THE BROADCAST BRIDGE

Connecting IT to Broadcast

IP – A Practical Application

Essential Guide

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Introduction from TSL Products

At the end of the day, it starts with the customer.

Every user, production, environment, and application is different, meaning that universal or 'one size fits all' tools simply can no longer provide the versatility required by today's customers. Production requirements are becoming ever more challenging, with new and more complex shows and events making it ever more difficult for customers to make the right investment in equipment and technology.

A solution that satisfies a customer's requirements today, may not satisfy their requirements in the future, so a platform where functionality can adapt and grow over time, maintain a user-friendly experience, regardless of the advances in underlying technology is paramount to customer satisfaction.

It is vital to keep our ear to the ground in terms of being active members of leading industry organizations, such as SMPTE and AMWA. Also, progress has to be built on customer feedback and their changing needs, to make sure that the solutions delivered stay at the forefront of evolving workflows. Whilst the shift to IP workflows is becoming more and more a reality, many customers are still working within an SDI infrastructure, and won't have the luxury of making a clean shift to IP.

Those of us on the manufacturing side must therefore continue to design products and solutions that support IP infrastructures and embrace emerging technologies while offering the support for existing standards to future-proof our customer's investments and support a hybrid transition in the years to come.

Mark Davies, Director of Products and Technology, TSL

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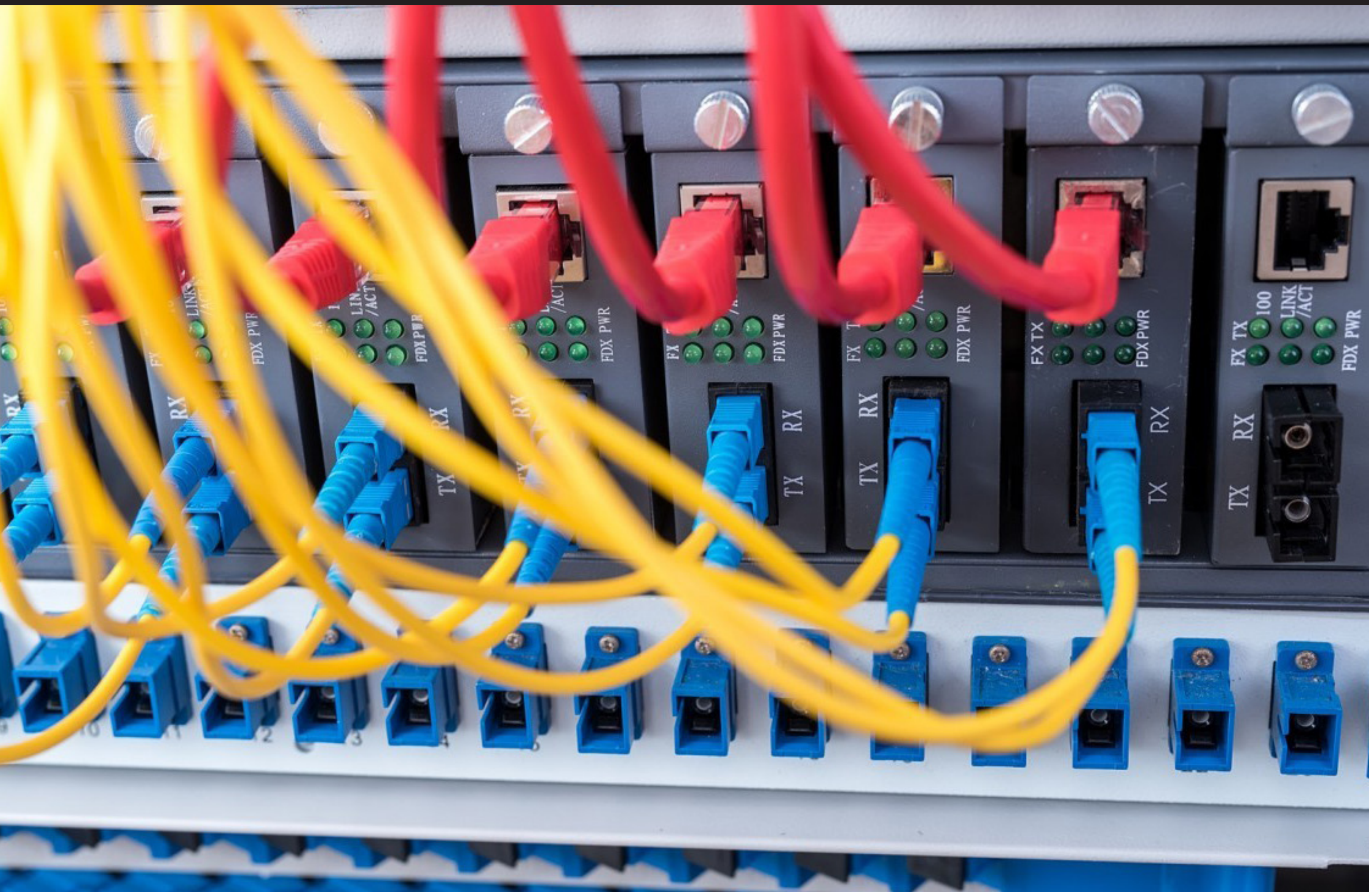
IP - A Practical Application



By Tony Orme, Editor at The Broadcast Bridge

Part 1 - IP Explored - ST2110 and ST2022

As broadcasters accelerate IP migration we must move from a position of theory to that of practical application. Whether we're building a greenfield site or transitioning through a hybrid solution, simply changing SDI components with analogous IP replacements will not achieve full COT's goals and the benefits associated with it.

Migrating to IP provides broadcasters with infrastructure flexibility and scalability. Traditional SDI solutions have stood the test of time, but they are rigid. Moving from SD to HD required large parts of the SDI infrastructure to be replaced as 270Mbit/s SD systems are not compatible with 1.485Gbit/s systems. Early adopters of HD could not move to progressive HD without changes to infrastructure. And the emerging UHD, 4K, and 8K formats are difficult to build with SDI technology.

