THE VRT SANDBOX LIVE IP EXPERIENCE

F. Poulin[1], W. Vermost[1], M. De Wolf[2], W. De Cuyper[3] and K. De Bondt[3]

[1] EBU, Switzerland, [2] Dwesam, Belgium, [3] VRT, Belgium

ABSTRACT

The LiveIP project is an exploration of the possibilities and opportunities achievable with today's IP-enabled broadcast technology in a live production environment. The paper gives an overview of the facts and findings from this hands-on project, in order to share it with the broadcasting community, thereby helping to advance knowledge of the current state of the technology and to identify areas where further work is needed. The project has shown that it is possible to build and to operate a live & IP production studio based upon open standards in a multivendor environment

INTRODUCTION

The LiveIP project is a practical exploration of the possibilities and opportunities achievable with today's IP enabled broadcast technology in a live production environment. It was made possible by building and operating a live TV production studio with state-of-the-art IP-based equipment using available interoperable open standards. LiveIP is the result of collaboration between Belgium's Flemish national broadcaster VRT, the European Broadcasting Union (EBU) and a group of innovative broadcast technology partners including Axon, D&MS, Dwesam, EVS, Genelec, Grass Valley, Lawo, Nevion, Tektronix and Trilogy.

Current SDI-based technology is not flexible enough to adapt to the changes the industry is facing. Whilst IP is often said to be the technology to support that transformation, there are many questions in the industry about its readiness for live production; can it, in its present state, bring to professional live media, the transformation seen in other areas such as telecoms, or media post production? Should broadcasters begin to move their facilities to IP, or not?

The project tries to provide answers to these questions by examining the different challenges and evaluating possible solutions. It reveals the current state of interoperability between available products from different vendors, as well as the benefits of using IP for live production applications.

This paper gives an overview of the facts and findings from this hands-on project in order to share it with the broadcast community, to advance knowledge of the current state of the technology and to identify areas where further work is needed.

MEDIA BUSINESS TRANSFORMATION

VRT has a live production facility with SDI-based technology; however it needs to become more flexible, scalable and shareable. Moreover, VRT plans to move to a new facility, which should be operational in 2021. This is an opportunity to embrace the new possibilities in a renewed infrastructure. The LiveIP project should provide support for the decisions needed about the technology that should be used in the new facilities.

Do More with Less

The continuous challenge of having to produce more content with less (i.e., fewer resources) is not new for the broadcasters. “Less” can mean a reduction in staff members but also in budget or time. However, there is a limit to how far resources can be reduced while the pressure to produce more content grows. So new ways need be found to increase efficiency and effectiveness in production, most notably new technological solutions are needed to automate the processes and enable new and better workflows.

Digital Shift

The digital environment has a clear impact on audiences. They want to be able to consume more media at anytime, anywhere and on any device. This obliges media organisations to provide new formats, and to package their content for different media delivery platforms. This has to be automated and data-driven, both of which characterize IT technology.

Connect & Share

By putting new technology in a real setting, the LiveIP project provides the opportunity not only to evaluate the state of today’s technology, but also to explore new workflow opportunities. The information obtained from this experience is in turn shared with the community of broadcasters and with the industry to accelerate the acquisition of know-how.

Maturity of Interoperability

The transition to IP video transport and IT architectures is a fundamental change. It brings more flexibility and modularity, but also adds complexity. The technology is also new to the users - as well as to many vendors. However, the users have a baseline expectation: they want the same level of robustness and interoperability as with SDI, which gives them the liberty of building systems from `best-of-breed` components.

Therefore, there is an advantage to bringing together technology pioneers on the premises of a broadcaster and interconnecting their hardware and software in a real use-case. Within this “safe haven”, engineers can cross company boundaries, and work together on the interoperability of their products without commercial concerns. Moreover, the findings are contributing to the international standardisation through the EBU, VSF, SMPTE, AMWA, AIMS and JT-NM.

