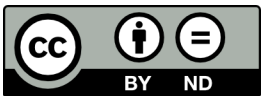
Video Services Forum (VSF)
Technical Recommendation TR-09-2

Transport of ST 2110 media essences over Wide Area Networks – Control Plane

November 17, 2022

VSF_TR-09-2_2022



INTELLECTUAL PROPERTY RIGHTS

LIMITATION OF LIABILITY

VSF SHALL NOT BE LIABLE FOR ANY AND ALL DAMAGES, DIRECT OR INDIRECT, ARISING FROM OR RELATING TO ANY USE OF THE CONTENTS CONTAINED HEREIN, INCLUDING WITHOUT LIMITATION ANY AND ALL INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES (INCLUDING DAMAGES FOR LOSS OF BUSINESS, LOSS OF PROFITS, LITIGATION, OR THE LIKE), WHETHER BASED UPON BREACH OF CONTRACT, BREACH OF WARRANTY, TORT (INCLUDING NEGLIGENCE), PRODUCT LIABILITY OR OTHERWISE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THE FOREGOING NEGATION OF DAMAGES IS A FUNDAMENTAL ELEMENT OF THE USE OF THE CONTENTS HEREOF, AND THESE CONTENTS WOULD NOT BE PUBLISHED BY VSF WITHOUT SUCH LIMITATIONS.

Executive Summary

SMPTE ST 2110 has been evolved to enable media production facilities to use IP connectivity for all media flow and control.

The standard is focused on intra-campus-based connections with negligible latencies and jitter, negligible packet loss, and uncontended high bandwidth.

With the increasing trend towards mesh/distributed/remote production and multi-campus operation, there is a need to define recommendations for the transport of the ST 2110 media essences over Wide Area Networks (WANs) and an associated control plane with appropriate security considerations.

This Technical Recommendation defines a method of media flows and related control plane information being shared securely and robustly over Wide Area connectivity. It is formed in two parts – a data plane section defining media flow transport and a control plane section defining the communications. This part defines the control plane.

Table of Contents

Table of Contents....4
1 Introduction....4
1.1 Contributors....4
1.2 About the Video Services Forum....5
2 Conformance Notation....5
3 References....6
4 Document Aims and Parts (informative)....6
5 Architectural Design (informative)....7
6 Control Plane Setup Stages....8

1 Introduction

As broadcasters look to extend their IP production beyond the boundaries of their facility, to facilitate essence-based remote production and federated production, there is a requirement to define the best practice and recommendations for interoperability.

This Technical Recommendation defines a method of media flows and related control plane information being shared securely and robustly over Wide Area connectivity. It is formed in two parts – a data plane section defining media flow transport and a control plane section defining the communications. This part defines the control plane.

1.1 Contributors

The following individuals participated in the Video Services Forum 2110-WAN activity group which developed this technical recommendation (listing people that attended multiple meetings, taken over final 9 months of drafting).

Andy Rayner (Nevion)	Michael Firth (Nevion)	John Mailhot (Imagine Comm)
Michael Bany (Disney)	Geoff Bowen (Nevion)	Peter Brightwell (BBC)
Rob Porter (Sony)	Rick Ackermans (CBS)	John Dale (Medialinks)
Jed Deame (Nextera Video)	Dan Engholm (AWS)	Mark Evans (Nevion)
Eric Fankhauser (Evertz)	Albert Faust (Arista)	Richard Friedel (Fox)
Louis Lamarre (CBC)	Pavlo Kondratenko (EBU)	Ivan Hassan (BBC)
Brad Gilmer (VSF)	Chris Lapp (Cisco)	Renaud Lavoie (Riedel)

Luann Linnebur (Telestream)	Sergio Ammirata (SipRadius)	NICK NICAS (AT&T)
Carl Ostrom (System Resource)	Danny Pierini (Matrox)	Gary D Schneider (LinkedIn)
Wes Simpson (LearnIPvideo)	Greg Stigall (Warner Media)	Jonathan Thorpe (Sony)
Paul Turner (AJA)	Laurence Venner (V-Nova)	Robert Welch (Arista)
Leigh Whitcomb (Imagine)	Charles Taylor-Young (Arqiva)	Gareth Sylvester-Bradley (Sony)

1.2 About the Video Services Forum

The Video Services Forum, Inc. (www.videoservicesforum.org) is an international association dedicated to video transport technologies, interoperability, quality metrics and education. The VSF is composed of service providers, users and manufacturers. The organization's activities include:

- providing forums to identify issues involving the development, engineering, installation, testing and maintenance of audio and video services;
- exchanging non-proprietary information to promote the development of video transport service technology and to foster resolution of issues common to the video services industry;
- identification of video services applications and educational services utilizing video transport services;
- promoting interoperability and encouraging technical standards for national and international standards bodies.

