The Commercialization and Economic Sphere of Video Over IP Technology

From both a technological and business perspective, we have reached the dawn of a new era in video over IP. Standards for this technology are expected to be published in 2018, and manufacturers are scrambling to comply with these standards. Broadcasters in North America and Europe are also rapidly showing an interest, and sessions featuring this technology have been held at broadcasting equipment exhibitions in Japan. In this report, we will provide details on video over IP technology that many stakeholders have high hopes for.

3.1 Everything is Using IP

It is said to have already been 20 to 30 years since the Internet began to proliferate. Over this period, a variety of media have come to use IP as infrastructure. Media such as newspapers, magazines, and books that used printing technology have embraced the World Wide Web from quite an early stage. The shift of telephone technology from conventional circuit-switching networks to IP infrastructure will also be remembered as a groundbreaking event. That is because this was the moment that telegraph and telephone corporations transformed (or were forced to transform) into telecommunications carriers. Radio is also establishing its presence as an IP-based media through the use of streaming technology. Television broadcasts are actively using IP technology as well. The data broadcasts available through the "d" button on television remote controls adopted streaming technology when they evolved into Hybridcast in 2013. 4K and 8K broadcasts also use an IP format for the broadcast signal itself. As these examples demonstrate, many forms of media have begun to obtain and utilize IP technology.

Among these trends, the latest and most significant involve video and audio signals. Uncompressed audio and video signals (also known as "baseband") that had not been used in streaming technology until now are about to join the IP revolution.

3.2 Baseband and Coaxial Cables

So, where is baseband being used? The main users of baseband are broadcasters and studios. In these kinds of environment, emphasis is placed on obtaining maximum signal quality. For example, broadcasters compress the video signal just before it is converted to broadcast waves. Until this final stage, it is necessary to maintain the highest quality possible for the video signal. This is because image quality will suffer when video with a lot of noise is introduced during the compression process. In other words, the images that television viewers see are originally of a considerably high quality. Coaxial cables have been used as the physical transmission media for video signals in these environments. Looking at a cross section of a coaxial cable, the inner conductor is covered with insulation. Outside of that is the outer conductor, and finally a protective sheathing on the outermost layer. Until now, they have often been used to transmit high-frequency signals, and they are highly resistant to noise. However, due to their characteristics, when you wish to transmit electronic signals in greater numbers or over longer distances, it is necessary to increase the diameter of the coaxial cables to prevent the electronic signal from degrading.

Standards that have been established for the transmission of video using coaxial cables include "SD-SDI" (270 Mb/s, 1990), "HD-SDI" (1.5 Gb/s, 1998), "3G-SDI" (3 Gb/s, 2002), and "6G-SDI" (6 Gb/s, 2015). These standards were created by the SMPTE, and were given the name Serial Digital Interface. 4K broadcasts are implemented at 60 frames per second, so it is not possible to support these using 6G-SDI, which maxes out at 30 frames per second. As a result, a transmission format supporting 4K called "12G-SDI" was established in 2017. It is likely that 12G-SDI will be used for 4K content.

Standard Name	Video Signal (Resolution and Framerate)	Bitrate
HD-SDI	1080i30	1.485 Gbps
3G-SDI	1080p60	2.97 Gbps
6G-SDI	2160p30	6 Gbps
12G-SDI	2160p60	12 Gbps

Table 1: SDI Types and Bandwidth

As it is, a method of transmitting 4K video by bundling four 3G-SDI cables together is presently being used. However, having four coaxial cables bundled together results in a cable that is hard to handle. This is only being used as a stopgap measure, and we expect that migration to 12G-SDI will eventually be necessary.

However, with 12G-SDI there is an issue where cables cannot be lengthened to transmit large amounts of data, so it falls short from a handling perspective. It can only deliver a signal up to about a few dozen meters. Thus, manufacturers focused on optical fiber as the next-generation physical transmission media at the same time as they began developing 12G-SDI. Considering the spread of 4K and 8K going forward, it is clear that coaxial cables will not be able to provide sufficient bandwidth. Because the use of optical fiber is already commonplace in the telecommunications industry, this is a natural choice. When making this selection, Ethernet and IP were chosen as the higher-level protocol for optical fiber. Ethernet and IP technologies are more than widespread enough, and still have room for future development. Instead of creating a proprietary protocol, we will adopt technology that currently exists. This way we will be able to achieve the large-capacity transmissions that optical fiber enables more easily and at an earlier stage.

3.3 Standardization at the SMPTE

In 2017, a standard called “SMPTE ST 2110” became a keyword regarding video over IP. Final publication is scheduled for 2018, and this is expected to be the standard moving forward. Although it has yet to be published, the number of manufacturers planning to support it at the time of release has increased rapidly. This is evidence of how highly anticipated this standard is in the industry.

SMPTE stands for Society of Motion Picture and Television Engineers. The Japanese translation clearly states that it is based in the United States, but the standards it publishes have an impact across the globe. In other words, it serves as a standardization body responsible for global standards.

