CURATED BY

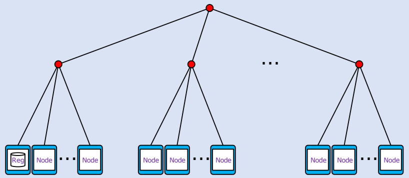
Scalability and Performance of IS-04 and IS-05 and How TR-1001-1 Helps

Rob Porter

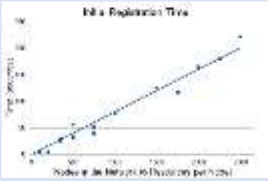
Sony Europe B.V.

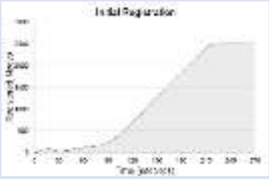
AMWA NMOS IS-04 and IS-05 APIs

The AMWA NMOS Scalability Study

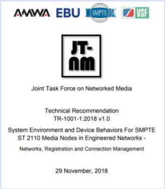


Scalability Study Results





Best Practice Recommendations
and How JT-NM TR-1001-1 Helps



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JT-NM

Joint Task Force on Networked Media

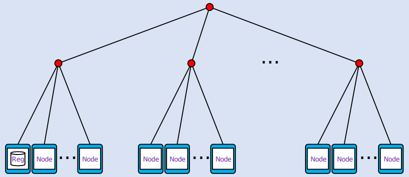
Technical Recommendation
TR-1001-1:2018 v1.0

System Environment and Device Behaviors For SMPTE ST 2110 Media Nodes in Engineered Networks -
Networks, Registration and Connection Management

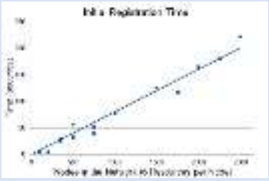
29 November, 2018

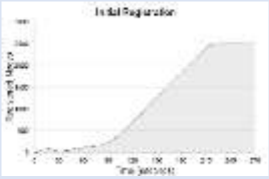
AMWA NMOS IS-04 and IS-05 APIs

The AMWA NMOS Scalability Study



Scalability Study Results





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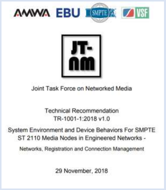

Joint Task Force on Networked Media

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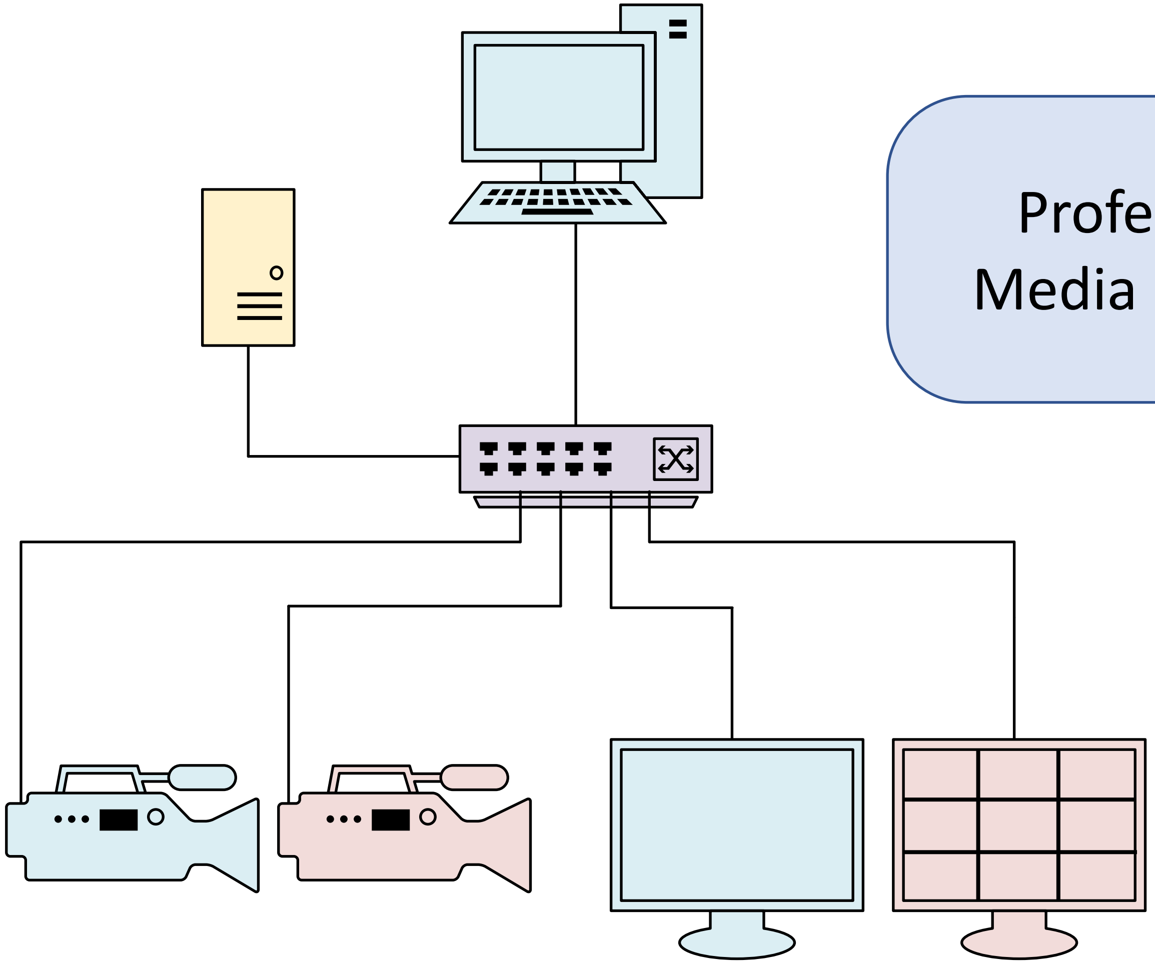
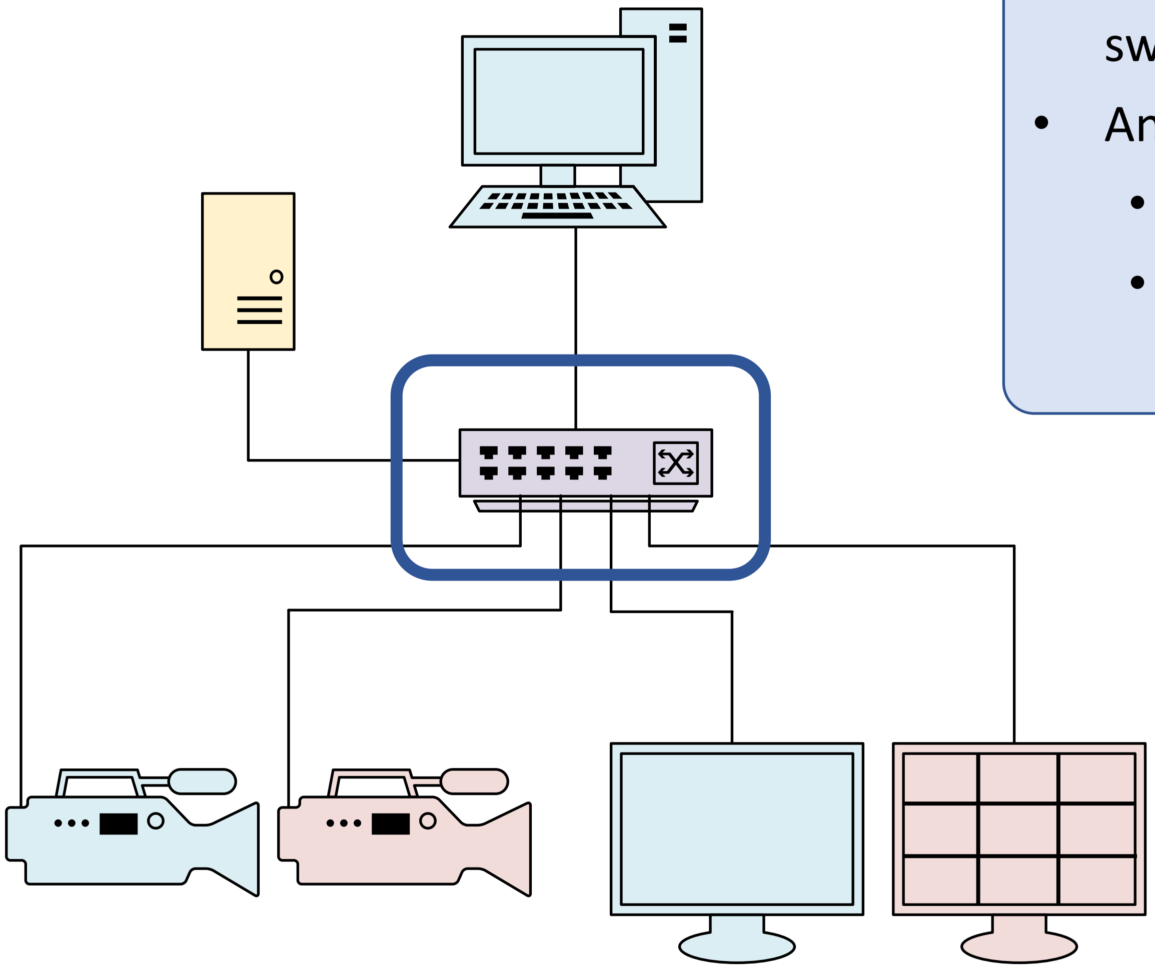


Professional Media Network

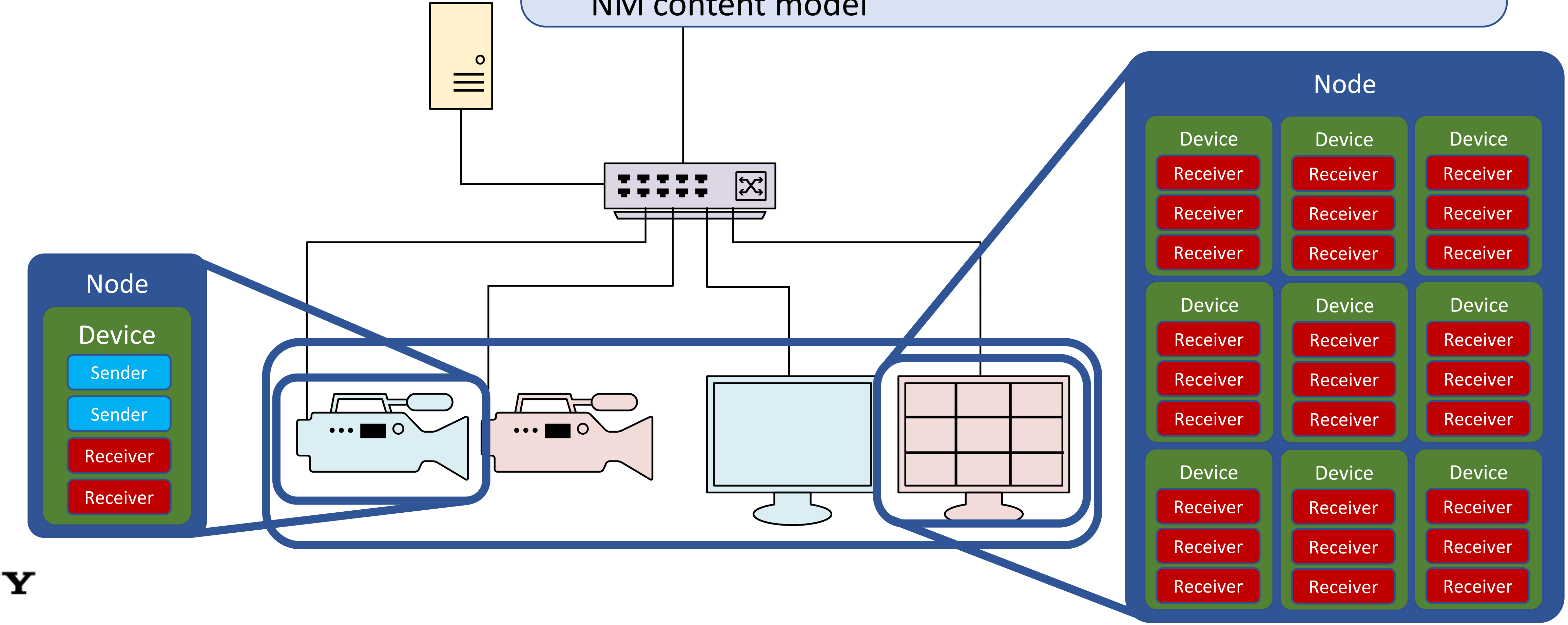
Network Infrastructure

- One or more network switches
- Any architecture
  - Single monolithic switch
  - Multi-layer spine-leaf network

