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Crafted Transmission for Multimode Distribution

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The Changing Landscape of Video Content Delivery

During the past ten years we have seen increasingly rapid advances in digital methods of video recording, storage and distribution. During this same period, the technologies available for the transport of digital data over both wired and wireless media have evolved to provide dramatic increases in available bandwidth at substantially lower cost. One of the most visible results of the confluence of these two trends is the explosion of relatively low cost consumer electronics for the reception, storage and playback of video content.

From 1950 through 1974, consumers had only two choices for receiving video content: movies or television. Both required viewers to adapt their schedule to the viewing times provided by distributors: movie houses or TV networks. With introduction of the Sony Betamax in 1975, viewers for the first time had full control of their video entertainment schedule. As the Betamax concept evolved into today's widespread adoption of products like DVD media and intelligent DVRs, viewers have been provided more and more options to manage their scheduling and selection of content viewing. However, despite this substantially increased flexibility, and until very recently, one basic fact has remained true: video content was ultimately delivered to the viewer in one of two ways — at a movie theater or on a home television set.

Now, just within the past few years, a potential change in this legacy delivery model is emerging. New modes of distribution utilizing available high-bandwidth paths all the way to the consumer, coupled with new devices that are capable of utilizing this bandwidth for video reception, are knocking at the consumer's door. In other words, while movie theaters have generally retained their market share of viewers and may well increase it with digital cinema, television sets in the home now have challengers for their share of consumer eyeballs.

I say "potential" change because despite the availability of technology and devices that support this change, the vast majority of video consumers have not yet spoken. After a seemingly slow transition, these consumers are just now buying high-definition television sets in volume. For most viewers, the move to a large, flat panel HDTV display — perhaps accompanied by their first exposure to surround sound audio — is by far the biggest change in their home video experience since moving to color TV in the 1960s. These consumers expect that broadcasters will validate their buying decision by continuing to provide the content they want through this new receiver.

So what about those new modes of delivery?

With their new 50-inch HDTV in place, why should consumers care about receiving TV on the 3-inch display of their mobile phones, PDAs or iPods? Why would they want to take the time and trouble to learn how they can find and watch TV programming on their home computer when their smart DVR makes it all so much easier? Just because it's possible — or even relatively inexpensive — doesn't drive acceptance beyond the "lunatic fringe" of early adopters. In short, what's the payoff for the viewer? In many ways, new modes of video delivery to devices like mobiles phones or home computers seem like answers searching for questions.

The one clear potential benefit of these new modes of delivery, however, is their flexibility. The new receivers such as mobile devices and laptop computers are portable and can support both push (scheduled) and pull (VOD) delivery models. For the viewer, this means more choices of when and how they can get the content they want. These are powerful incentives, but the widespread adoption of these new delivery models by content consumers still depends on broadcasters' responses to several major questions. Besides the obvious issues of cost and coverage, one key question is this: What must the viewer sacrifice in quality and aesthetics in order to get the benefits of this flexibility?

Lessons Learned from Sixty Years of Television

Predicting consumer acceptance is an inexact science at best. Why was the home VCR such a major success while the video phone of the 60s remained an idea whose time never came? For largely utilitarian products, the answers usually lie in reliability, ease of use, and cost/benefit evaluation. For aesthetic products like broadcast television, the answers are not nearly as evident.

Your choice of a local evening newscast from among the three or four available in your market could certainly be based on your preference for the anchor, but it might just as likely be a result of not bothering to change channels after the national newscast you prefer. Perhaps you find the weather reporter humorous or attractive, or like the graphics they use for the five-day forecast? Maybe the sports anchor focuses more time on college sports than his competitors? Your choice could just as well be a subconscious preference that you can't easily describe. Perhaps to you the implied urgency in the music and graphics of their newscast opening implies the very latest news, or their split screen interview format lets you watch the facial expressions of the participants on both sides of an issue. This type of subjective decision process isn't just limited to news. Similarly obscure factors may be at work when the typically longer length of the opening segment results in you choosing CBS's "CSI:NY" over NBC's "Law and Order" airing at the same time.

The point here is that the viewer's choice of a TV channel involves more than just the program content it offers. A channel's presentation of a program creates a perceived "added value" that may influence your choice when the program content on two channels is equally appealing.

