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AIMS GUIDELINES TO PREPARING BROADCAST FACILITIES FOR IP-BASED LIVE TV PRODUCTION

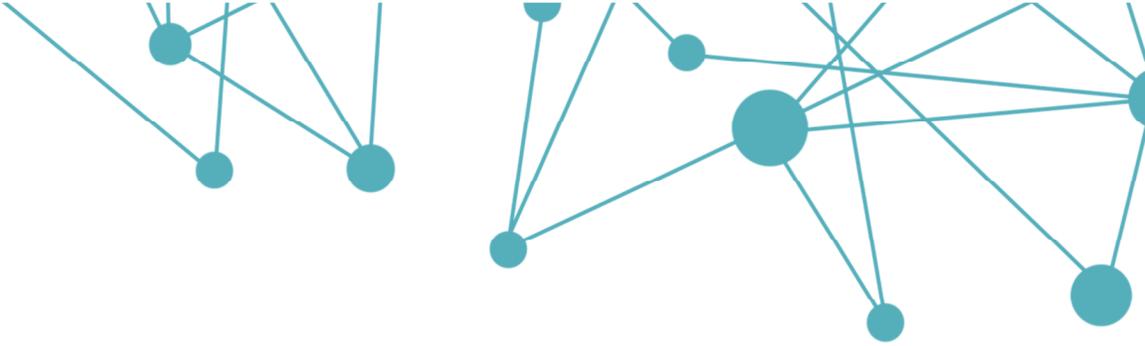
Key Points Relative to Designing for Operations
in All Studio Environments – APRIL 2017

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The Alliance for IP Media Solutions (AIMS) is a non-profit trade organization founded by leading companies to foster the adoption of industry standards for the broadcast and media industry as it transitions from SDI to IP.



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INTRODUCTION

Now that the television industry's call for interoperability across the next-generation production supply chain has been answered by vendors worldwide, broadcasters can confidently pursue their transitions to IP with minimal disruption by following certain basic guidelines.

Many broadcasters are already in various stages of IP transformation using products mapped to the Alliance for IP Media Solutions' interoperability framework in their live productions. These experiences are providing real-world confirmation that production infrastructures relying on IP technology operate as intended to deliver significant benefits over traditional SDI-based facilities. As a result, broadcasters everywhere can proceed with their transitions to IP, knowing that products incorporating the AIMS-endorsed protocols can be mixed and matched to fit each buyer's requirements.

The purpose of this document is to help broadcasters make the transition as trouble-free as possible by highlighting the many things that need to be taken into account in the design of IP-based production facilities, from the smallest studios to the most complex multi-location environments. The good news for producers, directors, engineers and their staffs is that the basic workflows long followed in live TV production remain unchanged, eliminating any need for learning new procedures while ensuring they can gracefully migrate to IP in mixed environments where SDI-based equipment remains in operation.