Ultimate Effects of the Transition

There will be business opportunities that are hard to predict, resulting from the following:

- Dedicated speciality hardware will make way for software-based applications running on standard IT infrastructure.
- Capability to share the infrastructure, and consequently make more cost effective use of investments.
- Capability to obtain live feedback from the audience straight to the production chain using end-to-end IP connectivity natively.

- Capability to accompany the live signal with data, such as real-time telemetry or metadata automatically extracted from the scene. This will result in enhanced or new formats.
- Possibility to use production infrastructure capabilities as pay-per-use or subscription-based services (an OpEx model) rather than owning the equipment (a CapEx model)
- Object-based production, enabling personalized and adaptive content will be made possible thanks to the data-rich nature of IT, where metadata can be bundled with the media in the same work-flow.
- Possibility to offer live production functionalities as a service from your own infrastructure.

LIVEIP'S AGILE APPROACH

The LiveIP project took place within the VRT Sandbox technology accelerator[1]. The idea of the VRT Sandbox is to set up partnerships for short pilots with relevant innovators. New media technology can be built and tested in a realistic context – the television, radio and production and distribution facilities of VRT. Projects are built around short phases with clearly defined goals. This approach has proven to result in practical, hands-on findings rather than just theory.

Iterative Process

The timeline of the LiveIP project had phases, built around typical workflows.

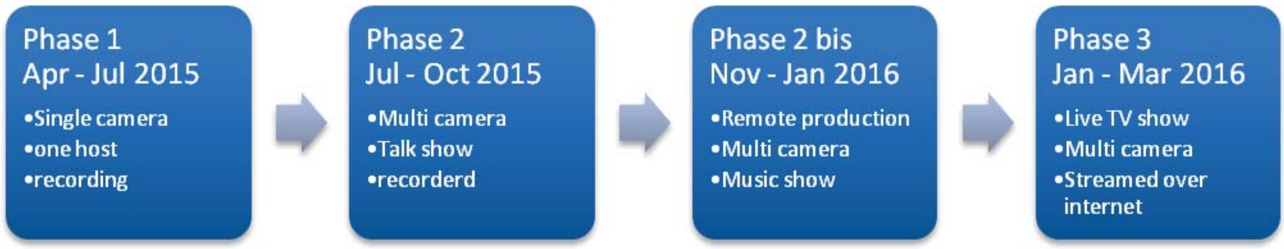

Figure 1 – LiveIP project timeline

Phase 1: A basic, single camera studio to establish the interoperability needed to produce content in an IP environment. The three locations (Studio floor, Data centre and Control room - see "High-Level Architecture", below) were interconnected with only three fibre cables. The system was well received by VRT's operational team.

Phase 2: The system was expanded to four cameras with new components introduced to reproduce full studio functionality. VRT simulated a multi-camera talk show production.

Phase 2 bis: The Control room was connected to a remote Studio floor, at the Bozar concert venue, situated in the centre of Brussels 5 km away from the VRT production centre. A live-to-tape recording of a piano concert could be produced remotely.

Phase 3: The network was scaled up to accommodate all the sources and drive additional screens on the stage set. In March 2016, an uninterrupted programme production of 90 minutes was streamed live on the Internet[2].

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[1] http://sandbox.vrt.be/
[2] The LiveIP Live Debate http://sandbox.vrt.be/liveip-news/2016/3/3/re-live-the-live-ip-live-debate

Phase 4: At the time of writing, the set-up is being used for a daily production to take place during the upcoming summer months.

Next Phases: There is the potential to further evolve the system to new standards as they become implemented in the products of technology partners.

ARCHITECTURAL VISION

The original plan was to end up with a system distributed in the three typical locations of the production studio, the Control room, the Data centre, and the Studio floor, that would be interconnected only with fibre optics with managed network connectivity that would feature as little “glueware” as possible.

With this streamlined connectivity, the distance between a Studio, its Data centre and the Control room are no longer limited by the length of the multitude of SDI cables. Therefore, in a single production centre, it is possible to link different Studios and Control rooms with the Data centre. Furthermore, with this set-up *remote* production can be achieved by simply extending the network connection to the location.