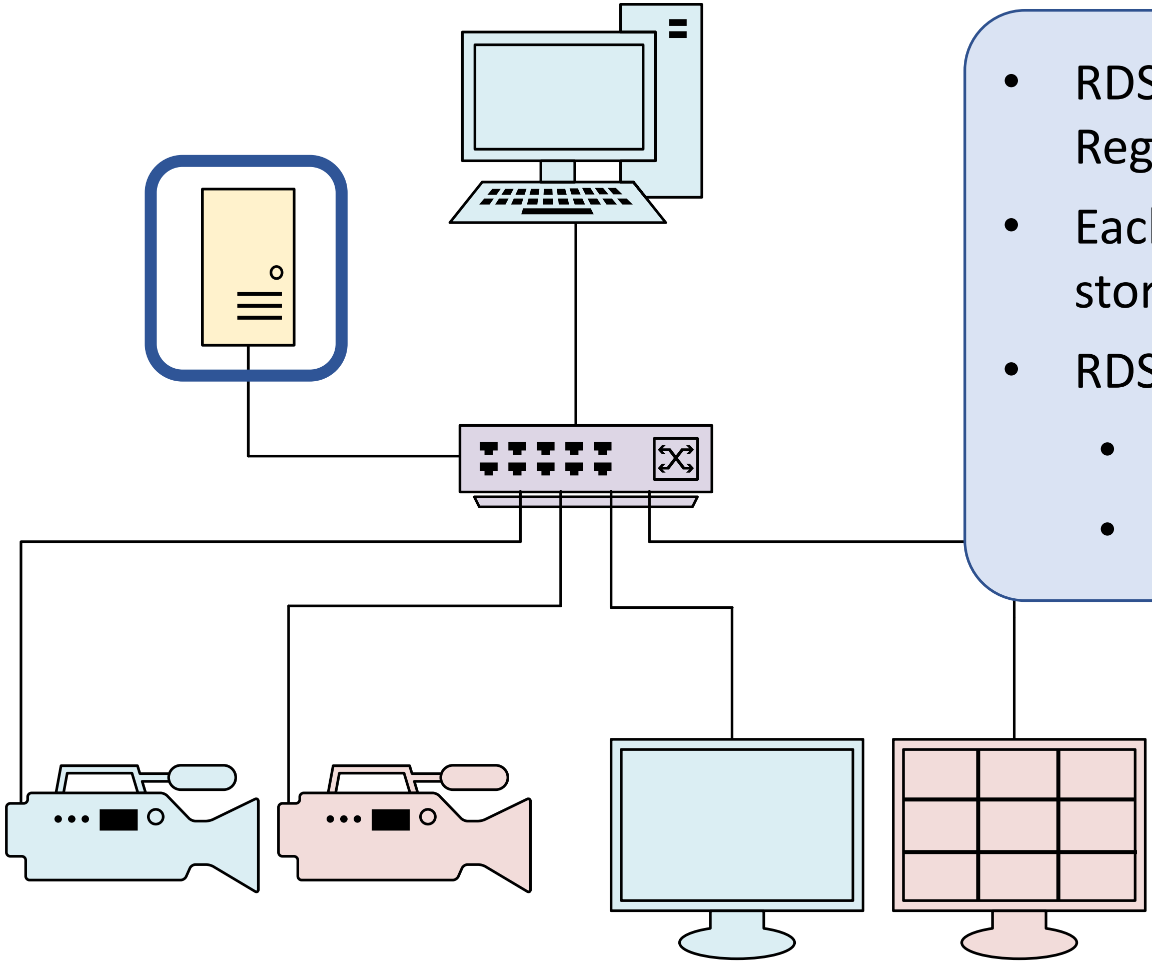


Media Nodes

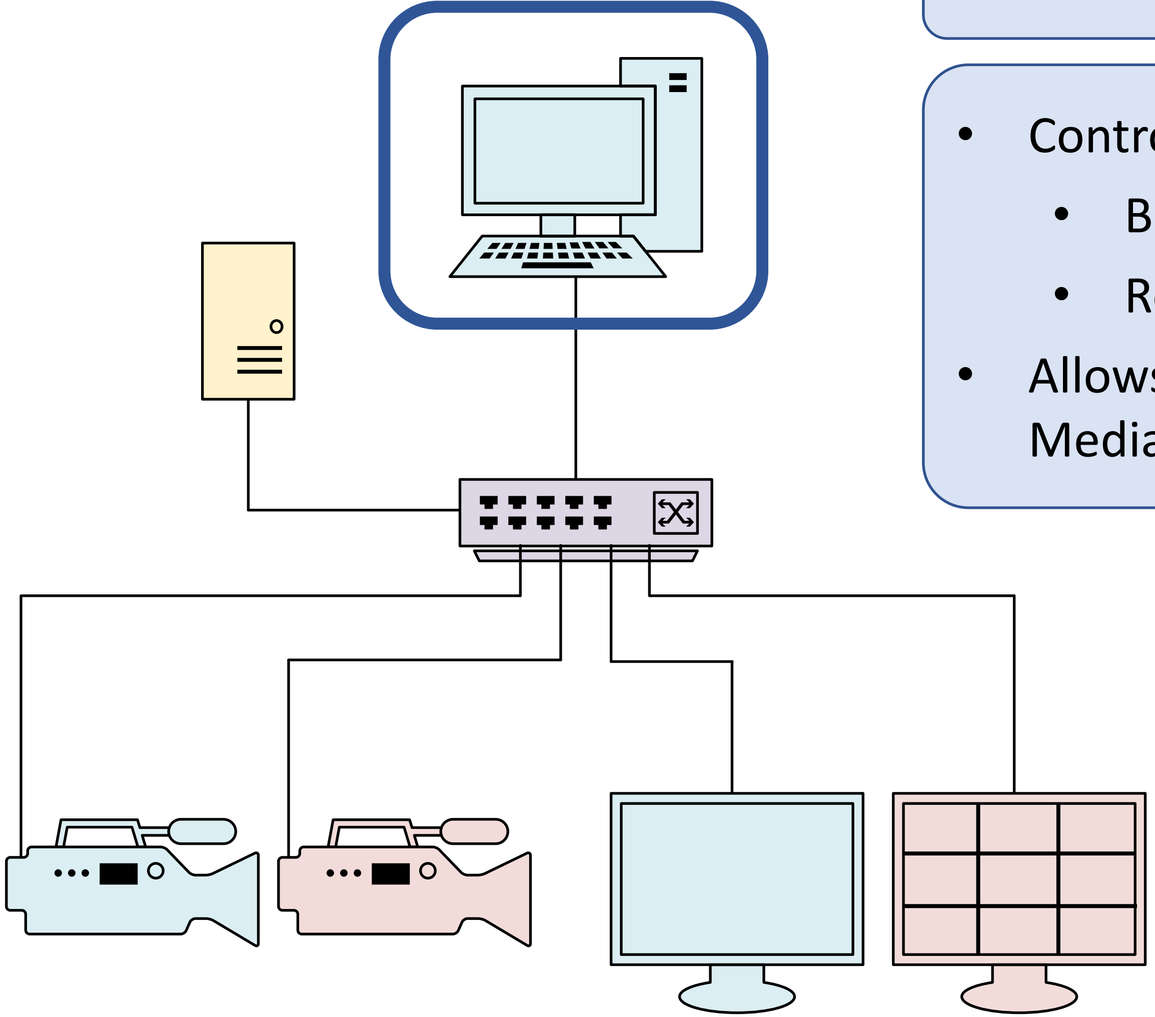
- **Node** is a logical host connected to the network
- Can host one or more **Devices** each with any number of associated **Senders**, **Receivers**, **Sources** and **Flows**
- These are known as *resources* and are all defined by the JT-NM content model



IS-04 Registration and Discovery System (RDS)



- RDS comprises one or more Registry instances
- Each includes a database storing all registered resources
- RDS exposes two APIs:
  - Registration API
  - Query API

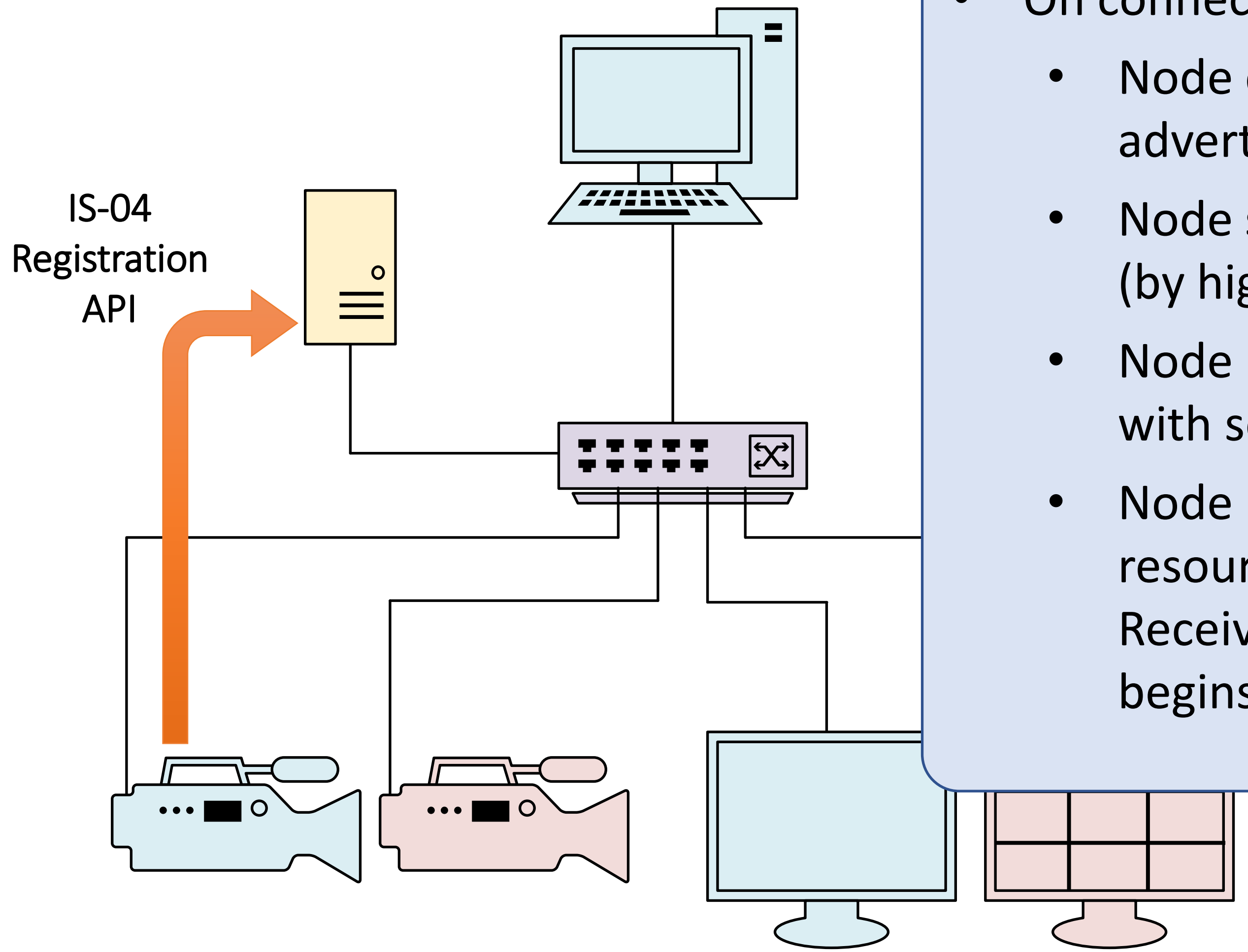


NMOS Client

- Control system, e.g.
  - Broadcast Controller
  - Routing panel
- Allows connections between Media Nodes to be set up

IP SHOWCASE™ THEATER

IS-04 Registration API



- On connecting a Node to the network:
  - Node discovers Registration APIs advertised over DNS-SD
  - Node selects a Registration API (by highest priority)
  - Node registers its Node resource with selected Registration API
  - Node registers each of its sub-resources (Devices, Senders, Receivers, Sources, Flows) and begins to post regular heartbeats

SONY

Registration API Request (Node→RDS):

