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Hybrid Routers: A New Era of Routing

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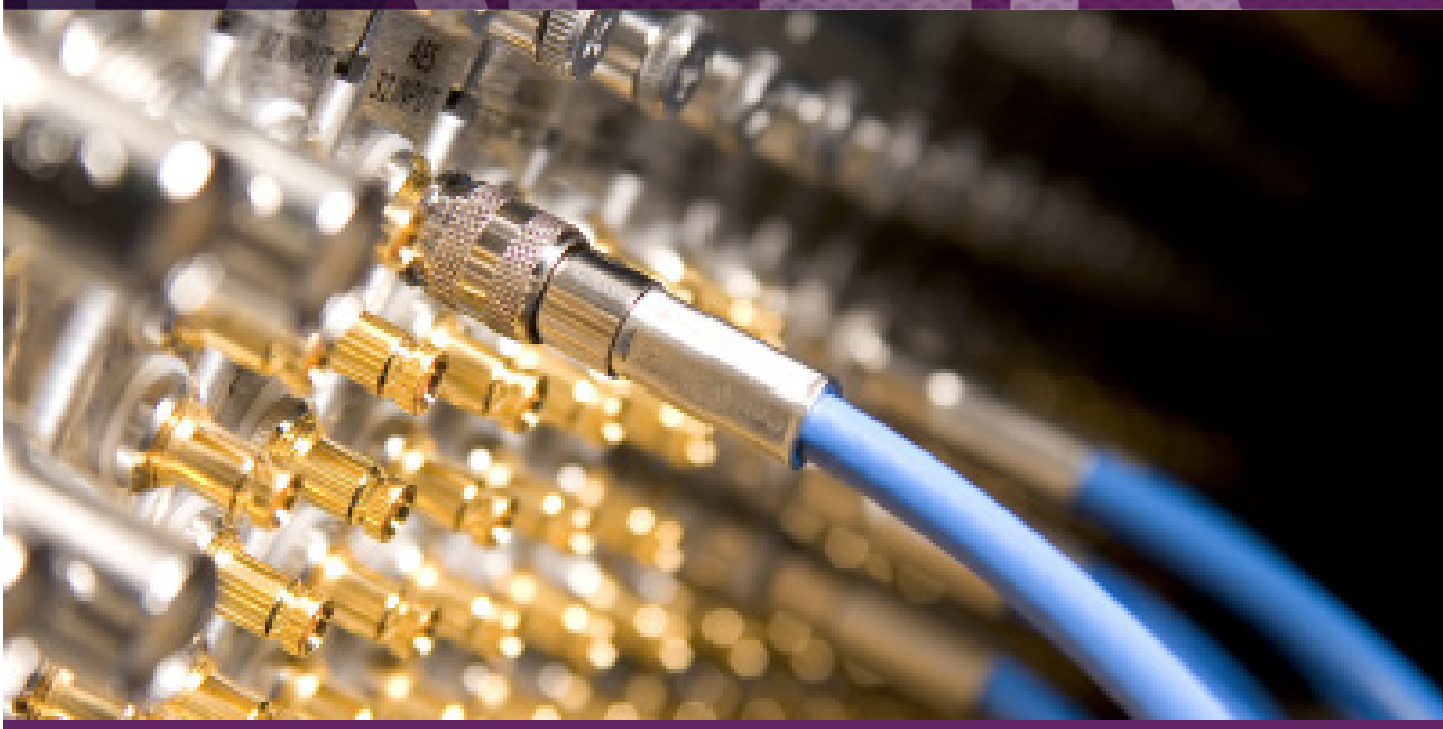
WHITE PAPER



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When embedded audio first came about it was considered a universal solution for many audio woes, for which it has been very useful. However, as is the case with many new technologies unforeseen problems may arise, specifically, when the embedded content needs to be manipulated.[3] Additionally, video and audio control rooms have to use both embedded and discrete audio coming from sources such as microphones.[1]

Up until now, in order to accommodate these scenarios, facilities maintained discrete audio and video routers combined with racks of embedders and disembedders. To keep track of the disembedded audio channels additional management was required on top of the traditional routing that needed to be done. It was discovered that using embedded audio was grand until breakaway or channel shuffling was required. The savings of using embedded audio in the first place was consumed by the racks of embedders and disembedders and all of their subsequent cabling, power and management needs.[1]

Is there a smarter, simpler and cost efficient way to handle these situations? Yes. By combining traditionally external processing equipment with discrete audio and video routers we have entered a new era in routing; the era of the hybrid router.