Since the back-end equipment is located in the Data centre, the resources are centralized and pooled, so can be *shared* amongst different Studios and Control-rooms and can be allocated according to the immediate needs of a production. This way, the investment can be optimized in a much better way than with the current SDI-based studio that has to be designed for the worst-case scenario.

Ultimately, to keep the operation simple and achieve the desired flexibility without the need for network expert support every time resources are needed by the production, a high-level of *automation* of the network and devices is required.

In practice, even though not all the technologies were available to fully implement this architectural vision, the “Remote, Shared and Automated” principles helped guide the system design and the technology providers at every stage of the project.

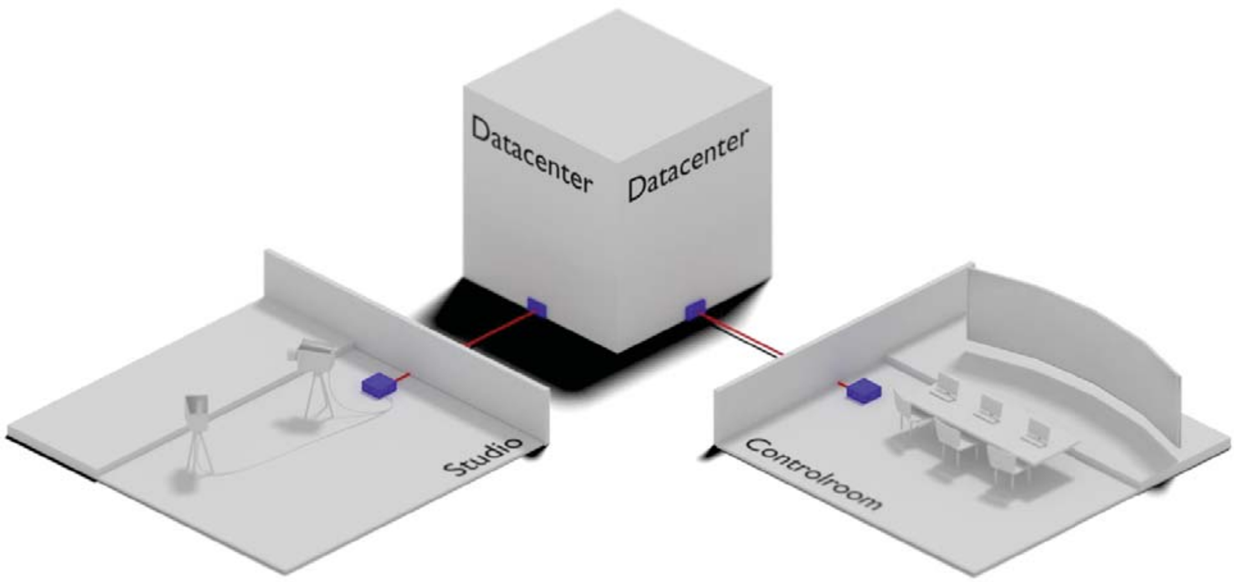

Figure 2 – The three rooms

OPERATIONAL CHANGES

Remote production workflows have many benefits such as:

- Reduced size and cost of the set-up (e.g., no OB van).
- Reduced time to install on-site.
- Reduced travel time, inconvenience, and expenses with less staff on the road.
- Easier access by the core of the production crew (which remains in the production centre) to regular resources like the archives, graphic artists and even the company restaurant.
- Ability of the crew to work on several productions staying in the same production centre.

With the simplification of the connectivity using Ethernet and IP networking running over fibre optic, remote production has never been simpler.

Those changes in technology and workflows require a different set of skills and a change in organisation across all the domains of production: operations, technical support, and project engineering teams.

Operational teams

The equipment used in the project provided a smooth transition for the operational crew. The LiveIP studio can be operated like a classic studio, with identical panels and controls. Therefore the crew didn't need special training before starting to use the LiveIP system.