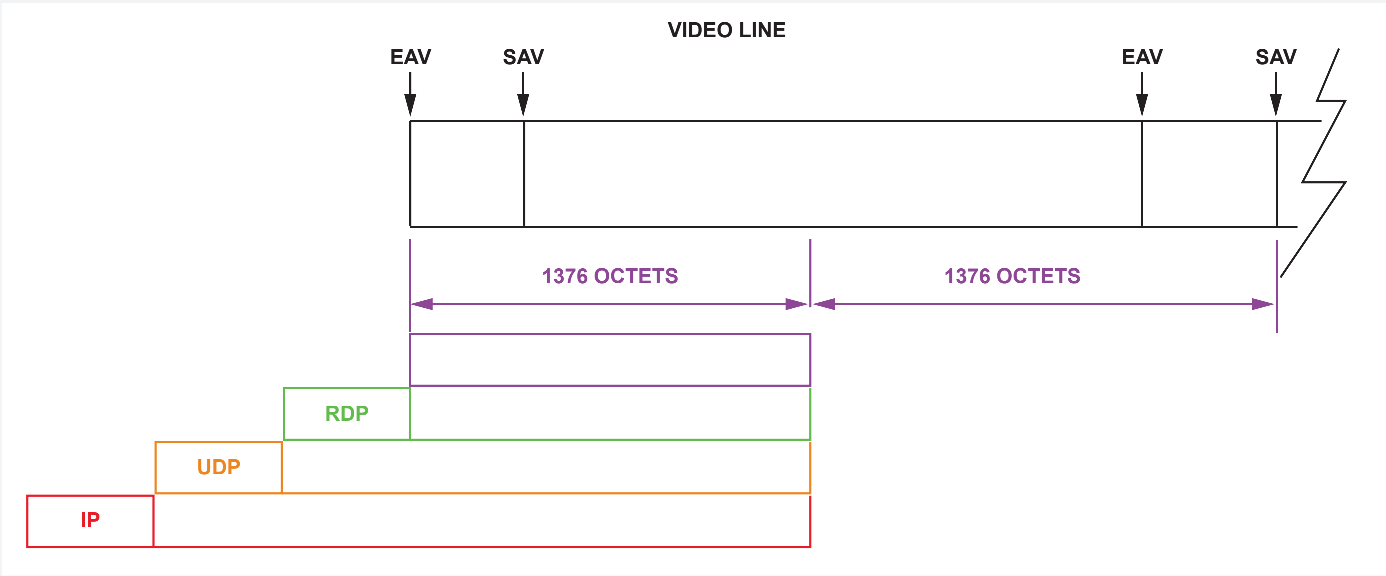


Diagram 1 – For ST2022-6, the SDI stream is split into 1376 octet packets, then encapsulated by an RDP packet, then UDP packet, and finally an IP packet. This process continues for the duration of the SDI stream at 1376 octet intervals.

IP is format agnostic and allows us to mix multiple television standards on one network. If enough capacity is available, then SD, HD, 25fps and 29.97fps formats can be simultaneously transported through the same network. It's even possible to mix 4K and 8K technologies into the same networks.

ST2022 Released

SMPTE are great proponents of IP and have been working hard to deliver IP standardization, and in 2007 they released the ST2022 group of specifications. As this was the first step for many broadcasters into IP, SMPTE tried to keep the infrastructure requirements as simple as possible. Few broadcasters have the privilege of green-field site installations and SMPTE acknowledged many would be migrating slowly and carefully.

Packetize SDI

ST2022-6 specifies the encapsulation of SDI into IP packets using a hierarchy of internet standards. SDI streams are divided into packets of 1376 octets. Each of these packets is wrapped by an RTP (Real Time Protocol) packet, then into UDP (User Datagram Packet), and then into the payload of an IP packet. A marker bit is used to signify the last IP packet in a video frame to assist downstream decoding.

Although ST2022-6 works well, it is primitive and wasteful of bandwidth. All the SDI signal, including the TRS (Timing Reference Signals) is wrapped into the IP packet hierarchy. Just over 76% of the original SD-SDI signal is active video, the rest is auxiliary data and TRS.

ST2110 Improvements

ST2110 addressed these inefficiencies by removing the timing relationship between the video and audio essence, and the underlying hardware transport stream. SDI, MADI, and AES all rely on clocking information encoded within the data signal, using methods such as bi-phase modulation, to keep video and audio synchronous between devices.

Ethernet is the preferred medium for network distribution in broadcasting as it is the IT industry de-facto standard for office and business systems. It crosses layers 1 and 2 in the ISO Seven Layer model, but in networking documentation is often referred to as layer-2, and distributes data using frames.

Remove TRS and Save Bandwidth

As Ethernet is asynchronous, there is no longer any underlying common clock to reference audio and video samples to. Although ST2022-6 didn't have an encoded clock, the system worked because the SDI packets were encapsulated in RTP packets, and these were sufficiently accurate to rebuild the SDI stream as it was a well-defined bit rate and the TRS was available.

By removing the TRS, ST2110 instantly reduces bit rates by a factor of 16% to 40% depending on the broadcast format used. But timing is the most important aspect of broadcast television and we still need to synchronize lines, fields, frames, audio samples, and metadata.

Line, field, and frame sync pulses are a relic of the past used to maintain backwards compatibility with cathode-ray-tube cameras and television sets. Although set top boxes still insert these pulses into a video stream to maintain backwards compatibility, we no longer need them in studios or the transmission system.

To achieve synchronization, ST2110 uses the IEEE 1588:2008 protocol. Commonly known as PTP (Precision Timing Protocol), it is used as the basis of timing for ST2110. PTP is a counter that represents the number of nano-seconds that have elapsed since the Epoch time that occurred at midnight on January 1st, 1970. Each ST2110 packet, whether it's video, audio, or metadata, is stamped with a PTP value in the RTP header encapsulated by the UDP and then IP datagram.

In the case of a camera, each packet of video is stamped with the PTP value determined at the beginning of that frame of video. Downstream equipment receiving the stream will be able to accurately rebuild the video frame and display it with sub micro-second accuracy.

Timestamp Samples

The same is true of audio. All audio packets are combined using a similar format to AES67 into samples and groups. Each group header is stamped with the PTP value at the time it was created. And meta-data uses the same method.

For ST2110 to effectively use PTP, all cameras, vision switchers, monitors, microphones, sound consoles, etc. must be referenced to the same PTP master time reference.

