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BROADCAST INFRASTRUCTURE
THE BRIDGE

Migrating to IP

Essential Guide

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Essential Guide to Migrating to IP

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Introduction

To leverage IT economies of scale business owners are demanding broadcast infrastructures move to IP. Structured cabling and fiber channels deliver high speed connectivity, commercial off the shelf switches and routers efficiently integrate networks to Telco's, and standardized network topologies simplify systems.

Broadcast engineers are reducing in numbers as each generation retires with fewer juniors filling the gaps they leave. Training is at an all-time low and the few colleges that are educating the next generation of broadcast engineers find their graduates snapped up faster than they can recruit.

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The business case to move to IP is compelling and driven by the needs of the business owners, not the latest technological fad. Business owners are making high demands on their broadcast engineers as they insist on moving to IP whilst simultaneously calling upon them to keep the existing infrastructure working with no down time.

An abundance of existing SDI already exists with years of coaxial cable based installations prevalent in broadcast systems. The upgrade path from composite to SDI was made easier as existing cables could be used and installation knowledge and experience was in abundance. Even if new cables needed to be installed they looked and felt like the composite installations already in situ.

Many infrastructures are live 24/7 with little scope to switch them off for upgrades. "If it's not broke don't fix it" attitudes thrive in live transmission areas, especially as many of the systems are lacking up-to-date documentation. There is a fear in turning off equipment as it may not power on again, and the manufacturer has probably ceased supporting the equipment anyway.

To facilitate change the broadcast engineer is left with two options; to build a completely new IP infrastructure and switch over on a specified day, or slowly and safely migrate the existing infrastructures into IP using hardware interfaces to de-risk the change.

Building new infrastructures for existing historic workflows is fraught with problems. Not only is this the most expensive option, but well intending engineers over many years will have made bespoke boxes to integrate disparate parts of the workflow. Over time these get forgotten as the documentation was either never completed or has been lost. The bespoke system is not integrated into the new system and no amount of testing uncovers its absence. The first clue the integration isn't complete is when the new system is made live and goes drastically wrong with devastating consequences.

Business Case for IP

IP seems to have come from nowhere, but the death of SDI has been predicted for at least ten years with industry pundits foreseeing a major shift in technology. But why has IP won when so many other technologies have failed? It wasn't so long ago that ISDN30 was the next "big thing", and ATM switching was going to take over broadcasting.

IP is different because its well understood by an international army of IT and network engineers, and has been in development since the 1970's. It's the de-facto standard for telecommunications and is pushed hard by blue chip corporates such as Cisco. Even IBM has shelved its token ring system in favor of IP.

Up to five years ago, broadcast engineers were driving the ship in terms of technological developments, which in turn dictated the type of programming producers make with limitations on their creativity.

IP has shifted the balance of power back to business owners who look at the progression in the internet online delivery world and want a part of it.

Simplification is the new mantra. Broadcast stations typically develop over many years as production requirements change and new services become available. Keeping to a standard model reduces maintenance costs and increases the pool of people available to fix the system if it does fail, and support is much more readily available if it is outsourced to a third-party supplier.

Routing IP packets is relatively easy as the standard is well defined and the packet structure is easily understood. With source and destination addressing using globally referenced addressing schemes, and private addressing schemes using their own address space, IP is ideally suited to move data across the globe, or privately within a facility.

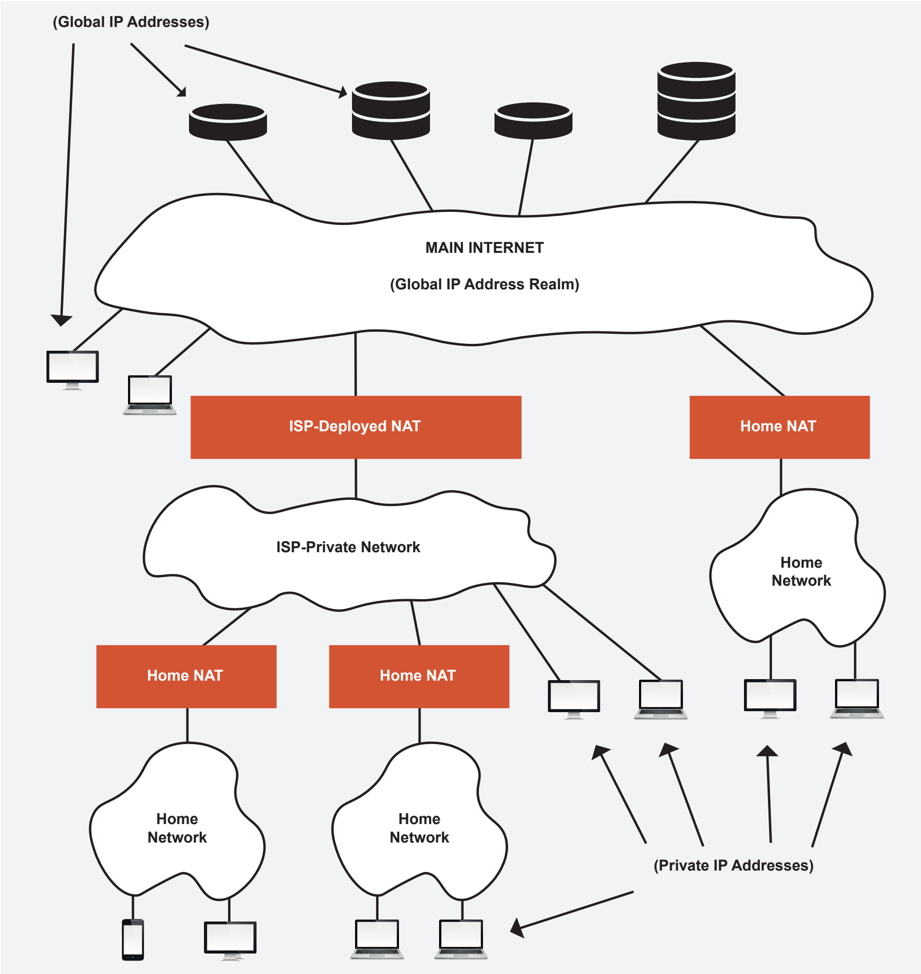

Diagram 1. Network Address Translation (NAT) allows for the mixing and duplication of private and public IP addresses.

Systems based on IP can be scaled much easier, faster and cheaper than traditional SDI systems. Distribution amplifiers are a thing of the past and increasing the size of a network is as simple as adding extra switches and routers. Fiber distribution is much easier in the IP world and connection between systems with different earth references, such as OB trucks is much safer and reliable.

Few broadcasters will have the luxury of building a green field site by designing IP from the ground up, but will instead need to introduce IP into a facility as equipment reaches the end of its life, or new services are installed.

Most broadcast stations will already have some sort of structured CAT5 or CAT6 cabling, with fiber backbones. Using interface equipment to move video over IP is the way forward and a quick and easy step into IP distribution for broadcasting.

Telco's provide IP connectivity through public internet connections or private interfaces. Although their internal distribution systems may use layer 2 connectivity that is not ethernet, they guarantee IP routing and protocols are respected.

A Telco's business model is geared towards providing a generic solution, and the costs of delivering video and audio quickly reduces using IP. Traditionally, broadcasters have had to buy expensive dedicated SDI and audio lines from Telco's. Broadcasters can benefit hugely from IP when distributing outside of their facility as the Telco's already provide much more affordable circuits.

Ethernet switch and IP router manufacturers have huge development budgets, and can innovate new technology at a speed and pace most broadcast manufacturers could only ever dream of.

Piggy backing on the back of the wave of innovation from IT manufacturers is to the benefit of broadcasters, and they will see their productivity, resilience and reliability increase as IT manufacturers continue to improve.

Migration Strategies

Broadcast stations operate 24/7 and the saying "if it ain't broke, don't fix it" is prevalent throughout the whole industry, especially in playout centers. Even in this age of multi-playout, advertising air time can be incredibly expensive, and it's a well-known fact that systems only ever fail during the most expensive broadcasts.

IP integration is more than just turning SDI into IP, it's a real opportunity for businesses to review their current working procedures, practices and workflows. Migrating to IP can be a long and slow process as many facilities must unravel years of working practices to find out how their systems work.

For IP to be truly successful, it must be driven by the CEO who should make one person responsible for reviewing each workflow and justifying it, or changing it. With best interests at heart, there will be many engineers, technicians and operational staff who will question the wisdom of the migration, especially when established procedures are picked apart and reworked.

There is the possibility of building a parallel workflow and then switching over at a predetermined time. This may work for smaller facilities, but is fraught with danger for larger systems, especially if they have been working for many years.

IP gives broadcasters the opportunity to deliver more efficiently over the internet. Instead of taking SDI video feeds and then converting them through broadcast hardware transcoders, the file or IP stream can be converted on the fly using faster-than-real-time software to deliver virtually any version of delivery format needed.

Care must be taken however, once the transmission is in the IP domain, there is a real tendency to start transcoding workflows many times. A live sports channel may be broadcast as HD to air, and then further compressed for desktops, laptops and mobile phones, giving rise to the potential of concatenation when transcoding multiple times.

Broadcast centers already have CAT5 and CAT6 cabled infrastructures, and many have IP installed in their playout areas, especially between video servers and control systems. But there is a significant difference between using IP to move files around in non-real-time, and streaming live transmissions.

Timing, latency and delay are three key issues that broadcasters must be aware of and have strategies to detect, measure and fix. Care must be taken to understand the interaction with other IP systems, such as finance. If a network has been poorly designed, and payroll execute the check-run during the first Ad of the Super Bowl, some interesting artifacts might be observed, such as the Ad going to black, stuttering or freezing.

Paradoxically, over engineering a network can create considerable delay, cost and complication. The three-key area's IP is looking to improve on.

Opportunities for Interactivity

An area of interest for broadcasters is that of interactivity. Single direction, point-to-point SDI networks have dictated working practices and program output since Marconi-EMI transmitted their first broadcast in 1934, that is, the broadcast can only be delivered to the viewer, and no information can be received from them.

Internet streaming changed all this. Suddenly, users could interact with the company streaming the channel, even if it was only to post a comment or opinion. Installing an IP router now gives a broadcaster the option of receiving data, especially when simultaneously broadcasting over the internet.

Understanding viewing habits and which channels are being watched is a very patchy science. In traditional broadcasting, a relatively small number of viewers have special monitoring boxes installed in their homes to enable data gathers to determine what was watched and when, these statistics are then extrapolated to give viewing figures.

Set-top boxes allow broadcasters to know exactly which programs are being shown and when. They're not one hundred percent accurate as the set-top boxes cannot determine if anybody is watching the television at that time. Although the technology is there to do it, we must rely on the manufacturers assurances that they are not recording our every movements.

Streaming viewing data back to broadcasters gives them enormous power when selling advertising space, they know the viewing numbers with some degree of certainty. Whether this is ethically acceptable is another matter, but the technology is there to do it.

Portable computers such as iPads and notepads have delivered greater opportunities for broadcasters. As well as being used by viewers to watch and interact with a broadcast, they can be used in house to provide remote control and monitoring of critical systems.

Streaming to portable devices is not as easy as it sounds as the delivery system can be unreliable, slow and varying in bandwidth as internet connectivity is generally available in two varieties; contested and uncontested. Contested effectively means the network is shared with other users. A home ADSL line, or office wi-fi are two examples of contested networks. Telco's providing dedicated internet lines such as AWS-Direct, are usually uncontested.

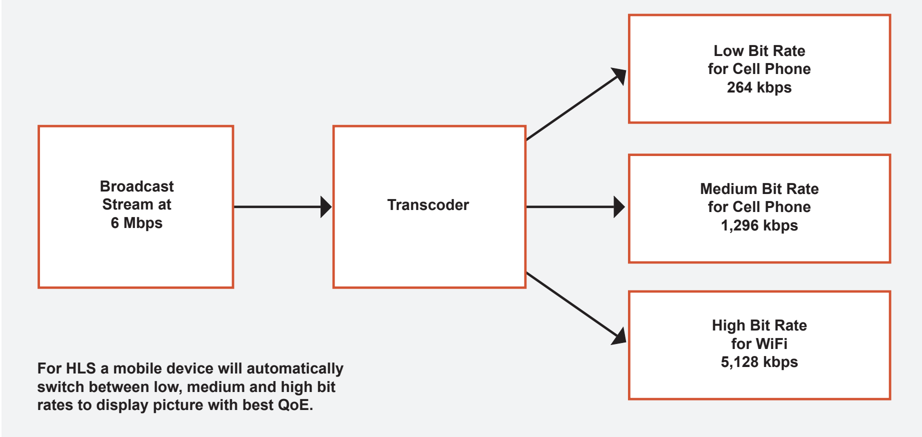

Diagram 2. Quality of Experience for the viewer can be improved using different compression rates with auto-switching protocols.

On a contested wi-fi network, all devices wanting to access the internet must share the available bandwidth and radio frequencies with all other users. In a heavily utilized area, such as a stadium, many devices will be trying to access the same number of radio frequencies at the same time. If a device cannot access a network it waits a small amount of random time before trying again. If access is still impaired, the network algorithm continues to wait further until it either eventually times-out, or gains access.

High contention results in reduced bandwidth and delay, this is a problem for streaming to mobile devices as the delay and bandwidth becomes dynamic and not fixed. If a server is streaming at 1Mbps and the network can only deliver 800kbps, then dropout, stuttering and freezing will occur. But if devices move out of the networks range then the bandwidth could improve to 5 or 10Mbps.

The whole effect of this is to give a poor "quality of experience" (QoE), one moment the transmission can be viewed, the next it cannot.

To combat QoE issues systems such as HLS (HTTP Live Streaming) and MPEG-Dash have been developed. These work by creating several different transcoded versions of the original video feed to give varying bit rates to work on different available network bandwidth. The viewing device can automatically switch between the different streams without user intervention to select the feed most appropriate to the device under the current network conditions. If the network bandwidth decreases, the device will switch to a lower bit rate stream, and then switch to a higher bit rate stream as the network bandwidth improves.

Although the picture quality may vary slightly between switching, it will stay stable and viewable, which is much preferable to an unstable picture that is breaking up, stuttering and freezing.

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Making IP Work

Many of the lessons learned from distributing audio over IP can be applied to video, specifically timing and latency. Using either analogue, AES or MADI, audio provides point to point uncontested connectivity between sender and receiver. A microphone is normally connected directly to a sound console or through analogue to digital converters, but even when digits were used, the cables to transfer the data to the sound desk are specific to that channel.

To truly leverage the power and versatility of IP we must use IT networks as they were intended, that is sharing the network capacity between different devices using time division multiplexing. It's easy enough to send each microphone to a port on a switch and then have that switch connect to the sound consoles IP router via a high-speed fiber router, and this configuration will work, but all we're doing is replacing the acronym MADI with IP.

Multiplexing audio samples on contested networks is a challenge, data packets from other devices destined for the same destination port all fight for the same space, and to deal with this, the router will delay some packets in favor of others resulting in packet jitter.

In our microphone and sound console example, IP packets relate to many samples of audio and these must be assembled in the correct sequence within a fixed time frame, with no errors introduced by the re-assembly process. Failure to achieve this will cause pops and squeaks for uncompressed audio, and long distortion, dropout and high energy spikes in compressed feeds.

Buffers at the send and receive devices help to overcome loss of packets through congestion. At the send end the switch can wait until the port becomes free before transmitting the IP packet, and at the receive end the sound console can assemble the packets in a buffer so the sequencing and time frames are respected.

However, this comes at a price – integrity of the audio is proportional to the size of the buffers, but longer buffers cause delay and latency, and if this is too long then lip-sync errors quickly become apparent.

Video suffers the same issues, but on a much larger and faster scale. Larger buffers provide much better resilience to packet loss, but at the price of increased latency, again causing significant lip-sync errors. In the extreme, this results in inferior quality of experience for the viewer as timed programs can be many minutes late.

Network engineers are not accustomed to worrying about such delays. From their point of view, increased time to delivery is the price paid for reliable accurate data, a hangover from IT working practices in the banking industry. We might accept a loss of one packet in a live transmission, but in the banking industry, if the lost packet related to a decimal point, the losses could be immense.

At an audio or video sampling level, the source and destination bit clocks must be both phase and frequency locked. IEEE 1588-2002 Precision Time Protocol is a system used in industry to synchronize manufacturing processes to nano-second accuracy. PTP, and variations of it have been adopted by broadcast manufacturers to synchronize clocks to establish phase and frequency lock so that audio and video samples are not lost.

For broadcasters to take advantage of scalable COTS systems offered by the IT industry, they must work very closely with network engineers. There will be a two-way learning process as IT engineers learn the intricacies of timing and latency issues, and broadcast engineers realize it's very difficult to prioritize traffic in an IP router.

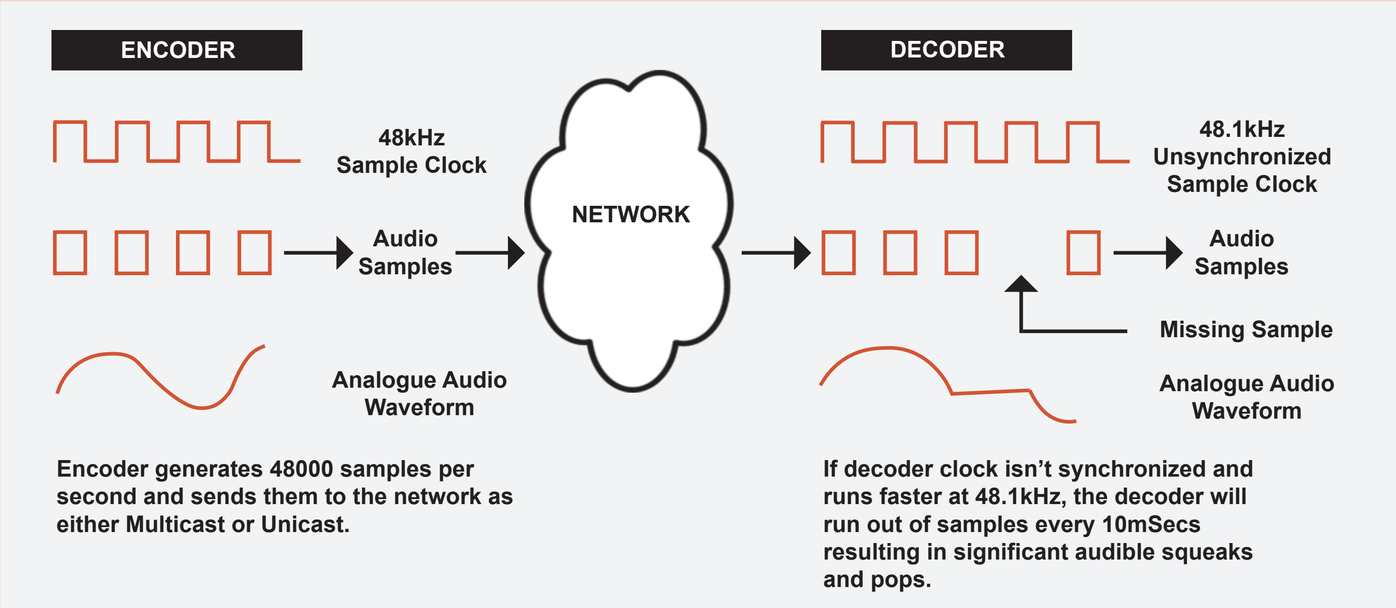

Diagram 3. For reliable signal reproduction, the ADC and DAC clocks must be the same frequency and in phase.

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ZeeVee HDbridge3000 Chassis

ZeeVee Solutions

As we move to IP many broadcasters will want to test the water with this new technology to de-risk their systems and learn by first-hand experience. Sending constant 5Mbps and 10Mbps video feeds over an IP network will cause the IT director to lose even more hair, as IT is accustomed to short bursts of high capacity data, not continuous packets at relatively high-rates.

ZeeVee, with their HDbridge3000 empowers broadcasters to test the IP water. A standalone, 3U rack mounting chassis with dual power supply and monitoring alarm systems, can have up to twenty-four HD-SDI input modules encoded onto an IP output, allowing broadcasters to converge SDI to IP with minimal risk.

Working in the SDI domain, broadcast engineers can see the video signal being transferred to IP and back to SDI, allowing them to isolate problems to the SDI or IP domains when testing and fault finding. Network analysis tools such as Wireshark are the engineers friend, and combined with normal video tools, engineers should be able to transition to IP video and audio distribution systems easily.

ZeeVee's ZyPer4K let broadcasters transition to 4K distribution over IP, the near plug and play technology uses industry standard ethernet switches to send high capacity video over standard IP networks. Large SDI routers can be replaced with ethernet and IP routers to take advantage of IT systems and improve efficiencies.

Conclusion

IP distribution within broadcast facilities is a given, the business case is compelling and massive efficiency savings are achievable if the broadcast engineers work in harmony with their IT counterparts to leverage COTS and scalability.

Moving to IP gives broadcasters a fantastic opportunity to review their workflows and improve efficiencies, especially with legacy systems. Bespoke, unsupported systems can be replaced with solutions that can be maintained by IT and network engineers, as well as broadcast engineers.

Exploiting the bi-directional nature of IP communications will provide new features for the viewer, such as interactive television. And advertisers will be able to achieve more accurate viewer analytics and target communications more effectively.

There are many problems facing broadcasting as we integrate to IP, most of them are unknown to us now, but slowly integrating from SDI to IP will help the transition run smoothly and reliably.

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