SMPTE ST 2110 is a standard titled “Professional Media Over Managed IP Networks.” Professional Media refers to technology used at corporations such as broadcasting companies. We also believe that Managed IP Networks refers to closed networks rather than the Internet. ST 2110 is made up of multiple standards, and is called a “protocol suite.” In short, ST 2110 is expected to be a compilation of video over IP standards.

There were examples of technology prior to ST 2110, such as the proprietary video over IP implementations developed by manufacturers. These include Media Global Links’ IP-VRS (IP Video Routing System, 2008 onward), Evertz Microsystems’ Aspen (2013 onward), and Sony’s NMI (Networked Media Interface, 2014 onward), which have all been released to market and put to practical use. Because each of these companies proceeded with development of technology ahead of other companies, they were

Standard Number	Standard Name	Overview and Characteristics
2110-10	System Overview	System timing model & Session Description
2110-20	Uncompressed Video	Based on RFC 4175 32k x 32k, 4:2:2, 4:4:4, HDR (PQ, HLG) etc.
2110-30	PCM Audio	Based on AES67
2110-21	Traffic Shaping	
2110-22	Compressed Video	TBC
2110-31	AES3 Transparent Transport	Includes compressed audio
2110-40	Ancillary Data	Captions, subtitles, time codes, active format description, dynamic range, etc.

Table 2: List of Published SMPTE ST 2110 Standards

forced to create their own standards. These contain functions that have yet to be implemented in ST 2110. However, Evertz has begun promoting support for SMPTE ST 2110, and Sony has given demonstrations and made announcements for gateways and CCUs that support 2110. Manufacturers that led the way will be tasked with finding benefits created through the fusion of their own technology with ST 2110, while manufacturers who enter the market later will need to find a way to market their distinguishing qualities amidst the tidal shift of standardization.

This existence of this prior technology undoubtedly aided the development of 2110. We imagine that the conviction toward and the desire for standardization was generated because technology working on a product level already existed (companies that developed this prior technology most likely wonder what all the fuss is about, although on the other hand, some may feel that this validates their course of action).

When creating the ST 2110 standard, the SMPTE adopted the approach of putting existing standards to effective use. Specifically, they referred to the RFCs of the IETF (Internet Engineering Task Force). Among the standards laid out in these RFCs was a protocol developed for multimedia communications called RTP (Real-time Transport Protocol). RTP has a proven track record in VoIP (Voice over IP), and it can be extended to handle various data payloads (this actually involves drawing up standards for each data format and publishing RFCs). It is also compatible with multicast, and it has been used in many multicast applications. With this history behind it, RTP was the perfect protocol for video over IP.

	Sony IP Live	Evertz Aspen	VSF TR-03 (SMPTE 2110)	VSF TR-04	SMPTE 2022-5/6	IntoPix TICO
Uncompressed Video	NMI	RDD 37 Video PES	RFC 4175	SMPTE 2022-6	Yes	SMPTE 2022-6
Uncompressed Audio	NMI	SMPTE ST 302 Audio PES	AES67 / RFC 3190	AES67 / RFC 3190	Embedded	SMPTE 2022-6
Compressed Video	LLVC	No	No	No	Opt JPEG2K	Yes
Metadata	NMI	SMPTE ST 2038 Meta PES	IETF RTP Proposal	SMPTE 2022-6	Embedded	SMPTE 2022-6
Forward Error Correction	Frame Aligned	No	No	No	Not Aligned	No
Independent Packetization	NMI	TS over SMPTE 2022-2	Yes	No	No	No
Registration and Discovery	Plug & Play (NDCP)	JSON-RPC	AMWA IS-04	AMWA IS-04	No	No
Connection Management	Sony IP Live System Manager	Evertz MAGNUM	AMWA IS-05	AMWA IS-05	No	No
Timing / Sync	SMPTE 2059	TS PCR/PTS	RFC 4566 (SDP)	RFC 4566 (SDP)	No	No
COTS IP Switch	Yes	No	Yes	Yes	Yes	Yes
SMPTE Standard	RDD 34 (LLVC) RDD 40 (NMI) RDD 38 (NDCP) SMPTE 2059 (PTP)	RDD 37 (ASPEN)	VSF Reccomendation (SMPTE 2110 in Process)	VSF Reccomendation	SMPTE 2022-5/6	RDD 35 (TICO)
Interoperability	Guaranteed	Demonstrated	Demonstrated	Demonstrated	Demonstrated	Within TICO Family
Endpoint Validation	Sony Testing Lab	No	No	No	No	No

Table 3: Video Over IP Comparison by Nextera Video*1

*1 Nextera Video, "Video over IP Comparison" (http://www.nexteravideo.com/resources).

Audio shifted to IP technology ahead of video. The CobraNET standard transmits audio data directly over Ethernet frames, and this can be considered the prototype for audio over IP. Then, Dante (Digital Audio Network Through Ethernet) made the leap to using IP. This protocol become popular after it was announced by Audinate in 2006, and it has been adopted in Japan by companies such as Yamaha. However, because this technology is proprietary, a license was required. Following on from this, Ravenna appeared in 2011. Ravenna has the merit of using more standard technology than Dante (Ravenna is the name of the city where Dante, a poet from Florence, met his end). Then, in 2013, AES67 (AES standard for audio applications of networks - High-performance streaming audio-over-IP interoperability) developed by the Audio Engineering Society was published, leading to the standardization of audio over IP. However, a mix of Dante and Ravenna remains in use today.

Multicast is a technology that was published as RFC988 in 1986. IP source address and destination address information is recorded in the header of IP packets. Unique IP addresses are assigned to individual nodes, so it is based on the assumption that communications will be carried out on a one-to-one basis. This communication method is called unicast. On the other hand, multicast implements one-to-many communications for the sender and recipient by applying a concept called "host group" to the IP destination address. This host group is like a television channel or a radio frequency. Put simply, everyone who joins that group can receive the same data simultaneously. For this reason, a special IP address is assigned to the host group.

Multicast is a technology that at one point showed promise for Internet use, and many tests were performed around the world. It was thought to be ideal for broadcast applications. The Rolling Stones live concert footage that was broadcast over multicast in 1994 is now the stuff of legend. IIJ also offered a multicast reception option in its IIJ4U access service.

Video		Audio	Ancillary
2110-20	2110-22	2110-30	2110-40
Uncompressed video	Compressed video	PCM audio	SMPTE ST 291
RFC4175	To be decided	AES67	Awaiting RFC publication
RTP RFC3550			
UDP RFC768			
IPv4 RFC791 (IPv6 RFC8200)			
Ethernet			
Physical Layer			

Figure 1: Relationship Between SMPTE ST 2110 and RFCs in Hierarchical Form

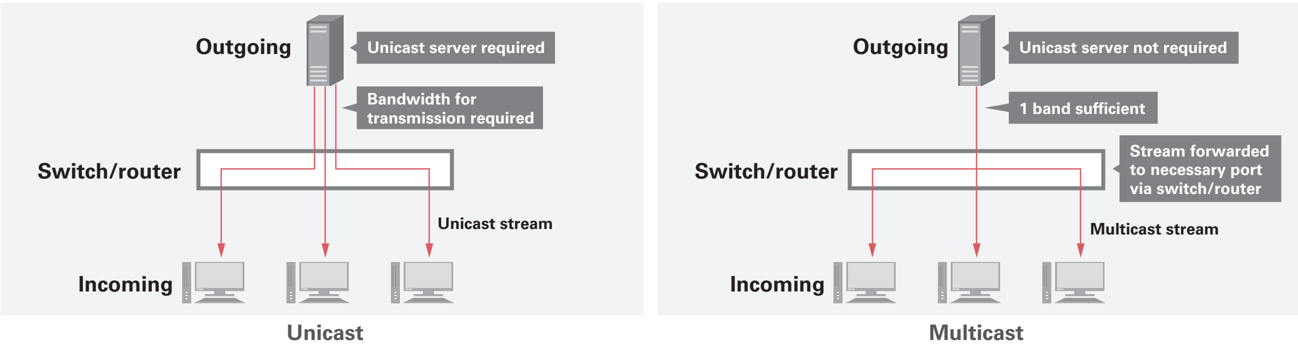

Figure 2: Comparison of Unicast and Multicast

Subsequently, multicast did not see widespread use, as issues such as finding an acceptable method for interconnection on the Internet could not be resolved. However, this technology is still highly effective in closed network environments. The reason for this is that "one-to-many" transmissions are used in broadcast production. Video shot with a single camera is passed on to wherever it is needed. In the world of SDI, there are also devices called routers that are responsible for distributing SDI input electronically and outputting it to designated ports. This flow is just like multicast behavior.

3.4 Trends at International Broadcasting Equipment Exhibitions

NAB Show and IBC are well-known international conventions in the broadcasting industry. The NAB Show is held in Las Vegas every April, attracting an attendance of around 100,000. Meanwhile, IBC is held in Amsterdam each September, and is attended by over 50,000 people. The atmosphere at each show is slightly different, reflecting the state of the U.S. and European broadcasting industries. The largest conventions take place about every six months, and it seems that manufacturers set their development and marketing milestones based on these, such as timing the announcement of new product and feature releases to match convention dates.

Video over IP technology has also attracted significant interest as a next-generation technology at the NAB Show and IBC. An "IP Showcase" where general connection test demonstrations were given for video over IP equipment has been held at successive events, including IBC2016, NAB Show 2017, and IBC2017, attracting industry-wide attention. Over 40 video over IP equipment manufacturers came together to test interconnectivity, and show the audience the connectivity of their equipment.

Figure 3: The IP Showcase at IBC2017

One of the benefits of adopting a standard is interconnectivity. A variety of connections should also be possible. IP and SDI were both originally aimed at achieving this, along with performance, so it assumed that video over IP will also offer this interconnectivity. That said, it is not always that easy to connect successfully. There are gaps in the written standards, and implementation sometimes involves case-by-case judgments, leading to variance in behavior between different manufacturers' equipment.

At these IP Showcases, a hot stage is prepared ahead of the convention, and a system for engineers to perform tests while confined in a "training camp" situation is established. Because it is rare to have the chance to perform tests with multiple manufacturers, it seems that manufacturers consider this a valuable opportunity as well.

3.5 Why Adopt IP?

What exactly are the benefits of IP? "Bidirectionality," "multiplexing," and "interconnection" are some advantages that IP has over SDI. These are all taken for granted with IP, which has been developed on the Internet, but they provide new functionality for broadcasting equipment. When using an optical fiber (one or two cores), there is no longer a need to fix the relationship between the sending and receiving parties. It will also be possible to handle multiple video streams and other media through a single optical fiber. For example, you can consolidate all the filmed images, sound, and its management using IP, such as remote control of audio, intercom systems, and Web-based cameras.

Another advantage of IP is that connections can be made between networks with relative ease. The physical distance between networks is not an issue for these connections. For example, you can set up transmission equipment for each segment to compensate for the degradation of optical fiber, allowing you to leave the problems that must be solved to enable long-distance connections to lower layer technology. As IP is not designed to take distance into account, remote connection can be achieved easily. Of course, the longer the distance, the more time it will take to transmit IP packets, but this issue is not limited to IP.

Also, IP is not only being used as a technology to replace SDI. IP technology is already being used in a variety of areas, such as CDN and OTT, mobile broadcasting out in the field, the migration of FPU to IP, and PC-based editing and station systems. The IP format has even been adopted for electronic wave-based 4K/8K broadcasts. The range of benefits that transition to IP can provide is not limited to switching from a coaxial cable. All station systems and workflows will now operate over IP.

From this perspective, the existence of an ecosystem surrounding IP may be a reason to choose it. The development of IP technology will continue going forward. Even if the SMPTE had come up with a new protocol, the market may not have supported it unless it provided more benefits than IP, or if there were assurances and confidence that it would be widely used.

3.6 A Case Study of IP Applications - Remote Production

Remote production has been proposed as an example of utilizing the benefits of IP. This concept involves broadcasting from a venue in a remote location using an IP network. Currently, broadcasters send a broadcasting vehicle and crew to the venue when creating a program. But when using this method in situations such as the Olympic Games and the Paralympic Games, where events take place at multiple venues simultaneously, there are constraints. Since the number of broadcast vans is limited, you are forced to choose the events to broadcast based on this number.

However, cameras already support remote operation. You can control the direction using a remote camera platform, and remote controls for aperture and focus are also now mainstream. Photographers in the field sometimes only need to be aware of the camera orientation. Other camera functions are controlled by a technician called a video engineer while watching a monitor in the broadcasting vehicle. If this is the case, you might as well connect the video output of the camera to an IP network directly. Then all you need to do is deliver this video via IP to the sub-studio inside the station where the program is being produced. This enables you to minimize the crew that must be physically sent out to venues. As a result, it will be possible for most staff to produce programs while stationed in a sub-studio.

These days, anywhere from two or three cameras to several dozen are set up at a venue for sport broadcasts. Of course, for events where a large number of cameras are required, broadcasting vehicles and crew will continue to be sent to the venue. However, if it is possible to follow the movements of an event with a small number of cameras, and there are no major production issues, we believe remote production will become more meaningful. Of course, you will need to install optical fiber with sufficient bandwidth at the site, but in many cases, this has already been done at major venues. Using this optical fiber to carry Ethernet and IP traffic will create an IP network with ample bandwidth. Broadcasters have also shown a high level of interest in remote production, so PoC tests and implementations are likely to become more prevalent in the future.

3.7 Full-Scale PoC Tests and Proposals

IIJ has carried out PoC (Proof of Concept) tests since 2015 to add momentum to the promotion of video over IP technology. The implementation of 100 GbE on the IIJ backbone is progressing. From a bandwidth perspective, we believed there would be no problem streaming multiple 4K videos. However, there were doubts when we first began working on video over IP technology. We wondered if it would be possible to transmit 4K video that is sensitive to loss and delay over the IIJ backbone, which is comprised of generic IP devices.

Ultimately, the only way to allay these doubts was to try it out. To achieve this, we built a virtual network that would make a

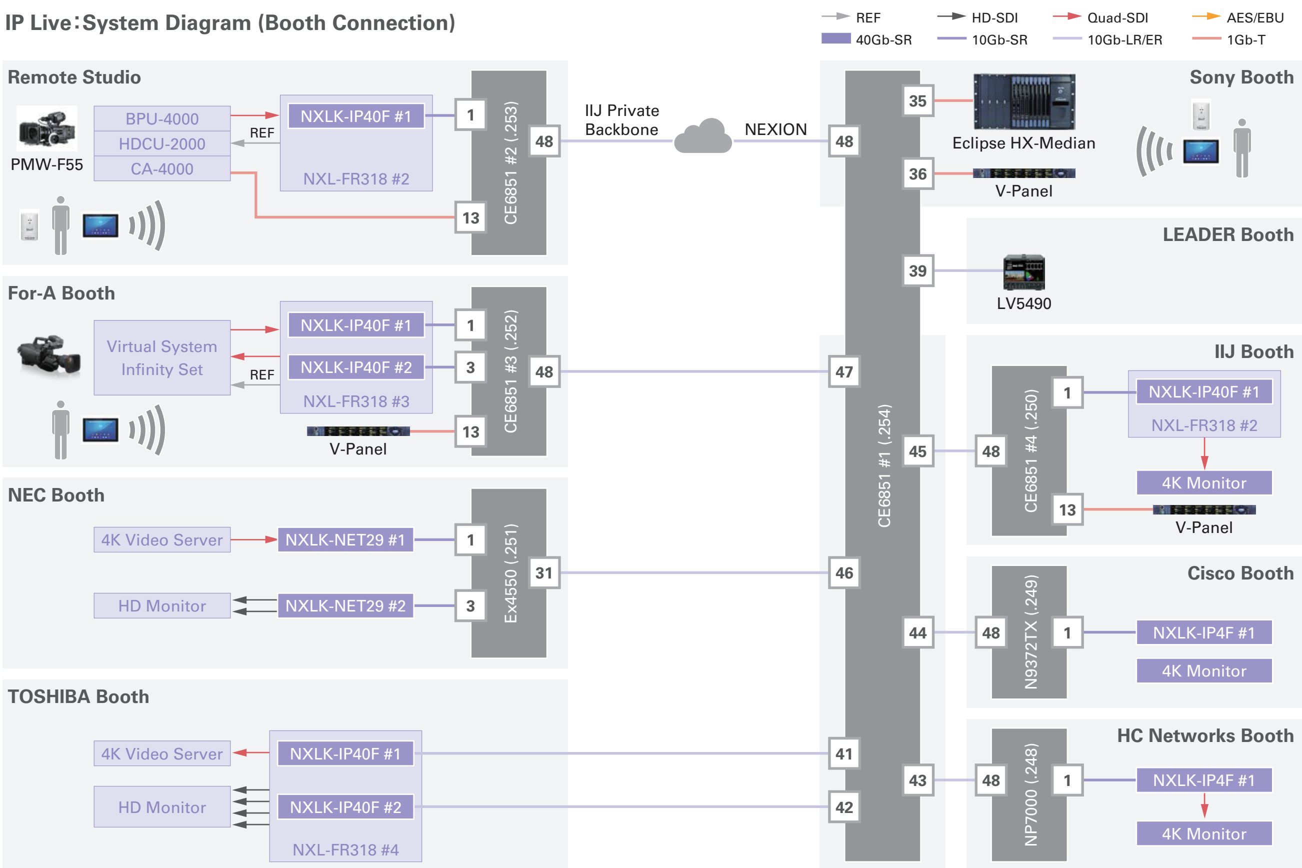

Figure 4: Remote Production Example at Inter BEE 2017
Using the Iidabashi Office of IIJ as a venue (top left of the figure), and connecting the Makuhari Messe Sony booth with the IIJ booth over the network

round trip from our office in Iidabashi, Tokyo, to Osaka. We used our backbone and access optical fiber, along with MPLS routers. Traffic traversing this network is transferred separately from traffic for IIJ's other services, but the dedicated line bandwidth used for lower-level layers is shared. This is because it is costly to construct using only dedicated lines, and IIJ was not interested in performing tests that do not use our actual backbone.

Using this environment, we have continued to perform PoC tests together with manufacturers that have offered to collaborate. The main test involves streaming one or more HD or 4K videos. Some manufacturers are also conducting PTP or audio over IP tests at the same time. Almost without fail, these PoC tests have been successful. When the PoC initiative began at IIJ, few stakeholders had faith in migrating to IP. I remember that users were particularly suspicious of the unfamiliar IP technology. During this period, we promoted the potential of this new technology to these people, but the situation remained unchanged for a while.

At the time, I thought that the shift to IP would come with support for 4K. Using simple calculations, 4K requires eight times the amount of data as HD content (four times the pixels, and double the frame rate). Consequently, when 4K is introduced, the transmission paths of all sections will require eight times the bandwidth. Transmission paths designed and built for HD content do not have enough capacity to transmit 4K signals. I thought that more parties would consider adopting IP technology when designing transmission lines to support 4K. However, HD video over IP is popular in Europe and the United States. This approach is an attempt to enjoy the benefits of IP without waiting for 4K. After asking why, it seems there are many who believe it would lead to cost benefits in the future, and they should start dealing with IP now, without waiting for 4K. This sounds plausible, but when considering the timing of the investment, there remained doubts about whether real benefits could be seen. It may be that there are differences between companies with regard to broadcaster investment. So, as an extreme example, I once saw a presentation where the question "what are the benefits of adopting IP technology?" was answered with a slide that read "because we can." It was most likely some kind of joke, but I felt it was an appropriate response for an engineer.

IIJ aims to build up experience through PoC tests and share this knowledge with manufacturers. This is because we would like to communicate what can be done with IP, while creating an accurate knowledge base and higher-quality know-how. In reality, few manufacturers have experience with tests using wide area networks. We provide manufacturers with data we have obtained through PoC tests, and provide feedback. We are also encouraging end users to observe our PoC projects. Demonstrations using actual networks are very effective, and they are held in high regard for sales and marketing as well.

Period	PoC Test Details
July 2015	Sony IP Live. 4 Gbps x 2 lines transmitted from Iidabashi to Osaka to Iidabashi. Our first video over IP test.
August 2015	Evertz ASPEN. 4K Koshien video transmitted from Grand Front Osaka to Iidabashi.
June 2016	PFU QG70 + NTT-IT StreamMonitor. 1.5 Gbps HD video transmitted from Iidabashi to Interop venue.
October 2016	Sony IP Live. Testing of newly-developed mode. Transmitted from Iidabashi to Osaka to Iidabashi.
November 2016	Sony IP Live. Connection of IIJ booth and Sony booth inside the Inter BEE venue.
February 2017	MediaLinks IP-VRS. Transmission test for HD/4K video. Transmitted from Iidabashi to Osaka to Iidabashi.
June 2017	Sony IP Live. Demonstration incorporating professional video equipment (remote cameras, audio console).
June 2017	Embrionix. HD transmission using SFP video IP conversion. Transmitted from Iidabashi to Osaka to Iidabashi.
June 2017	LAWO V__remote4 + Seiko TS-2950. HD and 4K, 64-channel multi-channel audio transmission. PTP interconnectivity test
November 2017	NHK Science & Technology Research Laboratories. NHK performed 8K transmission tests from Osaka to Tokyo at the 2017 NHK Trophy figure skating. IIJ provided a private backbone for these tests (10 GbE x 5 lines). The 8K footage used Dual Green format at 24 Gbps.

Table 4: Major PoC Tests at IIJ

Proven networking performance for all layers plays an essential role in the success of PoC projects like these. Of course, in addition to network layers, it requires technical knowledge of video and audio. I know from experience gained through many PoC tests that even when the equipment is installed, the necessary settings applied, and all wiring completed, it almost never works the first time. Let us consider why video may not transmit or be played back. There are a variety of possible reasons. These include router or switch configuration errors, bugs, traffic overflow, communication errors, and misunderstandings. Basically, anything could happen. Patiently unravelling these tangled threads one-by-one requires time and effort. We must call upon all the knowledge we possess as engineers, including multicast technology know-how, networking expertise in areas such as IP and Ethernet, and even the physical properties of fiber optic cables. Video often does not play back due to cabling errors. PoC tests are a process of trial and error, so there will inevitably be consideration shortfalls and mistakes. It is necessary to develop the capacity to notice minor points such as these. That said, mistakes and errors that occur during PoC tests are all “gifts” for the future.

3.8 Compression Technology

12G-SDI is necessary for the transmission of uncompressed 4K video. In other words, this requires 12 Gbps of bandwidth, so it is not possible to transmit using a single 10 GbE cable that is commonplace in the Ethernet world. In light of this, calls to shift to 25 GbE have begun to emerge in the broadcasting equipment industry. This will enable uncompressed 4K video to be sent via a single network interface. However, we believe it will be a little longer before for these calls work effectively. That is because it will be some time before Ethernet switches offer 25 GbE support and come down in price.

Uncompressed video is better in terms of latency and image quality, but it requires more bandwidth. Consequently, there have been moves to reduce bandwidth using compression technology. In this area, several compression techniques have already entered the stage.

- JPEG2000: A compression technology that has already been standardized.
- VC-2: Developed by BBC R&D and standardized as SMPTE ST 2042.
- LLVC: Developed by Sony. Stands for Low Latency Video Codec. Reference books have been published as SMPTE RDD 34.
- Tico: Developed by IntoPix. Currently undergoing standardization as JPEG-XS.

Each of these compression technologies are referred to as “visually lossless.” They do not offer lossless compression where all data can be retrieved intact after compression. This lossy compression does not allow you to restore the original data completely, but it does not affect the image quality. (So, it is not “lossless” in a strict sense, but this is used as a marketing term.) The fact that the compression does not affect image quality means that subsequent editing work will not be impeded by a deterioration in quality or delays due to compression. It is also called “light compression” in the sense that it “compresses slightly for transmission”, as opposed to high compression technology such as HEVC. Another name for it is “mezzanine,” because it is the middle ground between uncompressed and highly compressed data. It is mainly aimed at reducing the transmission rate for 4K video to between a half and a quarter.

In some cases, companies have been granted patents for these compression technologies, and it is said that their intentions will affect the standardization process. It is possible that intense discussions will be held regarding various points, such as which technology will be made a standard, and which standards will be mandatory or optional.

3.9 Case Studies and the Future Development of Video Over IP Technology

More and more actual case studies are being presented at the IP Showcases mentioned above. In particular, the shift to adopt IP in the OB Van and OB Truck broadcasting units that are used for outside broadcasting (OB) is making considerable progress. Because the video networks inside these broadcast vehicles are initially closed, it is relatively easy to introduce new technology. The adoption of IP technology in broadcasting vehicles is already gaining momentum in Japan.

A series of major system construction projects were announced in Japan in 2017. Perform Japan adopted Evertz for the DAZN Digital Live Sports Production Center. Sony IP routing equipment was also introduced at Shizuoka Broadcasting and SKY Perfect JSAT in quick succession.

There are also moves to increase the penetration of video over IP technology and draw up a roadmap. The Joint Task Force on Networked Media (JT-NM) is in charge of these efforts. The JT-NM is a joint activity involving the AMWA (Advanced Media Workflow Association), the EBU (European Broadcasting Union), SMPTE, and the VSF (Video Services Forum) that publishes reference architecture and roadmaps. The JT-NM Roadmap of Networked Media Open Interoperability indicates the current status and future development of technology, and it is shared throughout the industry. According to this roadmap, the first phase, "SDI over IP," and the second phase, "Elemental flows," are now almost complete. Up ahead are the third phase, "Auto-provisioning," and the fourth phase, "Dematerialized facilities." Auto-provisioning is aimed at the automation of resource management, and the AMWA has put together a working group and is hammering out standards for this.

As part of the activities of the AMWA, progress is being made with establishing the following three items as NMOS (Networked Media Open Specifications).

- IS-04: Discovery and Registration Specification
- IS-05: Device Connection Management Specification
- IS-06: Network Control Specification

Of these, IS-06 is the most ambitious.

1. Discovery of Network Topology and Discovery of endpoint devices that are connected to the Network Switches
2. Create/Retrieve/Update/Delete Network Streams (Flow Management)
3. Monitoring and Diagnostics

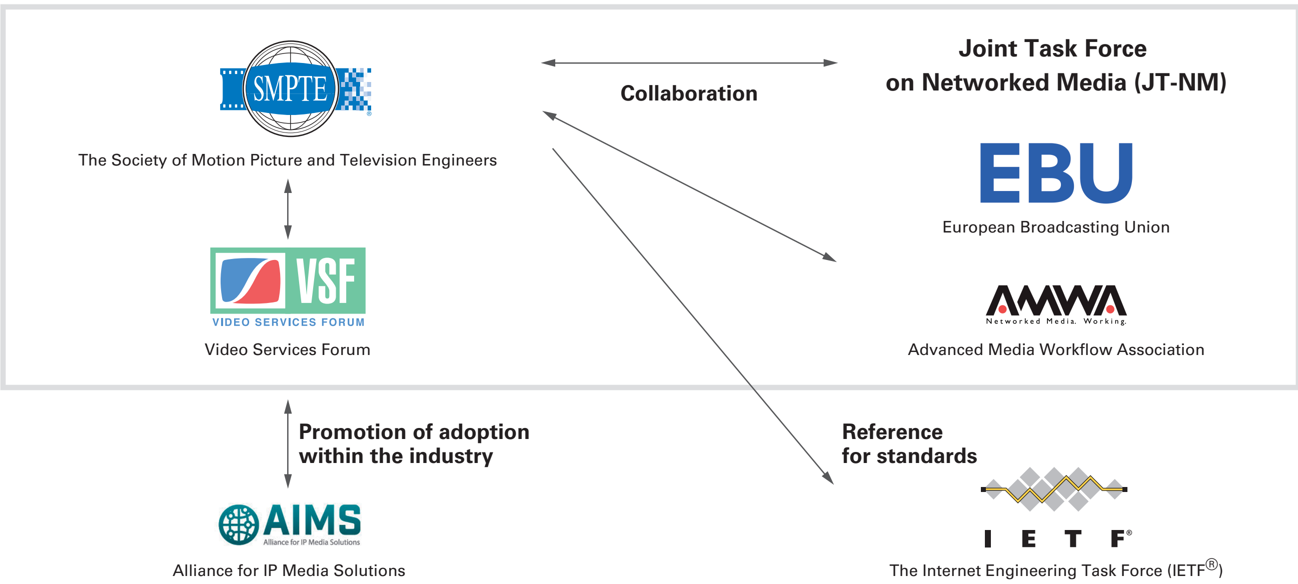

Figure 5: The Relationship Between Standardization Bodies

IS-06 is intended to cover these three functions (they are apparently working on the first of these). This is basically equivalent to the API between the controller and a network device, but you could think of it as an approach similar to SDN. Evertz has also promoted the concept of a Software Designed Video Network in which the network layer is accessed directly from the Application layer via API. The major difference is that IS-06 is attempting to create a standard. Consequently, it is necessary to obtain approval from many network equipment manufacturers. ARISTA has already taken a proactive stance at IBC2017. Support from other manufacturers will no doubt be made clear at some point.

Throughout the activities of the AMWA, there seems to be an increased awareness of security issues. Putting aside the question of which video over IP communities should take part in security-related discussions, there is no doubt that this must be discussed.

Because security covers a wide range of topics, it will be necessary to discuss the areas and perspectives to focus on. Data may still require encryption even when it will be sent over a closed network. In the IP sector, there is a system called IPsec for the generic encryption of IP packets. There is also a standard called Secure Real-time Transport (SRTP) that encrypts RTP, and both have been published as RFC. However, it seems the discussion of which kind of technology to adopt for video over IP has yet to begin.

As for IIJ, the question of how to monetize this video over IP technology is a subject for future analysis. Although we will of course use our backbone, we believe that integration with data centers and cloud solutions will be a major topic. As broadcaster transmissions shift to IP technology through CDN, OTT, Hybridcast, and 4K/8K broadcasts, we will have wide-ranging discussions regarding the benefits that shifting to video over IP will bring.

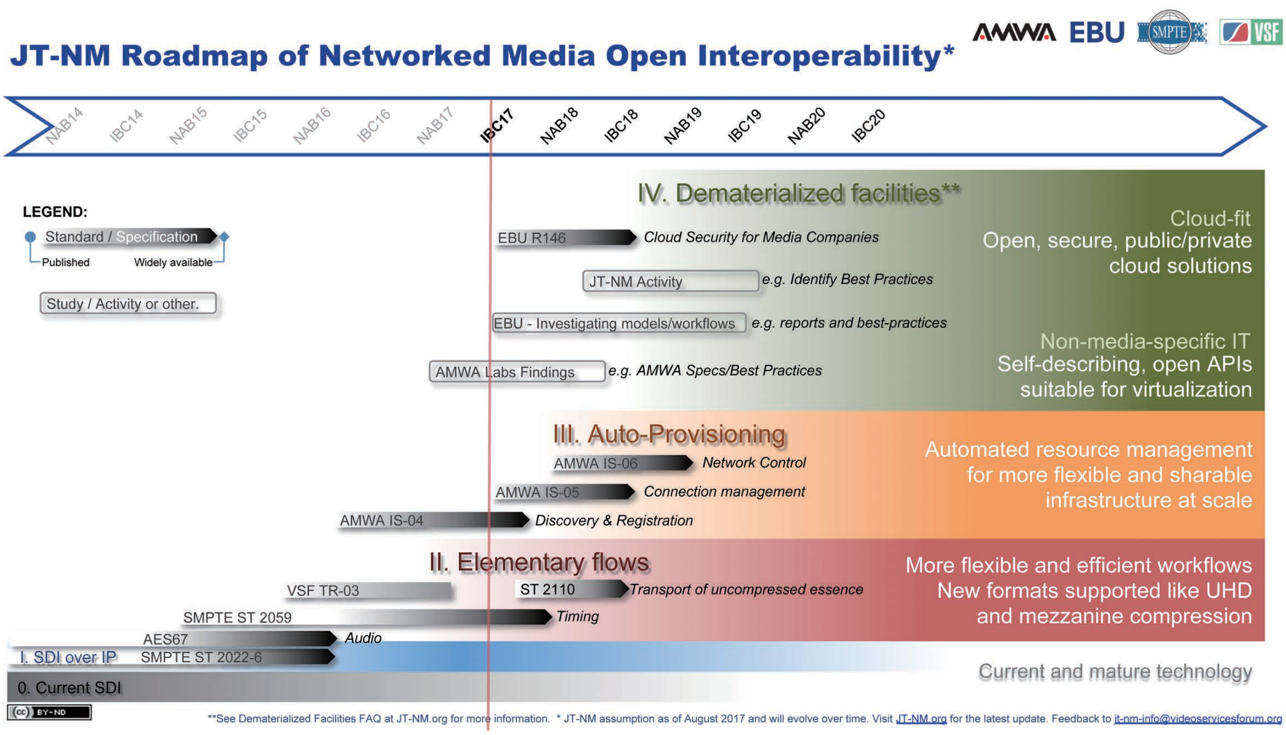

Figure 6: The JT-NM Roadmap of Open Interoperability (August 2017)*2

*2 Joint Task Force on Networked Media (JT-NM) (http://www.jt-nm.org/documents/JT-NM_Networked_Media_Roadmap_of_Open_Interoperability_1708-FINAL.pdf).

Learning about IP technology will be a priority for broadcasters as well. For technology companies in the broadcasting business, IP is already an indispensable technology. Video editing work is transitioning from video tapes to a “file-based” workflow using PC software. Large-capacity storage and workstation PCs are networked to enable the use of non-linear video editing software such as Adobe Premiere and Apple Final Cut Pro. This demonstrates that networks are already an integral part of business, and from an IP perspective video over IP is merely a new application. In any case, it is not possible to comprehend video over IP technology without an understanding of IP technology, so this will become part of an engineer’s education going forward.

We must also verify interconnectivity in Japan. IIJ has gained considerable experience through our PoC tests, and I believe this information should be shared widely. This will encourage more people to take part, and we can all work toward a unified goal. As it is not an actual project we can make bold configurations, and try all sorts of things. The best way to achieve this, is establishing a space to verify interconnectivity. With this mindset, IIJ launched an event called “VidMeet.” Opportunities to give lectures and demonstrations using video over IP technology in a public place are currently still limited. The video over IP market is now ready to mature, and I believe it is time for people with different needs and wisdom to come together. We intend this to be a place for users, manufacturers, and solution providers to meet, observe field demonstrations, and hold discussions.

The first event, “VidMeet1,” was held on October 4, 2017. We gave three lectures and demonstrations to over 100 participants, and received very positive responses. VidMeet2 is set to be held on December 11, 2017, and we look forward to seeing even more people taking part.

Video over IP technology is ripe with the kind of potential you see at the dawn of a new technological era. We are excited to obtain and develop new technology that could revolutionize engineering itself. This is a chance to make new acquaintances in the industry, and discuss topics from a fresh perspective. Times such as these make me thrilled to be an engineer.

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