What is a Hybrid router?

According to the Merriam Webster's Dictionary, Hybrid, when used as an adjective, is defined as "something heterogeneous in origin or composition" or "something that has two different types of components performing essentially the same function."

A Hybrid router is a router chassis that combines a video and/or audio matrix with traditionally external processing and/or modular equipment. Hybrid technology allows the consolidation of multiple functions into the router: embedding, disembedding, frame sync and format conversion. It is the convergence of modular products and traditional routers into one physical chassis with a single control environment. For the scope of this paper the focus is on a complete audio and video matrix inside one chassis coupled with internally placed embedders and disembedders.

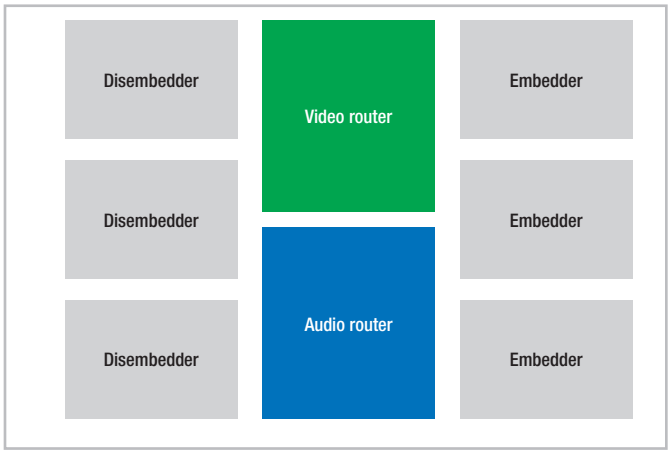

Figure 1

Driving factors?

The management of multichannel audio in an embedded broadcast facility was the driving factor for the production of the Hybrid router. There are two key contributors; multi-language audio and multichannel audio such as surround sound for HDTV.

Background

Many broadcasters, for mainly economic reasons, standardized upon embedded audio in 1992. This allowed them to get at first four (4) and then eight (8) and now sixteen (16) channels of audio embedded into a video stream that ran on a single coax. With embedded audio, broadcasters could keep the single-pipe infrastructure that was in place from the times of analog. Without having to replace the basic architecture, broadcasters were able to support multiple audio channels by universally exploiting embedded audio based on SMPTE 259M (10-bit SD-SDI at 143/270/360 Mb/s) [4] with SMPTE 272M [5] audio embedding specifications for SD and then SMPTE 292M (HD-SDI at 1.485 Gb/s) [6] with SMPTE 299M [7] audio embedding specifications for HD and now with SMPTE 424M (3G-SDI at 2.970 Gb/s). [8]

This method of routing video with embedded audio without the ability to independently switch the audio worked well in an environment that primarily supported one language and only mono or stereo audio. However, the evolution of culture and technology has brought all of us closer; which means that a show that used to be watched primarily by people of one area and one language is now available to wider demographics and geographical areas.

Multi-language support challenges systems that were designed to provide video with embedded audio sources to one demographic area. For instance, material originally aired in the U.S may now be viewed in Brazil or a specialty channel available in Germany becoming available in Sweden. For both of these cases, the original English or German audio embedded in the source needs to be replaced with new embedded audio of Portuguese or Swedish origin. Multi-language support requires the embedded audio to be disembedded and shuffled around or replaced altogether with audio from a different source.

Multichannel audio also creates headaches for embedded audio whenever one of the channels needs to be mixed, edited, shuffled or replaced. Multichannel audio requires facilities to be able to disembed the source and allow access to the individual channels to be routed and mixed. The multichannel audio problems are growing as more home users are buying home theatres with surround sound and as support for further channels grows.

One way to solve or simplify the problem is to make disembedders and embedders available to all audio channels within the router and condense the management, power and control to one point. The result of combining these functions into a single frame is the Hybrid router.

Great idea! But why wait until now?

In order to build a condensed product with so many capabilities the designers were faced with the challenge of fitting an immense set of functionality into a compact space. FPGAs with higher density, consuming less power enabled the design of the Hybrid router. Until recently the capabilities of FPGAs combined with their respective power requirements prohibited this combination in a relatively small unit. The decrease in power requirements for functional blocks means more complex functional blocks are possible. As an example, 16 channels of EQ, embed, de-embed in 2000 was about 175W for SD support only, whereas in 2010 it is about 60W for SD, HD and 3 Gb/s support. Based on a package design, more powerful functions are achieved, with a two to three times power savings, in one box.

Moore's Law (see Figure 2) resonates beyond the computer industry; just as the CPU transistor counts doubled every two years, the bits per second in a router switch fabric have also increased in a similar fashion, doubling throughput about every two to three years. Table 1 lists the data of a relevant example. See the graph in Figure 3:

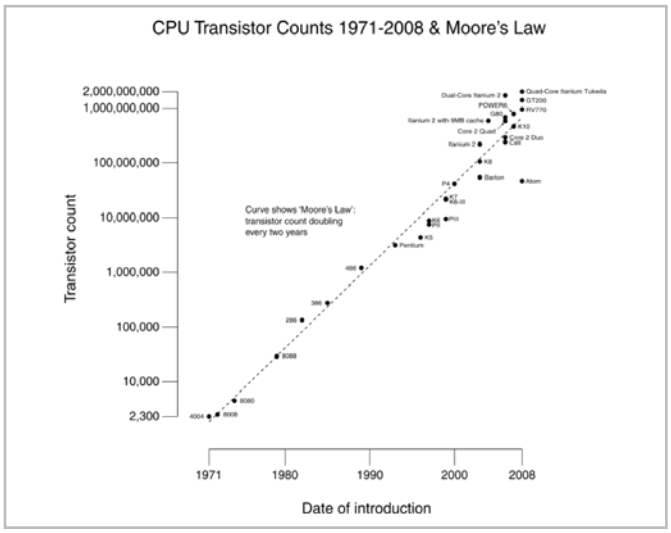

Figure 2

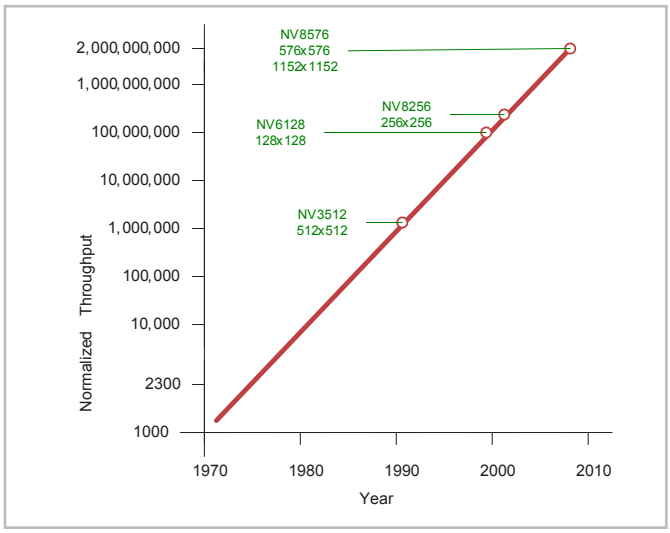

Figure 3

Year	Model	Size	Type	Throughput	Normalized
1991	NV3512	512x512	AES	1.572 Gb/s	1,000,000
1999	NV6128	128x128	HD	192 Gb/s	122,000,000
2002	NV8256	256x256	HD	384 Gb/s	244,000,000
2009	NV8576	1152x1152	3 Gb/s / HD	3,072 Gb/s	1,954,000,000

Table 1. Router throughput data

Increases in functionality coupled with lower space requirements due to advancements in FPGA technology have given designers the tools they need to consolidate functions of several small cards into one hybrid unit. In addition, system level control over capabilities previously external to the router can be presented in a single finely integrated interface.

Advantages of a Hybrid router

Combining video and audio routers into one chassis, along with modular equipment, such as disembedders and embedders, offers many advantages over using dedicated video and audio routers with external processing equipment. See Table 2 below.

Advantage	Explanation
Simplify setup, installation and maintenance	There are fewer pieces of equipment and less cabling between equipment, installation, setup and configuration is simpler. Long term overhead expenses are reduced due to simpler maintenance and trouble shooting.
Fewer cables	Fewer cables mean less cost and less weight, which in trucks leads to lower fuel cost and fewer points where connectors might fail. Setup is less complicated, requiring fewer man hours of labor for installation.
Fewer pieces of equipment	Fewer pieces of equipment reduce the amount of rack space required and reduce the weight, power consumption and outlets, reducing cooling requirements and man hours to move and install. Condensing functions into the router reduces the integration risk to only one vendor.
Fewer management systems to configure	Fewer management systems mean less user interfaces to learn and operate, less time to configure, and a single point of control.
Less power	Equivalent Hybrid systems require less power which produces less heat which leads to reduced cooling requirements.
Fewer fans	Fans are noisy in confined spaces and are a point of unreliability.
Less space	In already tight quarters, such as a truck, space is valuable. The internal disembedder and embedder modules eliminate the need for external equipment that takes up valuable rack space.
Integrated audio processing	The integrated audio processing for embedded audio provides a means to disembed the audio, allowing the audio to be routed independently to any point, such as for shuffling and breakaways, before re-embedding the audio.
Minimized audio delay	Having all the equipment in one box minimizes the delay incurred each time a source is disembedded and embedded, thus reducing lip sync errors.

Table 2. Advantages of Hybrid router

What signal processing and software management challenges can Hybrids help?

As noted above, there are several advantages to using a Hybrid router. From an application perspective, many areas within a television broadcast or production facility would benefit from the inclusion of a Hybrid router, especially production and ingest. These two key areas are a natural fit for a Hybrid router. We will cover these two areas, plus look at control and status of a Hybrid router, in more detail below.

Production

Production is no longer just providing audio; it is producing audio. In a production environment, operators are combining audio from different sources, such as analog from microphones, AES sources or MADI streams from mixing consoles along with audio from originally embedded sources. They are handling about 40 or 50 channels of background sound effects, dialog, musical scores and Low Frequency Effects (LFE) to produce a surround sound master image, in addition to handling multiple language content. Production facilities need the flexibility, robustness and cost savings of a Hybrid to achieve results economically.

Studio environment

In a typical large studio environment, such as a network sports broadcast facility, a single rack Hybrid router can typically reduce by a factor of two, at least two to five (2-5) racks of equipment. This is a modest estimate. The amount of savings for cabling charges, including the cost of the cables and connectors themselves plus the cost of high density wiring job could reach a hundred thousand dollars. The Hybrid simplifies installation, reduces equipment and operational costs while providing a more conducive environment for managing audio signals.

Within an audio environment, various points of delay wreck havoc with the carefully orchestrated production of sound including surround sound which has become increasingly popular with the rise of home theatres. With a traditional setup of routers equipped with external disembedders and embedders, delay is hard to regulate. Each time an audio source is disembedded it incurs lag time. A standard standalone disembedder single pass route would cost you between one to four (1-4) milliseconds each. That may be tolerable for a single pass, but once you start making multiple passes the increasing delay will cause significant undesirable effects. However, with a Hybrid router the disembedders and embedders are internal and operate in unison, reducing the delay. An internal path can cut the audio delay down to 1 or 2 lines of video, total, or about 65 microseconds. At this rate, the source can make several passes through the router and still maintain a much smaller delay than one pass through an external disembedder. This ability enables the Hybrid to preserve the phase of the audio, enabling HD Surround 5.1 audio. The quality of the original surround sound master image is maintained and the Dolby E guard band is preserved while also managing lip sync.

The Hybrid is valuable for minimizing the audio delay which can lead to lip sync errors. Each time a signal is disembedded, re-embedded and passed around it incurs delay. By having everything in one location, in one box, delay is reduced to a minimum. Appropriate audio/video (AV) sync limits have been set at a range considered acceptable. This range is from ±22 ms (±0.5 frames) and the range for video is 15 ms ahead or 45 ms (±15 ms) of lag time[2] for the whole signal chain, including delivery. With the disembedding and re-embedding included internally in the router, delay is reduced to 65 microseconds. Since all of the operations are internal, the sources can be monitored directly for lip sync errors.

A Hybrid router is useful in reducing overall power consumption. If the power consumption of all the equipment a Hybrid can replace was added up there would be a significant reduction in overall power consumed. For example, see Table 3 below. The reduction in power usage leads to less heat production which reduces cooling requirements. This is an important consideration for any environmentally conscious facility. Energy usage is becoming a worldwide concern. The European Union (EU) has adopted an Energy Labeling program rating the efficiency of electrical appliances and the International Energy Agency provides a limited amount of carbon credits that can be used by participating nations, including, but not limited to, the US, Japan, Australia and Europe.

Item	Typical rack space	Weight	Power	Hybrid rack space	Weight	Power
	Video router 576x576 — 38 RU	265 lbs	5900W	38 RU 512x1024 video 8192x16,384 audio Up to 512 disembed Up to 1024 embed	309 lbs router 100 lbs ps	5700W
	Audio router 512x512 — 19 RU	167 lb router 105 lbs ps	900W			
	Embed 100 15 RU	100 lbs	1500W			
	Disembed 100 15 RU	100 lbs	1500W			
Total	87 RU	737 lbs	9800W	38 RU	409 lbs	5700W

Table 3. Comparison of a typical router setup to Grass Valley's Hybrid router

Truck environment

Trucks need Hybrid routers for several reasons. The first and most obvious reason is the space saving qualities of the Hybrid router. Trucks have a relatively small, cramped and finite amount of space available. A typical truck, such as a 3D mobile video truck, would normally have a dedicated video router and a dedicated audio router with dozens each of external disembedders and external embedders. These external devices have another point of control and another user interface for operators to learn and use. All of these separate devices are also cabled together, incurring cabling costs. With a Hybrid router, the previously mentioned setup is replaced by one chassis with one interface (See figure 4).

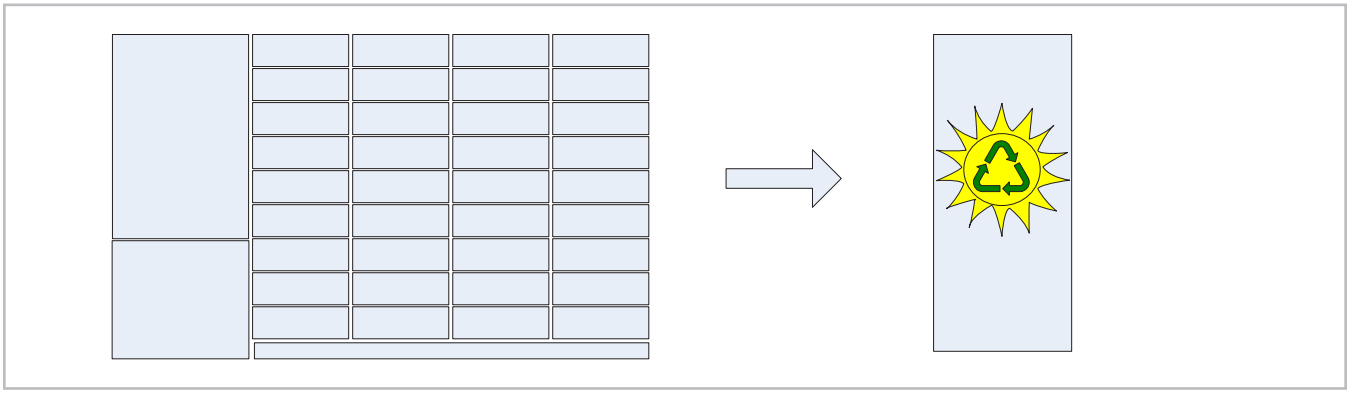

Figure 4.

Imagine building a similar truck within the EU, for example, where the height, width, length and weight of the truck are highly regulated. It would be a daunting task without a Hybrid router. The Hybrid router solution provides the truck company with less equipment, freeing up valuable space and also producing less heat thereby reducing cooling requirements. The reduction in equipment and cooling requirements mean a reduction in ambient noise levels, a very important aspect for operators inside the truck. Hybrid routers require fewer cables further reducing the weight load and reducing fuel costs. The reduction in cables also adds up to less labor required for installation of the cables and provides fewer points where cable connectors can fail. Trucks are especially vulnerable to cables rattling loose while moving. Hybrid routers are a natural fit within the production truck environment due to their space, weight, and power saving characteristics.

Ingest

Ingest at facilities such as a multi-language international broadcasting facility can be simplified using a Hybrid router. The embedded audio channels in a video source may be arranged in a particular order, with the primary stereo pair containing one language such as English. When the video source is ingested into a facility that supports multiple languages the embedded audio will need to be switched or shuffled around to support other languages in the primary pair or elsewhere. Before Hybrids, the facility would need several external disembedders and embedders to handle the audio exchange. For instance, a common situation would be substituting the embedded audio within a video source that is being routed to several different destinations with different target languages. To change the language on the primary audio pair from English to Spanish, the operator would need to route the source to an external disembedder at which point the operator would have to swizzle the now disembedded channels of audio via a separate user interface. After being shuffled around to the correct locations, the audio would need to be routed back to an embedder to be combined with the original video and then routed to the final destination. For one language exchange, the switch involves two external devices, a separate user interface and four routes. The extra steps may be inconvenient, but these steps are generally tolerated. However, some of these broadcasters handle in excess of ninety (90) languages. The extra steps add up.

With a Hybrid router, the user selects the video source and the audio sources they require, whether the audio source is within the same input feed or a completely different input feed, and push the “take” button. The router will take care of the rest. The Hybrid simplifies the language exchange to one step and one control interface.

The ability of the Hybrid router to handle shuffling and breakaways of 16 channels of embedded audio without using external equipment simplifies the overall workflow of the facility. Channel shuffling abilities can be applied to feed the downstream encoders in a file based system. The Hybrid router streamlines multilingual ingest for a cleaner workflow that is easier to manage.

Managing a hybrid: control and status

By reducing several pieces of equipment down to one, Hybrids have simplified the setup within a facility. Now Hybrids will also simplify the control aspects by presenting a unified interface for system control. There is one place to control multiple operations and determine status, simplifying the use of the equipment.

The size of the audio matrix inside a Hybrid router is enormous compared to conventional audio routers as all of the embedded audio is accessible. As a case in point, Grass Valley's Hybrid router has space for a 9,216x18,432 matrix of audio channels which provides over 169 million cross points in one frame. It takes a special form of control to handle a matrix of that size and special control panels to simplify the user interface. It is difficult to display and control sixteen (16) channels of audio from a control panel with only a few text lines of visibility. Working with a user interface in which audio stems and re-legendable buttons are presented eases understanding.

Not only has the size of the matrix and number of audio channels made control difficult, the flexible configuration increases the challenge. In order to make the most of an intermingled frame with standard input cards and standard output cards mixed with special function cards, a unique form of control is needed to handle internal pathfinding to allow complete access to all audio within the router, including the embedded audio on the standard cards.

This type of control essentially manages a dynamic address remapping system to provide transparency to the user or operator. For instance, to route video and some of the embedded audio from one source and combine it with embedded audio from a second source would require both sources to have their audio disembedded, shuffled and then re-embedded. In other words, the router handles the entire breakaway, including the break-out of the audio from the video source to the TDM matrix, the shuffling of the audio and then the "break-in" of the audio on a mono channel basis to a new video output. Figure 5 shows what the router is actually doing. Figure 6 shows what it looks like to the user.

These control mechanisms simplify the path finding, leaving the disembedding and embedding transparent, without requiring the operator to utilize a secondary interface to shuffle and recombine the audio. For example, before the Hybrid, in order to combine audio from two video sources, the user would have to perform one or more video takes to disembedders, shuffle the audio and then perform another video take to re-embed or "break-in" the audio to the destination. With a Hybrid system, the operator selects the video and audio sources, embedded or not, and the destination. When "Take" is pushed, the router automatically handles any sources that need to be disembedded and re-embedded. A complex task is simplified down to a single operation.

When the video and audio sources are from the same port the Hybrid routes all the signals straight through with an Audio Follows Video (AFV) take, leaving the original source untouched. The router is able to take advantage of this condition and allow video with embedded audio to travel through the system without being disembedded or embedded.

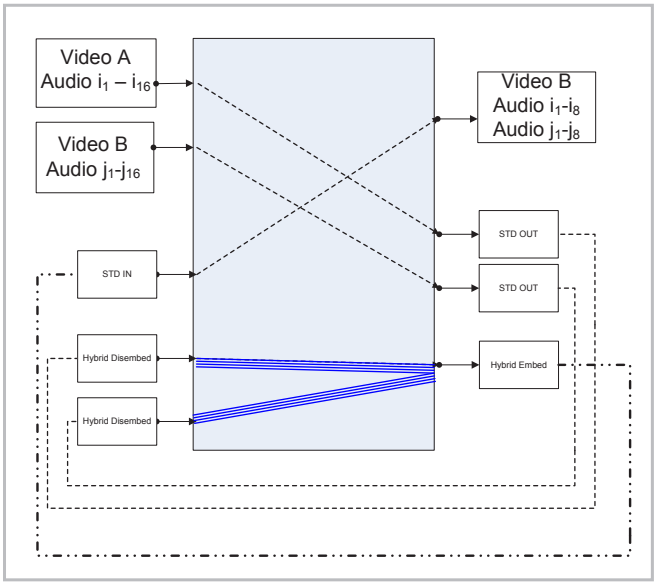

Figure 5

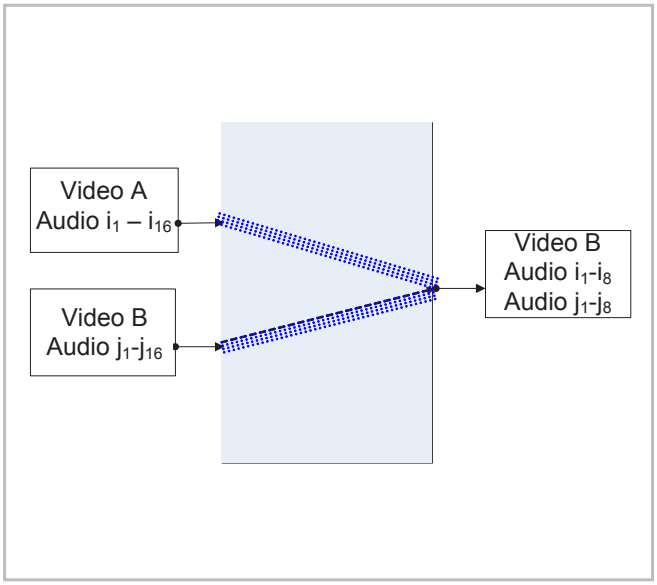

Figure 6

Wave of the future

Hybrids represent a previously unattainable set of capabilities and a means to reduce capital expenditures. A router is a core functional unit and a significant procurement, potentially a fifteen (15) year investment, and needs to be protected from obsolescence. The Hybrid offers a facility the unprecedented ability to accommodate future technological developments with relative ease. The Hybrid router, by its very nature, supports changes in functional blocks of the router in the near and possibly distant future.

To facilitate future expansion, Hybrids need to be flexible, allowing any configuration of cards within their frame. The most functional Hybrid router allows for card by card physical layer configuration. The flexibility in configuration lets the router adapt to the needs of the customer. Since new and special function cards often incur higher costs than standard or older cards, a broadcaster may only want to add a few at a time, creating a mixture of past and current cards intermingled within one frame. This design allows future cards to be added. This flexibility will allow the router to grow with new technology for years to come.

Conclusion

Hybrid routers represent the next evolutionary phase of router technology. Their capabilities and benefits represent a sensible solution to some of the many challenges television facilities face today. Hybrids are economical and space saving while bringing together and simplifying the advances of technology into one versatile product. The Hybrid router has application advantages in the areas of ingest, production for both studios and trucks, and by simplifying installation, control and management. This new type of router, the Hybrid router, is the beginning of a new era of super routers: routers that can do more than just route.

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