The VSF is an association incorporated under the Not For Profit Corporation Law of the State of New York. Membership is open to businesses, public sector organizations and individuals worldwide. For more information on the Video Services Forum or this document, please call +1 929-279-1995 or e-mail opsmgr@videoservicesforum.org.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except the Introduction and any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 References

AMWA IS-04 V1.3 NMOS Discovery and Registration Specification
AMWA IS-05 V1.1 NMOS Device Connection Management Specification
AMWA BCP-003-01 Secure Communications in NMOS Systems
AMWA BCP-003-02 Authorization in NMOS Systems
AMWA NMOS IS-10 Authorization Specification

4 Document Aims and Parts (informative)

This VSF TR-09 series defines a data plane for media flows and associated control information, and a control plane for determining which flows are present and for controlling the routing and enabling of such flows.

This document (TR-09-2) defines the control plane elements, and a companion document (TR-09-1) defines the data plane elements

The documents defines the behavior of a virtual gateway device that sits at the WAN boundary of a facility. This device performs a variety of data plane and control plane functions needed to interconnect two or more facilities. Some of the functions performed by this gateway include:

- Network Address Translation between the addressing schemes used in the two facilities (and a potential third scheme as the traffic flows across the wide area)
    - This includes both translating the addresses for the actual data flows, and modifying any control data structures or information associated with the data flows (e.g. NMOS resources and SDP files)
- Managing the bandwidth across the WAN link(s) to ensure that there is never a situation where more data is being sent from a facility than the WAN link can accept
- Where NMOS is being used within a facility, the creation of virtual NMOS resources advertised into each facility to represent the resources that are being extended from the remote facility(s)
- Providing a security boundary between the facility and the WAN link(s)
- The gateway may include a compression and decompression function (most commonly for video essences), due to the constrained bandwidth nature of some WAN links.

The gateway providing the sources into a site will reconcile the IDs signaled across the WAN connection from those used within the facility (which may or may not be NMOS-based).

5 Architectural Design (informative)

The principles of the control plane architecture described below work on the basis of minimal impact to the operation of each individual facility.

This document defines the additional control communication that is required to share resources between facilities.

As per the companion document (TR-09-1) the requirements here are to ensure interoperability at the WAN interface point into each facility. By necessity, some extra definitions are needed for behavior within each facility to allow a streamlined end-to-end operation.

One of the key challenges of such a control plane architecture is to balance a desire for simple plug and play behavior with the required security and autonomy of each facility.

As can be seen from the workflow below, some elements of the required overall end-to-end control plane operation are called out but not described in detail in this specification.

It is anticipated that the most common control architectures within each facility will be based upon the suite of NMOS recommendations defined by AMWA, but this document does not prevent any other suitable control architectures being used in situations where NMOS is not appropriate or not available.

One important element of the definitions below is the temporal nature of some of the setup and execution of creating the shared booking between the two facilities. One reason this is needed is

because the WAN bandwidth is typically more limited than that available within a facility, so control is needed to ensure that bandwidth is only consumed when it is needed.

6 Control Plane Setup Stages

For the process below to be possible, there shall be some appropriate WAN connectivity available between the locations concerned.

Throughout the following text, there is an assumption that there is a single logical gateway device at the boundary of each facility. This may be implemented as a single physical system, or as a group of systems with an appropriate internal communication method to manage and synchronize the operation of the components.

One of the features that such a gateway system will make available is the concept of virtual resources. These have both a presence into the facility to interconnect with the required internal systems, and a presence on the WAN link to connect to the remote facility. There is an implied one-to-one mapping between a virtual receiver on the internal side of the gateway and a transmitter on the WAN side of the gateway, and vice versa for transmitters inside the facility and receivers on the WAN side.

Depending on the design of the gateway system, there may either be a fixed number of virtual resources that are always present, or the virtual resources may be instantiated and removed as needed to match the requirements of the connectivity. There will inherently be some finite limit to the maximum number of virtual resources in as system that behaves in this more dynamic manner.

Each pair of facilities is considered to have a single pair of gateways between them. If more than one remote facility connects to a given local facility then there shall be multiple pairs of gateways, one pair for each remote facility (i.e. there is a one-to-one mapping between pairs of facilities and pairs of gateways).

Note: This is a logical view; nothing prevents the gateways for multiple remote sites being combined into a single physical entity.

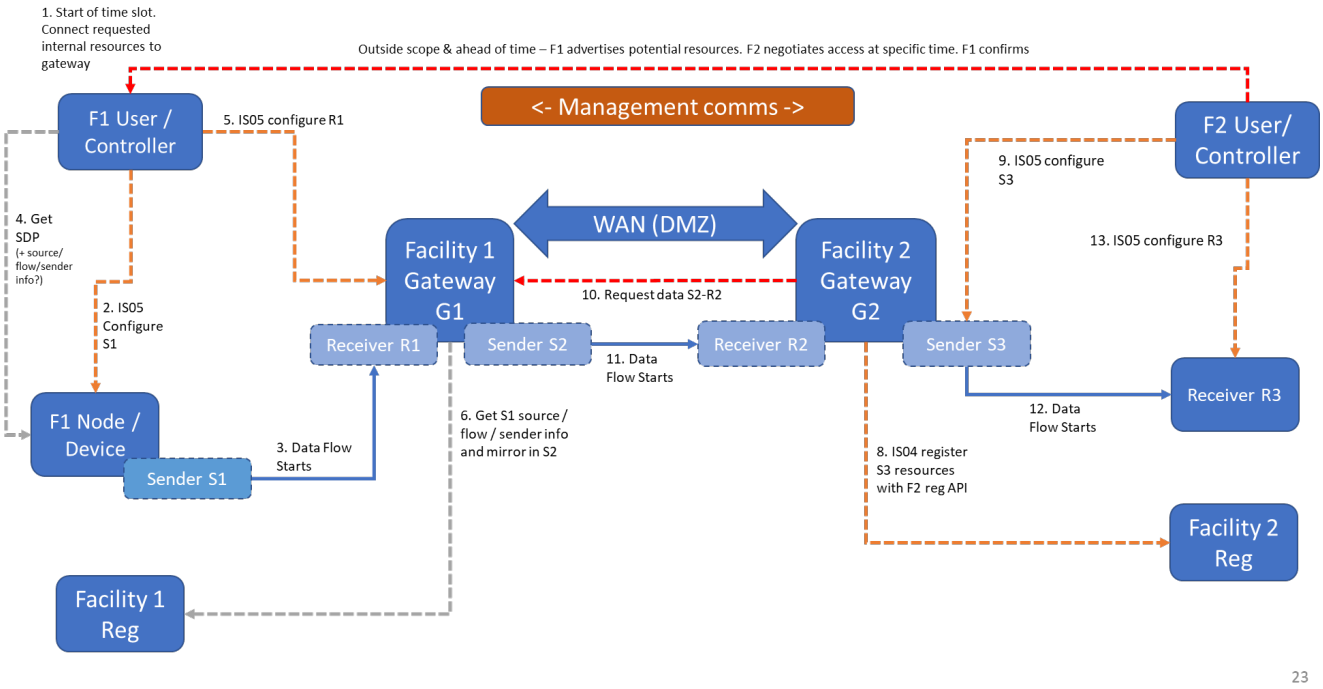


Figure 1: Control messaging overview

The above figure 1 shows the blocks that are referred to in the messaging described below:

- Facility 1 (the facility offering to share resources in this example) shall communicate information about the available resources to Facility 2 (the facility gaining access to the shared resources), using a means that is outside the scope of this document.
- This information shall include a consumer ID (which identifies Facility 2 uniquely from the perspective of Facility 1) and an element ID for each of the available resources. The same element ID may be used for a given resource across multiple bookings.
- Facility 2 shall request access to a specific subset of the resources available within Facility 1 to use for a specific event which has a specific start and end time using a means that is outside the scope of this document.
- This booking request shall include a booking ID defined by Facility 2 (which identifies the booking uniquely from the perspective of Facility 2) and a list of the element IDs which are required for the event. It may also include a user-friendly label for elements.
- Note: Because the consumer ID and booking ID are defined by the two facilities, the pair of (consumer ID, booking ID) provides an identifier for the booking which will be unique within both facilities. This also ensures that the triplet of (consumer ID, booking ID and element ID) will be unique.

- Facility 1 shall confirm reservation of the requested resources. These can be reconciled to the actual sources at the start time of the booking. The means of doing this is outside the scope of this document.

Note: The above stages of setup are potentially suitable for further study within the Video Services Forum at a future point.

Note: Within each facility, there is inherently an additional role that the control systems need to provide to fulfil the temporal nature of the booked connectivity as well as providing the gateways with sufficient information to reconcile the in-facility connections with the agreed unique booking references.

- The offering facility control system shall assign the gateway virtual resources with the unique consumer, booking and element IDs

For each resource to be shared the following sequence shall be followed (using NMOS as the example facility control system).

- At start of agreed booking timeslot, the Facility 1 (offering) orchestrator / controller shall create the necessary virtual resources on the gateway for the booking.
- It shall then make a connection from the internal facility resource to the virtual resource on the gateway – e.g. from Sender S1 to Receiver R1 above.
- Gateway G1 shall make information about the newly available resource available to Gateway G2 via WAN communication.
- A constrained version of the existing NMOS Specifications shall be used for the G1 to G2 communication. A diagram of how this appears on each gateway node is shown in Figure 2.

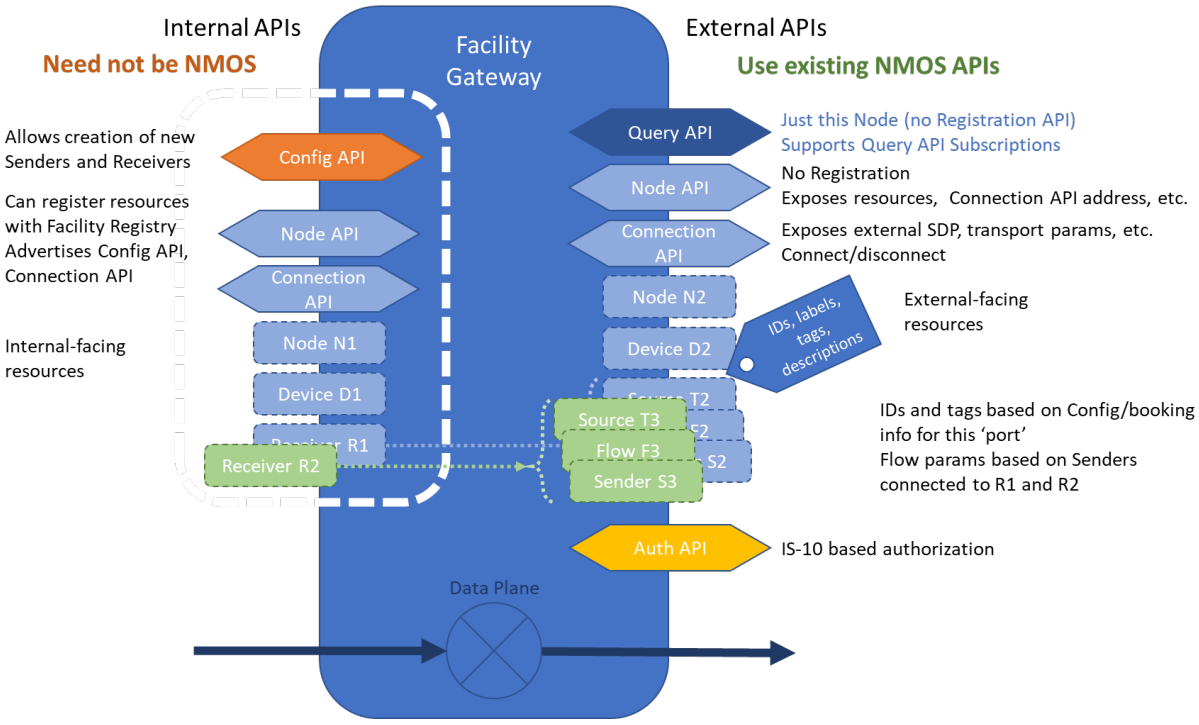


Figure 2: The 'constrained' NMOS approach adopted.

- The existing NMOS security recommendations (BCP-003-01, BCP-003-02 and IS-10) shall be applied to the communications between the gateways defined here, with the following restrictions:
    - NOTE: It is envisioned for this specific application that the authorization server API described in IS-10 would normally be integrated into the gateway, and would not be a separate device
    - Certificates for the NMOS implementation on the gateways shall be manually provisioned (BCP-003-03 shall not be used)
- The following constraints compared to a full NMOS environment shall be applied:
    - There shall be no central registry (all communications are point to point)
    - There shall be no service discovery (addresses of APIs on each gateway are provided out of band to the other gateway)
    - The gateway shall expose an IS-04 Node API and an IS-05 Connection API
    - The gateway may also expose other APIs necessary to provide required functionality such as the IS-08 Channel Mapping API
    - As a change to the standard NMOS model, the gateway shall additionally expose an IS-04 Query API
- IS-04 Resource information:
    - Tags shall be used in the resources to identify which are the corresponding 2110-WAN booking and virtual element IDs

    - Standard NMOS UUIDs shall be created for each resource. These shall not be the same as the UUIDs used within the facility, if the facility is using NMOS (i.e. they are unique IDs for the WAN connectivity)
- The sequence of discovering and using the NMOS facilities on the remote gateway shall be:
    - Gateway G2 is provided with IS-04 Query API address, consumer ID, booking ID and the element IDs of the booked resources
    - G2 uses the G1 IS-04 Query API to get list of resources with required consumer ID, booking ID and element IDs in tags
    - G2 subscribes to notifications on the G1 IS-04 Query API to receive WebSocket notifications of any changes of status
    - G2 obtains the IS-05 Connection API address for the resources from the G1 IS-04 Device information
    - G2 uses the discovered IS-05 Connection API to set up connections (e.g. configures Sender's transport settings, fetches SDP file) using either immediate or scheduled activation mode as required
    - Other NMOS APIs may be presented on the Gateways if appropriate (e.g. IS-07 and IS-08) to proxy those capabilities between the sites.

Note: Though the NMOS IS-04 Node API is mainly a duplicate of the Query API, it is retained because it makes the set of APIs available more conformant – and thus likely to pass the NMOS Testing Tool test suites.

- When S2-R2 control connection is established, G2 shall create NMOS Source/Flow/Sender S3 and register it with the F2 Registry.
- Additionally, though out of scope of this document, G2 may advertise virtual resources within F2 ahead of the actual resources being made available from F1 (for instance to allow virtual setup ahead of time) and these virtual resources shall then be reconciled with the real flows once available using the unique referencing, i.e. the consumer, booking and element IDs. At the point when the control connection is established between G1 and G2, the source and flow reconciliation shall take place in F2.
- The WAN data connection S2->R2 shall be instigated upon a connection to consume S3 being made by the control system in F2 (in example diagram above, upon the S3-R3 NMOS connection being made)
- The flow may be terminated by either F1 or F2 at the end of the event booking
- If there is service interruption, then the system should try and reestablish the connectivity as was intended when service is restored.

Below is the tag format as referenced above. The authoritative definition resides in the NMOS Parameter Registers located at the following URL:
https://specs.amwa.tv/nmos-parameter-registers/branches/main/tags/

The text below is included for information only. If there is any difference between the definitions in the two locations, the NMOS Parameter Registers take precedence.

```
"tags": {
  "urn:x-vsf:tag:tr-09-2:booking-list/v1.0": [
    # List constraints: 0 or more entries in the list.
    # If current-booking is declared then that booking-id MUST be
    # defined here, as this list defines the associated element-id
    # and optional label.
    #
    # Entry constraints:
    #   ^(?:[-_a-z0-9]{1,64}:){2}[-_a-z0-9]{1,64}(?::[^:]{1,128})?$
    #
    # Description of fields:
    #   consumer-id: A unique identifier for the receiving facility
    #   booking-id:  A unique identifier for the booking
    #   element-id:  A unique identifier for the resource
    #                within the booking
    #   label:       A user-friendly label for the resource
    #                within the booking (optional)
    "<consumer-id>:<booking-id1>:<element-id1>[:<label1>]",
    "<consumer-id>:<booking-id2>:<element-id2>[:<label2>]"
  ],
  "urn:x-vsf:tag:tr-09-2:current-booking/v1.0": [
    # List constraints: 0 or 1 entries in list depending
    # whether a booking is active.
    #
    # Entry constraints: ^[-_a-z0-9]{1,64}:[-_a-z0-9]{1,64}$
    #
    # Description of fields:
    #   consumer-id: The consumer-id parameter associated with the
    #                currently active booking
    #   booking-id:  The booking-id parameter associated with the
    #                currently active booking
    "<consumer-id>:<booking-id>"
  ]
}
```