One of the byproducts of 60 years of television experience and viewer reaction is that broadcasters understand that this perceived value is part of their brand. The "crafting" of a channel to add viewing value beyond the core program content becomes an essential part of the brand. Appealing graphics and audio/video transitions - even carefully timed black frame separations — that comprise interstitial sequences create a "look and feel" that is part of the channel's brand, and the brand creates viewer loyalty. Certainly program content is most important, but when this choice is a close call for the viewer, subconscious brand loyalty can make the difference.

Channel crafting also requires an awareness of viewer tolerances. Questions like "How many breaks and how much total commercial time will a viewer accept in a half-hour or hour-long program?" have been answered empirically over many years and these limits are ignored by broadcasters at their peril. Some such limits have even been imposed by legislation, such as for children's programming.

How do these lessons of crafted transmission apply to the new modes of distribution?

In many cases, the rush to bring these new delivery models to the consumer has so far ignored the lessons of commercial television brand creation. Simply dealing with the technical issues of delivering the signal to these new receivers reliably and in a minimally acceptable form has been challenge enough for the new mode delivery pioneers. In general, content has been taken "as is" from producers of traditional TV entertainment, news and sports programs and delivered in "cuts only", linear streams or unaltered as VOD files. In some cases, this lack of attention to the details of crafted delivery is simply due to inexperience. New players in content distribution such as Telcos and Internet portal operators often do not include staff experienced in the fine points of effective channel crafting.

Even where attempts have been made to follow traditional TV channel models, the results can be ineffective and sometimes detrimental to building viewer loyalty. Unlike the addition of new channels to traditional television delivery such as those brought about by DTV, the new modes of delivery to mobile and home computer are not simply more of the same. For example, delivery to a handheld, mobile device immediately changes the rules for some basic precepts of television like viewer attention span. If the viewer cannot be expected to watch a complete program segment without interruption, the continuity of the program and/or the dramatic effect of the segment may be lost. Moreover, the relatively small size of the mobile display (and its reduced resolution) may render some graphics unreadable, unusable and or simply ineffective.

Commercial spots are likewise troublesome. If the mobile viewer requires shorter program segments, what will their tolerance be for the length of commercial breaks between segments? One fact is certain: viewers will make these judgments in part by comparison to their tolerances established over many years of home television viewing.

For the home computer viewer, the change of venue brings other considerations. By its very nature the home computer, especially once connected to the Internet, is primarily a “pull” device or in the video realm a VOD appliance. Users (viewers) expect to get the content they want on demand, not on a schedule. At the same time, as with anything they do on the computer, they expect to have full control of the playout, stopping and restarting as desired, and skipping over unwanted commercial spots.

This point about commercial content tolerance among potential mobile device and home computer viewers is perhaps one of the best examples of the challenges faced by providers of new mode delivery.

One likely solution lies in the lessons of the past - crafted transmission, but crafted in new ways to overcome the inherent limitations of the new mode receivers. For example, in place of two-minute breaks of four 30-second spots, commercial messages could be delivered during the program. Not by ”product placement” within the program itself as we now see frequently in new programs, but rather as a discrete overlay during the program segment. Such “overlaid commercial spots” could consist of a short video clip or animated graphic, brought on screen with a pleasing transition, and including a very brief voice-over message or having no audio at all. An overlaid commercial spot like this need only linger on screen long enough to imprint the conscious (or subconscious) mind of the viewer. This type of element is already being seen as promos for some network programs.

By combining several such changes in the channel format (e.g., shorter segment lengths, fewer or shorter breaks, and overlaid commercial elements) linear delivery to a mobile phone could potentially appeal to the viewer and still provide a workable business model.

For a VOD model such as is likely for home computers, a revised format might include a single opening break combined with periodic overlaid commercials. If done well, such a format might provide the uninterrupted content expected by the VOD viewer, with commercial messages unobtrusive enough to escape the viewer’s ire but still deliver their message effectively.

The table below illustrates some potentially broad differences in format that may be required for commercially successful video content delivery to different types of receivers. The optimal parameters for each model could also vary by type of program content (e.g., entertainment, news, sports, educational).

	Home TV (Current)	Mobile Device	Home Computer
Type of Delivery	Scheduled linear	Scheduled linear	VOD
Practical Maximum Program Length	120 Minutes	30 minutes	60 minutes
Minimum Segment Length	10 Minutes	5 minutes	30 minutes
Maximum Break Length	2:30	:30	2:30 (opening break)
Maximum Spots/Break	5	2	3
Max Breaks/Program	12	5	1 (opening break)
3D Level Overlaid Commercial Messages	Possible	Likely	Very likely

Figure 1 – Possible Channel Format Parameters by Receiver Type

Changing Business Models for Broadcasting

Recalling our earlier assertion that the available new modes of delivery are, at this time, still only potential threats to home television viewing, the preceding discussion of channel crafting and its relationship to viewer acceptance is just one side of the coin. The other side is the economics of a successful broadcast business model.