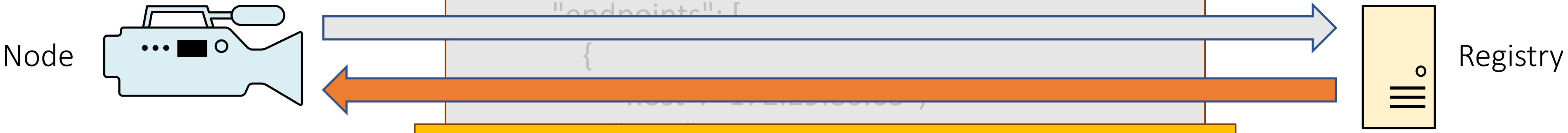
```
POST /x-nmos/registration/v1.2/resource HTTP/1.1
Content-Type: application/json
 {
   "type": "node",
   "data": {
      "version": "1441973902:879053935",
      "hostname": "host1",
      "label": "host1",
      "description": "host1",
      "tags": {},
      "href": "http://172.29.80.65:12345/",
      "api": {
         "versions": ["v1.1", "v1.2"],
         "endpoints": [
            {
               "host": "172.29.80.65",
               "port": 12345,
               "protocol": "http"
            },
            {
               "host": "172.29.80.65",
               "port": 443,
               "protocol": "https"
            }
         ]
      },
```

Node

Registry

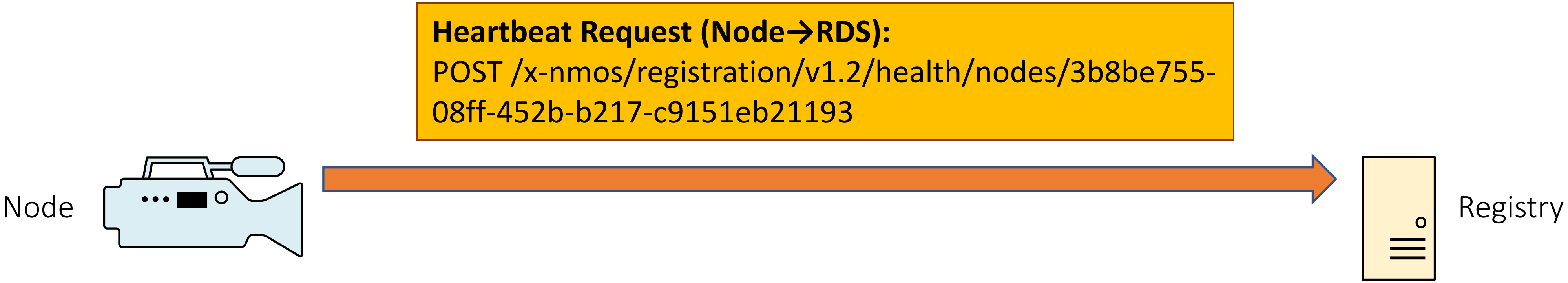
Registration API Request (Node→RDS):

```
POST /x-nmos/registration/v1.2/resource HTTP/1.1
Content-Type: application/json
{
  "type": "node",
  "data": {
    "version": "1441973902:879053935",
    "hostname": "host1",
    "label": "host1",
    "description": "host1",
    "tags": {},
    "href": "http://172.29.80.65:12345/",
    "api": {
      "versions": ["v1.1", "v1.2"],
      "endpoints": [
        {
          "host": "172.29.80.65",
```

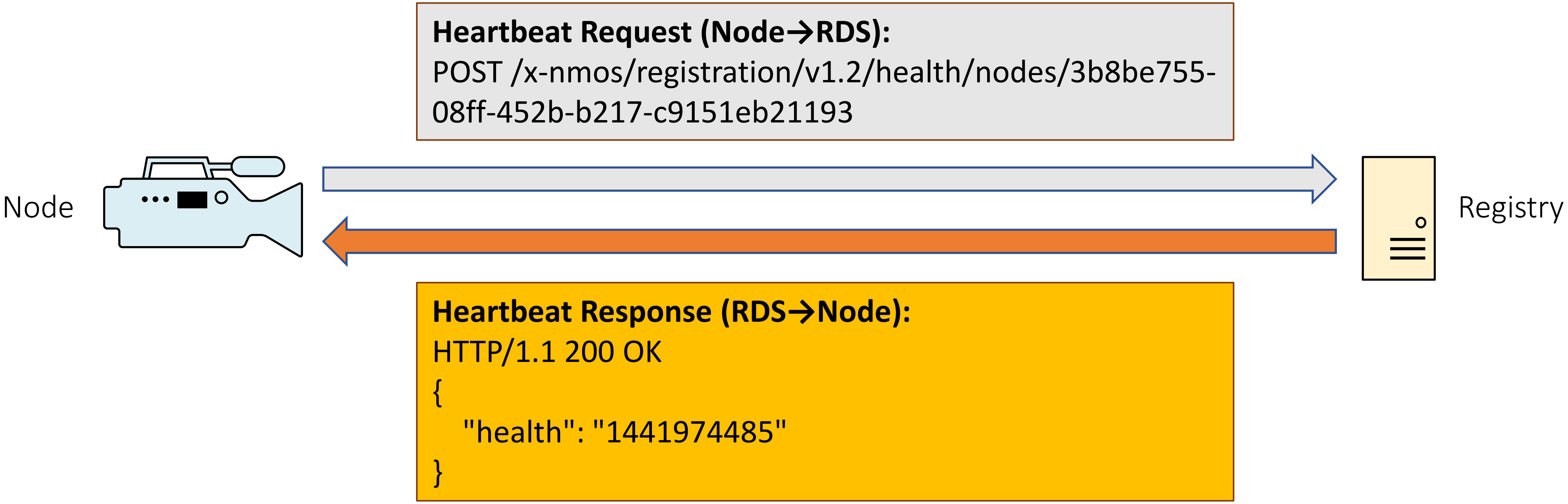


Registration API Response (RDS→Node):
HTTP/1.1 201 Created
/x-nmos/registration/v1.2/resource/nodes/3b8be755-08ff-452b-b217-c9151eb21193/

```
          "host": "172.29.80.65",
          "port": 443,
          "protocol": "https"
        }
      ]
    },
```



Heartbeat Request (Node→RDS):
POST /x-nmos/registration/v1.2/health/nodes/3b8be755-08ff-452b-b217-c9151eb21193



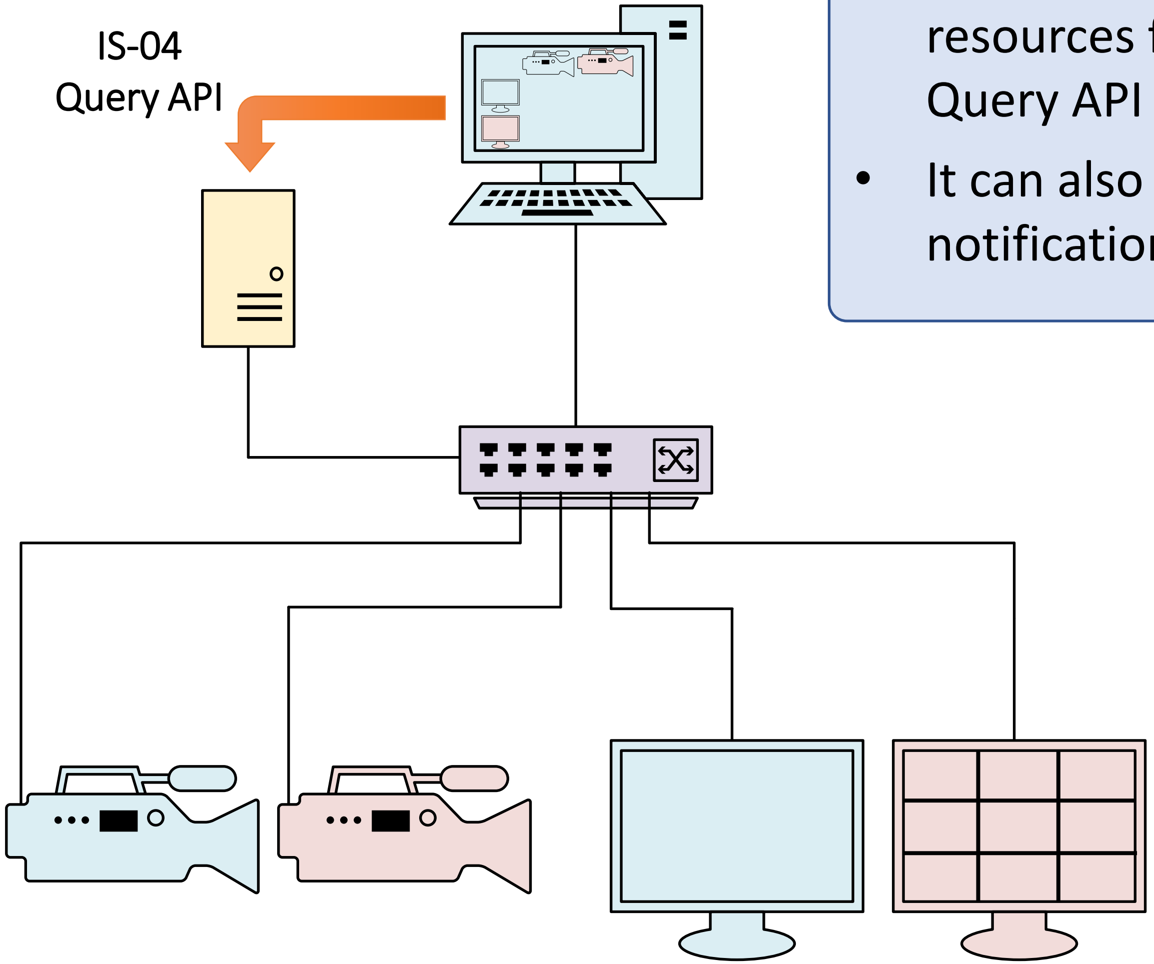
Heartbeat Request (Node→RDS):

```
POST /x-nmos/registration/v1.2/health/nodes/3b8be755-08ff-452b-b217-c9151eb21193
```

Heartbeat Response (RDS→Node):

```
HTTP/1.1 200 OK
{
   "health": "1441974485"
}
```