As each packet of video, audio, and meta-data is independently referenced to a global PTP, they can all be processed independently of each other and then combined with sub micro-second accuracy during transmission.

PTP Grandmaster

A network supporting PTP can use many distributed master clocks, but only one is nominated to be the Grandmaster. The BMC (Best Master Clock) algorithm runs on each master clock within a network to determine which clock should be nominated as the Grandmaster. Criteria such as GPS lock and the priority value set by the network administrator determine the most accurate clock.

BMC builds timing redundancy into the network so if the Grandmaster was to fail, or lose GPS lock, then the next most accurate clock would take over and be nominated as Grandmaster.

Distributed clocks throughout the network act as intermediaries to keep the network load low on the Grandmaster, thus helping to maintain accurate timing.

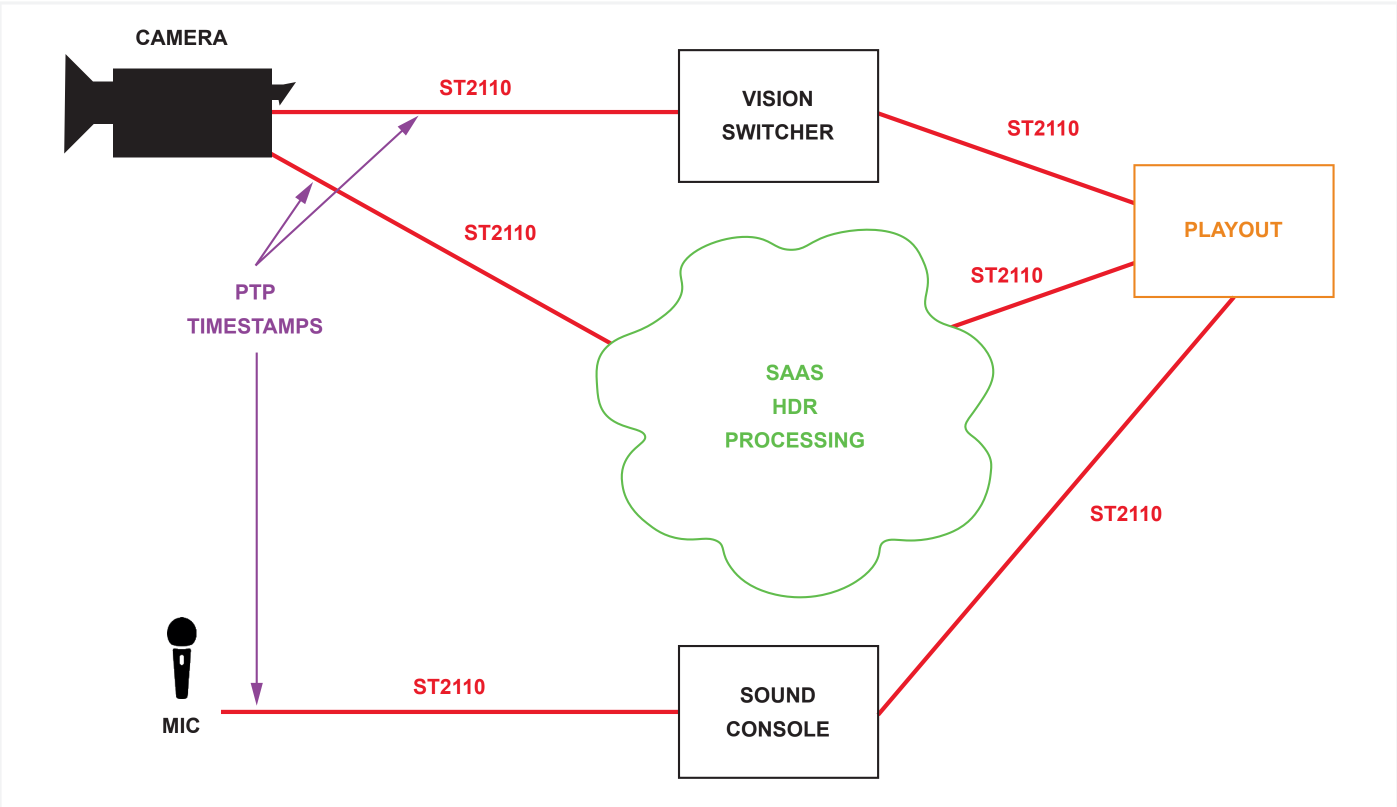


Diagram 2 – For ST2110, video, audio, and meta-data is stamped with a unique PTP timestamp referenced to the Epoch allowing essence streams to be processed independently of each other regardless of where they were handled.

ST2110 delivers boundless opportunities. Video can be processed in the studio at the same time HDR (High Dynamic Range) meta-data is processed in the public cloud, or on-prem datacenter. A whole plethora of SaaS (Software as a Solution) applications will become available facilitating the prevalence of pay-as-you-go pricing models.

Processor Demands

Servers offer the possibility of purely software monitoring solutions, however, there are many applications hosted on computers, all fighting for CPU resource. Operating systems, input-output routines, and storage devices all conspire to make the response times of software unpredictable.

Dedicated hardware solutions can be thought of as massive parallel processing systems. Each function, whether it's the screen drivers, keyboard input, or Ethernet controller, has its own hardware resource dedicated to that operation with no other tasks slowing it down.

ST2110 constantly streams media without flow control from the receiver. Therefore, the monitoring systems must be capable of receiving Ethernet frames without dropping a single bit of data. Hardware solutions are highly predictable and ideally suited to monitoring. However, as virtualized solutions progress and deliver better CPU resource, they will eventually start to fill the place of hardware only systems.

SaaS Delivers Real Pay-As-You-Go

A production may only need a standards-converter for two days after the final edit to process all the country versions. In SaaS it's easy to purchase this for the time required. And if you have your own cloud infrastructure you can spin up services as and when you need them.

Although many services are moving into software, hardware monitoring is still highly relevant in broadcast infrastructures, but this will change as Telco IP circuits improve in speed and reduce in cost, and virtualization delivers higher performance.