Along with, and in part because of, the availability of new modes of distribution, the number of potentially available channels has expanded exponentially. As recently as the 1980s most TV viewers had to select among fewer than ten VHF/UHF channels in their local area. With the wide deployment of cable television and later DBS, the number of channels available to most home TVs is now in the hundreds.

Independent of any new modes of delivery, the economics of broadcast television have changed dramatically. More specifically, the business model for a new channel bears little resemblance to the model of a local network affiliate station in 1980. From a single channel that enjoyed a 10-25% share of an advertising market split among a small number of local media outlets (TV, radio, print), we have moved to a single channel among hundreds of TV channel competitors – plus radio and print – and further diluted by Internet advertising.

For the broadcast operator, the changes that this new reality forces on the business model are draconian:

- Much smaller audience = Less market penetration to offer advertisers
- More competition for advertising = Lower airtime rates required
- Added value required for differentiation = Content selection and effective channel crafting

These factors add up to one inescapable conclusion:

In order to survive, a broadcast channel must provide more perceived value than most competitors, but operate at a progressively lower cost of delivery to accommodate lower advertising or subscriber rates.

Broadcast Technology for Crafted Transmission

There are many components included in the cost of delivering a channel, some of which are largely outside the control of an individual broadcast operator such as the cost of content or of satellite transponder time. Two of the most controllable costs at the individual channel or facility level are those of staff and equipment. These two costs are also interrelated in that, for operations and maintenance staff, the number and skill level of staff required is mandated by the complexity and reliability of the equipment.

In response to the demand for channel crafting, broadcast equipment manufacturers have responded to the demands of broadcasters by producing a wide array of specialized devices that comprise a modern "transmission chain" — essentially an assembly line for the television channel they deliver. This model is familiar to anyone who has worked in television and it has been proven to be both reliable in operation and flexible enough to meet the continuing demand for more channel crafting.

In most broadcast operations originating channels, the current transmission chain is built from specialized broadcast hardware and looks something like this:

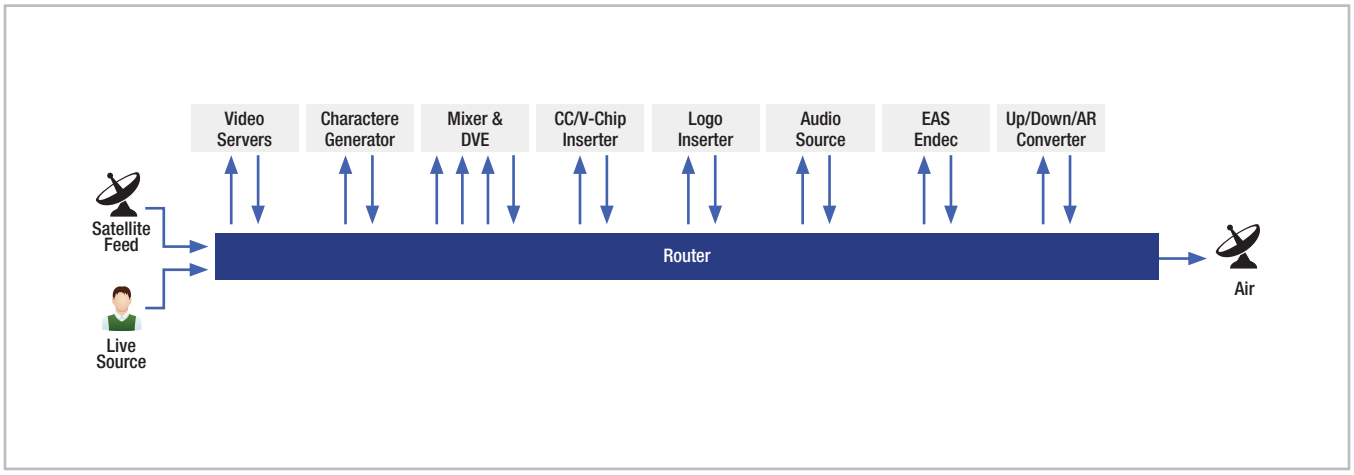

Figure 2 – Conventional Broadcast Transmission Chain

Each device in the chain either originates or modifies a part of the signal (video, audio or ancillary data) while the router moves the output of each operation to the next step in the process. This simplistic depiction and description of a broadcast transmission chain illustrate the largely serial flow of this process. While each individual channel may not utilize all of these components and may require some I have not shown, the assembly line metaphor is a good one. Each component provides a specific process (or set of processes) acting on the composite result of prior components.