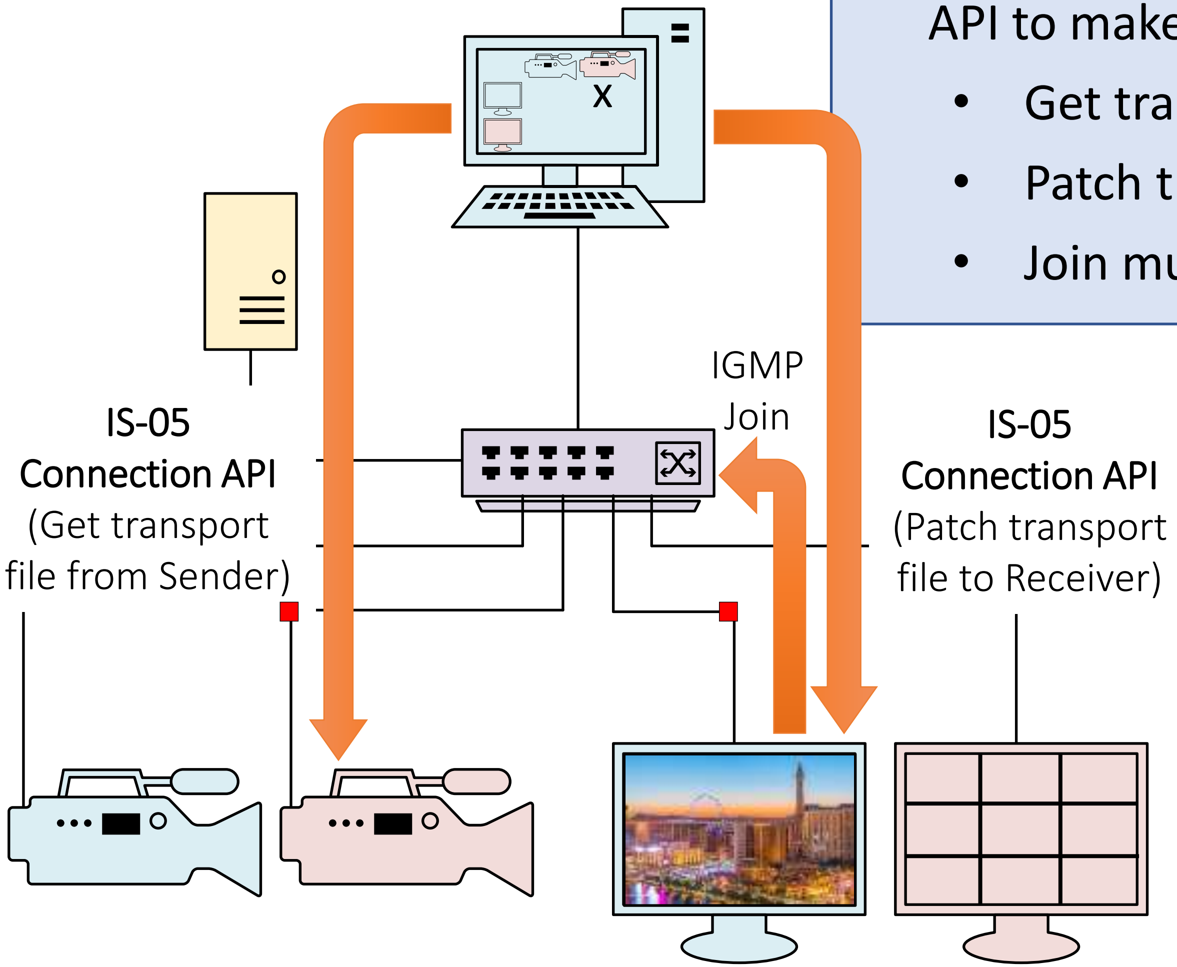
IS-04 Query API

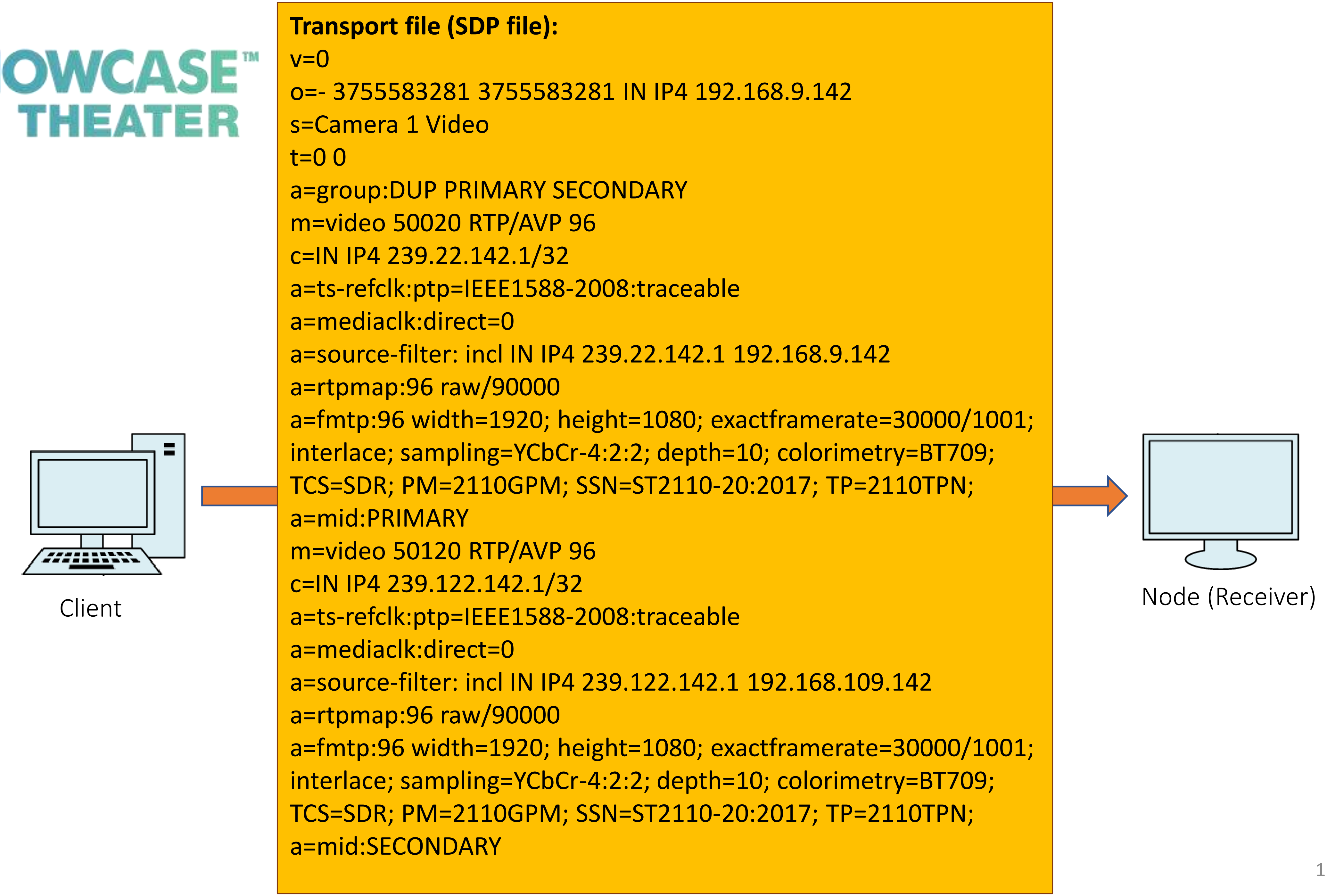


- Client is able to get list of registered resources from Registry using IS-04 Query API
- It can also subscribe to WebSocket notifications of changes in the RDS

IS-05 Connection API

- Client can use a Node’s IS-05 Connection API to make a connection
  - Get transport file from Sender
  - Patch transport file to Receiver
  - Join multicast group


X
IS-05
Connection API
(Get transport file from Sender)
IGMP Join
IS-05
Connection API
(Patch transport file to Receiver)



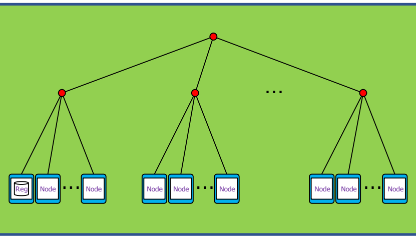
Transport file (SDP file):

```
v=0
o=- 3755583281 3755583281 IN IP4 192.168.9.142
s=Camera 1 Video
t=0 0
a=group:DUP PRIMARY SECONDARY
m=video 50020 RTP/AVP 96
c=IN IP4 239.22.142.1/32
a=ts-refclk:ptp=IEEE1588-2008:traceable
a=mediaclk:direct=0
a=source-filter: incl IN IP4 239.22.142.1 192.168.9.142
a=rtpmap:96 raw/90000
a=fmtp:96 width=1920; height=1080; exactframerate=30000/1001;
interlace; sampling=YCbCr-4:2:2; depth=10; colorimetry=BT709;
TCS=SDR; PM=2110GPM; SSN=ST2110-20:2017; TP=2110TPN;
a=mid:PRIMARY
m=video 50120 RTP/AVP 96
c=IN IP4 239.122.142.1/32
a=ts-refclk:ptp=IEEE1588-2008:traceable
a=mediaclk:direct=0
a=source-filter: incl IN IP4 239.122.142.1 192.168.109.142
a=rtpmap:96 raw/90000
a=fmtp:96 width=1920; height=1080; exactframerate=30000/1001;
interlace; sampling=YCbCr-4:2:2; depth=10; colorimetry=BT709;
TCS=SDR; PM=2110GPM; SSN=ST2110-20:2017; TP=2110TPN;
a=mid:SECONDARY
```

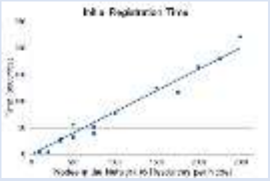
AMWA NMOS IS-04 and IS-05 APIs

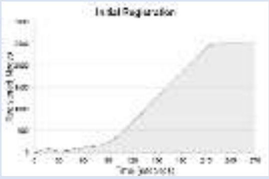
AMWA networked media NMOS open specifications

The AMWA NMOS Scalability Study

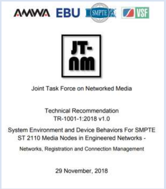


Scalability Study Results





Best Practice Recommendations
and How JT-NM TR-1001-1 Helps



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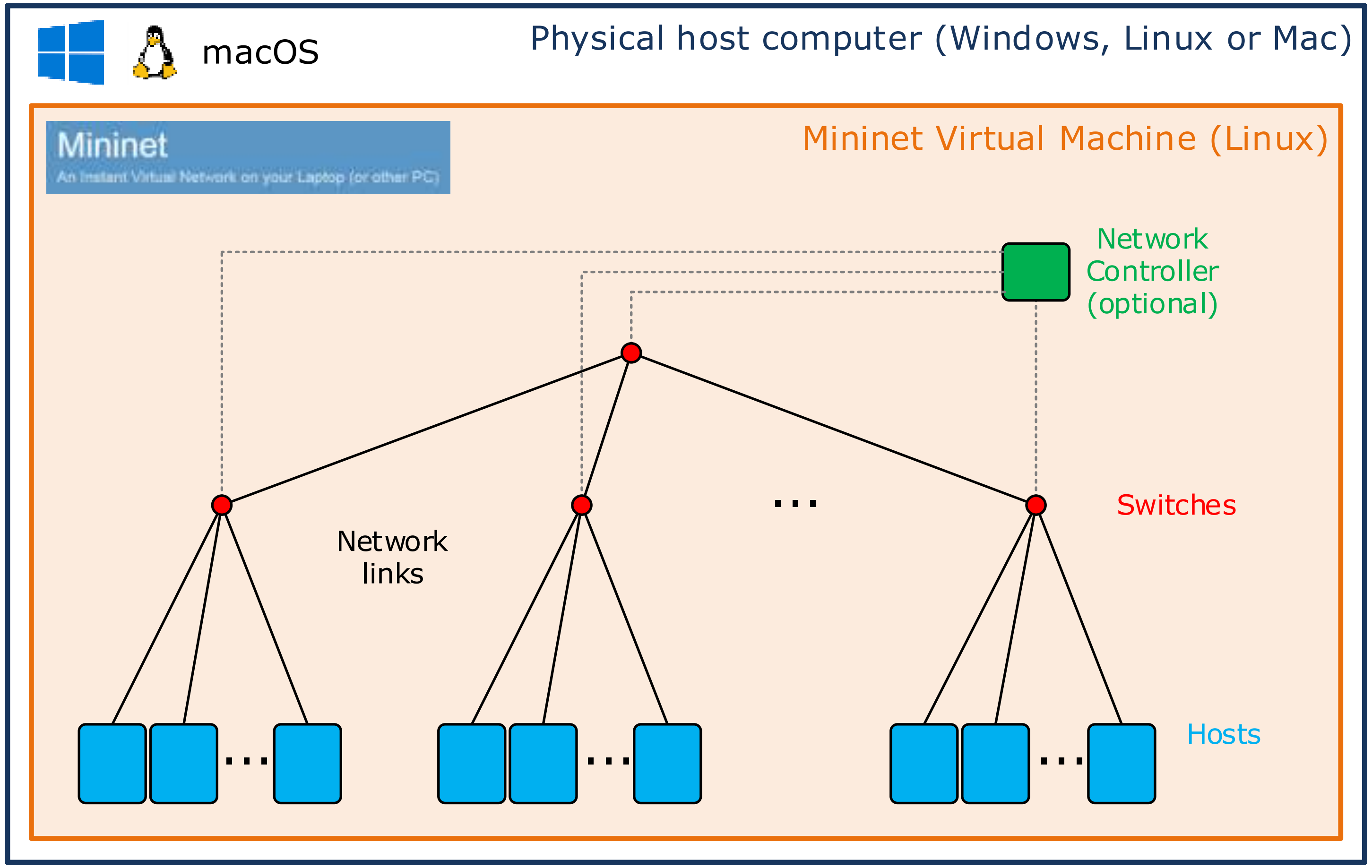
The AMWA NMOS Scalability Study

- A key requirement of the AMWA IS-04 and IS-05 APIs is that they can be used reliably at scale
  - i.e. for very large networks comprising thousands of NMOS Nodes such as might be found in a typical broadcast installation.
- The aim of the AMWA NMOS Scalability Study was to help address this
- Study took place within the AMWA community and was led by Sony
- The study used a virtualised network to test and make timing measurements of various IS-04 and IS-05 operations at scale