However, when the set-up eventually moves to more software-based user interfaces, this will enable changes in the way the functions are distributed. This should lead to a more flexible organisation of the work, where staff must adapt to changing and mixed roles according to the needs of the specific production.

In the “Remote Production” trial, it was found that, as the crew was split between two locations, attention needed to be paid to communication, to compensate for the limited visibility crew members had of each other, even with telepresence cameras that were installed to help overcome this lack of visibility. Related to that, care needs to be given to building trust between the team members, in order to get good results when distributing the working positions geographically.

Technical support

Whilst the current generation of IP-enabled equipment used still featured legacy technology (such as black burst and some SDI links), the novelty is that the backbone of the system is a fully standards-based IP network. This means that production needs people with network management skills as well as the more traditional broadcast engineering skills. Since it is still rare to find this combination of specialist knowledge in the same person today, multidisciplinary teams are needed. However, all the support team need to understand the layers of the architecture in order to communicate in the same language.

System design and implementation teams

The current state of the technology used in LiveIP requires a hybrid skill set of broadcast system design with network architecture for the interconnections.

At this stage, the system is mainly composed of specialised devices interconnected using IP transport. As we expect to use more and more software applications running on standard IT hardware in future, software integrators and developers, both for front and back-end layers, will need to join forces with the design teams until, eventually, software know-how will become the predominant skill needed.

Project management will also need to become familiar with the best practices of IT, such as the formalized process of ITIL and agile practices.

TECHNICAL ASPECTS

The block diagram below provides a high-level view of the main components of the system as used in the LiveIP Phase 3. The video format was 1080i/25 (1.5 Gbit/s) and the audio is 48 kHz sampling frequency and a 24-bit word length.

Open Standards

One of the architectural prerequisites of this project was the use of open standards and that the products used should be (almost) market-ready. Thus the choice was made for the most supported open standards in the market at the beginning of the project in April 2015. The reason for using open standards is to ensure there is no vendor lock-in, therefore allowing the product with the most suitable features for the job to be selected.