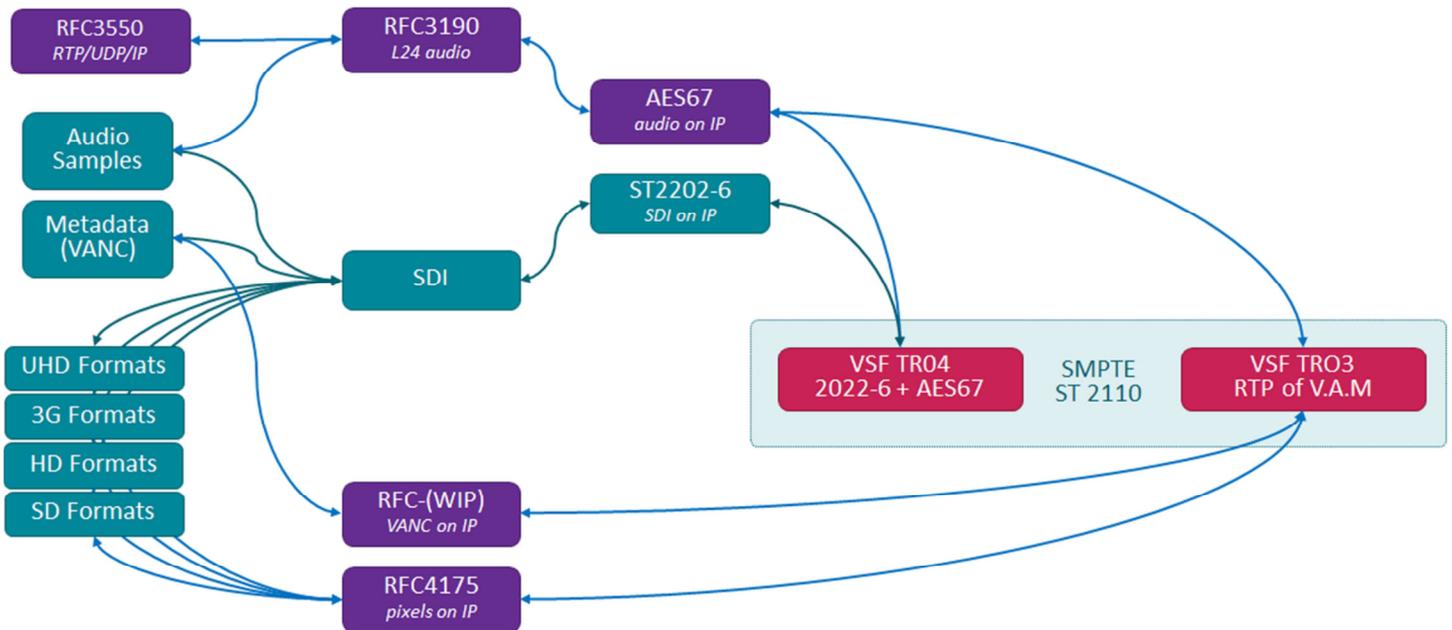
AIMS-Endorsed Specifications

AIMS is providing this guidance at a moment when the full scope of interoperability requirements as embodied in SMPTE ST 2110, a crucial step on the AIMS roadmap, have been met by leading vendors in all product categories. While SMPTE ST 2110 was still in the final phases of testing and ratification going into 2017, AIMS has confirmed in a survey of suppliers comprising most of the TV production marketplace worldwide that 72 percent are committed to shipping SMPTE ST 2110 products in one or more of 23 major product categories for commercial deployment in 2017 (*see page 7 Survey*).

As explained in an earlier AIMS whitepaper¹, SMPTE ST 2110 is the standard that builds on and goes beyond three earlier phases of the AIMS roadmap, which include:

- SMPTE ST 2022-6, the protocol that supports bridging between SDI-based and IP-based equipment by describing how SDI payloads are embedded in an IP RTP (Real-time Transport Protocol) stream;
- TR-04, the technical recommendation developed by the Video Services Forum (VSF) that maintains the SDI-over-IP capability for video within SMPTE ST 2022-6 while defining an AES67-based option for transporting and processing discrete IP audio streams;
- TR-03, another VSF technical recommendation which defines how separate uncompressed streams of IP video, audio and metadata are packetized for mapping into RTP, thereby enabling independent processing of these components in IP while retaining the ability through synchronization to treat them as a whole in production workflows.

FIGURE 1 – VIDEO / AUDIO OVER IP STANDARDS UNIVERSE



¹ An Argument for Open IP Standards in the Media Industry Alliance for IP Media Solutions – November 2016 <http://aimsalliance.org/wp-content/uploads/2017/01/An-Argument-for-Open-IP-Standards-Jan-3-2016-FINAL.pdf>



AIMS-Endorsed Specifications Continued

As illustrated in **FIGURE 1**, SMPTE ST 2110, working in tandem with SDI-based aspects of production, incorporates and builds on TR-03 to provide the foundation for implementing IP technology workflows with a full range of interoperable products. Specifications apply to processing, switching and transporting the essences of video with pixels formatted to RFC-4175, audio formatted to AES67 and metadata formatted to SMPTE ST 291. These elements can be streamed and processed independently or in seamlessly synchronized combinations as dictated by the workflows of live TV production.

This advancement in interoperability is especially timely as the industry prepares to adopt next-generation formats such as Ultra HD (4K), UHD-HDR and 1080p HDR as successors to HD formats. As a format-independent superset of multiple protocols, SMPTE ST 2110 is ideally suited for production of any video format including uncompressed UHD TV video and audio flows, including flows enhanced with any of the HDR formats where producers need to be able to accommodate variations down to the per-frame level in bit depth, dynamic range, color spaces and other parameters to a degree that was never anticipated or possible with HD.

Visual quality, latency and processing parameters of SMPTE ST 2110 all meet the high standards set for any video format, including UHD, with broad support from vendors offering SMPTE ST 2110-compatible products. It's also important to note that SMPTE ST 2110 has been designed to accommodate 8K UHD whenever the market is ready to move in that direction.

Moving Forward

The AIMS agenda does not end with SMPTE ST 2110. The latest ratified objective to be reached on the roadmap provides a common means of identifying and registering devices across all workflows and locations based on the Network Media Open Specifications (NMOS) IS-04 developed by the Advanced Media Workflow Association (AMWA). The processes embodied in AMWA-NMOS greatly simplify building and expanding IP production facilities by automating configuration of device connectivity in all environments, from the simplest to the most complex.

For our purposes here it's important to recognize that, no matter where you are in your decision to move to IP, the industry has achieved consensus on a foundation to interoperability that allows broadcasters to move forward with implementation of IP-based production at whatever pace suits their needs.



Moving Forward Continued

Thanks to the SDI-to-IP bridging support provided by SMPTE ST 2110, broadcasters can take an incremental approach by building new islands of IP-centric operations while continuing to rely on legacy equipment elsewhere. Or, following a well-traveled path when it comes to introducing new technology, they can start out by building IP-based facilities as replacements to the resources they've allocated for redundancy, which they can switch to for primary operations once they're satisfied everything works as expected. And when they find themselves in greenfield situations with no existing SDI facilities, they can build all-IP infrastructures from scratch.

The guidance we're providing here can be applied in any of these situations. In the ensuing discussion, we follow a logical sequence that begins with the factors that must be taken into account when implementing IP-based production in the simplest standalone studios and self-contained production trucks. We then move to the next level of complexity, where productions are executed across multiple locations in a LAN-linked campus environment. We conclude with the additional factors that have to be accounted for when multiple facilities are linked over distances of 2 km. or more.