IP SHOWCASE™ THEATER


macOS

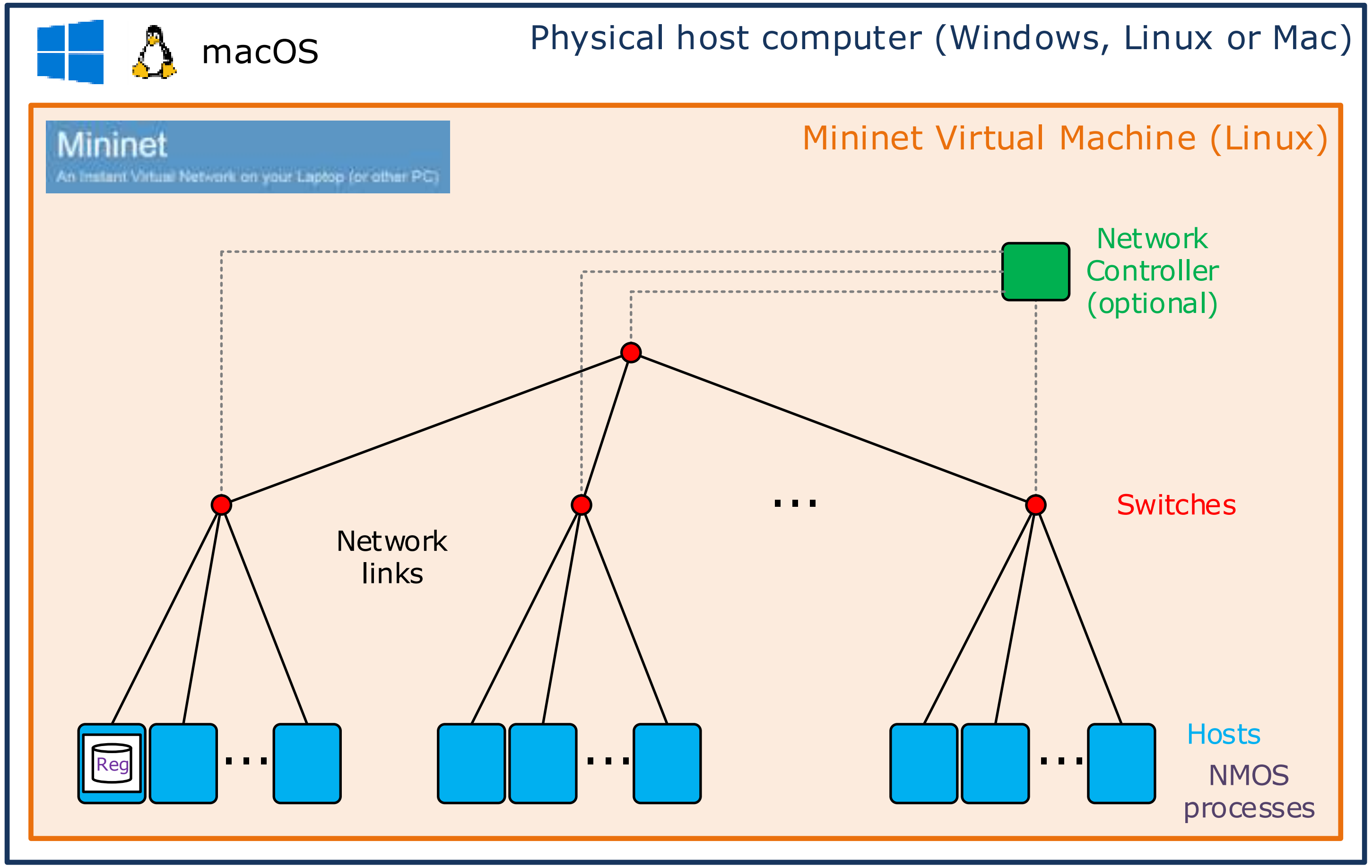
Physical host computer (Windows, Linux or Mac)

Mininet Virtual Machine (Linux)

Mininet
An Instant Virtual Network on your Laptop (or other PC)
Network Controller (optional)
Switches
Network links
Hosts
…

Scalability Study Methodology

- Use Mininet virtualised network to simulate large number of network endpoints
- Mininet extended for NMOS to allow NMOS processes to be run on each Mininet host

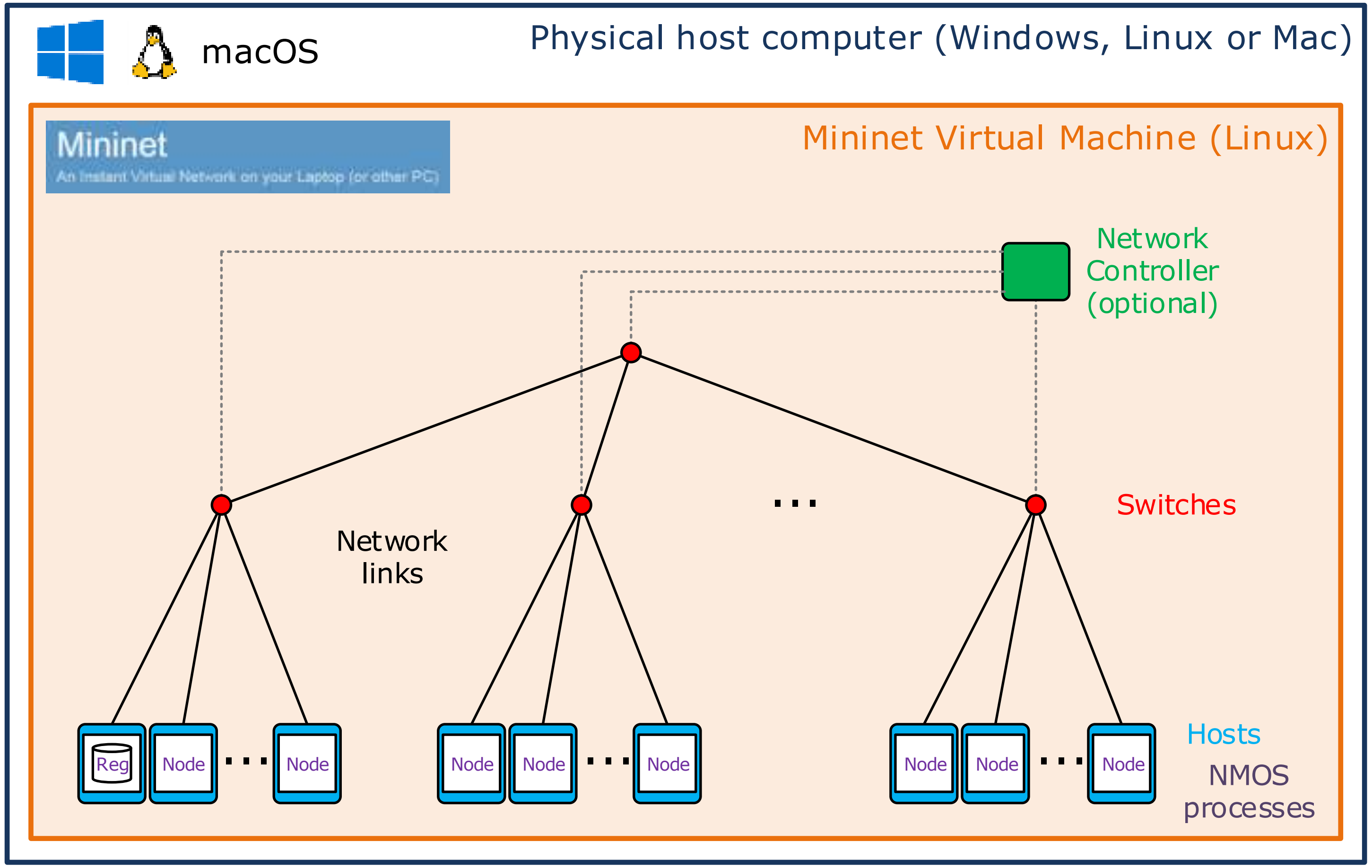

macOS
Physical host computer (Windows, Linux or Mac)
Mininet
An Instant Virtual Network on your Laptop (or other PC)
Mininet Virtual Machine (Linux)
Network Controller (optional)
...
Switches
Network links
Reg
...
...
...
Hosts
NMOS processes

Scalability Study Methodology

- Use Mininet virtualised network to simulate large number of network endpoints
- Mininet extended for NMOS to allow NMOS processes to be run on each Mininet host
- Run nmos-cpp-registry* on one Mininet host

* https://github.com/sony/nmos-cpp

IP SHOWCASE™ THEATER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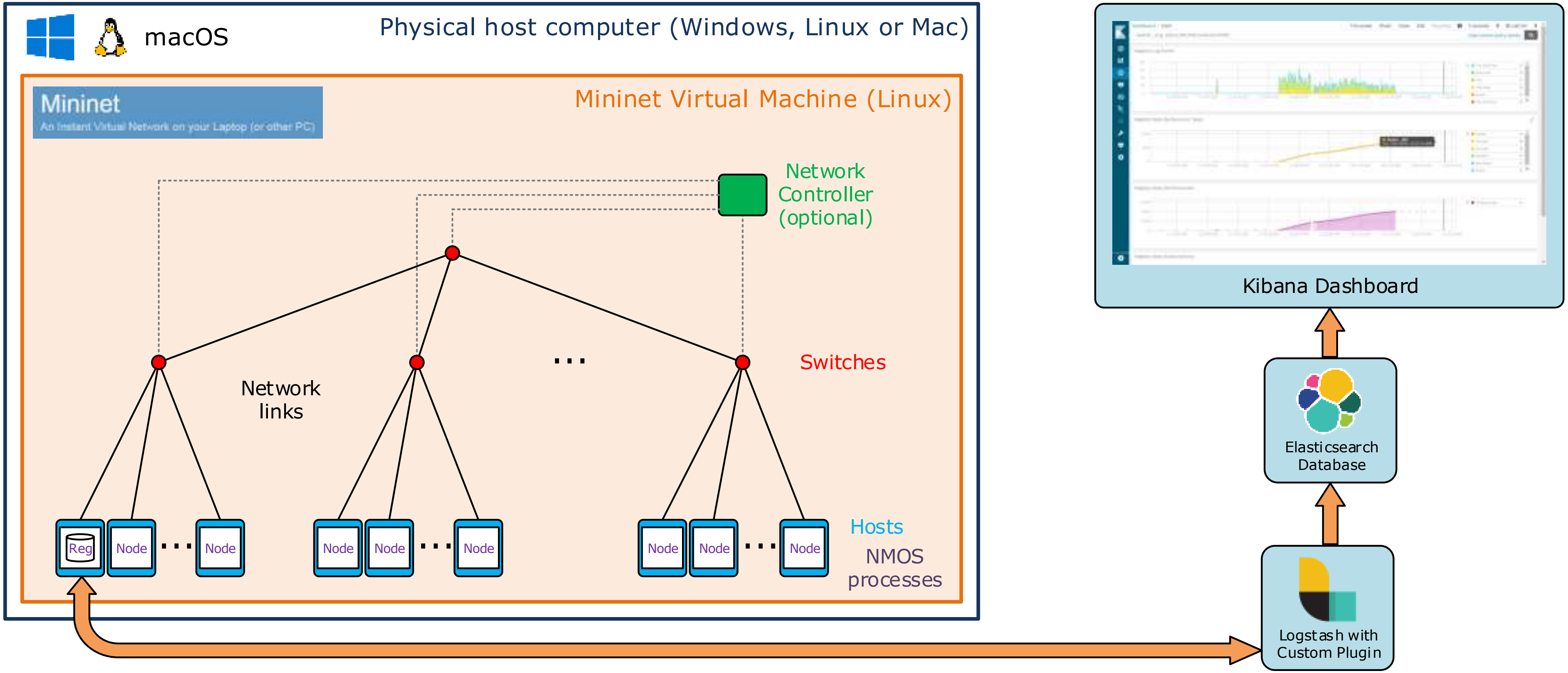
Mininet
An Instant Virtual Network on your Laptop (or other PC)
Mininet Virtual Machine (Linux)
Network Controller (optional)
Switches
...
Network links
Reg
Node
Node
Node
Node
Node
Node
Node
Node
Hosts
NMOS processes

Scalability Study Methodology

- Use Mininet virtualised network to simulate large number of network endpoints
- Mininet extended for NMOS to allow NMOS processes to be run on each Mininet host
- Run nmos-cpp-registry* on one Mininet host
- Run multiple instances of nmos-cpp-node* on multiple other Mininet hosts

* https://github.com/sony/nmos-cpp



Physical host computer (Windows, Linux or Mac)

macOS

Mininet Virtual Machine (Linux)

Mininet

An Instant Virtual Network on your Laptop (or other PC)

Network Controller (optional)

Switches

Network links

Hosts

NMOS processes

Reg

Node

Kibana Dashboard

Elasticsearch Database

Logstash with Custom Plugin

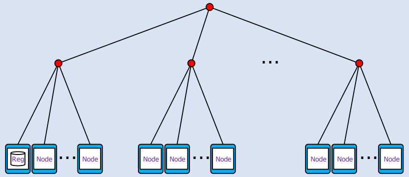
IP SHOWCASE™ THEATER

AMWA NMOS IS-04 and IS-05 APIs

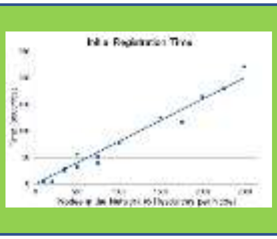
AMWA

networked media NMOS open specifications

The AMWA NMOS Scalability Study



Scalability Study Results



Initial Registration
Time (seconds)

