings, lock, edit, save, and help. The main window is divided into several sections:

- Mode:** Inactive. Below this, there are radio buttons for **Mode**: Auto, P2P, and Static (selected). To the right, under **General network settings**, there are fields for **Network Interface** (set to 'all') and **SearchDomain (Unicast-DNS)**.
- HTTPS:** A checkbox for **Use HTTPS** is unchecked. Below it is a field for **CA Certificate**.
- Static settings:** A section containing a **QueryAPI** field (set to 'nmos.mnip.net'), a **Port** field (set to '80'), and a **Version** dropdown (set to 'v1'). There is also an **Auth** checkbox.
- Downgrade:** A section with an **Enable** checkbox and a **Version** dropdown (set to 'v1.2').
- Explorer:** A vertical sidebar on the left with a 'Bonjour' button and a list of categories: Nodes, Devices, Senders, and Receivers. Each category has a 'Type to filter..' input field.
- Detailed information:** A sidebar on the right showing a tree view of resource information, including **Resource Core** (Id, Version, Label, Description, Tags), **Node** (Href, Caps, Endpoints), **Versions**, **Services**, **Clocks**, **Interfaces**, and **Child resources** (Devices).
- Explorer Log:** A bottom section showing log messages: '[08:55:30.418] InfoService: STOPPING' and '[08:55:30.419] InfoService: STOPPED'. Below the log is a checkbox for **Enable logging** and a **Max lines** field set to 1000.

## IS-04 &amp; IS-05

Riedel NMOS Explorer 1.5.5

Mode: **Static-Mode** <http://nmos.mnip.net:80/x-nmos/query/v1.3/>

Mode: **General network settings**

Auto settings

Preferred Query API version: Highest

Static settings

QueryAPI: nmos.mnip.net 80 v1

Auth: 0 v1

Downgrade

Enable v1.2

HTTPS

Use HTTPS

CA Certificate

**Bonjour Explorer**

Nodes	Devices	Senders	Receivers
Type to filter..	Type to filter..	Type to filter..	Type to filter..
<ul style="list-style-type: none"><li>easy-nmos-registry 172.18.0.2:80</li><li>Riedel Artist (Net 1 / Node 10) 10.42.20.120:8989</li><li>Config. #1 10.42.20.123:8989</li></ul>	<ul style="list-style-type: none"><li>AES67-108 G2 Bay 1</li><li>Config. #1 AES67</li></ul>	<ul style="list-style-type: none"><li>IP Audio Sender 2 of AES67-108 Source: AES67-108 G2 Node 10 Bay 1 Sou</li><li>Audio Sender on 'Out. 2.35 - Ai Source: Out. 2.35 - Artist 1024, Node 20</li><li>Audio Sender on 'Out. 2.34 - Ai Source: Out. 2.34 - Artist 1024, Node 20</li><li>Audio Sender on 'Out. 2.36 - Ai Source: Out. 2.36 - Artist 1024, Node 20</li><li>Audio Sender on 'Out. 2.37 - Ai Source: Out. 2.37 - Artist 1024, Node 20</li><li>Audio Sender on 'Out. 2.40 - Ai Source: Out. 2.40 - Artist 1024, Node 20</li></ul>	<ul style="list-style-type: none"><li>IP Audio Receiver 2 of AES67-1 connected flow not found</li><li>Audio Receiver on 'In. 2.38 urn:x-nmos:format:audio</li><li>Audio Receiver on 'In. 2.34 urn:x-nmos:format:audio</li><li>Audio Receiver on 'In. 2.35 urn:x-nmos:format:audio</li><li>Audio Receiver on 'In. 2.39 urn:x-nmos:format:audio</li><li>Audio Receiver on 'In. 2.36 urn:x-nmos:format:audio</li></ul>

Explorer Log

```
[08:56:00.143] QueryService: Added source: {26818b6f-2e26-5679-8171-57c8226124a7}
[08:56:00.143] QueryService: Added source: {ce641784-a78b-55be-8f88-4e0464b142a5}
```