Moving to an IT-Based Transmission Chain

Coincident with the evolution of the broadcast business model, the past fifteen years have seen an increased use of computer components and software in new broadcast equipment. Two prominent examples are the emergence during the 1990s of video servers, essentially computers acting on files of digitized content, and branding devices like logo inserters – computers that manipulate and insert graphic images into digital video streams. Both these devices utilize off-the-shelf IT processor and memory chips developed for general purpose computers, but provide their unique functionality via specially designed software, in a few cases augmented by custom-designed hardware acceleration. Unfortunately for broadcasters, the pricing of these IT-based devices continues to be derived from their packaging and market positioning as special purpose broadcast equipment rather than reflecting their lower costs of development and manufacture.

In other words, while these products enjoy the benefits of IT in their design and development, end users are not always among the beneficiaries. This fact applies not only to equipment prices, but also to lack of interoperability, flexible configuration and incremental scalability as compared to solutions operating on standard IT platforms.

One of the factors that had stalled the application of IT to more of the television transmission process was the emergence of HDTV. This is a simple question of requirements outpacing technology – something that has not often occurred in the history of IT. As the bandwidth requirements of HDTV became known and initial delivery solutions were planned, the performance of general purpose IT processor chips like the Intel Pentium and their supporting infrastructure of memory and busses were not yet capable of the required throughput.

In testing done by our company's labs in 2004, the mixing of two HD video frames as part of a cross fade transition (one of the most processor intensive video operations) required 28 milliseconds on an enterprise IT server. Less than a frame, but just barely, and with not nearly enough headroom for consistently smooth video transitions, much less when other operations such as logo insertion are to be done in the same frame interval. By late 2005 the situation had changed. Testing with the then-new AMD Opteron dual-core processor (including software redesign to take advantage of the DSP instruction set in the Opteron CPU) resulted in the same HD frame mix requiring less than 2 milliseconds.

Today, Moore's Law continues and processor power from both Intel and AMD has outstripped the requirements of HDTV by a wide margin. While it's a big step from lab testing to deployed product, a significant milestone has been reached. IT is now capable of replacing all the components of a typical broadcast transmission chain with an all-software solution. Equally as significant, such a solution can be deployed on standard, general purpose computer hardware and operating system software. What this means is that the "special purpose" requirements of broadcast transmission can be encapsulated entirely in software to provide transmission solutions at lower cost and with greatly simplified configuration, increased flexibility and improved scalability.

Based on the encouraging results of our preliminary R&D done in 2004-2005, we have continued development of such a software-based transmission chain. The resultant operational system provides a process flow that closely resembles the processing done by the broadcast hardware devices shown in Figure 2 above. This software-based system has been implemented on the Microsoft .NET platform and employs distributed services architecture with "plug in" software modules for each area of functionality required. As you can see from the diagram below, the process flow and software modules map closely to the sequence and functions of the hardware components of a conventional transmission chain.