Best Practice Recommendations
and How JT-NM TR-1001-1 Helps

AMWA EBU SMPTE VSF

JT-NM

Joint Task Force on Networked Media

Technical Recommendation
TR-1001-1:2018 v1.0

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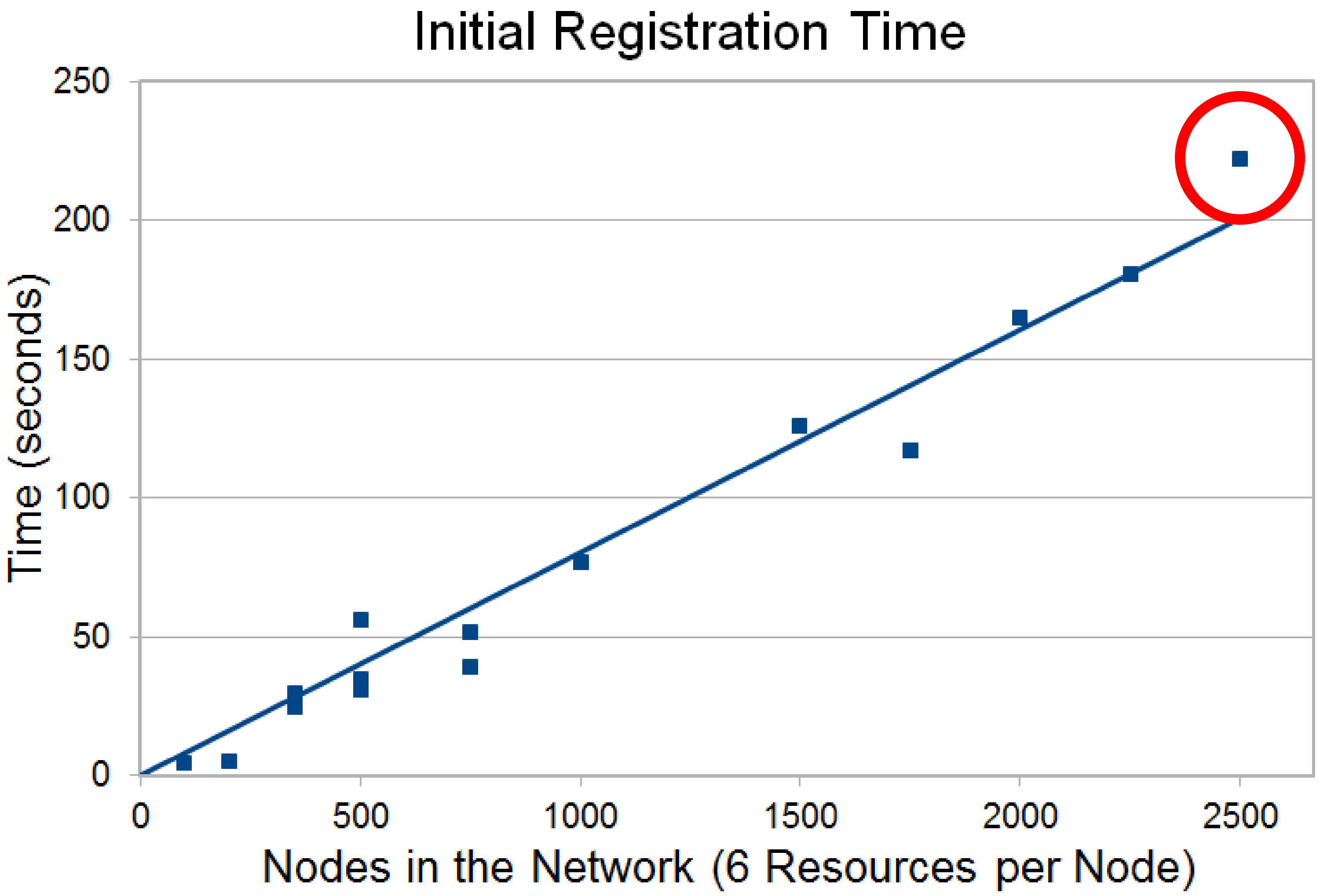
SONY

Initial registration

Test: Registration of 100 - 2,500 Nodes with 6 resources per Node - one of each resource type: Node, Device, Sender, Receiver, Source, Flow

Result: Total registration time scales linearly with number of resources

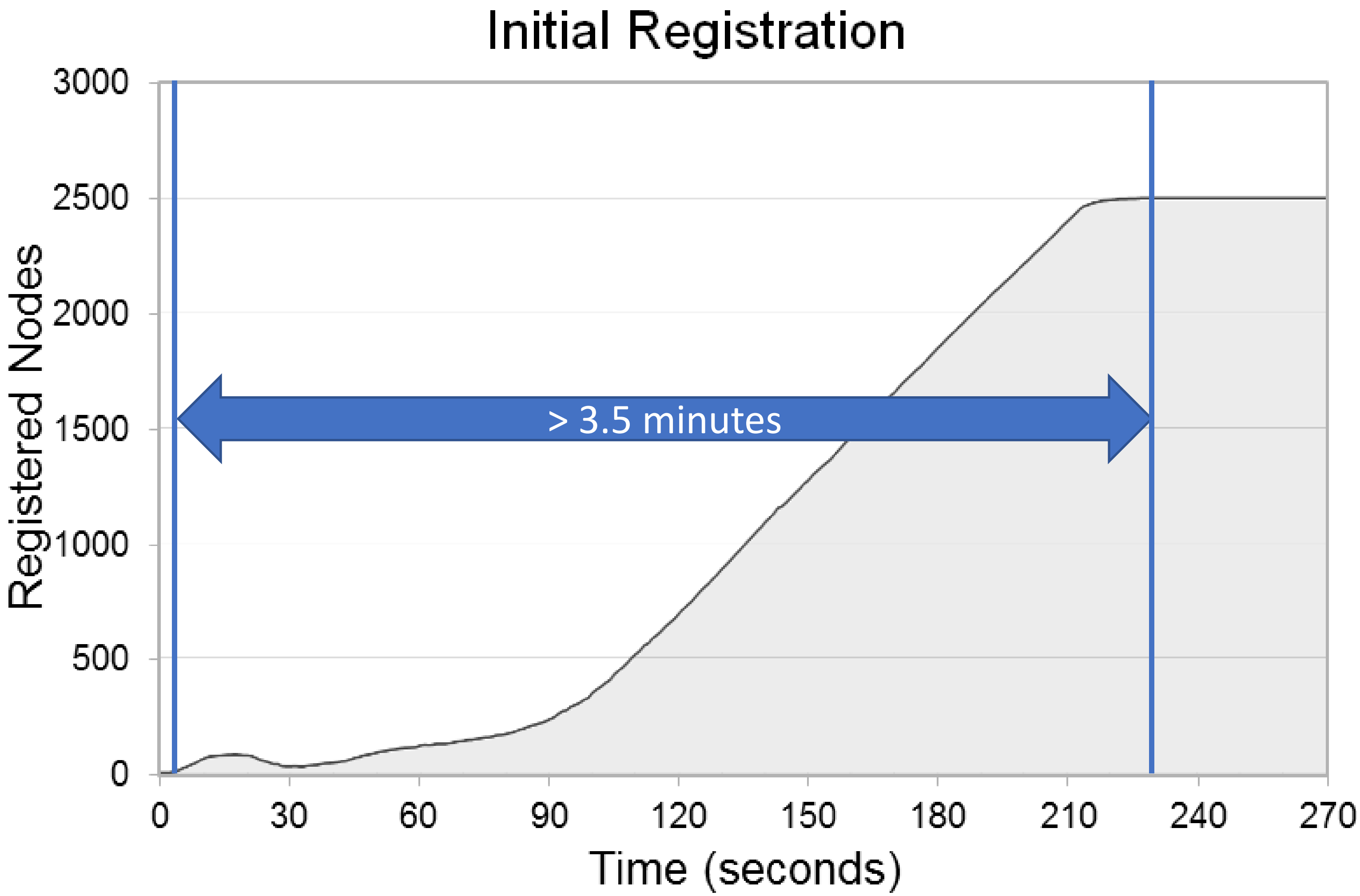


Initial registration

Test: Registration of 2,500 Nodes with 6 resources per Node

Result: Total registration time > 3.5 minutes

Rate of registration varies over time – slow start and long tail

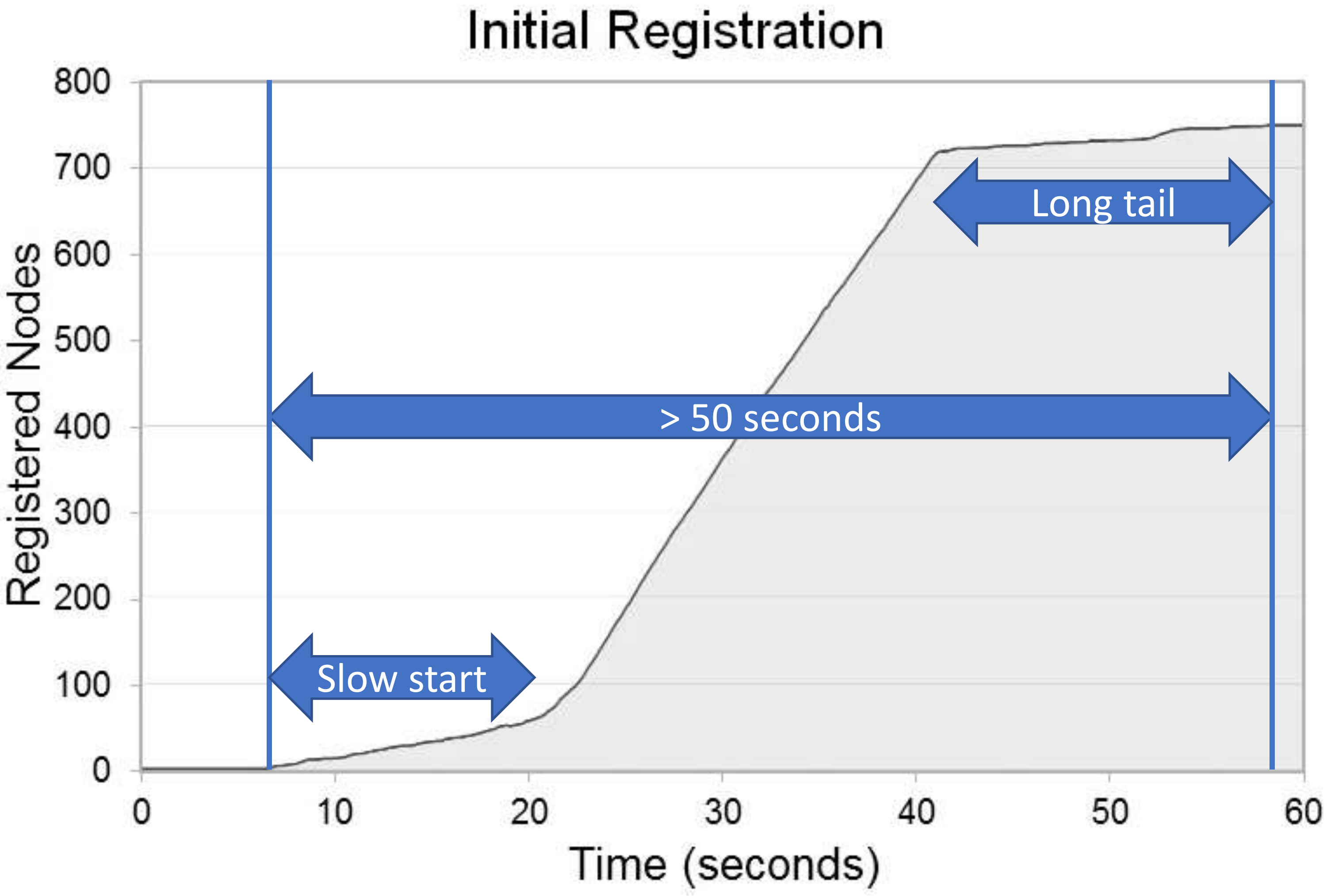


Initial registration

Test: Registration of 750 Nodes with 6 resources per Node

Result: Total registration time > 50 seconds

Slow start and long tail due to long DNS-SD and HTTP timeout and retry intervals



Initial registration

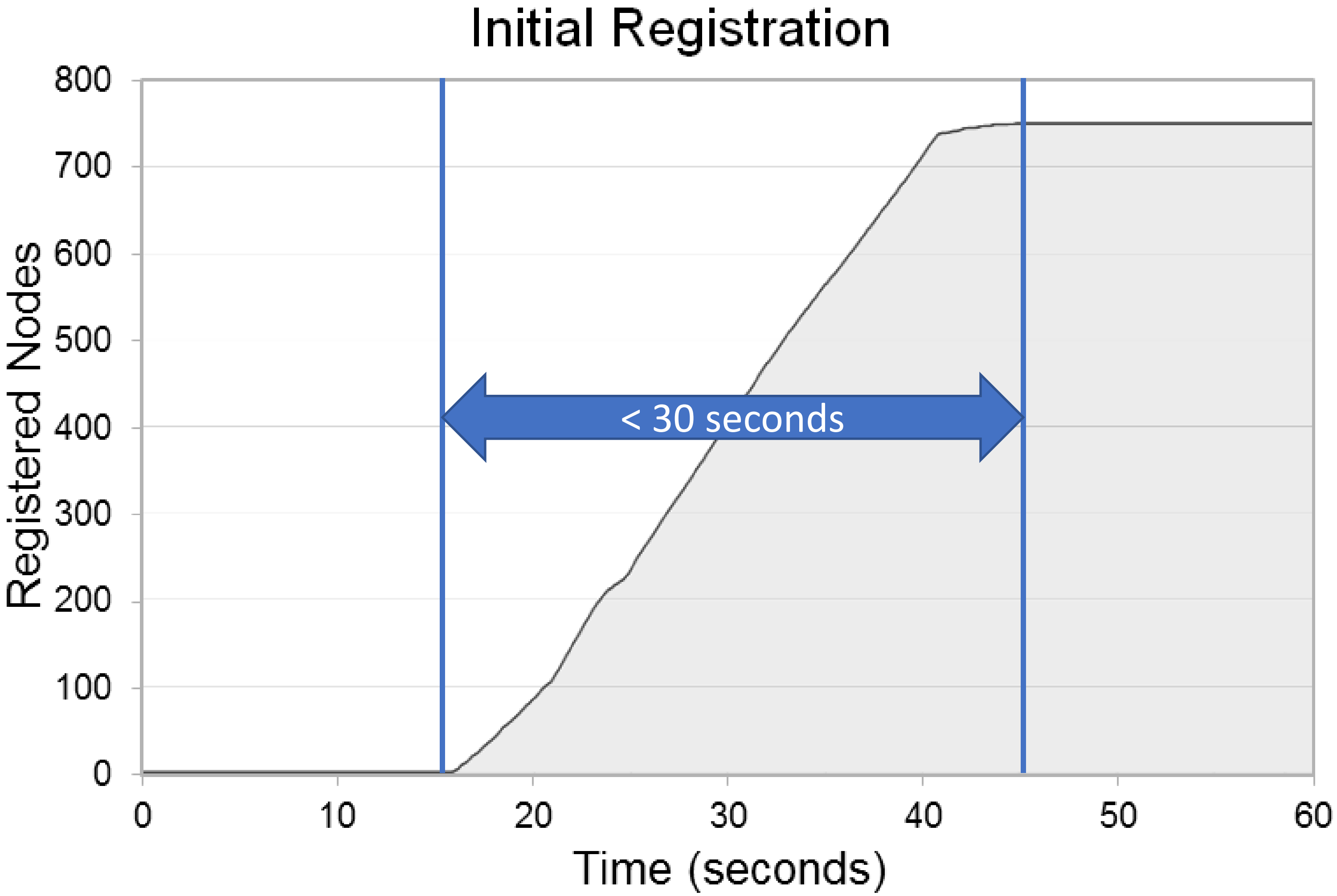
Test: Registration of 750 Nodes with 6 resources per Node.

With optimisations to:

- DNS-SD retry interval
- HTTP timeout

Result: Total registration time < 30 seconds

No slow start or long tail



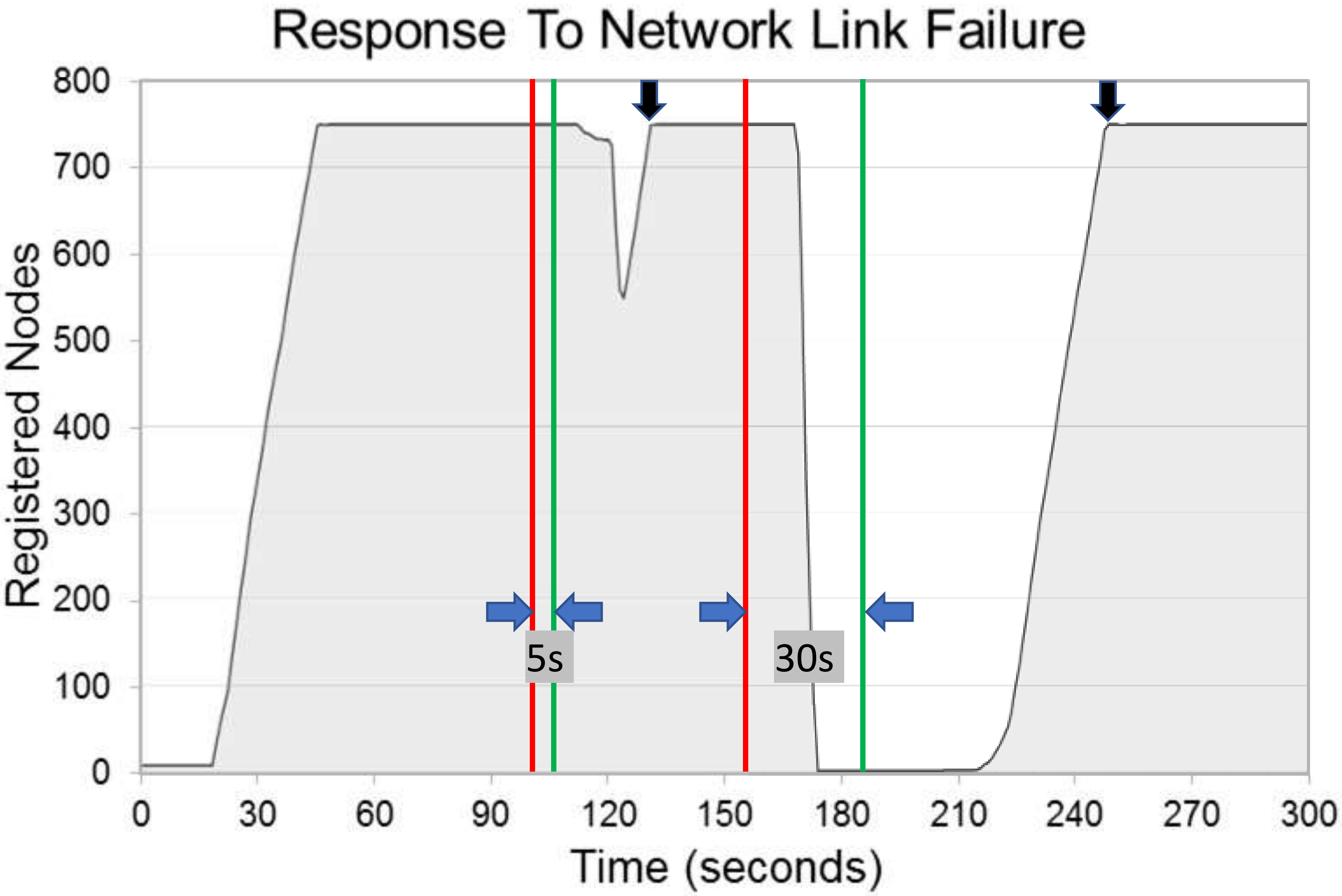
Recovery after a failure

Test: Register 750 Nodes with 6 resources per Node.

Break network link to registry for a short period

Result 1: Break for 5s -> Full recovery within 30s

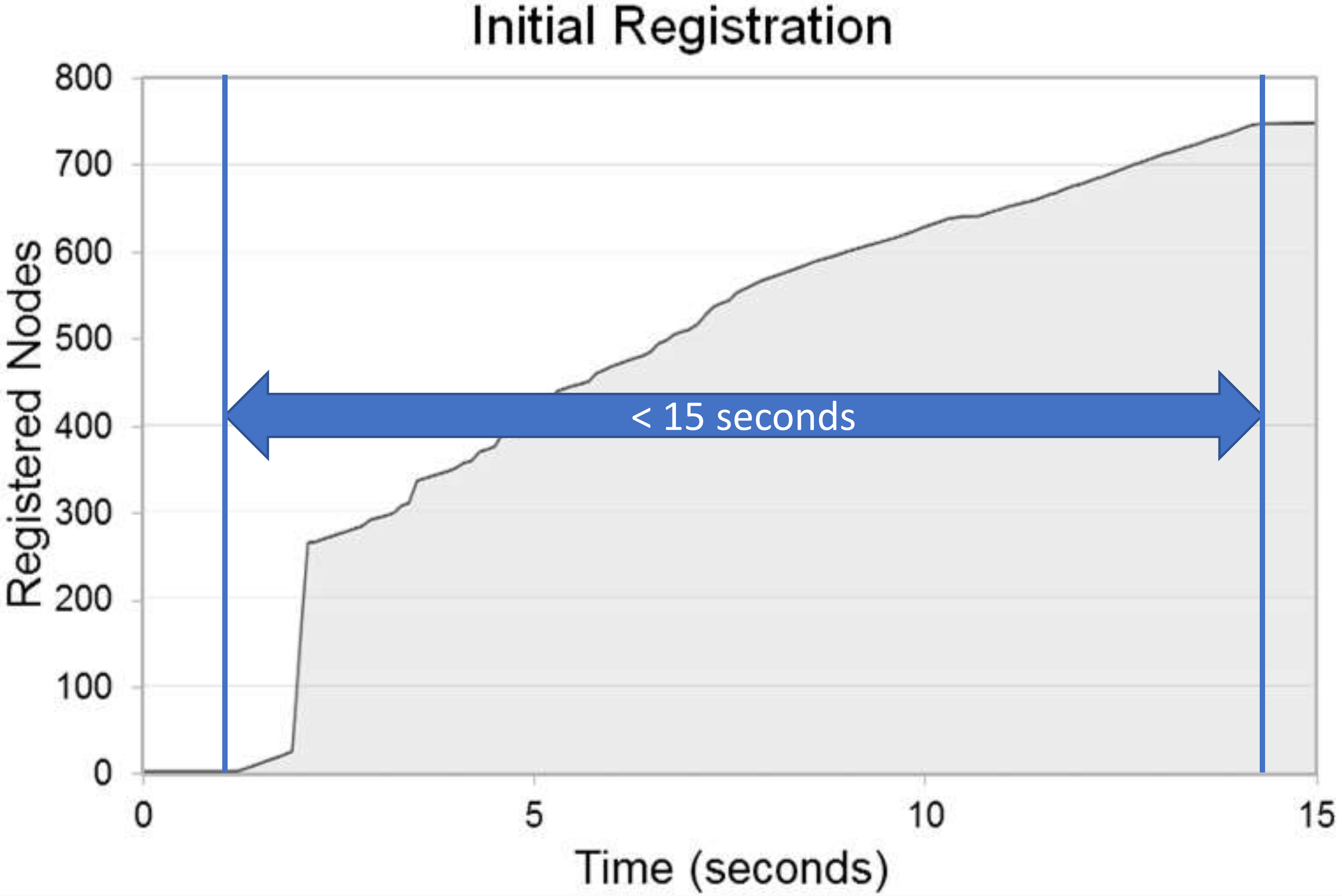
Result 2: Break for 30s -> Full recovery within 90s



Multiple registries

Test: Registration of 750 Nodes with 6 resources per Node with two-way replication in a federated RDS

Result: Total registration time reduced from 30 seconds to <15 seconds

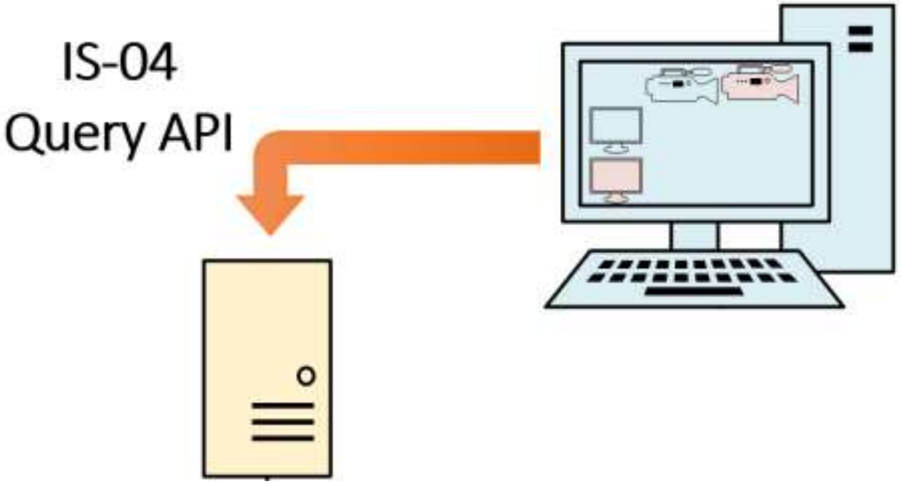


SONY

Connection management at scale

Test: Populate Client’s crosspoint matrix (2,500 x 2,500) using IS-04 Query API

Result: Total time to populate matrix < 1.0s

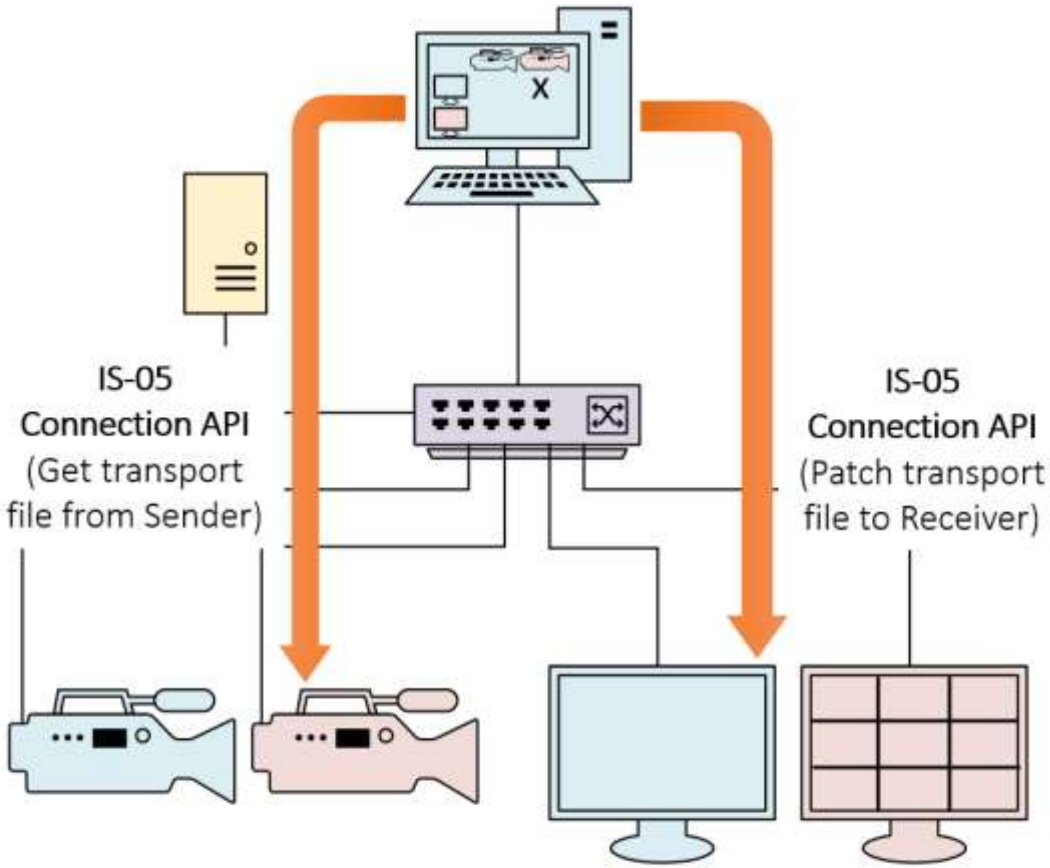


Connection management at scale

Test: Update 750 crosspoints using IS-05 Connection API

Result: Total time to update crosspoints < 3.0s

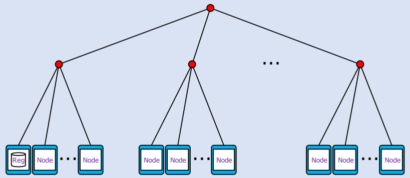
Optimised API usage is important - make good use of paging, push notifications and WebSocket API.



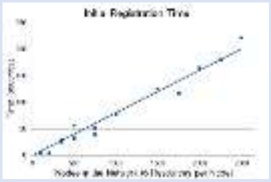
AMWA NMOS IS-04 and IS-05 APIs

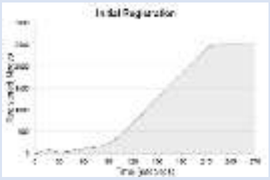
networked media NMOS open specifications

The AMWA NMOS Scalability Study

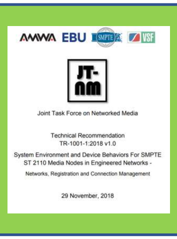


Scalability Study Results





Best Practice Recommendations
and How JT-NM TR-1001-1 Helps



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29 November, 2018

Best Practice Recommendation

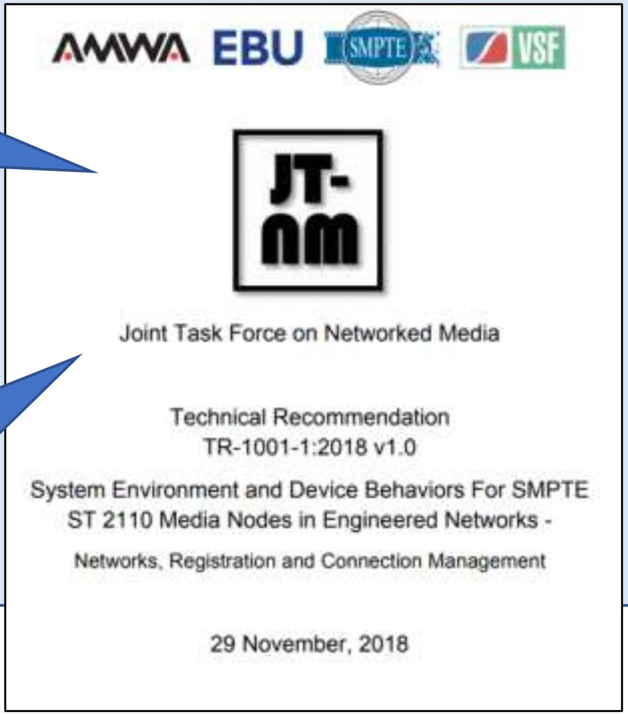
- Use IS-04 and IS-05 across all Media Nodes
  - Ensures interoperability!

Media Nodes shall expose an AMWA NMOS IS-04 1.2 or higher node API, and shall register using the IS-04 registration API

Media Nodes shall expose an AMWA NMOS IS-05 1.0.2 STABLE or higher device connection management API

How JT-NM TR-1001-1 Helps

- Mandates use of IS-04 and IS-05



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Joint Task Force on Networked Media

Technical Recommendation
TR-1001-1:2018 v1.0

System Environment and Device Behaviors For SMPTE ST 2110 Media Nodes in Engineered Networks - Networks, Registration and Connection Management

29 November, 2018

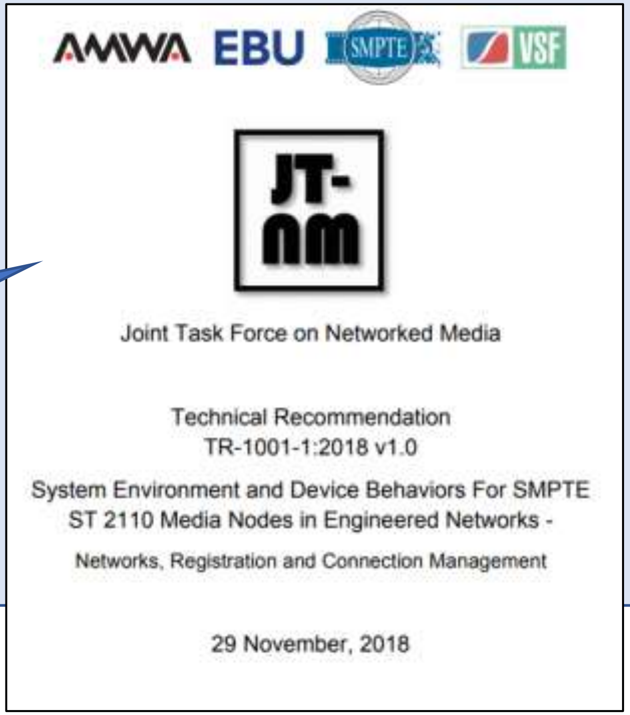
Best Practice Recommendation

- Use clustered / federated registries to improve performance
  - Faster registration
  - Better fault tolerance

How JT-NM TR-1001-1 Helps

- Multiple registries supported

The Network Environment shall contain **one or more registries** implementing AMWA NMOS IS-04 Registration and Query APIs



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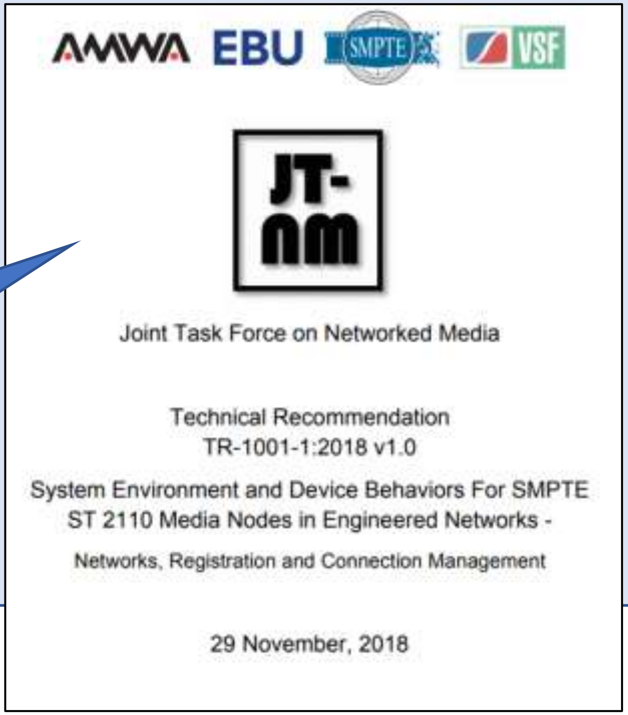
Best Practice Recommendation

- Choose heartbeat and registry expiry intervals carefully
  - Use common heartbeat intervals across all Media Nodes
  - Can be used to guide choice of DNS-SD and HTTP timeout and retry intervals
  - Recommended values from IS-04 spec worked well in our experiments

How JT-NM TR-1001-1 Helps

- Heartbeat interval is stored in System Resource and must be used by all Media Nodes



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Media Nodes shall use the registry heartbeat_interval value specified in the System Resource … when maintaining their registration

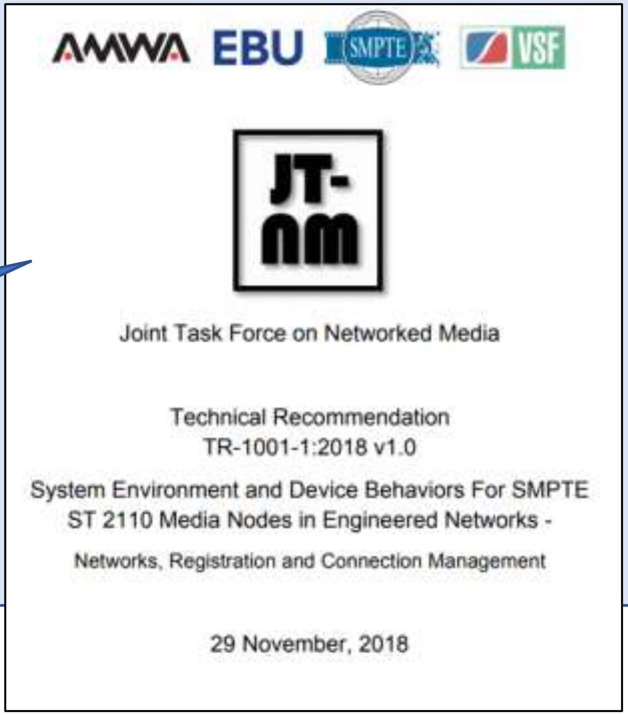
Best Practice Recommendation

- Use unicast DNS-SD
  - Improved registration performance
  - Better for scalability
  - Essential for layer 3 networks
  - Multicast DNS is being deprecated from IS-04

How JT-NM TR-1001-1 Helps

- Unicast DNS-SD is mandated

Media Nodes shall use unicast DNS Service Discovery (DNS-SD) to locate the registration APIs as described in IS-04



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Resources

- AMWA NMOS Scalability Study test environment
  - https://github.com/AMWA-TV/nmos-scalability
- Sony nmos-cpp open source software for IS-04 Registry and IS-04/-05 Node
  - https://github.com/sony/nmos-cpp
- SMPTE Annual Technical Conference 2018 paper
  - “Scalability and Performance of the AMWA IS-04 and IS-05 NMOS Specifications for Networked Media” – Robert Porter and Gareth Sylvester-Bradley
  - https://ieeexplore.ieee.org/document/8610041

Thank You

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