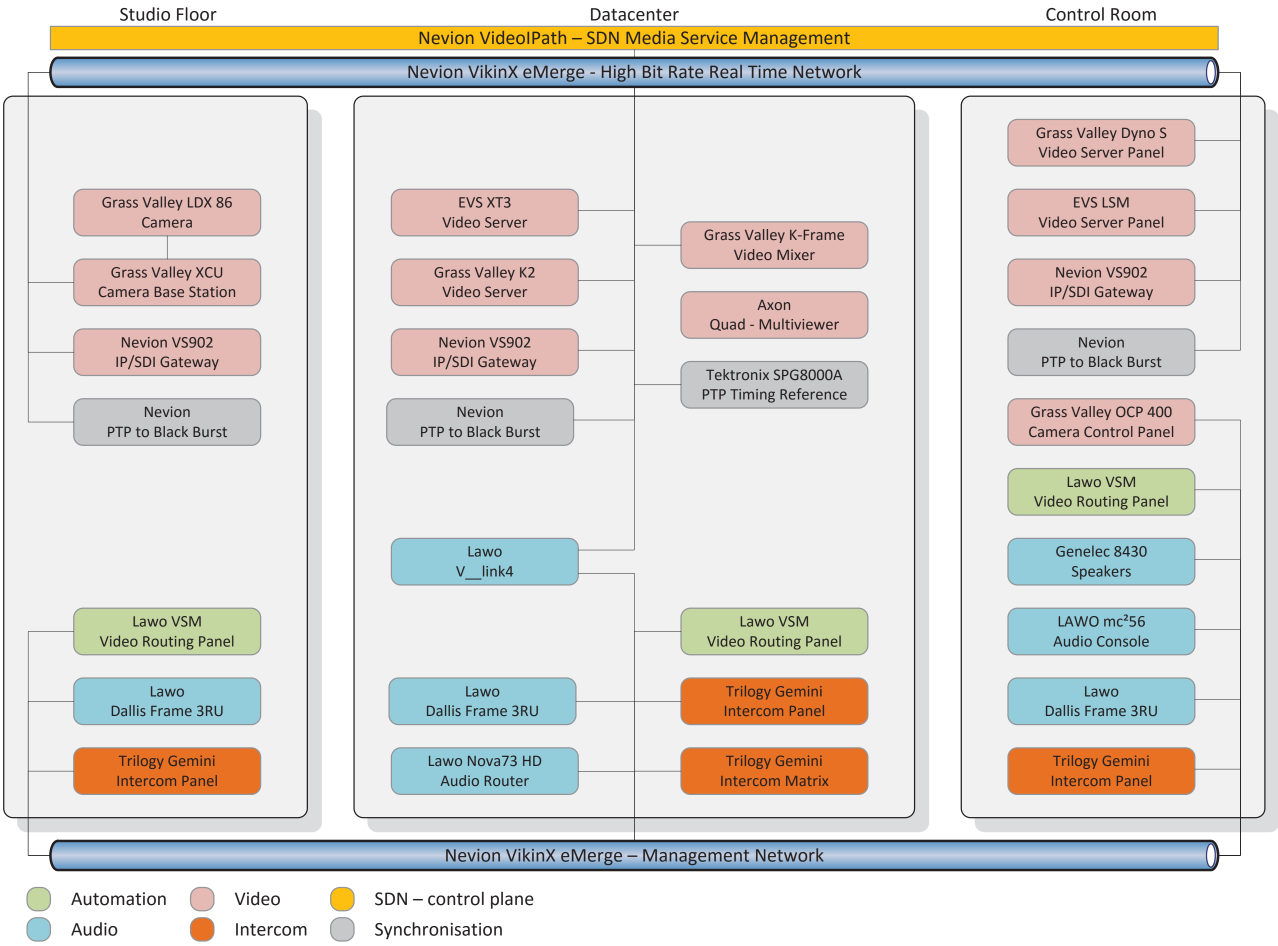

Figure 3 – System diagram

Video

The proof-of-concept uses SMPTE ST 2022-6 [See Reference 1] to transport uncompressed video. This standard specifies that the entire payload of the Serial Digital Interface (SDI) signal, including VANC and HANC ancillary data spaces carrying audio and data such as timecode and closed-captions, is encapsulated as one RTP/UDP flow.

Progress towards all IP

At the beginning of the project, not all the components were available to support the chosen standards. Therefore a number of gateways to convert between standards were necessary. Moreover, a baseband bridge was originally necessary for embedding and de-embedding audio in and out of the 2022-6 [See Reference 1] streams. By Phase 3, gateway equipment could handle the embedding operations internally, thus reducing the need for extra SDI interconnections. As we can see in the chart below, vendors made progress continuously throughout the project, to bring their equipment closer to the target of 100% of flows using IP.