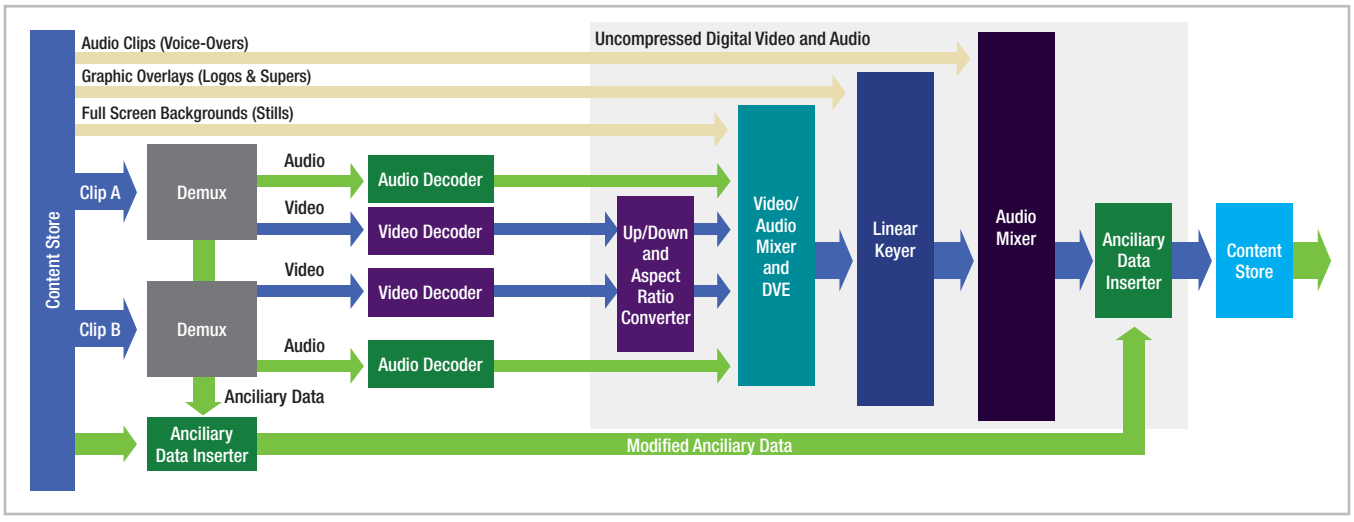

Figure 3 — Software-Based Transmission Chain

As shown in the diagram above:

- Demuxing and Decoding software replicates video clip processing functions provided by video servers;
- Up/Down/Aspect Ratio Converter software replaces hardware converters to normalize video content to the target format, allowing mixed resolution content to be used for any type of channel;
- Video/Audio Mixer software replicates the functions of a master control switcher (vision mixer) and is augmented by DVE software replicating the DVE option of a master switcher;
- Linear Keyer software provides the functions of master switcher keyers or downstream logo inserters (DSKs);
- Audio Mixer software provides secondary audio mixing of voice-overs, SAP or insertion of cue tones;
- An Ancillary Data Processor and associated Inserter manage captions, audio metadata and other information carried in the VBI or VANC space of the transmission signal.

After the initial demux/decode steps, the subsequent software processes operate on uncompressed digital video in the YUV colorspace and uncompressed digital audio (PCM). As a final step, a standard PC I/O card is used to convert the resultant video/audio/data signals to 601/SDI, HD/SDI or IP streaming video as required for the channel. Similarly, live content sources can be introduced into this process through the same card (not shown).

Benefits of IT-Based Solutions

Moving to an IT-based solution for transmission brings the direct benefits of lower initial (capital) and ongoing (operating) costs for the broadcaster. In multi-channel facilities transmitting six (6) channels or more, the estimated reduction in power consumption to be realized by replacing a typical broadcast hardware transmission chain with a software solution on an IT hardware platform exceeds 40%.

Moreover, an IT-based solution brings two other benefits that are not easily quantified in advance, but could have major long-term significance for broadcasters:

(1) Product Market Size — The size of the IT marketplace dwarfs the current market for conventional broadcast technology products. Massive R&D investments by companies like Microsoft, Intel, AMD, Cisco and Hewlett Packard continue to go into general purpose components such as operating and database system software, server architecture, processors, memory chips, networks and large capacity storage devices. By deploying solutions based on such widely-used technology, broadcasters will benefit from these massive investments with rapid improvements and the broad selection of products that IT continues to produce, along with the high quality and lowering prices that enterprise IT users demand.

(2) Availability of Technical Staff — Any broadcaster who has tried to fill a "broadcast engineer" position recently knows that this task is becoming more difficult every year. Conversely, the available pool of IT-trained personnel continues to grow. Like any specific application of IT, broadcasting requires some specialized knowledge, but with broadcast operations becoming more and more "file processing" operations, the requirements for specialized knowledge are reduced and more easily satisfied with on-the-job training.

At this time, based on products shown at the most recent NAB and IBC conferences (April and September 2007), eleven (11) companies are offering IT-based software transmission systems. While not all of these products fully implement the model described here by using software components for all functions of the transmission chain, several of them are "all software" and all the referenced products provide IT-based playout of at least the primary video content.

IT-based solutions continue to expand the scope of their coverage of broadcast requirements. The inherent benefits of configuration simplicity, available redundancy and scalability have particular appeal to large multi-channel operators and to those broadcasters launching new channels or new modes of delivery for existing channels.