White Paper

Evolving IP Standards – the dB Broadcast Approach

The earliest deployments of IP video transport began around 2001, when one large cable company sought ways of reducing the quantities of coax associated with the use of ASI for transporting video. Although initially not standardised, the distribution of MPEG-2 Transport Streams (TS) began the transition to IP video. dB Broadcast became the UK's leading integrator and installer of encoding and compression systems, and by around 2007 they were installing and commissioning fewer ASI coax systems than IP based systems. This major shift meant the company had to develop internal expertise in video over IP, networking technology and, in particular, configuring IP switches.

In the period 2007-2011, SMPTE defined four standards for the transport of MPEG-2 TS over IP (SMPTE ST 2022-1:2007 to ST 2022-4:2011). In 2012 and 2013, SMPTE extended these with the addition of three new ST2022 standards for the transport of 'high bitrate media signals' (uncompressed video) over IP networks (SMPTE ST 2022-5:2013, ST 2022-6:2012 and ST 2022-7:2011). ST 2022-5 is a standard method for providing forward error correction (FEC), ST 2022-6 is a standard method for the carriage of SDI over IP and ST 2022-7 is a standard method for seamless protection switching of ST 2022-6 streams.

Yet while these new standards would bring enhanced flexibility and demonstrable cost savings over the long term, the pace of change was presenting new challenges as the products, standards and skills necessary to realise this vision fully were not in place. This required workarounds and bespoke approaches – a challenge that dB Broadcast was uniquely placed to address.

For example, a global technology company chose dB as its partner to help design and implement its flagship London production facility for its content creators. Yet in 2016 when this project was undertaken, the move to IP was still at an early stage. One of the biggest challenges at this time was that IP video systems were transitioning from proof-of-concept (PoC) test systems to operational production facilities while many products were not yet interoperable using the SMPTE standards, or had not been tested 'at scale'. Consequently this project was successfully delivered using a proprietary solution for video, audio and metadata over IP and the use of IP infrastructure made this 4K equipped facility extremely versatile.

Also during 2015–16, dB Broadcast was working with industry suppliers to create PoC systems based on the emerging SMPTE ST 2022 suite of standards, and in 2017, dB

delivered the first fully IP production centre in the UK based on SMPTE ST 2022-6 and -7, at a major new facility sited in the City of London.

It should be noted that all the of the ST 2022 media transport standards are related to the carriage of multiplexed data, that is video, audio and any metadata are all carried together on a single IP stream as shown below:

Simplified SMPTE ST 2022-6 IP Packet Format

Although MPEG-TS over IP is often carried over UDP (User Datagram Protocol), SMPTE ST 2022-6 (and the later evolved standards for high bitrate video) is carried using RTP (Real Time Protocol) over UDP. This allows the detection of lost and out of order packets and also provides time stamping to allow timing reconstruction (this being critical in SMPTE ST 2110). Most early deployments of IP Video in production environments used SMPTE ST 2022-6, sometimes with 2022-7 protection switching but rarely with 2022-5 FEC. Using FEC in such an application requires extra bandwidth, but also requires additional receiver processing along with the associated latency that introduces. During 2015 and 2016, dB Broadcast was working with suppliers to undertake Proof of Concept IP systems based on these emerging standards, and in 2017, dB Broadcast delivered the first fully IP production system, sited in central London.

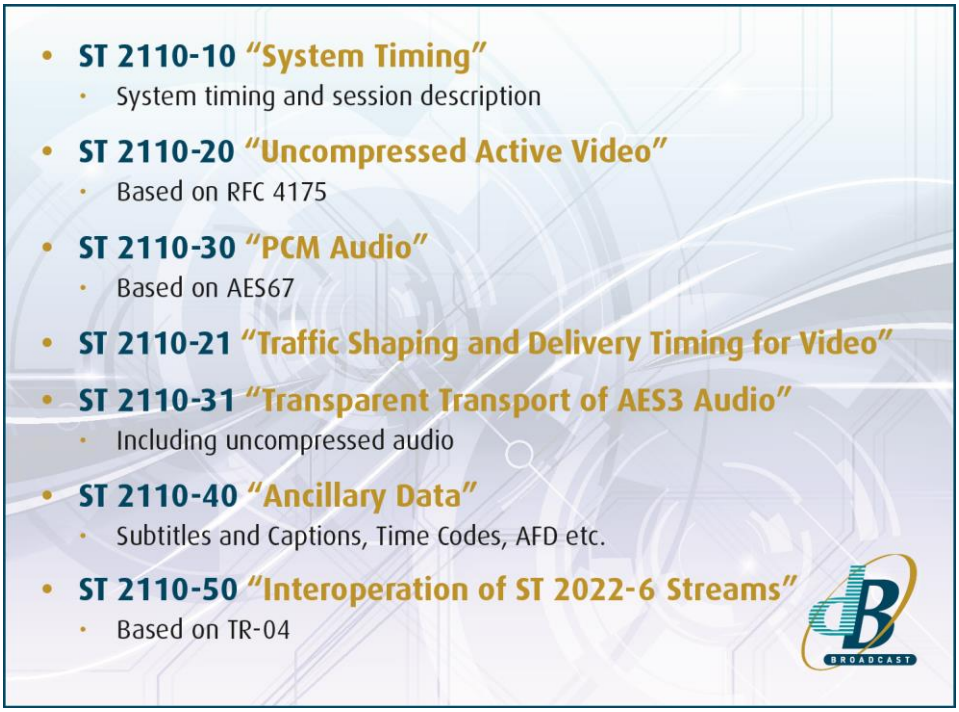
As the SDI payload is intended to carry video, audio and metadata, it is quite inflexible. If for example, an audio mixing desk needed to access a stereo pair, it would have to receive the entire stream and de-embed the required pair. Although it is possible to send audio via separate flows using AES67, this is wasteful of bandwidth as the ST 2022-6 stream uses a constant bandwidth irrespective of whether embedded audio is carried or not.

