IP Live Production and the business of broadcasting

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Welcome

While the Internet Protocol (IP) has triumphed in so many aspects of our personal and professional lives, the conventional live broadcast infrastructure based on the Serial Digital Interface (SDI) has endured. Sony helped develop and standardize SDI, led the way with SDI chipsets and nurtured SDI from standard definition to high definition, 3G and most recently to 4K. Nobody appreciates the importance of SDI more than Sony.

But powerful new requirements are changing the broadcast landscape. Broadcasters are under unprecedented pressure to originate more and more content at lower and lower cost. They also need to anticipate future transitions beyond HD to 4K, High Frame Rates and even 8K. These requirements are driving the industry to transition from SDI to IP Live production. And once again, Sony is in the forefront.

For 15 years, Sony has been committed to implementing IP technology at the core of the broadcast infrastructure. Our commitment has led us to work side by side with like-minded parties in the SMPTE and EBU standardization committees. But Sony is not only contributing to the standardization of the relevant technologies, but is also forging cooperative links and making these standards available to leading third-party vendors. To achieve this goal, Sony developed a dedicated application-specific integrated circuit (ASIC). FPGA and PCIe board are also available for vendors and suppliers to develop compatible products. Sony expects that these efforts will help build a multi-vendor IP Live ecosystem, ensuring interoperability.

This document places IP Live technology in the context of broadcaster needs, tracks the emergence of key industry standards, and demonstrates the overwhelming advantages of IP Live in terms of cost, agility and scalability. Along the way, we’ll show how Sony’s IP Live implementation meets the most stringent requirements for broadcast picture quality, operating simplicity and reliability.
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1. Broadcaster challenges

IP Live production technology is so compelling because the broadcast environment is so challenging. Onrushing trends are rapidly transforming the broadcasting business.

1.1 Reluctance to build a second IP network

Today, post-production departments at broadcast stations are boosting their deployment of nonlinear editing equipment, setting up file-based systems, and implementing fully networked editing environments. Because these editing environments do not have strict requirements regarding signal latency and synchronization, conventional “best-effort” packet delivery is good enough. Conventional IP routers suffice. And costs are low.

In live production, however, best-effort packet delivery is nowhere near good enough. Live broadcasting requires low latencies and seamless switching without signal loss or interruption. Networks must not only be fast, but also completely reliable.

For these reasons, some have argued that IP Live production would require a second, dedicated IP network, entailing dedicated, high-cost systems, and large capital investments. This belief has resulted in inefficient, side-by-side deployments of two separate IP system: one for file-based production and another for live production. And this inefficiency has limited the broad adoption of IP Live systems.

1.2 Scaling up to 4K, 8K, HFR

Meanwhile, video distribution formats are moving beyond high definition. Content creators have embraced the story-telling potential of 4K cameras. 4K Ultra HD television sets now dominate the high end of the consumer market, gaining share far faster than many analysts had predicted. Over-the-top streaming services such as Netflix and Amazon Prime are distributing 4K to the home.
Movie directors, cinematographers and technologists have also made a compelling case for the added sense of reality made possible by High Frame Rates (HFR). And looming beyond is the possibility of 8K.

These developments threaten to overwhelm the SDI infrastructure. For example, implementing 4K in SDI requires four times the cables and four times the router capacity. This imposes huge cost, space and weight penalties on broadcast stations and outside broadcast trucks.

While substantial business and regulatory hurdles remain before widespread 4K broadcast services can begin, any infrastructure investment with a ten-year horizon must anticipate these emerging technologies.

1.3 Originating more channels at lower cost

These days, broadcasters are not just feeding a single antenna. They're generating secondary channels for cable, satellite and digital over-the-air. They're streaming content on-demand and over-the-top. They're feeding content to IPTV and mobile apps. They’re even creating post-broadcast packaged media. While these ever-multiplying distribution channels all promise to generate revenue, one thing is certain. They're straining your broadcast production plant – and your team members. Your technical staff is expected to distribute more content than ever before, in more ways than ever before.

Ironically, the same explosion of distribution channels is driving audience fragmentation that puts advertising revenue under strain. So while your workload keeps expanding, your budgets are rising more slowly – or not at all. You’re under constant pressure to achieve more results – using fewer resources.
Sony’s IP Live vision

Sony envisions a future in which IP replaces SDI as the standard broadcast signal connection. IP has the capacity to handle all signals: video, audio, metadata, sync and control. We look forward to IP Live interfaces on cameras, monitors, switchers and production servers. Legacy SDI equipment will be easily accommodated through SDI-to-IP converters. At the core of the IP Live system, large, expensive SDI routers will be replaced by inexpensive, commercial off-the-shelf (COTS) IP switches. And the ubiquitous coaxial cables and BNC connectors will be replaced by Ethernet cables and connectors such as capper, fiber and coaxial. This is Sony’s IP Live Production System.

Sony also developed a key technology called Networked Media Interface for IP Live Production System. It is an AV transmission interface, highly scalable to future format such as 4K, 8K and HFR.

This new IP Live Production System promises to deliver a wealth of benefits that speak directly to the business imperatives of today’s broadcasters.

2.1 A single network for file-based and live

Broadcasters concerned about the need to maintain a dedicated network for IP Live will be happy to hear that Sony designed IP Live Production System to solve this dilemma. On IP Live Production System, not only video, but all-important on-air signals for live such as audio, meta are transformed to IP, meaning that live system becomes all IP-based that can easily share resources. In short, live system and file-based post production system can be integrated into one. In this way, broadcast stations won’t need to invest twice in two different IP networks. This dramatically improves investment efficiency.

2.2 Future-proofed system optimizes investment

Within the next ten years, broadcasters may be tasked to originate 4K, HFR and eventually even 8K signals. SDI cables and routers will have a hard time keeping pace. Where a single SDI cable will suffice to carry
High definition, four coaxial cables and four BNC connectors are required for 4K. This is a severe penalty in cable cost and router capacity.

By its very nature, the routers at the core of the IP Live system are format agnostic. To them, an 8K, 4K or HFR packet looks exactly the same as an HD packet, there are simply more of them. So it’s natural to ask whether IP networks and routers will keep pace with these new broadcast formats.

### 2.3 The virtual broadcast facility

The benefit of IP is that you’re not constrained by location. Any piece of equipment is physically consolidated in a server room, but all available anywhere on network, allowing live production from any venue. In the long run, all equipment can be concentrated in the server room, with processor and User Interface separated. Broadcast functions such as switching and conversion can be provided as applications on computer hardware, available to all users as shared resources on the network. You can do necessary set-up and maintenance centrally. This is the future of IP: unprecedented efficiency.

However it doesn’t stop only within content creation area. In the process of providing service, various IT system is working such as financial system, human resource system etc.

By integrating IT infrastructure in a whole company, system integration between content creation area and business area can potentially be considered.

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Pursuit further efficiency by integration of IT infrastructure in a whole organization
This is powerful technology. As we mentioned earlier, Sony’s IP Live Production System has a huge advantage for any broadcaster required to originate more content, in less time, at lower cost.
3 IP Live Technology

3.1 Concept of the system

Previous architectures proposed separate IP networks for conventional file-based operations and IP live broadcasting. Sony proposes a single, integrated system. IP ready devices such as cameras and switchers connect to a core IP switch. The system is controlled centrally by a software application, enabling superb agility and global setup.

3.1.1 Leveraging conventional IP switches

Sony's IP Live Production System does not depend on special, Sony-branded IP switches. Neither does the system require IP switches with specific, high-end features, such as flow-control capable SDN or IEEE.
1588 support. Instead, Sony designed the system around ordinary, commercial off-the-shelf (COTS) IP switches. Not only is this cost effective in the short run, but it also enables you to ride the tremendous wave of IT industry progress. IP networking is a multi-billion dollar market driven by intense competition and rapid-fire innovation. This drives the cost of IP switches ever lower, as it drives capacity ever higher. Network bandwidth is doubling and redoubling at an impressive pace. And this suggests that when broadcasters are ready for 4K, 8K or HFR, the IP switch fabric will also be ready and affordable.

3.2 Highly scalable AV transmission interface: Networked Media Interface

The Networked Media Interface is Sony’s newly developed AV transmission interface complied with not only current formats SD, HD but also future formats 4K, HFR and 8K in both compression and non-compression. The Networked Media Interface is highly scalable transmission interface having necessary functions for live transmission over IP.

3.2.1 Essence-independent packetizing

The Networked Media Interface supplies packet headers that readily identify packets as video data, audio data or metadata. This makes it easy to extract, combine, distribute, and switch among different types of data without placing an excessive load on the system. For example, it’s easy to send only the audio data out to your audio production system.

3.2.2 Low Latency Video Codec (LLVC)

The Low Latency Video Codec is an image compression codec delivering extremely high image quality and low latency, while using modest computing power.

Sony’s unique algorithm is based on the wavelet scheme adopted in JPEG2000, but reduces the computational load characteristic of wavelet compression. In video with relatively simple images (low entropy), LLVC achieves lossless compression. That is, the decoded image is a bit-for-bit copy of the original. In video with extremely high complexity (high entropy), LLVC reproduces visually lossless images. While the reproduced image is not mathematically identical to the original, differences are too small for human observers to detect. Even considering clean-video switching, a 4K signal can be transmitted on a single 10 Gpbs Ethernet cable. To promote interoperability of the LLVC, Sony submitted Registered Disclosure Document No.34 (RDD 34) to SMPTE (Society of Motion Picture and Television Engineers) making its technology info. available to the public.
3.2.3 Recovery of lost packet by Forward Error Correction (FEC)

Any time you transmit an AV stream over IP, electrostatic noise can cause packet loss. When Sony’s Networked Media Interface packetizes the AV stream, it generates redundant data stream intentionally by a Forward Error Correction (FEC) technology. These enable the system to immediately recover lost packets, maintaining the signal integrity that broadcasters need.

3.2.4 Reference signal synchronization: SMPTE ST 2059-2

Switching multiple AV sources requires precise signal synchronization. That’s why conventional SDI transmission includes a sync signal. In the IP Live Production System, Sony’s Networked Media Interface performs sync in compliance with SMPTE ST 2059-2, using IEEE 1588 PTP (Precision Time Protocol).

3.2.5 Dedicated application-specific integrated circuit (ASIC)

Sony developed a dedicated application-specific integrated circuit (ASIC) for Networked Media Interface. Sony anticipates embedding the new ASIC into future cameras, monitors, switchers and other broadcast equipment, making them “ready” at the outset for IP Live production.

3.3 Clean Video Switching: Destination Timed Switching

We’ve seen that broadcasters absolutely require clean video switching, no glitches allowed. Method of clean video switching depends on which IP switch adopted. While other switching systems depend on
specific IP switches, Sony’s method, Destination Timed Switching works with conventional, off-the-shelf (COTS) IP switches. Neither specific IP switches nor limited network configurations are necessary. Unlike other methods, Destination Timed Switching does not require synchronous control. There’s no need to do complicated setup such as video signal synchronization in the IP switch. You retain a high degree of freedom and flexibility in system configuration. However, Sony has not ruled out the use of other approaches. If other methods present new advantages in cost, implementation, or in meeting specific customer needs, we are ready to extend our designs as necessary.

In operation, Destination Timed Switching works as follows:

- The Controller sends a transmission request to the IP stream receiver.
- The IP stream receiver (or “destination”) issues Internet Group Management Protocol (IGMP) messages to join stream B. After receiving stream B, it issues IGMP messages to leave stream A.
- The Ethernet switch starts and stops the corresponding streams according to the IGMP message.
- The two streams temporarily overlap at the destination and output a clean, switched stream.

### 3.4 Stable transmission: Quality of Service (QoS) Technologies

We’ve seen that the “best effort” packet delivery of file-based IP networks is not nearly good enough for IP Live production. It’s essential to avoid packet loss and latency from traffic congestion. So the question arises, how can we differentiate IP Live packets – which absolutely must arrive on time – from file-based packets, which can continue to use “best effort” delivery? The answer is Quality of Service (QoS) guaranteed technology, which is widely used in IT communication. Priority Control and Access Control effectively place time-critical live broadcast packets into a “fast lane” of guaranteed quality, while diverting file-based operations to a “slow lane.”

#### 3.4.1 Priority Control

When a live broadcast begins, the system prioritizes live production signals, including video, audio, metadata, synchronization and control. File-based signals are assigned best-effort bandwidth.

#### 3.4.2 Access Control

You can also reserve bandwidth with advanced planning. Bandwidth is reserved based on when and how much traffic comes in to the network. When incoming traffic exceeds the reservation, the system
handles each exceeded stream as low prioritized traffic or denies access to traffic. In this way, high-priority traffic is always kept on network.

Priority Control and Access Control are triggered by QoS information originated by Sony's IP Live System Manager, a software application for centralized system control.

![Diagram of QoS and Priority Control](image)

**QoS guaranteed technologies ensure stable, reliable AV transmission**

### 3.5 Perfectly redundant architecture

To provide reliable transmission, Sony’s IP Live Production System’s architecture is fully redundant. The system duplicates not only the AV stream, but also the network and the server where Sony’s IP Live System Manager software is installed. This duplexed system runs all the time (Active-Active), synchronizing between systems. So operation continues even in the case of network failure.

#### 3.5.1 Hitless Failover (SMPTE ST 2022-7 compliant)

Redundant AV streams ensure highly reliable operation. Even if one of the AV streams goes out of service, the system immediately switches to the other for uninterrupted transmission.
3.6 Network security

Compared to conventional SDI infrastructure, IP delivers powerful efficiency and agility. However, IP does raise the possibility of network attacks. This makes network security a major priority. Sony’s IP Live Production System protects the entire control path using Transport Layer Security (TLS). In addition, we deploy standard, proven IT technology against security risks.

The system prevents these risks via User Authentication and Device Authentication.

3.6.1 User authentication

This function denies access by unauthorized users. Users are authenticated by role (administrator, operator, etc.).

3.6.2 Device authentication

Sony’s IP Live System Manager authenticates each device by public key certificate. The system administrator can identify each device with the certificate whether it should be authorized or not. Unauthorized devices are denied access.
3.7 A software application for centralized system control

Because the IP Live Production System connects all devices to a single network, the entire system can be set up and administered from a single software application, Sony’s IP Live System Manager. The application runs on a dedicated server. Smart functions provided by the IP Live System Manager maximize the benefits of IP, reduce production cost, and provide more opportunities for production.

3.7.1 Workgroup set-up: Fast and easy changeovers

With Sony’s IP Live System Manager, you set-up and maintain the system centrally. The Workgroup function can save full sets of parameters for multiple Workgroups (usage setups). This enables fast and easy changeovers. For example, when Show A and Show B are originated from the same studio, you can save the required equipment setups as Workgroup A and B.

By activating the Workgroup before production begins, set-up is done in the system immediately and automatically. There’s no need to run around setting up equipment by hand. Advance registration can always be done on system, even when equipment is in use.

When using an outside broadcast vehicle for live sports, settings and functions will typically need to be changed at each location. For example, a baseball match will be broadcasted in HD on one day at Stadium C, and a football match will be planned on the next day at Stadium D.

Using Workgroups, however, you only need to make these settings once at each location. Once all settings are made, you can export them into a Workgroup so that they can be recalled as needed. This frees your staff for more productive tasks – and makes your vehicles more available to generate revenue.

The IP Live System Manager application provides a modern graphical user interface (GUI) for registering equipment and settings. The intuitive design follows the concept of a conventional AV system. The GUI itself can be customized for each Workgroup, and even for each user within a Workgroup.
3.7.2 Centralized system monitoring

Sony’s IP Live System Manager conducts full-time monitoring of the network and connected devices. When equipment parameters fall out of spec, indicating a failure, the IP Live System Manager issues an alert. You can take action in a timely manner.

*Sony’s IP Live System Manager in network control view. Impending and actual device failures are shown with red and yellow warnings.*

*The toolbar at the right also enables you to monitor network traffic.*
4 Standards and cooperation

To bring this system into the mainstream, it will be necessary to have interoperability among a wide variety of compatible products on the market to support robust broadcaster workflows. Compatible cameras, switchers, servers, computer graphics, display devices, and master system will all have to readily available.

Sony is not only contributing to the standardization of the relevant technologies, but is also forging cooperative links and making these standards available to leading third-party vendors. Developers and vendors can selectively incorporate these technologies into their own compatible products. Sony is ready to provide technical support, connectivity testing, and other assistance to facilitate product development.

More than 30 leading companies in the industry support IP Live Production System.
4.1 Contribution to industry standards

Sony has been developing IP Live technology since 2000. But the effort is far greater than one company. It requires an ecosystem of compatible standards, practices and interoperating equipment. That’s why Sony has been an early and eager participant in the EBU (European Broadcast Union) and SMPTE (Society of Motion Picture and Television Engineers) standardization processes.

- In 2007, Sony participated in the development project (originally a joint task force of SMPTE and EBU) on next-generation synchronization signals and time codes as an original member. In April, 2015, the standardization was completed as ST2059-2 Precision Time Protocol (PTP) SMPTE profile.
- Regarding SMPTE ST 2022 defined by SDHP mapping, Sony proposed necessary technological elements for live production in IP, such as essence independent packetizing and a low latency video codec.
- In 2013, the Joint Taskforce on Professional Networked Streamed Media (JT-NM), combining representatives of EBU, SMPTE and the Video Services Forum (VSF) was established to formulate IP network technical standards. Sony participated as an original member and continues to contribute.
- In June 2015 Sony participated as a proponent in the SMPTE Media Flow Management Study Group, launched to investigate and recommend clean video switching technology and system control technology.

4.2 ASIC product development

We’ve been active in sharing the technology around a key element of Sony’s IP Live Production System: the Network Media Interface. And just as Sony led the way with early SDI encoder/decoder chips, we’ve created an application-specific integrated circuit (ASIC) to support the Networked Media Interface.

4.3 FPGA and PCIe board product development

Third-party vendors can also develop compatible products dynamically using FPGAs (field-programmable gate arrays). Sony is encouraging leading IP core vendors to develop and market Networked Media Interface-compliant IP core products for major FPGA platforms. The marketplace
availability of these cores will provide equipment vendors with even more flexibility in designing compatible devices, and can be expected to lead to a rapid influx of new products.

Finally, Sony is encouraging computer board vendors to produce PCIe boards and other expansion cards to support development of compatible computer graphics, playout servers, and more. Availability of these boards will make it much easier to develop broadcast-related devices directly on PC platforms.

We expect that these efforts will help build a multi-vendor IP Live ecosystem.
A final word

Sony has been serving broadcast and production professionals since 1958, when we announced our first videotape recorder (a black & white 2-inch machine). Since that time, we have continued to advance the technology for users throughout the world. We led in the transition to videocassettes (U-matic® system), component video (Betacam® system), digital video (D-1, D-2 and Digital Betacam® systems), high definition (HDCAM® system) and file-based production (XDCAM® system).

As a company steeped in the business realities and workflow requirements of our broadcast and production customers, Sony is uniquely positioned to deliver the amazing advantages of IP Live.

- Unifies file-based production and IP live production on a single network.
- Scales to support next-generation video formats, including 4K, 8K and High Frame Rates.
- Enables you to do more with less thanks to an unprecedented degree of resource sharing by virtual broadcast facility

In the end, the story is not about IP. It’s about empowering your broadcast plant to meet your business needs. It’s about exploiting new revenue opportunities while controlling costs. It’s about meeting the ever-increasing demands of ever-more-sophisticated audiences.

A whole new world is waiting. Sony takes you there.