Utah Scientific

UTAH-400
Video Network Gateway Solutions

INTRODUCTION

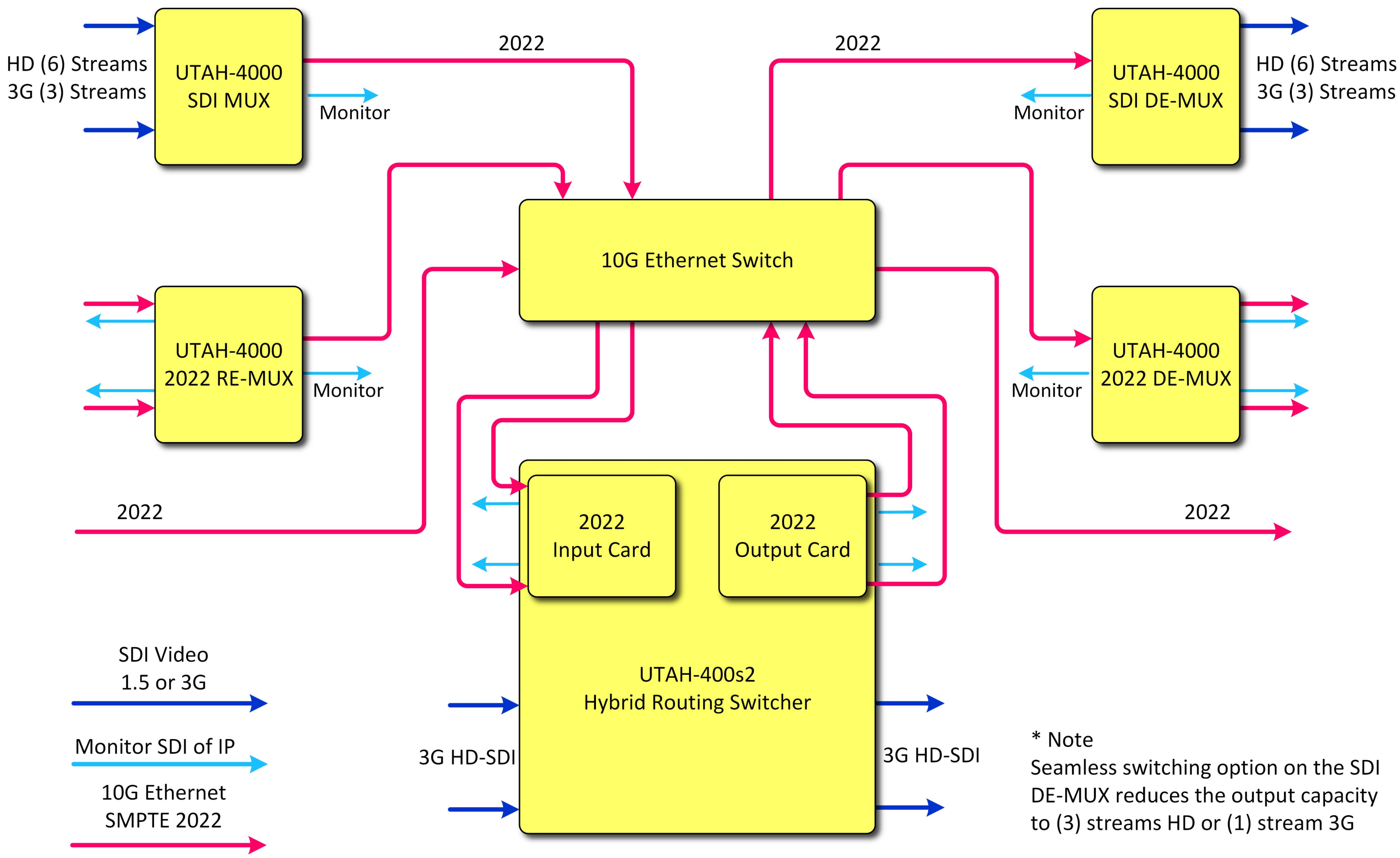
The broadcast systems of today exist in two separate and largely disconnected worlds: a network-based world where audio/video information is stored and passed in the form of computer files from stage to stage in the workflow process of preparing it for distribution to the audience; and a real-time infrastructure that was designed for reliable delivery of live signals from the lens of a camera to the TV set of the viewer.

The infrastructures that support these two worlds have evolved separately to incorporate the latest advances in component technology and current system designs are immeasurably more reliable and efficient than those used as recently as five years ago. On the network side, increases in network throughput capacity, storage capacity, and processing speed have enabled system designers to provide systems that support tremendous improvements in efficiency at much lower cost. On the real-time side, systems are today supporting flawless delivery of digital video at 3 Gigabits per second – more than ten times the data rate of the first digital video systems that were deployed less than ten years ago.

The challenge that faces system designers today is to find the best ways to bridge the gap between the two worlds in a way that efficiently takes advantage of the strengths and advantages of each. While it may seem that the time has come for moving to a completely network-based infrastructure, most systems will be required to support a wide variety of legacy devices that are not easily converted to operate in the network world. The solution that Utah Scientific is proposing is to provide a practical bridge between the two worlds, allowing the legacy infrastructure to contribute its advantages while supporting the ever-growing capabilities of the network-based environment.

The first steps in this process have resulted in the introduction of a family of Gateway Modules that support the conversion between HD-SDI (1.5Gbps and 3Gbps) and IP-encapsulated Video that follows the specifications of the SMPTE ST-2022 standards. 2022 is a proven technology for transporting uncompressed HD-SDI and 3G-SDI over non-dedicated generic Ethernet infrastructures. The details of this product family are described in the following pages.
Future additions to this family of solutions are planned for supporting AVC-enabled networks and for decoding transport streams carrying various forms of compressed video streams including MPEG-2, MPEG-4, JPEG-2000, AVC, HEVC, etc.

SMPTE ST-2022 GATEWAY SOLUTION



Block diagram of hybrid HD-SDI and SMPTE 2022 IP streams

THE UTAH-400 SERIES 2 2022 OUTPUT CARD

This card handles encapsulation and multiplexing of up to 12 separate HD-SDI video streams into one or two 10GigE output streams. The encapsulation process can be selected to be in the 2022-5 format which inserts Forward Error Correction (FEC) data into the output stream to provide for recovery of data lost in the network transmission. The addition of the FEC data does result in additional latency which is variable with the amount of FEC data that is added. The card can also be controlled to use the 2022-6 format which does not include FEC insertion. The -6 variant is designed for use in controlled networks where performance is known and predictable. Latency with this form of encapsulation is extremely low (in the range of 10 microseconds) making it preferable for use with “Live On-Air” signals.

THE UTAH-400 SERIES 2 2022 INPUT CARD

This card receives one or two 10GigE input streams and decodes them into up to 12 SDI video streams that are then passed to the internal connections of the video router. The card will automatically detect the format of the incoming streams and decode them accordingly.

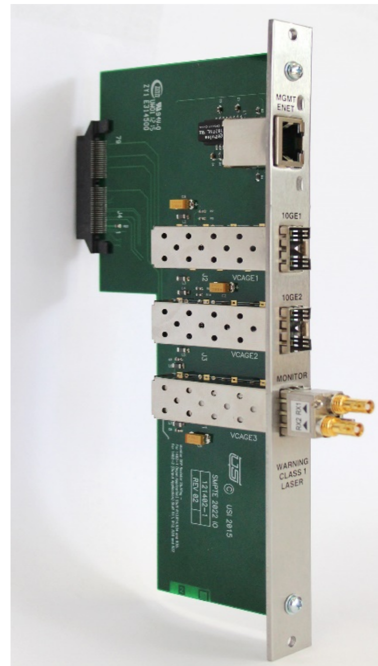
THE UTAH-4000 MULTIPLEX / DEMULTIPLEX CARDS

These cards provide equivalent functionality to the UTAH-400 cards but are designed to serve as edge devices for bringing HD-SDI or externally-generated 2022 streams into the system or delivering decoded and demultiplexed streams to external devices. Each card has the capacity to handle one full 10GigE data stream. These cards are housed in a compact 2RU rack-mount frame that can hold up to ten modules.

SYSTEM CONNECTIONS

Each of the UTAH-400 Series 2 cards is supplied with a rear-panel connector strip that has two SFP cages for standard 10GigE fiber or direct-attach SFPs. A third SFP provides a switched SDI version of the 2022 stream, simplifying the monitoring of IP streams.

An additional RJ-45 connector is provided for connection to the Utah Scientific control network that provides a complete set of monitoring and configuration tools.

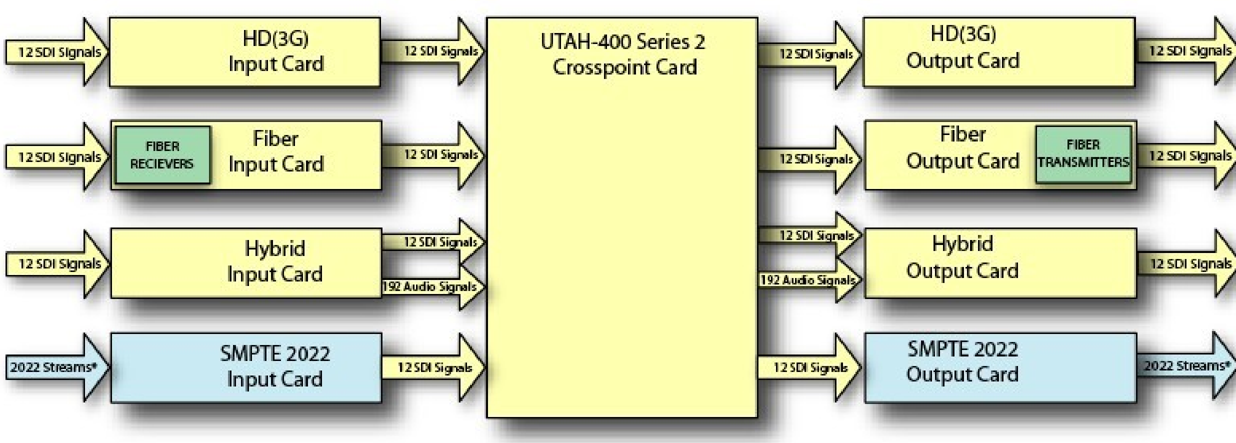


SMPTE 2022 Rear Panel

UTAH-400 SERIES 2 ROUTERS ADDITIONAL FUNCTIONALITY

In addition to the Gateway Modules described here, the UTAH-400 Series 2 Router family offers a wide variety of optional signal processing and advanced routing capabilities that can be very useful in building a system that provides maximum efficiency and flexibility. The UTAH-400 Series 2 is the ideal solution when your system design calls for:

- **Fiber Inputs or Outputs - Single-Mode, Multi-Mode, DWDM**
- **Embedded Audio Insertion / Extraction**
- **Frame Synchronized Inputs**
- **Clean-Quiet Switching on Outputs**
- **Audio Routing - AES, Analog, MADI**



*Two SMPTE 2022 Ports per card. Each port can carry 12 SD streams or 6 HD streams or 3 3G streams.

SOME BACKGROUND ON ADVANCED ROUTING ARCHITECTURES

Questions around the choice between traditional baseband signal routing and IT-based packetized routing are very current throughout the broadcast industry today. While the much-discussed "convergence" of IT and broadcast technologies is undeniably happening, it is happening at a much slower pace than most industry observers have been predicting over the last 20 years.

In this document, we will summarize the current state of our development programs for what we see as the future of signal routing systems over the next 5-10 years as this convergence process continues.

THE "NETWORK" APPROACH

As file-based video storage and editing systems have almost completely replaced VTRs (except for image acquisition) the broadcast industry has embraced standard IT technologies as an economical and reliable alternative to dedicated infrastructure. Ethernet LANs form an essential part of program production, post-production, and play-out facilities in all segments of the broadcast industry, from small independent stations to national broadcasting networks. Where audio/video programming is transported in files, Ethernet is ubiquitous.

But there remains a significant barrier to fully integrating the broadcast infrastructure into a network architecture and that is the requirement for real-time delivery of signals to the final broadcast output. The IP protocol that is used in standard Ethernet networks was designed for the reliable delivery of packets of data from one device on the network to another device. It is remarkably dependable for this purpose. But this system is simply not capable of reliably delivering continuous streams of high-speed data without errors or delays.

Advanced network architectures have been recently developed that are intended to overcome these problems with transport of real-time signals. There are a number of mechanisms that have been developed to extend the real-time performance of Ethernet networks by adding new protocols to set up special paths which are optimized for this purpose. One of these is Audio-Video Bridging (AVB) that has been standardized under IEEE 1722. This approach shows promise in overcoming the real-time delivery problem but it requires specially-designed routing and switching equipment so it is not compatible with non-AVB networks or mixed-network environments. Large-scale implementation of networks based on this technology is still waiting for the availability of AVB-enabled routers and switches with sufficient capacity to support a large number of uncompressed HD streams. A serious problem that occurs in non-AVB Ethernet networks is related to the nature of "packetized" transmission of the data. In a TCP/IP network, the receipt of each packet is acknowledged by the receiving device before the next packet is transmitted. If an error or a lost packet is detected, that packet is re-transmitted and the transmission continues. This process is extremely reliable and it is essential to the accurate transmission of large data files. But it is completely incompatible with transmitting a continuous stream of real-time data.

A solution to this problem has been standardized under SMPTE ST-2022 incorporating the inclusion of Forward Error Correction data into the packetized stream that allows the receiving device to reconstruct the data in an errored or missing packet by analyzing the error correction data in packets already received.

This approach has been proven successful for transmission of live HD programming over general-purpose telecom networks and is widely used for remote feeds from special events to a network center for broadcasting. While ST-2022 has been adopted for long-distance transmission of packetized video, it is not practical for wide-spread use within a facility due to the cost and complexity of the encoding and decoding terminal equipment.

Using currently available equipment and assuming that all HD signals will be carried within the system as uncompressed 1.5Gbps or 3.0Gbps streams, we would need to provision an Ethernet router with a 10GigE port for each input/output device and uplinks between routers which could carry the full aggregate bandwidth of the number of ports on the router. While the price of routers with such large bandwidth capacity is dropping very rapidly, it is quite comparable to the price of a similarly sized baseband router for broadcast applications. To the cost of the Ethernet routing and switching equipment we must add the terminal equipment that will receive the HD video streams and convert them to packets that can be sent into the network and to convert the received packets into HD video streams at the receiving end. The result for a large system with hundreds of connected devices is that baseband routing is significantly more cost effective and that cost advantage becomes more significant as the system size is increased.

Another consideration in evaluating system cost is the investment in the physical cabling that can represent a very large part of the overall system cost. If it is possible to reuse existing coax or optical fiber cabling this must be considered against the cost of installing network cable for a dedicated signal transport network.

Utah Scientific has been involved with Ethernet video for a number of years, supporting MPEG-2, MPEG-4, and DVB-ASI in our routing system for a number of special applications. We are currently working on development of a new family of gateway modules that will support both AVB and ST-2022 I/O, with the internal routing remaining in the HD-SDI domain.

It is our firm belief that for the next 3-5 years, the most cost-effective and reliable video routing systems will continue to be built around baseband routing with an increasing adoption of network-based systems as a means to connect smaller workgroup clusters to the baseband router through IP-to-video and video-to-IP gateway devices.

A very important aspect in evaluating the network-based approach is operational reliability. The central element of any IP network is the router that takes the data streams from the end devices and sends them on to their destination. While it is common practice to build large networks with resilient architectures that support redundant paths between the routers, it is very difficult to provide protection against failure of the edge routers themselves. This means that fairly large potential failure blocks will exist at the points where the data streams enter and leave the network.

BASEBAND ROUTING

The traditional baseband router offers a very simple architecture with input modules that receive the SDI signal streams, pass the signals to a crosspoint array which selects the signal to be fed to each of the outputs on the output modules. Through careful system design, crosstalk between the signal paths is kept to a very low number and the transit time through the matrix is essentially at wire speed, eliminating problems that can be caused by differential delay.

Modern routers have deviated somewhat from this essential simplicity by adding signal processing options that involve de-serializing the incoming streams, performing some processing such as embedded audio extraction, shuffling and re-embedding the audio on the outputs. The trade-off in complexity is justified by the flexibility that is afforded by having all of the various signal elements available within the router, eliminating a much more complex system of external devices and their interconnections.

It is very important to remember, however, that even with the added complexity of internal signal processing, the router architecture is still based on modules that can be readily replaced in the event of a failure and that the modular architecture lends itself to designing a system with internal redundancy to provide protection of critical paths through the router.

This modular architecture offers another advantage in accommodating various physical I/O requirements. It is very easy to adapt the connector assemblies to accommodate fiber or coax connections for the HD-SDI signals as well as to provide fiber or copper connections for signals that are carried on Ethernet. In the case of fiber connections, the optical-to-electrical and electrical-to-optical conversion can take place inside the router frame, eliminating the need for external devices.

The following article, reprinted from TVTechnology, gives some additional background on SMPTE ST-2022:

WES SIMPSON / VIDEO NETWORKING 07.09.2013

SMPTE 2022 and the Future of Video Over IP

Realizing packet-based media networks

As broadcasters migrate towards IP networks for video transport both outside and inside the studio, many existing, proprietary systems are being phased out in favor of products that offer interoperability based on standards.

First introduced in 2007, the SMPTE 2022 standard has since expanded to cover more types of IP video transport. The first two sections of the standard cover IP protocols for compressed, constant bit-rate video signals in MPEG- 2 transport streams, based on COP3 from the Pro MPEG Forum. Newer sections of the standard cover two different kinds of variable-rate compressed video signals, as well as methods for carrying uncompressed video and hitless protection switching. Each section of 2022 is described below.

ST 2022-1:2007 "Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks" defines row/column FEC (Forward Error Correction) for IP video streams. Along with Section 2, this standard has been widely implemented. Row/Column FEC works by grouping IP video packets into logical rows and columns, and then appending one FEC packet to each row and each column.

In the event that one packet is lost from a row or a column, the data in that packet can be perfectly recreated using the contents of the FEC packet in conjunction with the other packets in the row or column. This method works quite well, and allows the packet stream to survive lengthy bursts of lost packets.

ST 2022-2:2007 "Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks" specifies how constant bit rate compressed video signals that are encoded within MPEG-2 transport streams are encapsulated into IP packets. This standard covers the transport layer (RTP and UDP) as well as comments about timing and buffer sizes.

ST 2022-3:2010 "Unidirectional Transport of Variable Bit Rate MPEG-2 Transport Streams on IP Networks" defines IP packets for variable bit-rate MPEG-2 TS streams that are constrained to have a constant bit rate between PCR messages (called piecewise-constant).

ST 2022-4:2011 "Unidirectional Transport of Non-Piecewise Constant Variable Bit Rate MPEG-2 Streams on IP Networks" is similar to Section 3, except that it removes the constraint on bit rates.

ST 2022-5:2012 "Forward Error Correction for High Bit Rate Media Transport Over IP Networks" expands on Section 1 to allow larger row/column FEC combinations to support signals with bit rates up to 3 Gbps and beyond. A minor revision to this standard is scheduled to be published in 2013 by SMPTE.

ST 2022-6:2012 "Transport of High Bit Rate Media Signals over IP Networks (HBRMT)" specifies a way to transport high bit-rate signals (including uncompressed 3 Gbps 1080p video) that are not encapsulated in MPEG-2 transport streams.

2022-7 (approval pending) "Seamless Protection Switching of SMPTE ST 2022 IP Datagrams" describes a way to send two matching streams of packets from a source to a destination over different paths, and have the receiver switch automatically between them. This allows a perfect video signal to be reconstructed at the receiver as long as both paths do not fail simultaneously.

Another section originally called 2022- 8 was proposed to define a mapping for JPEG2000 over MPEG-2TS over IP with FEC. This capability appears to have been fulfilled by the publication of VSF (Video Services Forum, www.videoservicesforum.org) Technical Recommendation TR- 01 "Transport of JPEG 2000 Broadcast Profile Video in MPEG-2 TS over IP."

The VSF has also arranged a number of successful interoperability tests ("interops") to demonstrate that devices from different manufacturers are able to send and receive bit streams to one another. Fig. 1 shows a list of the interoperability tests that have been performed to date.

2022 INSIDE THE STUDIO?

Work is currently underway in the Joint Task Force on Networked Media to map out a strategy for using packet- based networks in the professional media industry. This group, which held its first meeting in March, is a cooperative effort between SMPTE, the VSF and the European

Broadcasting Union. SMPTE 2022 may be considered by the task force for encapsulating uncompressed SDI and HD-SDI signals so they can be transported over IP networks within a studio, in place of baseband signals over coaxial cables.

Other standards groups, such as IEEE 1722 Audio Video Transport Protocol, use different methods for encapsulating SDI video, one of which eliminates the RTP headers found in 2022 and maps video into Ethernet frames (packets). IEEE 1722 also dispenses with FEC (since packet loss is very rare within local networks) and groups all of the data associated with each line of video into an integer number of Ethernet frames, potentially making it easier to build devices that perform switching between video signals. Results from the task force are expected to be ready in 2014.

As a wide-ranging standard for IP video, SMPTE 2022 will certainly become more important as IP technology continues to penetrate the professional video production market.

- Link to the original TVTechnology article:
http://www.tvtechnology.com/it-&-networking/0151/smpte--and-the-future-of-video-over-pp/220188#sthash.QLg3QfNT.dpuf