To address these concerns, in 2015 the Video Services Forum (VSF) proposed TR-03, which separates the video, audio and metadata essence into discrete flows. By using separate flows, TR-03 avoided wasted bandwidth and offered greater flexibility to the production team by accessing only the flows they needed. In the case of the audio desk above, it would need to receive only the flow carrying the required stereo pair.

IP Source	IP Dest	RTP Header	Video Payload (RFC 4175)
IP Source	IP Dest	RTP Header	Audio Payload (AES67)
IP Source	IP Dest	RTP Header	Metadata Payload (IETF Draft)

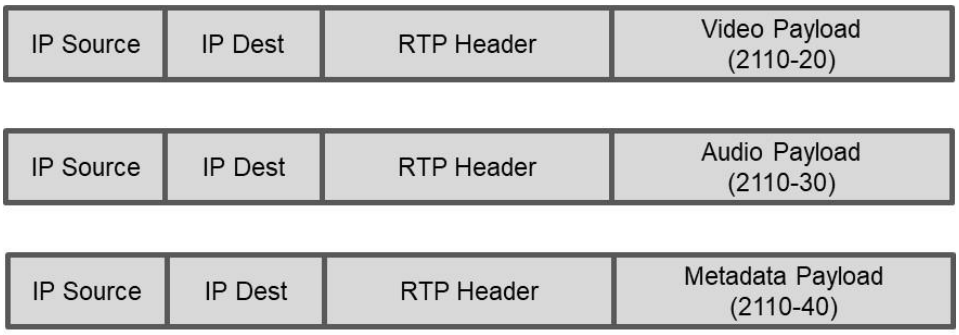
Simplified VSF TR-03 IP Packet Format

A closely related standard is TR-04, which defines that interoperation of ST 2022-6 streams with TR-03 streams. There were however other competing IP video methods that offered the advantage of essence-based flows. In the networked audio market, multiple conflicting and incompatible methods competed for the same space, which resulted in many years of delay before the widespread adoption of AES67.



SMPTE ST 2110 Parts

What the broadcast market needed was a single SMPTE standard that used the same basic principles as TR-03, and that requirement resulted in the development of the new ST 2110 suite of standards. ST 2110 is founded on TR-03 but goes much further in its ambitions. The core of the new suite is ST 2110-10 'System Timing and session description', with several other parts dealing with 'Uncompressed Active Video' (based on RFC 4175), 'PCM Audio' (based on AES67) and 'Ancillary Data' (based on ST291). The separate video and audio essence flow parts are derived from those specified by TR-03. The basic structure of these flows is shown below:



Simplified SMPTE ST 2110 IP Packet Format

As can be seen, the video and audio essence flow parts are derived from those specified by TR-03.

Obviously, with any essence-based IP flows, there needs to be a timing mechanism that allows each essence to be time synchronised, to avoid issues such as A/V delay and to enable frame accurate switching and the use of time code. This is enabled within ST 2110 by using the RTP timestamps as the reference point. But, where does the clock come from? Precision Time Protocol (IEEE 1588), commonly known as PTP is the protocol used to synchronise the clocks of devices connected to a network. It is this protocol that synchronises the clocks of sending and receiving devices using ST 2110. This allows the sender to generate accurate and synchronous RTP timestamps, and the receiver to be able to time-align multiple essence flows with great accuracy. The version of PTP that is to be used with ST 2110, is another SMPTE standard SMPTE ST 2059 parts 1 and 2. Part 2 refers to a "SMPTE profile for use of IEEE 1588 Precision Time Protocol in professional broadcast applications", which is intended to maintain the accuracy between the clocks of different devices to within 1 micro second. Part 1 refers to the "Generation and Alignment of Interface Signals to the SMPTE Epoch".

SMPTE ST 2110 offers all the flexibility and bandwidth advantages of essence-based media IP flows, with the reassurance that comes from a unified industry standard that ensures the same interoperability we have enjoyed with SDI for almost thirty years.

One of dB Broadcast's biggest challenges in seeking to implement emerging standards, such as SMTPE ST 2110 is that it may lead to interoperability challenges between different products, an issue that needs to be carefully managed by the system integrator.

To provide easier interoperability and configurability within IP networks, there has been a trend towards the use of Software Defined Networks (SDNs), which allow networks to be programmatically configured and managed. In the broadcast world, the AMWA Networked Media Open Specifications (NMOS) is a suite of open specifications that, amongst other capabilities, allows device discovery and registration (IS-04), connection management (IS-05) and network control (IS-06). Although NMOS is a work in progress, it will in time provide an open framework for the interoperable configuration and management of broadcast IP networks.

In the UK, the BBC is committing to these emerging standards and for its new BBC Wales headquarters currently being built in Central Square, Cardiff, the BBC have specified a facility based on the new SMPTE ST 2110 standards and AMWA NMOS IS04.

During 2018 and 2019 dB Broadcast will be working closely with customers and key IP video technology suppliers to deliver systems based on ST 2110. dB has extensive experience and capability in broadcast engineering, and already has a proven track record in implementing IP based systems based on emerging standards, and integrating best-of-breed software products from multiple suppliers.