Tactile Controls Win

Hardware user interfaces are important in operational environments and the ability to be able to press dedicated buttons or rotate controls to change parameters cannot be over stated. Touch screens have their place, but when trying to diagnose a fault or understand a problem, being able to operate a tactile control improves our perception of reliability.

Migrating to IP delivers outstanding benefits for broadcasters wanting to future-proof their infrastructures, whilst being able to take advantage of the ability to scale systems and quickly meet the needs of operational demands. ST2022-6 has paved the way for many to realize the potential for IP. And with the introduction of ST2110, the opportunities to improve workflows, create greater efficiencies, and build flexible, scalable infrastructures will continue for many years to come.

Diagram 3 – Hardware devices provide dedicated user interface controls to give tactile feedback when operating the equipment, especially in highly pressured live broadcasts.

Part 2 - IP Control Uncovered

As broadcasters continue to successfully migrate video and audio to IP, attention soon turns to control, interoperability, and interconnectivity to improve reliability and efficiency. In this article, we investigate IP control as we move to IP infrastructures.

System control has been one of the most important aspects of broadcast television since pictures and sound were first transmitted. Many equipment vendors used closed-control protocols and for countless years the default method of interoperability control was the GPIO (General Purpose Input Output).

A network of bulky control cables distributed relay closures around a broadcast facility to form the basis of event triggers. The systems were hard-wired and had little scope for configuration and flexibility. There was no approved standardization for cables, connector types, or even the level of control voltages used.

SWP-08 Prevails

Serial protocols soon followed using RS232 and RS422. Although the EIA (Electrical Industries Alliance) specified voltage levels, connector types, and flow protocols, many vendors drifted from the official specifications to provide their own version subset. SWP-08 is one of the control protocols that has stood the test of time and is supported by many vendors.

Although SWP-08 and protocols like it were significantly more flexible than GPIO's using relay closures and opto-isolators, they still relied on a network of specialist cables and connectivity. Some vendors made RS422 operate over CAT-5 type twisted pair cabling, this could be made to work over structured cabling but not through Ethernet switches.

IP Flexibility

Internet Protocol has proved its worth for many computer applications and one of the reasons broadcasters are adopting it with such enthusiasm is that IP is transport-stream agnostic. The IP data packets function independently of the distribution medium they are transferring across. IP can seamlessly move across Ethernet, ATM, or one of the many other forms of Telco networks.

This helps enormously when distributing signals outside of the broadcast facility as IP packets can be sent using standard Telco infrastructures. Before IP, broadcasters used expensive and inflexible RS422 and RS232 control standards. The number of Telco's supporting them was limited which lead to long delivery times and convoluted and often unreliable international routing.

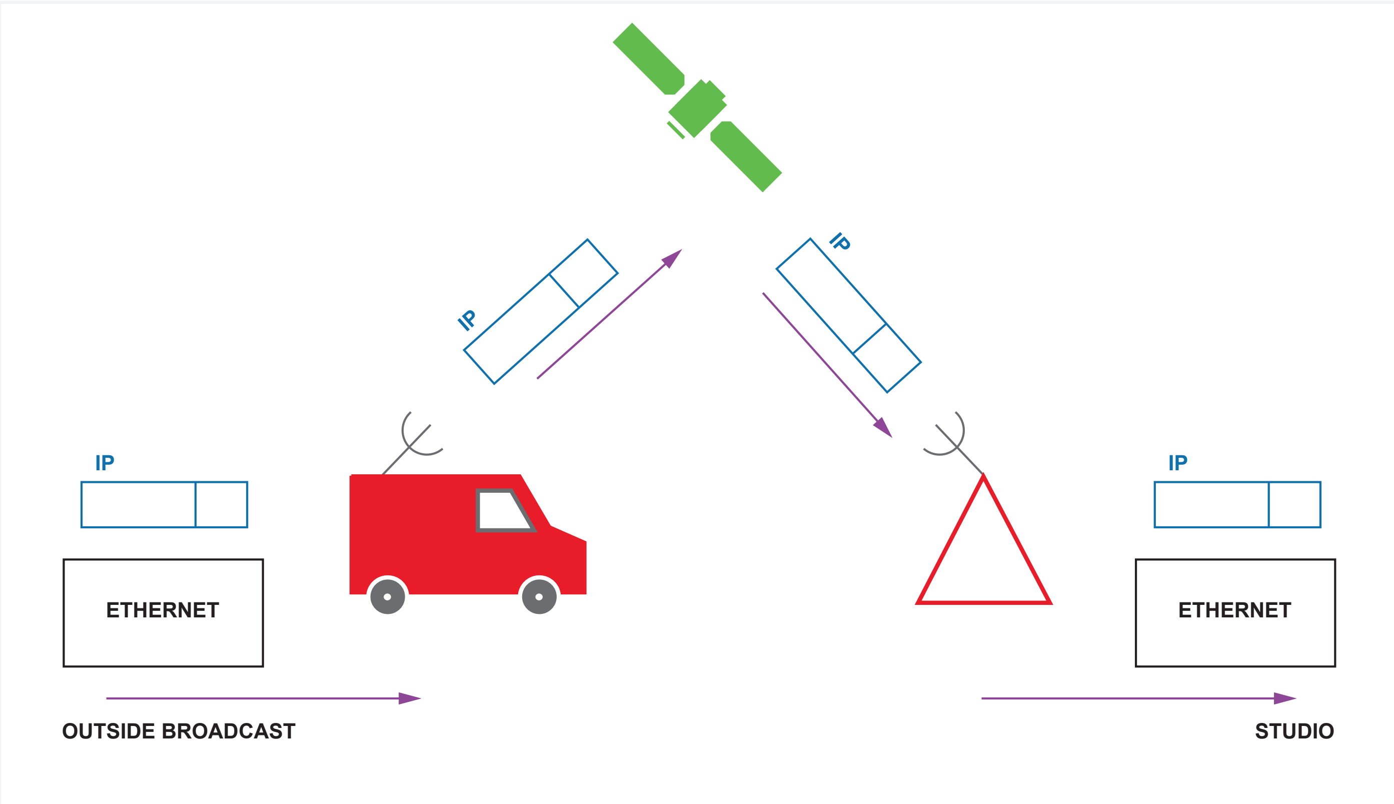


Diagram 1 – The success of IP has been due to the flexibility with which it can be distributed over diverse communication networks. In this example, IP packets leave the studio embedded in Ethernet frames, are modulated for satellite transmission using CODFM, and then converted back to Ethernet for the studio. The IP packet is completely unaware of these changes.