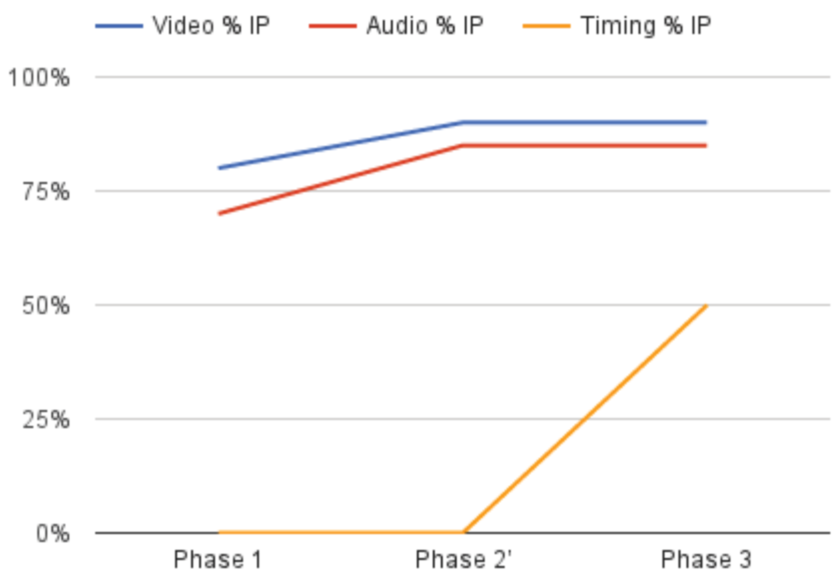

Figure 4 – Progression of IP vs Baseband

Network Architecture

The LiveIP network was constructed as two separated networks. One IP network was assigned for the high bitrate real-time signals, i.e. the video, the audio and the timing. The other IP network was used for the management communication protocols of the devices. The real-time network was designed as an SDN (Software Defined Network), whereas the management network was built around self-managing network components.

In the first three phases of the project, the audio streams were carried on the management network. For the next step, the AES67 [See Reference 2] audio streams were migrated to the high bitrate real-time network.

High Bit Rate Real Time Network

Software Defined Network. The network solution uses a Software Defined Network (SDN) approach. By definition, a SDN separates the control plane from the data plane. The data plane remains on the individual switches, the control plane (routing decisions) is moved to a separate central controller.

There are several flavours of SDN emerging on the market of real-time media networks. Following the requirement to use open standards, the choice was made to deploy technology that uses OpenFlow 1.3.

However, not every vendor that supports OpenFlow 1.3 has implemented every functional option that might be needed by a specific implementation. A good choice may be to use switches tested and approved by the SDN supplier, however this can limit the choice of suitable switches

Flow routing. In the LiveIP set-up, both sources and destinations used fixed multicast addresses, in other words, a source (e.g. a camera) would always "broadcast" its stream on a specific multicast address, and a destination would always "listen" in on a particular multicast address.

Fast switching. The connection between a source and a destination is done by making sure the network fabric's NAT is configured in such a way that the source multicast address is translated to the destination multicast address. At a network level, switching between sources is achieved by rapidly reconfiguring the NAT.

A major advantage of this approach - compared to "destination switching" technique - is that there is no need for both sources to be forwarded to the destination, i.e. there is no double bandwidth usage. And most importantly, the switching in the fabric means that there is no need to have drivers for every destination device like in "destination switching".

Clean switching. Since the IP network is not content-aware, the switching may take place at any point in the video frame. Therefore, in order to achieve clean switching, there is a need to "clean-up" the stream so that the first and seconds sources are switched at the right points in their respective streams (e.g. top of frame) before being used by the destination device(s). In the LiveIP, this is performed by the edge media gateways.

This technique was chosen because of the speed of operation, providing a switching impression that is "clean enough" for most cases as experienced by the operation crew, e.g. for preview operations. However, some operations like those going "on air" would require the option for a "clean perfect" switching as if it were produced in "destination switching" - which the equipment also supports, along with IGMP switching. Nevertheless, this was not an issue with the LiveIP set-up, since the "on air" signal was realized by the vision mixer.

Finally, to support multi-vendor interoperability, this "break-before-make" switching technique would benefit from being standardized.

Spine-Leaf. For the third phase of the project when more bandwidth was required, the real-time network was scaled up using a Spine-Leaf architecture.