The AIMS survey found that broadcasters will be able to purchase solutions compliant with SMPTE ST 2110 in 2017 in all of the following product categories:

Audio Mixers and Processors
Branding Devices
Broadcast Encoders
Cameras
Encode/Decode Contribution Links
FPGA IP
FPGA IP supporting ST 2110
Graphics Compositors
Ingest Systems
Integrated Playback/Channel-in-a-Box
Master Control Systems
Multiviewers

OTT Encoders
PCI-Form Factor Capture/Playback Cards
Production Switchers
PTP/Sync Generators
Replay Servers
Routers
SDI-IP Gateways
Standards Conversion Products
Video Processing Products
Video Servers
WAN/LAN Bridges
Displays



ACCOMMODATING HYBRID OPERATIONS WITH SDI-BASED FACILITIES

Most planning for implementation of IP-based production begins with consideration of how the buildout should proceed in the context of reliance on legacy SDI-based operations for some or even most aspects of production. Does the IP buildout strategy entail implementation of IP-based production in one or more studio locations where much of the workflow will continue to utilize legacy SDI equipment or does it entail converting an entire location to IP while continuing to rely on SDI-based systems housed in other locations?

If all the SDI systems are in locations separate from the one(s) designated for IP-based production, the placement of gateways supporting SMPTE ST 2110 conversions between flows going to and from the two types of facilities will be all that's necessary to maintain seamless operations. The incentive to build a separate IP production environment is especially strong when it comes to accommodating UHD production requirements.

IP-Based Production for UHD

Implementing UHD over SDI equipment requires adding wiring for the quad interfaces used with UHD SDI components and quadrupling the link capacity between components from the typical 3 Gb/s rate used with HD and 1080p signals. Counting the costs of new SDI UHD components, all of this adds up to a far more time consuming and costly process than installing an IP-compliant infrastructure to handle UHD production.

In fact, even in cases where a broadcaster has already committed to installing SDI-based UHD equipment, use of IP gateways to consolidate the quad-interface outputs for delivery over IP connections within that facility is well advised. It's also important to note that while studios implementing UHD typically equip their quality control points and set up a primary on-air display station that is UHD-capable, they often continue to use HD displays at monitoring points in the production process. In order to use these displays to monitor UHD processing, they must add a feed to transmit the UHD output from production components to the HD monitors, which is better accommodated over multi-layered IP-based network connections. IP infrastructures exist today supporting uncompressed video and following the AIMS roadmap towards the proposed SMPTE ST 2110 suite of standards. Additionally, IP system deployments using lite codecs for *live* production have been deployed since 2016. Either method provides imperceptible latency and these new CODECs offer visually lossless performance. There are standardization efforts underway supporting both CODECs and their transport. As these standards progress, the AIMS roadmap may include them and provide more definitive guidance for system design at that time.



Switching in Hybrid Scenarios

In the case of adding IP-based production for hybrid operations with SDI-based production within a given facility there will be a need to use IP gateways at all points of interaction between the two domains. This brings into play the use of IP switches to direct all the traffic flowing over IP-based connections.

Indeed, if the level of integration between IP-based and SDI-based components is such that there are no SDI-only clusters requiring SDI-based routing within the clusters, the facility-wide routing control system can be immediately transitioned to reliance on IP switching, enabling expeditious replacement of SDI gear as it ages. The move to IP switching is an important future-proofing step insofar as 10 GigE and 25 GigE ports are standard with most current-generation switches and aggregation ports are already available in 40 and 100 GigE with 200 and even 400 GigE on the near horizon.

Addressing the Audio Question

The capabilities of SMPTE ST 2110 brings into play the option to break out audio, along with timing and data components, for transport and processing in IP, essentially bringing the granularity of essence processing as enabled by SMPTE ST 2110 into play for audio while retaining use of SDI-based processing for video. Determining whether breakaway audio will be a feature supported in the hybrid studio environment is an important step in the planning process.

If the breakaway strategy is adopted utilizing SMPTE ST 2110-30 as the format for processing uncompressed audio as a separate essence as prescribed by SMPTE ST 2110, designers will need to take into account the bandwidth required to handle the multiple channels of audio in the production process. While audio takes up relatively little bandwidth capacity compared to video, even this minimal impact does need to be factored in when calculating the bandwidth required for each link. While not commonly used in live production, any transport & routing of compressed audio to and from external remote contribution links should also be taken into account.

It's also important to keep in mind that some audio solution vendors commonly refer to their support for SMPTE ST 2110-30 as being the same as AES67 which they claim support for. While this is "almost" true, there are specific parameter settings in SMPTE ST 2110-30 that are a subset of those possible in AES67 solutions and many vendors have also added proprietary extensions to AES67. In such cases, those solutions should be configured to use a SMPTE ST 2110-30 compatible mode or there will be a need for conversion to the pure standard version when the audio stream leaves the processing environment supported by that vendor's solutions.

PLANNING FOR IP-BASED PRODUCTION IN SIMPLE STUDIO ENVIRONMENTS

The factors that need to be taken into account in the design of IP-based production facilities used in small fixed-location and mobile studios are summarized in **FIGURE 2**.

- Simple “dual-switches” model
- 2022-7 style redundancy
- Devices register via IS-04
- IGMP between devices and switches
- Switches organized into VLANs as needed to organize traffic
- Single PTP domain
- Control System leverages IS-04 to manage connections/routes

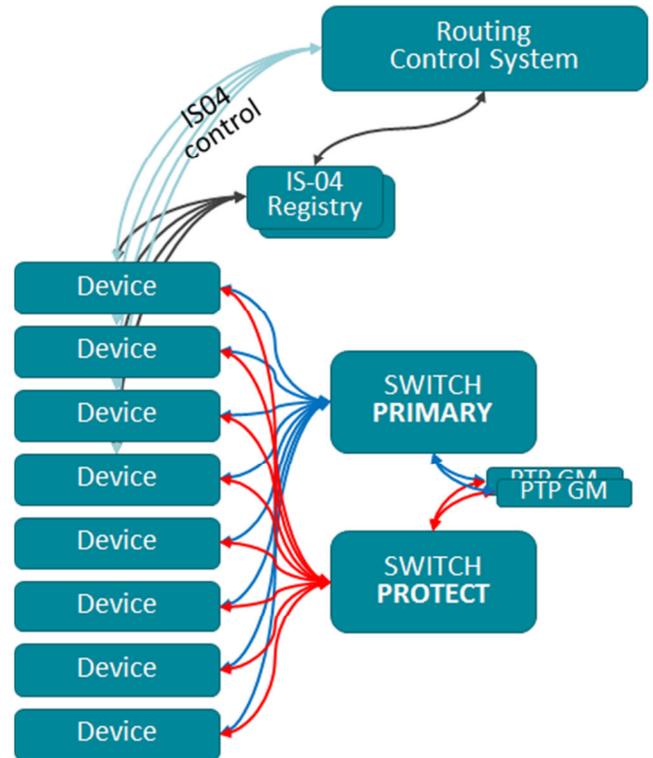


FIGURE 2 - SMALL / SIMPLE SYSTEMS TEMPLATE

A Simplified Approach to Redundancy

Even in the most basic studio environments production devices and their workflows are commonly interconnected utilizing a primary and secondary IP switch network utilizing COTS IP switches with the second providing complete redundancy. As many devices and solutions designed to support SMPTE ST 2110 provide support for SMPTE ST 2022-7 Seamless Protection Switching, transmitting devices can provide simultaneous redundant transmission of each packet on dual network interfaces (NICs) and receiving devices can receive, compare and validate each packet on redundant NICs allowing a connection, wire, fiber, SFP or complete network to fail with zero loss of signal.

In the SDI environment support for redundancy required use of DA’s and a backup SDI switch separately threaded into all devices, but more often systems were single threaded with single points of failure and no or very limited support for redundancy. When moving to an IP domain, selecting devices and solutions which support SMPTE ST 2022-7 Seamless Protection Switching can greatly enhance the reliability of your system design allowing it to provide complete and seamless end-to-end redundancy.



Device Discovery and Registration

One of the great advantages to building IP infrastructures is the support provided by AMWA-NMOS for automating much of the processing that's required to configure connectivity of each device into the production network. In the SDI domain, every device has to be configured independently with its name, address, native functions and specific connectivity contours and usage rules as dictated by its role in the workflow. All of this information for each device had to be input into the logical data base used by the routing control system to orchestrate the execution of tasks for each workflow.

In the IP production environment the logical data base remains as the point of reference for the routing control system to use in support of the traditional workflows. However with utilization of IS-04 as described in AMWA-NMOS the system is able to automatically discover the basic device information and register the device for specific workflow applications on the network. Currently this process requires that the devices refer to Session Description Protocol (SDP) files to supply the basic information into the configuration process. AMWA is further refining NMOS to enable extraction of the required information directly from the devices, which will add specificity to further reduce any manual intervention in the set-up.

Another network design consideration to take into account is the separation of the control & management network traffic from the essence traffic (video, audio, metadata). While not always required, especially in smaller, simple systems, separating these onto different network interfaces provides advantages. Some proprietary control and management systems use layer 2 protocols (including mDNS frequently used for discovery and registration). Separating this traffic onto different network interfaces prevents having to limit the network routing your essence traffic from operating at layer 2.

The Role of IGMP in IP Switch Routing

In the simple studio environment, there's frequently no need for complex communications conveying feedback and control messages between the switches and routing control systems, as is the case in the larger, more complex studio environments discussed below. Instead, mirroring the simplicity of SDI traffic routing, the routing of IP switches governing the aggregation of signals and the direction of their individual paths is enabled through the basic join and leave functions of multicasting supported by the Internet Group Management Protocol (IGMP), which is supported by virtually all IP switch vendors.



The Role of IGMP in IP Switch Routing Continued

This high-level communications protocol governs which devices, as identified by their specific addresses, join communications to deliver a specific multicast flow from a given source address and which ones leave a multicast to join one from another multicast source. This mode of signal path direction provides all the support needed in the simple studio environment to enable orchestration of traffic. The IP devices can be both dedicated appliances or software services running on dedicated COTS resources throughout the studio.

The layering at the VLAN OSI Layer 2 level ensures producers can operate at the granular essence level within layers dedicated to video, audio and metadata as supported by SMPTE ST 2110. While VLAN's can work with a Layer 3 switch as well, in a simple, single switch environment, a Layer 2 application is probably sufficient and is simpler to deploy and operate. Regardless of the approach, it's essential to account for the throughput levels required at each step in the studio network planning process to ensure sufficient bandwidth is allocated to the transport facilities and all device and switch ports from the outset.

Supporting Synchronization

Synchronization requirements are less complicated in the single studio environment, which is an important consideration when it comes to setting funding levels for the new infrastructure. As in all studio environments, there needs to be support for aggregating the video, audio and metadata in various combinations into single coherent flows, which requires utilization of synchronization enabled by PTP. As articulated in SMPTE ST 2110 for use in TV production, PTP (IEEE 1588) combined with SMPTE ST 2059 allows device clocks to be synchronized to a GPS-locked reference time domain over a standard PTP-enabled IP network.

In order to enable the highly granular operations supported by SMPTE ST 2110, devices must apply original time stamps referencing their internal clocks with the generation of packets for each essence within any given layer. When synchronization is required, the PTP generator produces synchronization timestamps to be paired with the original time stamps as a means of cross referencing between flows navigating different paths.

In simple studio environments synchronization of those packet flows to the studio master clock only has to occur when two or more flows have to be brought together for aggregated transport or for specific production processes. Otherwise, basic switching functions can be performed on the individual flows asynchronously. This obviates the need to buffer and synchronize every packet flow at the point of generation from each device.



Supporting Synchronization Continued

However in all studio environments, including the most basic, there's a need to apply PTP synchronization to all flows coming into the studio from outside sources, which is the norm when a studio is managing production of live content. This requires a contribution receiver gateway that can manage all the processes as described in **FIGURE 3**.

USE STANDARDS-BASED COMPRESSION

- H.264 4:2:2/10 (10-30 Mbits/sec @ HD)
- J2K VSF TR-01 (100-200 Mbits/sec @ HD)

AT RECEIVE SIDE

decode the contribution link compression, synchronize to local timebase, and map into ST2110...

- Contribution receiver registers signal into IS-04
- Specifics of the registration could reflect the actual contributed signal

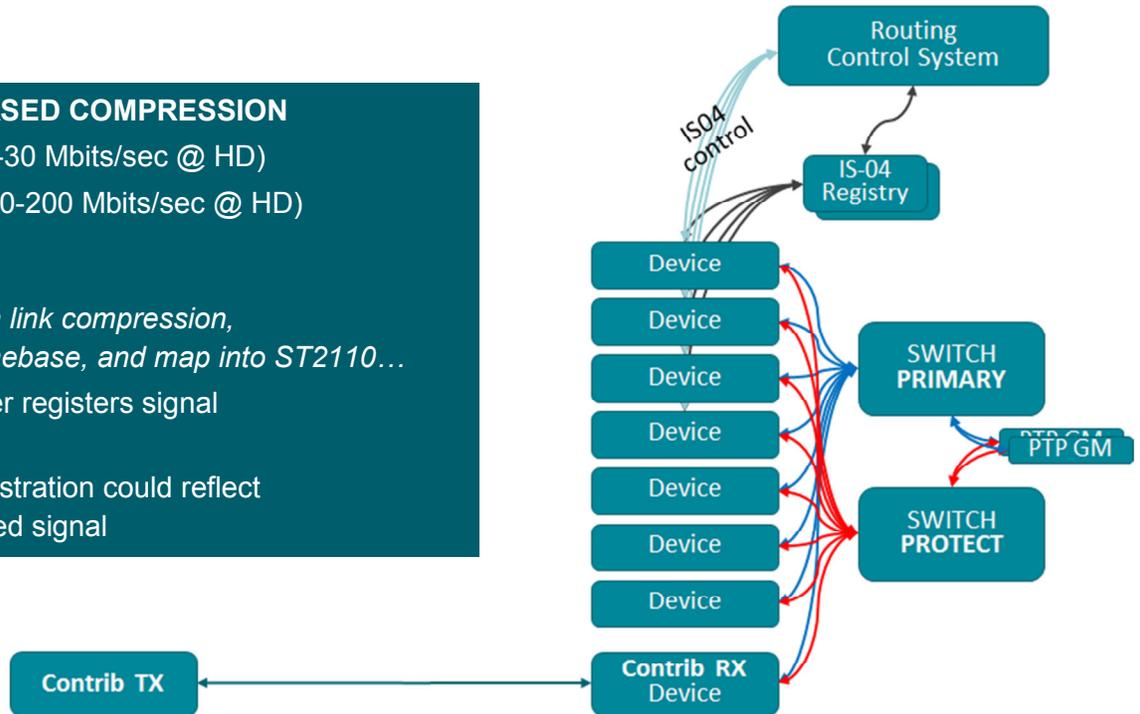


FIGURE 3 – CONTRIBUTION TEMPLATE

The AIMS interoperability framework is neutral to types of compression modes used in transporting content, therefore the gateway must be equipped with whatever codecs are needed to decode the flows any given studio is likely receive. Following the prescriptions of SMPTE ST 2110, once decompressed the feed must be broken into its constituent elements for routing and distribution within the studio.

Contributed feeds must also be registered at the gateway into the studio's registrar through use of AMWA NMOS IS-04. Each of the signal flows generated through SMPTE ST 2110 after decompression are registered, possibly in conjunction with registration of the contributed signal as a whole to enable association of all components with each other within the registrar.



Supporting Synchronization Continued

In any event, there's automatic mutual association of all elements in the contribution feed through the synchronization process that must be applied at the receiving gateway. All the individual flows broken out of the decoded incoming feed must be simultaneously synchronized to the local time domain via a synchronization timestamp produced by the PTP generator. Once that is accomplished, the content can be treated on the network like any locally generated signal.

It's important to note that the role played by the contribution receiving gateway eliminates any need to retain the original IP addresses of the contribution source within the signal flows or to perform Network Address Translation (NAT) to assign private addresses for local use. With its performance of the decoding, regeneration, registration and synchronization processes, the gateway plays the role of content source like any other local source as viewed by the switches and other devices in the local network environment.

DESIGNING FOR LARGE STUDIOS IN ONE LOCATION

As summarized in **FIGURE 4**, the range of things to consider in the design of IP-based production facilities greatly expands in larger studio environments.

- Spine/Leaf model, redundant
- 2022-7 style redundancy
- Devices register via IS-04
- IGMP+PIM and/or network controller signal management
- Control system leverages IS-04 to manage connections/routes

NON-BLOCKING BANDWIDTH MODEL

every signal can come from outside the leaf

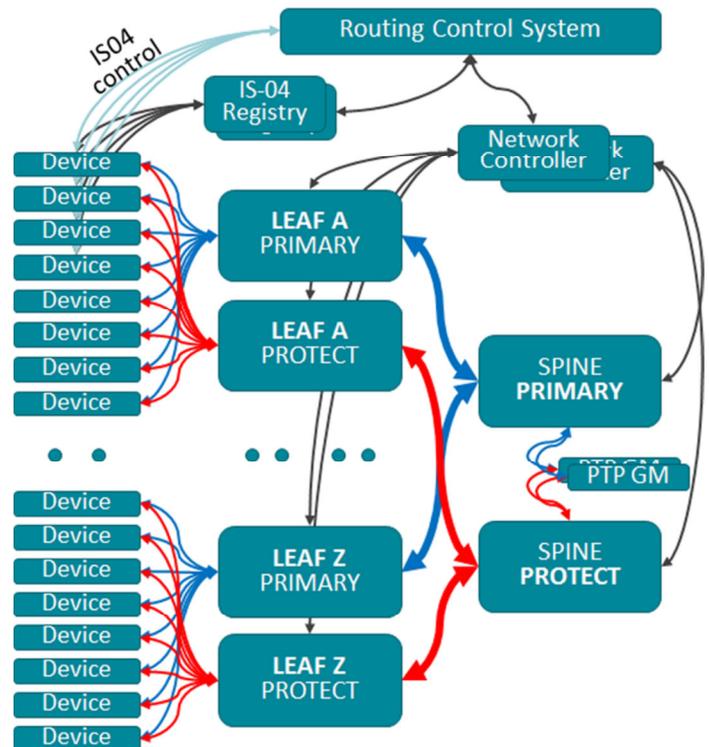


FIGURE 4 – LARGER SYSTEMS TEMPLATE



Designing for Large Studios in One Location Continued

Here we start with the factors impacting design of a complex system used for live broadcast production, such as a large network's core facilities, where everything is housed in a single building or multi-building campus. We'll then look at additional factors that must be considered when the production operation is extended across remote locations and mobile units.

No matter how large the operation, IP production benefits from the capabilities of SMPTE ST 2022-7 redundancy and AMWA NMOS IS-04 device discovery and registration as described earlier for smaller studios.

Planning for a Spine / Leaf Switching Topology

The topology over which routing processes are implemented is likely to be much different. When there are multiple concentrations of devices and switches in production facilities to be managed, designers are well advised to implement a hierarchical spine/leaf topology as depicted in **FIGURE 4**. For simplicity, only a single spine is shown but, in practice, more than one spine may be included.

While it's possible to manage all flows from a central switch connected over multiple links to what can be dozens of production rooms, this type of set-up "can sometimes" add costs and imposes significant limitations on scalability. The cost of the optical interfaces for each high bandwidth link used between each cluster of devices and the central switch can be significant and should be taken into account when comparing this architecture with a more centralized, modular switch architecture. This cost, however, is sometimes preferable vs running individual device connections back to a higher bandwidth port on a centralized, modular IP switch as this often leads to the underutilization and therefore inefficient use of those ports.

In the spine/leaf scenario a local (leaf) switch aggregates local switching functions for a local cluster of devices. Given that most current-generation production devices are equipped with 10 GigE ports and some even use 25 GigE ports, a 1 RU leaf switch capable of supporting 48 10- or 25-GigE ports on a common core can serve several production clusters. The costs of such links running at these throughput levels with utilization of small form factor pluggable (SFP) transceivers are far lower than the costs of supporting dozens of long high-capacity links feeding 40- or 100-GigE ports on a central switch to handle all the switching requirements for each device cluster.

In the spine/leaf topology there are far fewer high-capacity 40- or 100-gig links connecting leaf switches to the ports on the core spine switch, which is tasked with performing whatever switching functions are required to handle interoperations between leaf switches and the transfer of content to and from external sources into the leaf domains. This frequently results in more efficient use of bandwidth on all links across the entire topology.

As each situation and design is different, it is important to compare the full cost and advantages of a spine/leaf (or aggregation) type architecture (including all links and optical interfaces) with



that of using a more centralized, modular switch architecture as the differences can be significant both to the initial costs as well as the ability to easily and cost effectively expand.



Going Beyond IGMP in Setting Up Switch Routing Control

In larger studio environments designers must take into account the need to manage more complex traffic patterns than can be achieved with IGMP alone. One approach is to use IGMP with Protocol Independent Multicast (PIM) technology, which sets up a multicasting tree that supports aggregation of multiple instances of multicasting in local switching scenarios into a centralized IGMP layer that manages joins and leaves among the local instances. However, an IGMP+PIM approach does not automatically provide admission control or bandwidth management. This means that the devices can issue IGMP joins but have no way of ensuring that there is sufficient bandwidth for all the flows. Therefore, without additional manual or static calculation, one can easily oversubscribe and cause packets to be dropped.

To avoid this problem, large studios transitioning to IP are now implementing IP network controllers that tie all the studio switches together to appear as a single switch under the traditional broadcast routing control system and pro-actively manage the bandwidth utilization. The IP network controller in some respects mirrors the routing control enabled by SDI tie-line management systems, but with a greater range of functionality and far more switch management capacity. Today's IP network controllers can control thousands of switches at once, a common necessity in broadcast TV at moments like the top of the hour when production has to orchestrate video, audio and metadata in myriad feeds flashing across TV screens at the top of the hour.

These controllers are also able to manage dynamic allocation of bandwidth resources in instances like the rerouting that occurs with capacity saturation on any given link or when a production component has run out of processing capacity. Dynamic bandwidth management is also vital to supporting a studio-wide non-blocking policy, which should be factored into the initial studio design in order to ensure that the controller can route any signal from any point to any other point as required for any given production workflow. It's important to note that in designing for non-blocking, planners must ensure there's enough bandwidth on all links to accommodate a high level of fluctuation in traffic patterns at the leaf and spine switching levels.

Another advantage IP network controllers provide over traditional SDI tie-in management systems is that most controllers employ telemetry feeds over the link connections to gather information on what's going on at each device. Capitalizing on the ubiquitous use of IP-based interfaces and communications among all components, such capabilities used in conjunction with advanced analytics serve to streamline and lower the costs of quality control by giving managers real-time visibility into whatever issues might be taking shape as a result of degradations in device performance. The IP network controller approach provides complete visibility to the flows in the network fabric, the senders and receivers of any given flow and the path that the flow is taking. This is similar to the complete visibility that one had in the SDI-based system. Another key advantage provided by an IP network controller is the authorization and policy control system. Using the API one can authorize devices and prevent either malicious or misconfigured devices from consuming the bandwidth and preventing failures in legitimate devices. Lastly, one can use an IP network controller approach and devices on the network can continue to send IGMP joins and leaves. All the benefits of the IP network controller can continue to be realized with this approach.



DESIGNING FOR PRODUCTION EXTENDING OVER MULTIPLE LOCATIONS

IP-based production can be seamlessly integrated across multiple facilities with all the benefits that accrue in single-location environments. Producers can collaborate in realtime in dispersed locations linked by high-speed terrestrial backbones whether they're across town from each other or a continent apart. For example, in one recent implementation of IP production at a broadcaster's core facilities in Los Angeles and New York, the operational latency between the two sites has been reduced to less than 100 milliseconds.

The range of facilities to be integrated into the unified production process can include mobile as well as fixed studios. It's also important to incorporate any turnaround facilities where new elements are added into the production stream. In all cases, operations can be brought into a unified production process with utilization of switching based on the leaf/spine topology discussed in the previous section.

Choosing Time Domain Set-up and Modes of Synchronization

The key question that must be addressed in designing for such capabilities concerns the approach to synchronizing remotely generated flows with flows at core facilities. One approach involves universal synchronization of all operations to the time domain used in operations at the core facility. The other involves use of different time domains at remote locations in conjunction with application of the synchronization processes discussed earlier and as illustrated in **FIGURE 5**, where all incoming flows are locked to the primary studio's time domain.

SIGNALS FROM DIFFERENT TIME DOMAINS require synchronization and address coordination

CONTROL is organized through a control gateway between the local and remote routing systems

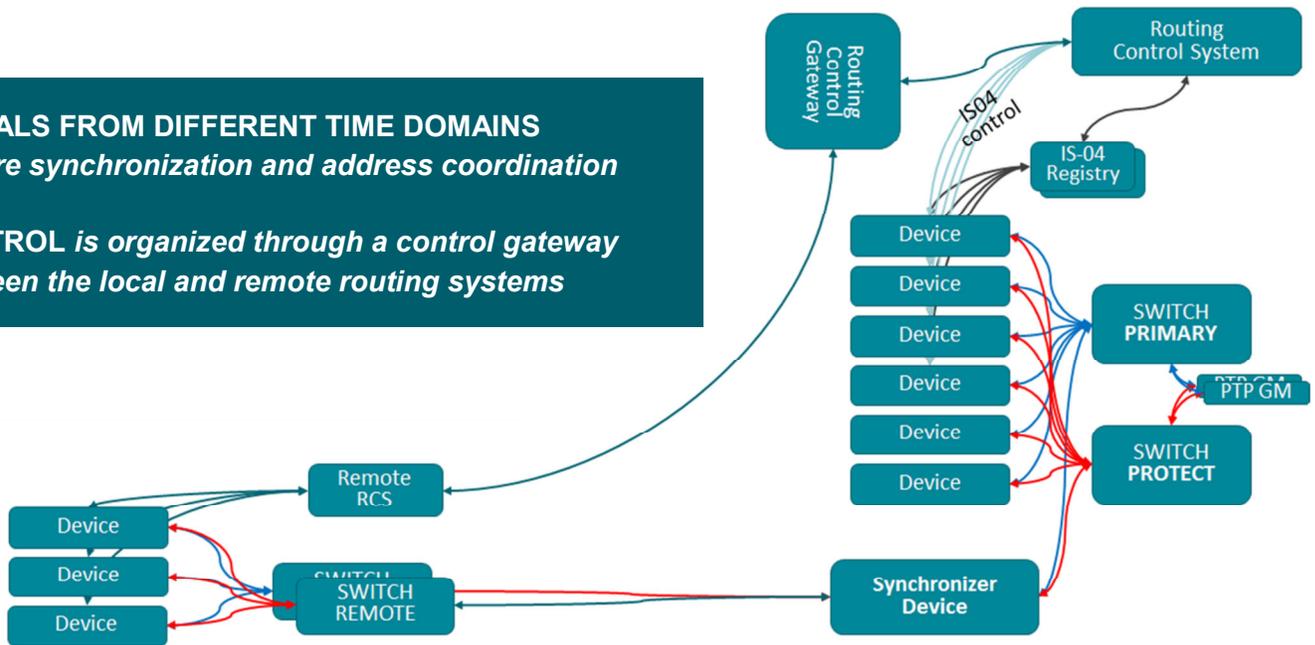


FIGURE 5 - PTP BRIDGING TEMPLATE



Choosing Time Domain Set-up and Modes of Synchronization Continued

There are several issues that need to be considered in deciding which approach to take, and no matter which one is chosen, it's important to ensure that selection of a vendor's solution accounts for capabilities that are required to support that choice.

In many cases, if all locations are meant to always operate as an integrated whole in the execution of live TV production it will make sense to synchronize everything to a single time domain. In so doing, designers must consider how they want to accommodate delivering the pings from the master PTP generator that maintain precise timing on all devices across the entire infrastructure.

This can be done in two ways, the most common of which is direct pass through where the packets from the master PTP are transparently delivered by the local switches to all devices at each location. However when the device count at any given location reaches a point where the cascading pings eat up more switching capacity than the local network can comfortably support, pass through doesn't work.

In such instances the switch handling the incoming pings must be equipped with a boundary clock and configured into the PTP synchronization process so that it can ingest all the PTP packets from the master generator and regenerate the clock locally. Designers pursuing this approach will have to take into account whether such capabilities are supported by their prospective switch vendors. While the boundary clock instantiation is an intrinsic component of the master-slave PTP architecture as embodied in the IEEE 1588 standard, some vendor switches only work with pass-through clock management.

Another factor to be considered with design of a single time domain infrastructure has to do with the need to logically segregate different types of devices and locations. As noted previously, when remote signals operating in different time domains are synchronized to the primary studio time domain on entry into that domain there's no need for NAT or any other ancillary means of identifying remote sources; all signals are automatically mapped into the local discovery and registration system. However in the uniform time domain approach there's a need to apply the discovery and registration process enabled by NMOS IS-04 across all locations.



The Benefits and Design Implications of Using Diverse Control Domains

Generally speaking, the more distributed approach to control utilizing independent but coordinated control systems is best suited to the multi-location operations of big broadcasters. One reason for this is the need to maintain a high level of reliability and survivability. Another reason is to provide increased security in today's hack-infested network environment.

While a direct point-to-point link under end-to-end control of the broadcaster may provide a sufficiently secure environment for transporting content between facilities, the use of WAN facilities creates exposures that need greater protection, even when a given wavelength or set of wavelengths is under long-term lease by the broadcaster. Routers, light wave cross connects, and other points of interconnection in these long-haul facilities are highly vulnerable attack points and subject to failures beyond the broadcasters control.

In such cases broadcasters will want to implement impenetrable firewalls between all sites which means signals on either side will have to be buffered, regenerated and resynchronized to each time domain in the destination facility. Such a set-up eliminates the option of relying on the master facility PTP generator to lock all devices in all locations to the primary time domain.

Another factor that pushes towards reliance on local time domains at remote facilities arises when there's a need to use remote locations as standalone studios as well as production extensions of the primary facility. In such instances, the remote locations must be equipped with their own routing control systems and primary locations must be able to coordinate with those systems in order to determine where network control resides in any given production operation. This set-up also ensures that the remote location can continue operating in the event of a link break with the primary facility and that the location can be brought back online for integrated production operations when the break is repaired.

Designers have to take all this into account when choosing vendors. Some primary and secondary routing systems will be equipped to coordinate between the two levels while others won't.

CONCLUSION

Many of the considerations that go into planning for implementation of IP-based facilities for live TV production are fairly straight forward under prescriptions set by the specifications in the AIMS framework. But there are many questions that need to be given much thought in each type of studio environment to ensure broadcasters will be able to achieve goals set for their IP production facilities.

Careful consideration of points made in this document should help designers choose approaches that will serve broadcasters' immediate needs while smoothing the way for ongoing migration from SDI to IP-based production. With finalization of the SMPTE ST 2110 and AMWA NMOS IS-04 specifications, broadcasters have the basic formulas for maintaining interoperability as they take full advantage of the efficiencies and functionalities introduced with IP-based production of their live programming.

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