SDI is Already Interoperable

Protocols such as SWP-08 have been upgraded to work over IP and can now benefit from the advantages network delivery offers. That is, broadcasters can use IT infrastructures to facilitate control of connected equipment such as vision mixers, sound consoles, cameras, and lighting systems.

But as we progress to IP, specifically ST2022-6 and ST2110, interoperability is emerging as the new solution to be found. One of the major benefits of SDI, AES, and MADI is that interoperability is built into the specification and inherent in the design. We know that if we connect an HD-SDI camera output to a vision switcher, both complying with SMPTE-292 specification, the pictures generated by the camera will be available to the vision switcher without further configuration. However, the price we pay for this interoperability is lack of flexibility.

SDI is Rigid

An SDI network using SMPTE-292 will distribute HD video at 1.485Gbits/s or 1.485/1.001 Gbits/s. It is very difficult to seamlessly add other standards to the network such as 4K or even standard definition. Embedded audio can be used to help distribute the audio, but complexity soon arises due to the number of embedder and de-embedder devices required. And control becomes more of an issue as separate IP or RS422/RS232 networks must be provided.

IP is incredibly flexible as asynchronous packets are distributed without reference to the underlying hardware infrastructure. Multiple formats and standards can be simultaneously transported within the network along with audio, metadata and control. IP has no knowledge of the data the payload is carrying.

Challenges of IP Flexibility

But this flexibility presents IP systems with new challenges as the end points cannot easily determine the type or format of data exchanged between them. A video camera with a 25Gb/s connection can simultaneously send and receive many different video, communications, and control signals. We don’t even know if the camera is using UDP, TCP, or a combination of them. And IP addressing becomes a greater challenge.

Interoperability in IP is only getting us to where we already are with SDI, AES, and MADI, albeit with considerably more flexibility.

To help address these challenges AMWA was formed. According to their website, AMWA is an open, community-driven forum, advancing business-driven solutions for Networked Media workflows. In turn, AMWA established NMOS, the Networked Media Open Specifications. NMOS has been collaborating with industry partners to provide interoperability and interconnectivity specifications.

NMOS Specifications

NMOS is building a series of specifications that encapsulate control to enable low level configuration and to ensure that network management is abstracted away from the user.

IS-04 provides registration and discovery. Like plug-n-play, IS-04 automatically detects any IP equipment added to the network and provides it with an IP address. Networks are dynamic by nature and constant connection and disconnection of equipment should be expected.

IS-05 is intended to seamlessly connect senders and receivers such as a microphone to a sound console, to allow them to communicate together. A suitably equipped sound console could control the pre-amp inside the microphone using IS-05. As each type of device has different parameters, control, and signals, the Session Descriptor Protocol file is used to describe them to facilitate interoperability.

IS-06 abstracts away the underlying IP network to a series of software interfaces. Broadcast controllers use the standardized interfaces to control routing parameters between endpoints, such as a camera and monitor, and define parameters including bandwidths and QoS (Quality of Service).

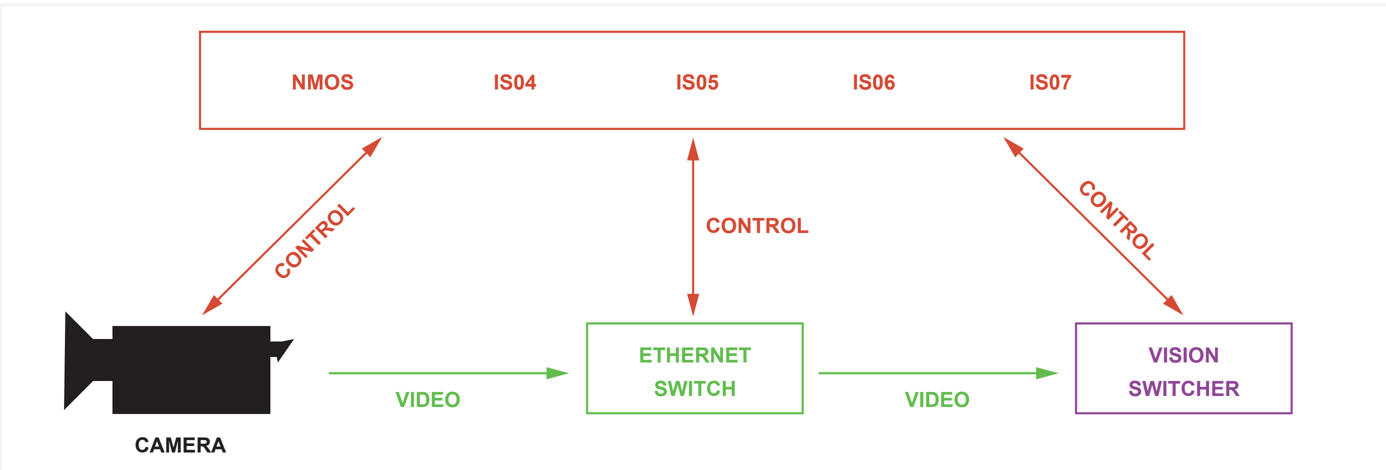


Diagram 2 – Video signals provided by ST2110 do not contain interoperability or interconnectivity information to facilitate seamless connectivity as with SDI. Instead, this is left to NMOS and the suite of protocols.

Event and Tally Control

IS-07 is the event and tally specification. This provides a mechanism to exchange and distribute time related events either created in software or from sensors. In effect it replaces GPIO distribution and control, although a suitable interface is required to convert to legacy hardware opto-isolator inputs and relay outputs.

The AMWA specifications are in various stages of release and manufacturers are busy coding solutions. It's clear that to get to where we already are with SDI, a great deal of work is still yet to be done. However, once this is complete, ST2110 and ST2022-6 video and audio over IP will be much more flexible than the current SDI, AES, and MADI offerings.

These specifications further open the possibility of innovation from manufacturers and system integrators. As AMWA are succeeding in abstracting away the underlying specialist IT hardware through standardized API software interfaces, generic monitoring and control systems can be better provisioned.

Migration is Key

Only a few broadcasters have the luxury of developing a complete green field site and most facilities are migrating their SDI systems piece-meal. Consequently, control systems will still need to provide SWP-08 type protocol conversion as well as traditional hardware GPIO's. Legacy equipment still proliferates throughout many facilities and the need to provide traditional control will be evident for many years to come.

The beauty of IP systems is that they generally use standard off-the-shelf hardware interfaces such as 10GBASE-T or 25GBASE-T. Although 40GBASE-T and 100GBASE-T network interface cards are expensive, they are readily available from professional IT vendors. Therefore, any advances to the control protocol specifications are easily facilitated in software, thus making the system future proof and highly adaptable.

AI Data-Sets

Control systems are a rich source of accurate data for AI (Artificial Intelligence), especially when correlated with timed events. Generally, each node is based on an x86 type computer system and can easily record control data thus making it available to AI controllers. This further increases the possibility of automated solutions.

Highly correlated data-sets further pave the way for systems that can self-diagnose and repair, or at least send meaningful alarms. This is especially true when anonymous monitoring data is shared around multiple facilities throughout the globe.

But control systems still need to be delivered today and solutions with traditional GPIO, RS422/232 interfaces, combined with Ethernet network interface cards should be considered. As broadcasters venture more into SMPTE's ST2022-6 and ST2110 systems with flexible control, they will future proof themselves as well as supporting and simplifying the progressive migration.

Part 3 - Next Generation Audio

Agility and flexibility" are the mantra of the new broadcast paradigm. Audio has always been the trailblazer for new technology, it was first to go IP and first to provide software solutions. But where is the next generation of audio taking us?

Broadcasters are chomping at the bit to take advantage of the new opportunities IP and software solutions have to offer. The traditional Capex models will still be with us for some time to come as they have a place to play in core infrastructure design. But new business models based on pay-as-you-go solutions are getting closer, and broadcasters are driving vendors hard to deliver.

Science Meets Art

Audio is unique as the demarcation line between science and art has been blurred for as long as people have been reproducing sound. Whether a 7th century Byzantine organ or a 21st century AI composition, the crossover and the influences each has on the other is far from clear. Primarily, this is due to the way we experience sound.

Turning sound waves into electrical stimuli for the brain to interpret is only part of our experience. The sound waves act as a stimulus to draw on deep emotions embedded in the human mind. They draw on our own memories of happiness, anger, and passion. Consequently, audio is never experienced by two people identically.

Monitoring Experiences Differ

And if no two people experience audio identically then it's not unreasonable to expect no two people should be expected to monitor sound in the same way. Up to recently, the rigid form factor of hardware products has imposed standard working practices on creatives and technologists alike. This is partly due to the physics of the design limitations, but more significantly due to the cost and time taken to redesign products.

A typical design cycle for a new audio product could easily take twelve months, and that's if the design process progresses well.

Software based solutions have the potential to release manufacturers and hence broadcasters from the shackles of these historic working practices. But as with most of the advance's technology has given us, human nature often dictates that we take small safe progressive steps instead of huge risky leaps.

Small Safe Steps

It is possible to take a giant leap from hardware bespoke designs straight into COTS software monitoring running on x86-type servers. But over tens of years of experience and evolution, broadcasters have learned that they must be able to trust their monitoring. This is truer now than ever, especially as more and more audio processing algorithms are available for COTS platforms.

Few broadcasters can completely build a greenfield IP installation. Instead, they move piecemeal from their SDI, AES and MADI systems to IP installations. They may even maintain these hybrid systems for many years. Having systems that can reliably monitor both IP and traditional infrastructures as they progress forward.

This leads to the next development in broadcast sound; hybrid-agile monitoring. This flexible approach provides the best of both worlds for broadcasters and manufacturers; a dedicated hardware platform with installable software modules to improve flexibility and agility.

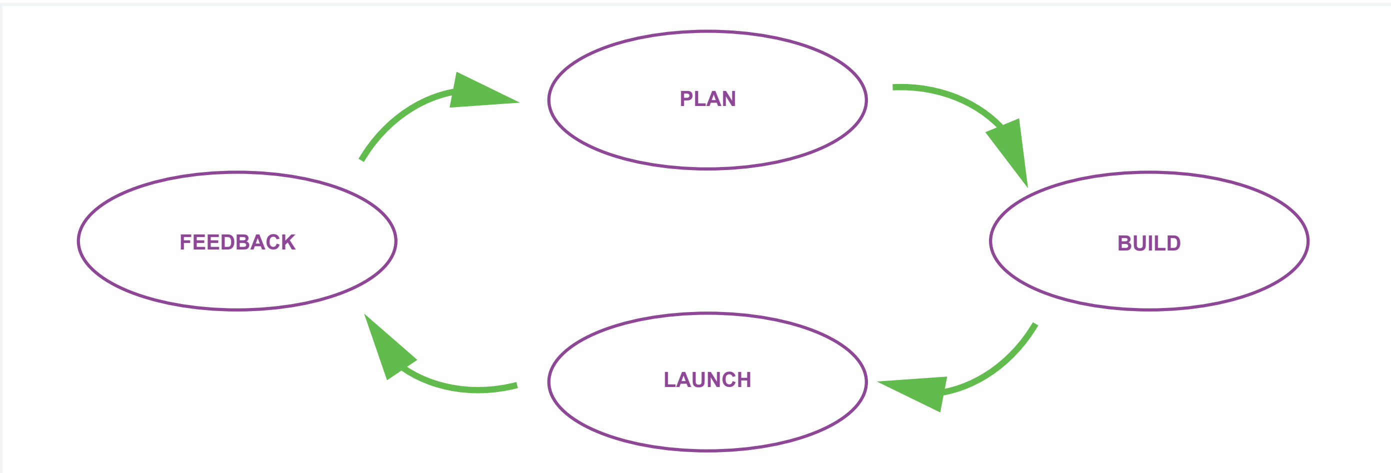


Figure 1 – The Agile software development method empowers manufacturers to bring features to market in the fastest time possible. Typically, plan, build, and launch cycles total two weeks to a month to deliver features quickly for client evaluation.

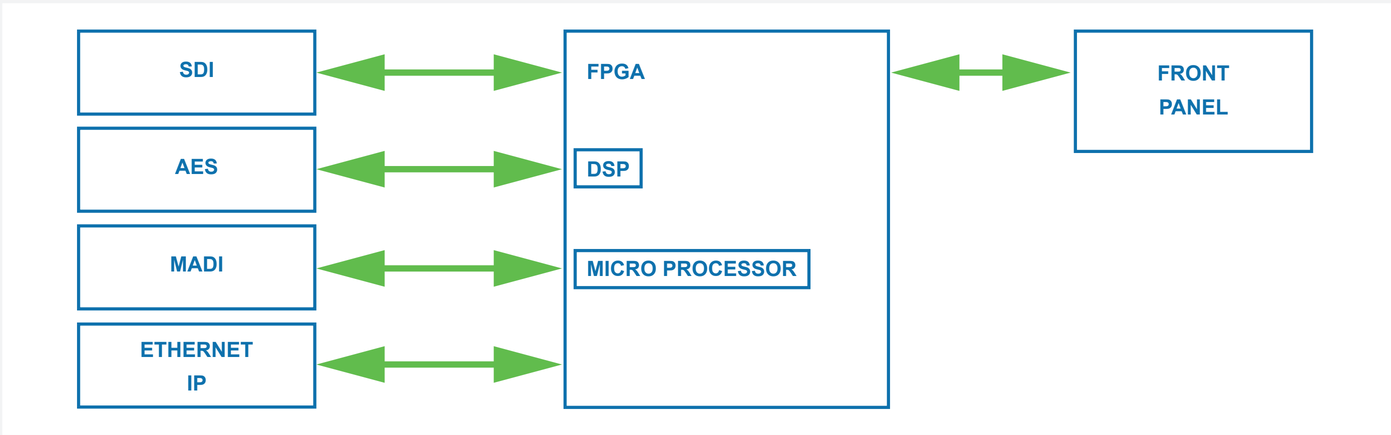


Figure 2 – Embedded FPGA hybrid-agile hardware platforms are ideally suited to broadcast applications as their behavior is highly predictable.

Reliable Monitoring is Essential

The technology to monitor on a COTS platform does exist and it is possible to do. We may even monitor on a COTS platform in the future. But as we migrate to IP, or even stay with SDI, AES, and MADI, broadcasters must be sure their monitoring platforms are solid and reliable. There is a plethora of SDI, AES, and MADI PCI-type interface cards currently available to facilitate COTS solutions. But installing them detracts from the true benefits of using off-the-shelf servers. It also limits public cloud options and with the current state of technology, it's often safer to use hybrid-agile monitoring.

Embedded designs offer the most reliable hardware. SDI, AES, and MADI chipsets facilitate direct connection to FPGA's (Field Programmable Gate Arrays) to deliver very low latency processing (in the order of a few microseconds). Furthermore, FPGA's have DSP's and microprocessors directly available on the silicon, thus improving processing efficiency and speed.

Optimized Operating Systems

Although embedded systems don't dispense with operating systems, the versions they offer are highly optimized and incredibly reliable. Heartbeat and watchdog monitoring further adds to their dependability. Their low power consumption generates little heat and reduced size makes them easy to install in operational areas.

COTS platforms tend to offer general solutions. An x86 processing platform running in isolation could be optimized for audio by using a bespoke operating system. But this would render the design useless for virtualization and hence negate many of the advantages COTS has to offer.

Virtualization requires a software control application running directly on the hardware, this governs access to the IO including the PCI interface to the SDI, AES, or MADI connectivity. Blocking can occur as the virtualization software prioritizes access resulting in potential latency and delay. Strategies and solutions are available to reduce this using method such as kernel bypass and DPDK (Data Plane Development Kit), but they add significant complexity to a system.

Virtualization for real-time applications is still a developing technology and only just finding its way into broadcast television. At least during the transition and migration phase, broadcasters need to have some constants they can rely on. Hybrid-agile hardware platforms are a development on a theme, a small safe step, as opposed to a giant risky leap. They provide the constants needed for monitoring highly complex broadcast infrastructures.

Software Modules Improve Flexibility

As more vendors move to software processing, availability of soft-modules is becoming more prevalent. A hybrid-agile hardware platform could be shipped with a basic operational configuration as part of its design. That is, it might have basic SDI ancillary audio monitoring, with AES and MADI decoding.

Adding extra features such as Dolby Atmos or Loudness monitoring is easily achievable. These software modules can be permanently installed and even enabled and disabled as a user demand. An integrated automation system may even be able to procure, install, and enable software modules from the front panel.

There are many licensing options and strategies available. From time-enabled to hardware-specific, users can enable and unlock features as their business use-case demands. This pay-as-you-go model greatly improves a broadcaster's flexibility and agility.

Intelligent Automation

Authorization frameworks such as OAUTH2 enable other applications to gain limited access to the platform through API's. This opens the door wide open for highly intelligent automation systems that can configure monitoring platforms. Sound engineers may even be able to create their own bespoke monitoring profiles that they load when they start their shift.

Agile-hardware platforms combined with software-module licensing opens a world of opportunity for broadcasters. New workflows can be provided. And business models more suited to the demands of the production team came be better facilitated.

Interoperability is critical for broadcasters and many are driving vendors hard to achieve this, especially with SMPTE's ST2110 standard. The industry collaboration group AMWA (Advanced Media Workflow Association) is pushing forward NMOS (Network Media Open Specifications) to deliver a suite of specifications to enable vendors to operate seamlessly together.

Flexibility is Key

SDI, AES, and MADI are interoperable by default. An output from an SDI matrix from one manufacturer directly to the SDI input of a monitoring device will work. The same is true of AES and MADI. Although these standards are rigid, they do lack flexibility, hence the reason many broadcasters are moving to IP.

Consequently, during the migration phase, hybrid-agile hardware options deliver the most optimum solutions. Vendors can design, implement, and install software-modules with incredible speed and consistency. The pay-as-you-go model also helps vendors as they can react to client demands faster and be able to cost effectively test the market with new features and options.

As we progress to the next audio formats, whether this is immersive or object audio, improved surround sound or higher sample rates, the hybrid-agile hardware platform is best suited to meet the demands of the next generation of audio. And this isn't just about sound, it's also about the business model and how vendors can help broadcaster's transition to IP.

The Sponsors Perspective

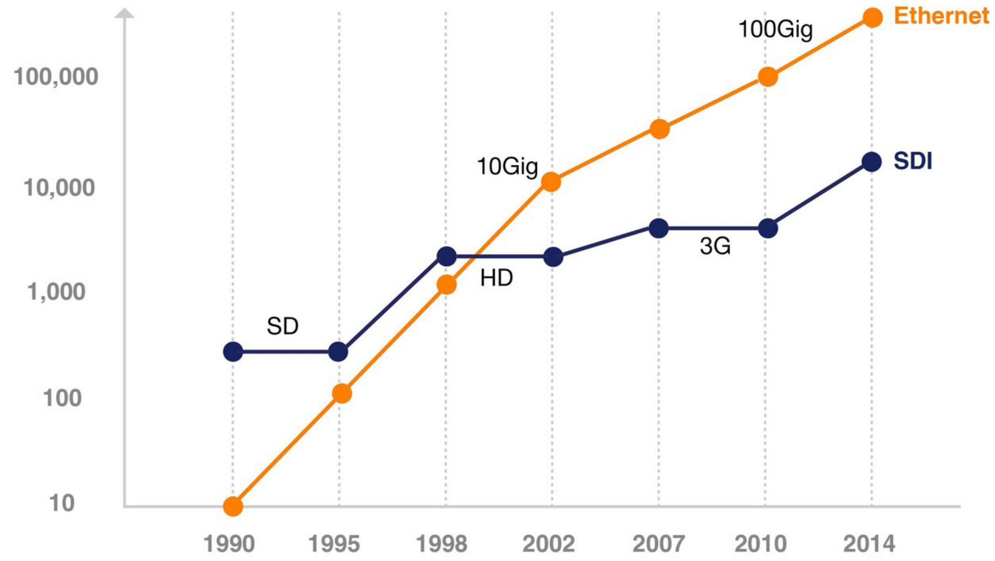
The Move Towards Next Generation Platforms

By Mark Davies, Director of Products and Technology, TSL

Whenever I'm asked about my opinion on the transition to IP, I always state that the impact can't be appreciated until its history is understood.

This brings into context the need for broadcasters to educate and surround themselves with those who have in depth knowledge and understanding of the subject. I remember when SDI was first introduced in the 1990's. It was sufficient to allow broadcasters to achieve what they needed. At the time, IP systems could only pass 1 to 10 Mbit/s and couldn't yet support the industry's requirements, so we developed our own standards and chipsets.

Moving forward to the present, 10 Gbit/s, 25 Gbit/s, and even 100 Gbit/s can be supported in standard IP switches which can now be bought economically. In the light of new formats such as 4K and HDR, switching requirements have changed dramatically and commercially available SDI routers just become too large for broadcasters, especially OBs, to use. Just take an OB 4K truck that requires 1152 sources and 1152 destinations, it would require 72RU of SDI router space. Compare this to 10RU for a COTS solution and it's all too clear to see why the space and weight savings in a truck means the logical decision is to adopt COTS packet-based switching for this size system.



Meanwhile, a business that relies on attracting and retaining subscribers as well as advertising revenue in order to be competitive must continually provide content in the highest quality available. This means being able to provide the best services to their subscriber base, which in turn may mean being able to provide content in new formats such as UHD, HDR, WCG and Virtual Reality. An IP infrastructure supporting ST-2022-6 and/or ST-2110 can provide this technical agility without requiring 'fork-lift' infrastructure changes. Once the video is in the IP packets, it does not matter if the format is 4K or 8K, the fundamental architecture remains unchanged.

TSL is currently working with several major greenfield sites and POCs based on ST-2110 and it seems that are as many questions being raised as there are being answered. ST-2110 deployments require Precision Timing Protocol (PTP) as their reference and this is a new way of working for the broadcast industry. Security is also gaining in importance and from a control perspective, the continuing pressure on production budgets is accelerating the deployment of remote production solutions. The move to IP is also driving the need to be able to control devices differently, moving to edge device control, which requires a whole new set of standards such as the AMWA NMOS suite.

We have grown used to 'plug and play' behaviour in the broadcast world when using SDI, AES, MADI and Analogue infrastructures to transport content. If IP networks are to provide the same level of flexibility, then a clear policy on discovery and registration is required and having a deep understanding of third-party device control means TSL is well-positioned to provide complete solutions with our own products but also through interoperability with third party kit.

Another key challenge customers are seeking is to protect investment. The great thing about a COTS infrastructure is that the broadcast industry now has the ability to embrace virtualisation, so customers can invest in the resources they need as and when, with COTS hardware, ST-2110 and AMWA/NMOS meaning that it is now feasible for the cloud to host the kind of services that are becoming increasingly more relevant to broadcasters and TSL customers. As production requirements become ever more challenging, with new and more complex shows and events customers' requirements are dynamic, where in a years' time they may need to be able to quickly spin up their services for a small period, e.g. for the 2020 Olympics. COTS and services in the cloud provides a more agile infrastructure to provide services as and when they need.

The rapid adoption of IP and remote production also means that it is essential for systems to be able to hide underlying complexities so that operators can remain focused on making great content. By providing a unified platform layer with agile feature sets, ownership can be put back into the hands of the user, while maintaining high quality production values.

In addition, as TSL recognises that customers are seeking more flexibility with how they purchase services, this approach will feed into our next generation development, keeping rapidly maturing technologies such as immersive and object-based audio, improved surround sound or higher sample rates front of mind. The drive to address our customers' need for agility and flexibility also feeds into our control and power solutions, and we will continue to explore the opportunities provided by advancing technologies such as the cloud and virtualisation to maintain the momentum.

In summary, at TSL's core remains the desire to maintain technical excellence and to keep pace with the latest technologies and industry standards. Any new platform from TSL comes complete with a roadmap designed in response to today's rapid changing environments. Of course, maintaining a user-friendly experience, regardless of the advances in underlying technology is paramount to customer satisfaction and remains our key focus.

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