Enable logging Max lines 1000

Detailed information

Resource Core

Id

Version

Label

Description

Tags

Node

Href

Caps

Endpoints

Versions

Services

Clocks

Interfaces

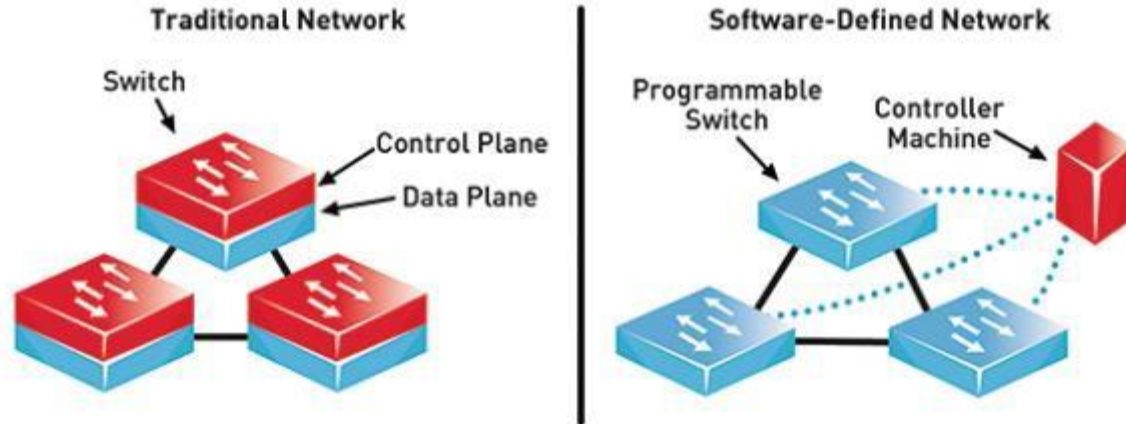
Child resources

Devices

# **IS-06**

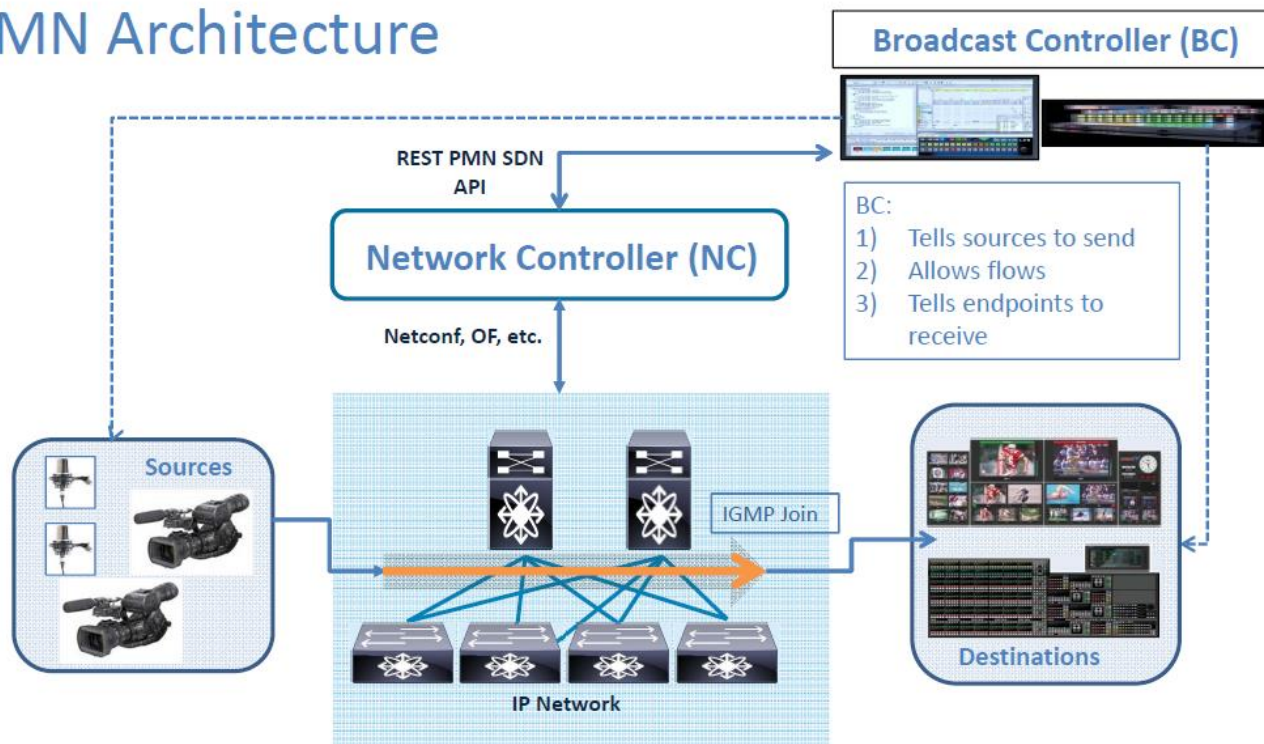
# **Network Control**

# SDN – Software Define Networking

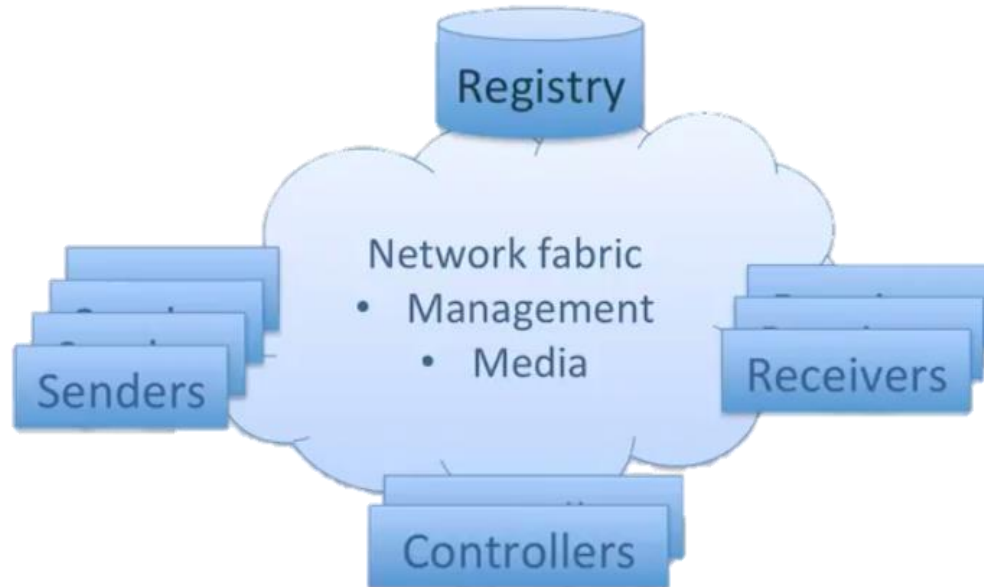


## Software Defined Networking (SDN)

## PMN Architecture



Goal: registered network with all devices, controllers and flows





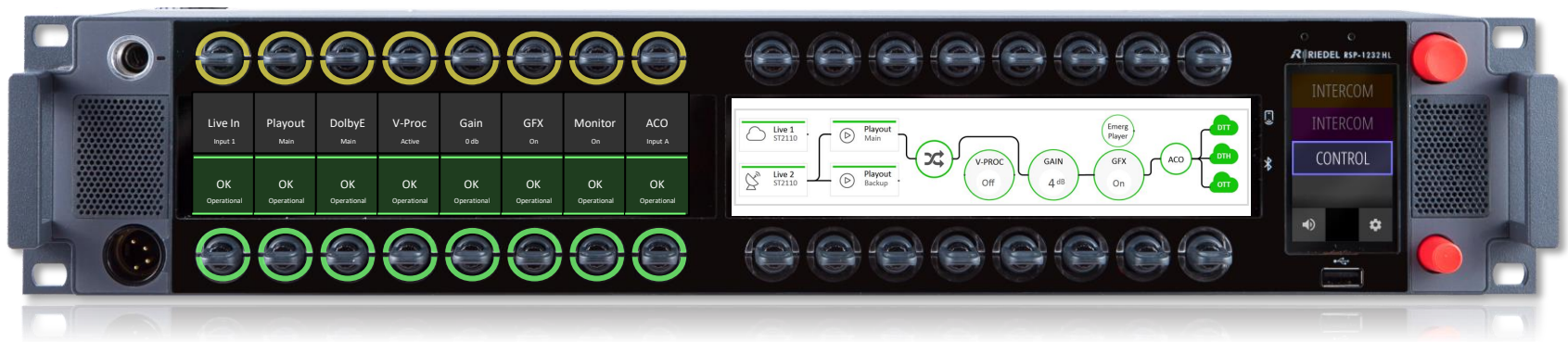
# **IS-07**

# **Event & Tally Specification**

# NMOS IS-07



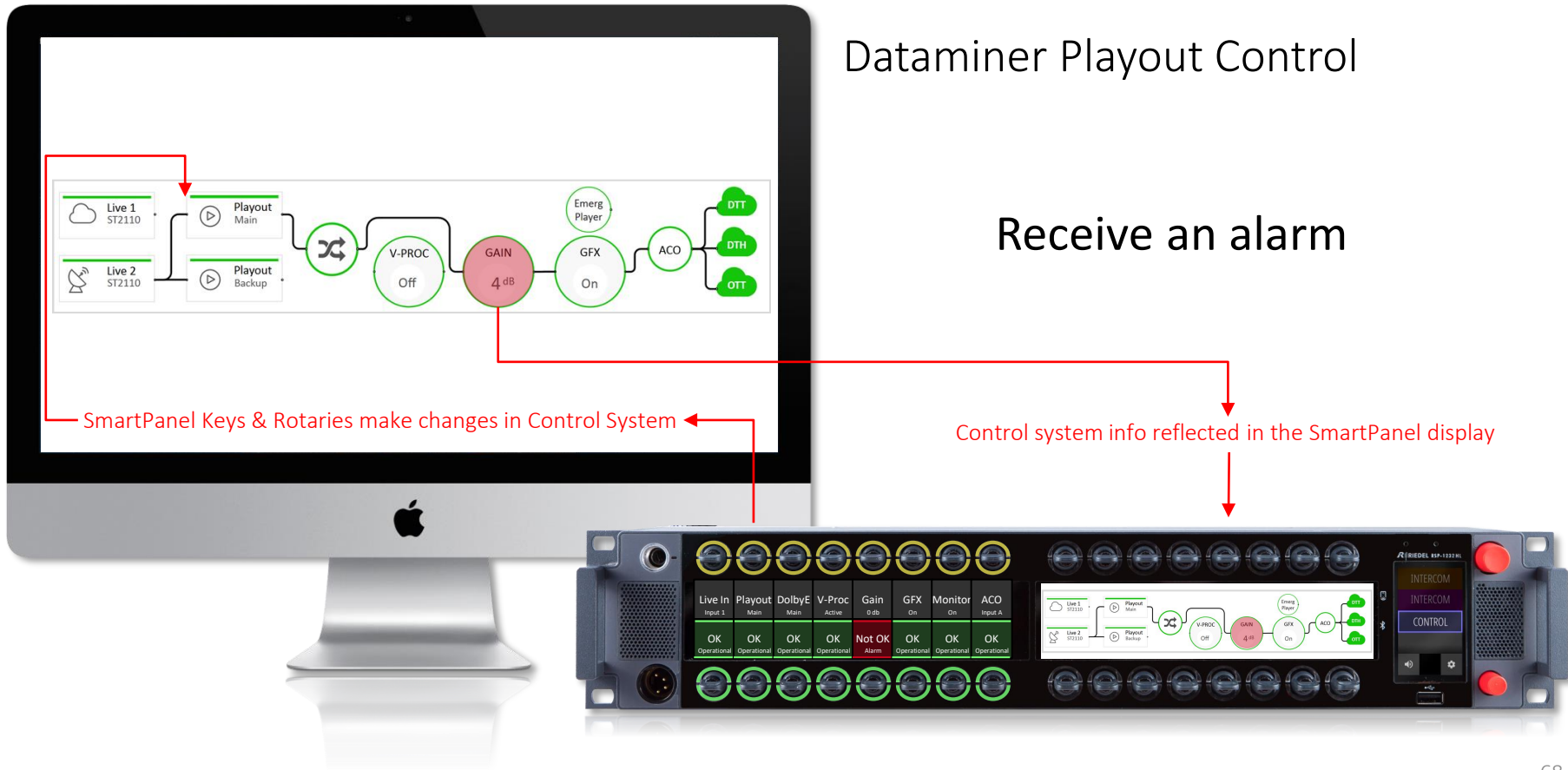
# NMOS IS-07



# NMOS IS-07

## Dataminer Payout Control

Receive an alarm



# Interoperability Considerations



Payload

Timing

Control

# Interoperability

- Key to IP Intercom Interoperability is
  - Remove payload limitations
    - Don't Island your network
    - Keep Your Protocols Open
  - Remove Timing Limitations
    - Keep your timing as accurate as possible with as robust a PTP implementation as possible
  - Remove Control Limitations
    - Implement open control protocols
    - Implement monitoring for troubleshooting and security



# Interoperability

Questions?



# Interoperable Intercom in an IP World

Thank You!

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