In such topology, a series of leaf switches form the access layer. These switches are fully meshed to a series of spine switches. This topology, together with non-blocking and low-latency switches, minimizes the amount of buffers to pass through, the latency and the likelihood of bottlenecks between access-layer switches. This architecture is used in data centres where it has proven scalability

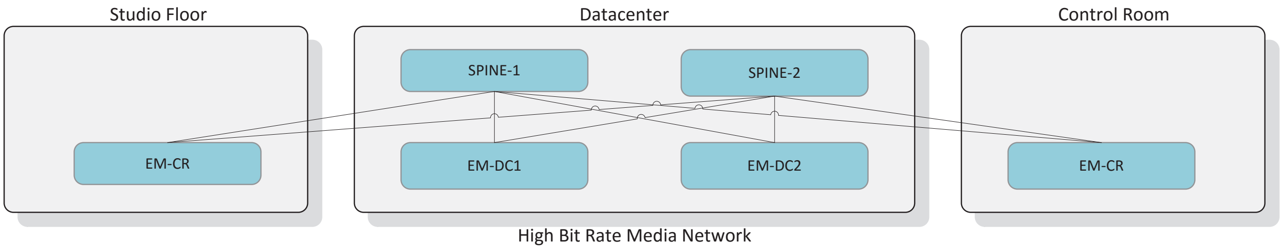

Figure 5 – High Bit Rate Media Network

LESSONS LEARNT

By building, configuring and operating this LiveIP studio, many insights were gained. The reduction of cabling between the different locations is an obvious benefit.
The main technical findings were:

- A common PTP profile for audio and video devices is needed for using one common clock. PTP support for video equipment is not widely available yet.
- FEC was not enabled on the set-up, but this did not have any noticeable issues.
- A small number of gateways are still needed today. However this will not be needed when all equipment will support IP.
- During the set-up and configuration of equipment, it is not easy to identify or to detect problems or configuration mistakes. You have to rely on software tools to measure what happens on the network. This needs an in-depth knowledge of the system.
- Controlled automatic discovery of newly inserted equipment will be needed to create the flexibility and ease of set-up in dynamic environments such as for outside broadcast productions and at larger scale facilities.
- If AES67 [See Reference 2] were supported by more devices (e.g. camera, intercom, etc.), the set-up would be simplified, removing extra gateways.

FURTHER WORK

Measurements

The LiveIP project approach was to “make it and try” and this resulted in a very positive and rapid learning process for the VRT, the technology partners, and the EBU community.

So far, a limited amount of measurement has been done to quantify the assessment of the users. Now that the set-up is up and running, there will be an opportunity to quantify parameters such as latency, video and audio transparency, bit-error-rate, degradation behaviour in case of packet loss, etc. To do so, new procedures need to be investigated and new measurement tools are required.

New Workflows

Since this system is basically about interconnecting existing studio devices using IP for the transport of the media, timing and control signals, the workflow reproduced is the same as a typical SDI-based live production studio. This has the benefit of familiarity for the users.

In the future, since the IP network is at the core of the system, it will be valuable to try new possibilities, such as the geographic distribution of the crew, object-based production and mixed live, near-live and non-live workflows.

Next Evolutions of Standards

This project started in spring 2015 and the design of the system was based on the technology that was available at the time that vendors had committed to provide.
In the meantime, industry has been actively developing further standards and open specifications that should enable the realisation of the RSA architectural vision in the near to medium term.

The LiveIP project is investigating the possibility of upgrading the components of the system to take advantage of new standards as they become available.

CONCLUSION

This project has proven that it is possible to build and to operate a live & IP production studio based upon open standards in a multivendor environment. LiveIP was a practical hands-on project; it was not just about testing building blocks, it was an end-to-end working studio setup in collaboration with an operational crew and manufacturers working closely together to make it happen. No blocking barriers were encountered throughout the entire project. At first some workarounds were implemented. As the project moved on, the manufacturers came up with improved software updates. The setup has proven to be more flexible because less cabling is needed. Overall additional IT skills are needed to implement and support such a system, and new language is needed to talk about a Live & IP studio. The operational crew did not have any major complaints, and even latency, perceived as very critical, was not reported to be an issue.

ACKNOWLEDGEMENTS

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REFERENCES

[1] SMPTE ST 2022-6:2012 Transport of High Bit Rate Media Signals over IP Networks (HBRMT)

[2] AES67-2015 AES standard for audio applications of networks - High-performance streaming audio-over-IP interoperability

[3] IEEE 1588-2008 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems