LIMITED VISION

The Techno-Political War to Control the Future of Digital Mass Media

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In his book, “Defining Vision: The Battle for the Future of Television,” reporter Joel Brinkley tells how the drive for Advanced Television has its roots in an FCC proposal to take spectrum space away from broadcasters and reserve it for land mobile applications. In an effort to hang onto their precious frequencies-and inspired by Japanese High Definition Television experiments—the broadcasters were struck by a brainstorm: they would say they needed the spectrum space for HDTV.

Brinkley’s book describes the discussion that ensued at that 1986 meeting. An unidentified participant in the meeting reportedly raised a concern: “‘Yeah, but what if we really get it?’”

Starting Gun or Warning Shot?

A decade latter, on April 3, 1997, the Federal Communications Commission issued two historic orders, allocating a second digital television channel to each of the nation’s high-powered analog television broadcasters. Instead of using this channel to augment NTSC broadcasts, as the broadcasters had proposed 10 years previously, the digital channel will entirely replace NTSC service after a proposed 9-year transition period.

This is a techno-political war that will eventually touch every aspect of our lives. It is not just about the transition to a high resolution version of broadcast television. It is a story about the efforts of the privileged few to prolong their dominance of mass media. At the same time, it is a story about the birth of a new communications medium, enabled by a shift from a profusion of non-interoperable standards associated with analog communication and consumer electronics products, to open, interoperable and extensible standards for digital information appliances.

Delaying Tactics

When the National Association of Broadcasters asked to FCC in 1987 to investigate the spectrum requirements for HDTV, they had little reason to be concerned that they would ever be asked to actually deliver it. There was no urgency in the early years of the advanced television process, except perhaps on the part of the Japanese, who had a clear lead with HDTV technology and expected their system to be selected.

There was another phenomenon taking place across the land, however, that would soon change this picture and the tactics used by broadcasters to control their destiny: the astonishing growth of the personal computer.

Throughout the ’80s, as computing power became cheaper and simpler, the video industry created digitized version of the analog video formats used by video professionals in broadcast and video production applications. Digital video became the “high-priced spread,” available only to the privileged few.

In 1990, Moore’s Law caught up to the video production industry, when General Instruments announced it would submit a digital HDTV system for testing in the advanced television process. Video compression technology not only made it possible to deliver a digital television signal to the masses, GI claimed it could deliver HDTV in a single 6 MHz terrestrial broadcast channel. So much for the NAB’s stated need for extra spectrum.

Within a matter of months, four of the industry groups with analog HDTV proposals switched to a digital approach-only Japan’s NHK continued to promote an analog HDTV solution.

Perhaps of even greater significance, several system proponents indicated that it would be possible to place new digital channels into vacant channels, without causing interference with existing NTSC service.

The Chairman of the FCC at that time, Al Sikes, quickly jumped on the opportunity, and the Commission changed the rules of the advanced television process. Broadcasters would be loaned a 6 MHz digital channel to simulcast programs carried on their NTSC channel. After a seven year transition period the NTSC channels would be returned and reassigned for new services. Rather than tying up all of the spectrum for a two-channel augmentation approach to HDTV, Digital HDTV would allow the government to reclaim a major chunk of the broadcast spectrum, eventually.

In 1992, I presented a paper at a Society of Motion Picture and Television Engineers Advanced Technology Conference entitled, “The Advantages of Scalable Digital Video.” The paper advocated a much different approach to standards for digital video.

Every other imaging industry in the world has a hierarchy of standards for image quality. With photography, sampling resolution can range from the ubiquitous 35mm negative to 8 x 10 inch negatives, or larger; prints of almost any size and aspect ratio can be produced from these negatives. In print publishing quality can range from printing screens with less than 100 line per inch resolution, used in newspapers and laser printers, to hundreds of line per inch for high quality lithography.

By comparison, however, video has defined limits on image quality based on the sampling parameters of video formats. NTSC compatible products may not fully utilize the capacity of the 6 MHz channel, but the upper limit on resolution is fixed, along with the raster size and aspect ratio. The five proposed systems for advanced television broadcasts, which by 1992 was being called digital television (DTV), were based on a single video format with a 16:9 aspect ratio.

I proposed that video should have the same flexibility as any other imaging system; that we simply specify the horizontal and vertical size of the image and the temporal rate, in progressively scanned frames per second. Furthermore, I suggested that for many applications it might be desirable to encode the images in a spatial resolution hierarchy using a sub-band coding technique. In this way, the end-user could retrieve only the level of image quality that they could display, pulling the required information from a packetized digital bit stream.

This was in essence, the exact concept that the broadcasters had advocated in 1987, when they asked for a second channel to augment existing broadcasts to deliver HDTV. A base-layer encoding would deliver standard quality to low cost receivers, while augmentation bitstreams would deliver higher levels of image quality to HDTV receivers.

The theme of the conference was “Video and Computing: Convergence or Collision?” The traditional SMPTE audience saw a collision; members of the computer industry in the audience saw convergence. Battle lines were drawn.

Several computer companies, including Apple and Digital Equipment Corp., were making lots of noise about the potential benefits of the convergence of video and computing. They caught the ear of several members of Congress and FCC Chairman Sikes, who requested that the Advisory Committee on Advanced Television Service consider three new requirements to promote the convergence of television and computing: the system should be *interoperable*, *scalable* and *extensible*.

In April of 1992, I became a participant in the SMPTE Task Force on Digital Image Architecture. The task force was created at the request of several international standards organizations to develop a report on the requirements for an interoperable, scalable and extensible architecture for digital imaging systems. Over a period of six remarkable weeks, some of the leading engineering talent from the video and computer industries met via telephone conferences and a then-novel communications medium called an e-mail reflector list, to create the report.

The report, published in the fall of 1992, is available on the Web <http://icib.igd.fhg.de/icib/tv/org/smpte/s17.42/dia-fr.html>. The video industry was stunned by the speed with which the report was created, not to mention the recommendations. They dug in their heels to delay the inevitable convergence of video and computing.

Display Scalability and Decoupling

The display in your family room operates synchronously with the signal delivered by the broadcaster. You're seeing exactly what the broadcaster is sending, when it's being sent. Digital technology can erase that limitation. A computer can display video in a different resolution than what was transmitted, in a different size window than it was intended for, and at a different time. This illustrates the decoupling of the acquisition, transmission and display components of the digital television systems.

Figure 1 illustrates the relationship between actual display resolution and viewing distance, relative to perceived resolution. The letters in this figure are reproduced at four levels of resolution. Each "layer" has double the resolution of the one above it, forming a power-of-two image hierarchy. If you take the test described in the figure, it becomes clear that excess resolution provides little if any benefit to the viewer.

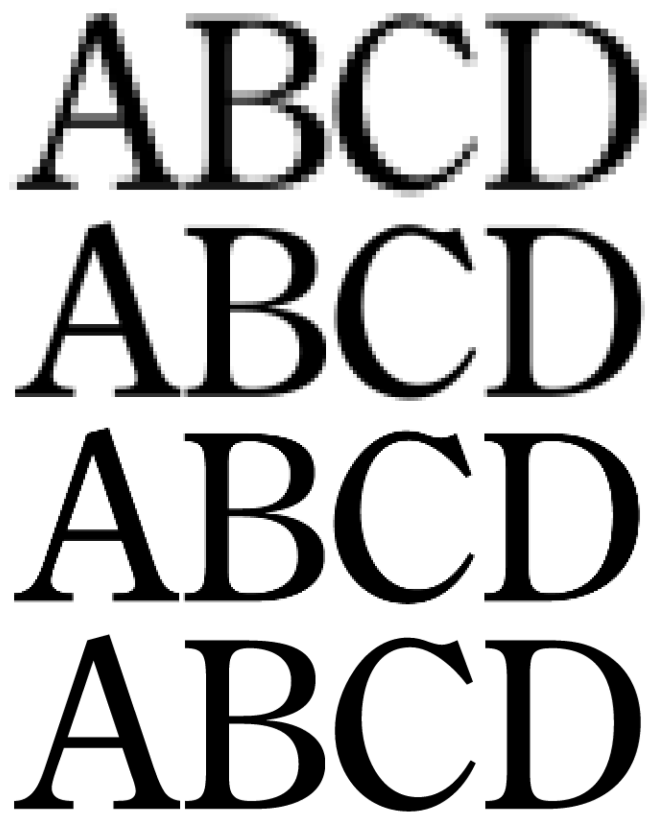
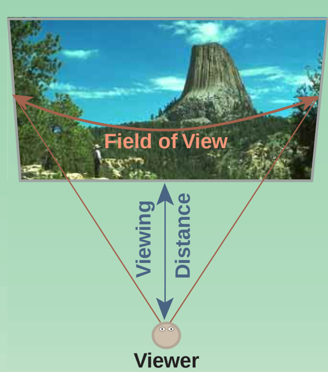


Figure 1. A Resolution Hierarchy
These groups of letters represent a power-of-two spatial resolution hierarchy–each level has double the resolution of the layer above it. To better understand the practical application in displays, place this figure where it can be viewed from a distance of between 30 inches and 15 feet. The letters on the bottom should be sharp at 30 inches; as you increase the viewing distance each level will become sharp as your eyes can no longer perceive the differences in resolution.

Resolution Level	Average Field of View	Average Viewing Distance	Target Display H x V (rounded)	Pixels H x V (square)	Approximate Resolution cycles/degree
Level 1 Low Resolution	25°	30″ 76 cm	12″ x 7″ 30 x 18 cm	512 x 288	10
		108″ 274 cm	44″ x 25″ 112 x 64 cm		
Level 2 Normal Resolution	25°	30″ 76 cm	12″ x 7″ 30 x 18 cm	1024 x 576	20
		108″ 274 cm	44″ x 25″ 112 x 64 cm		
Level 3 High Resolution	35°	30″ 76 cm	19″ x 11″ 48 x 28 cm	2048 x 1152	30
		108″ 274 cm	68″ x 38″ 173 x 97 cm		
		360″ 914 cm	227″ x 127″ 577 x 323 cm		
	50°	108″ 274 cm	101″ x 57″ 257 x 145 cm		20
		360″ 914 cm	336″ x 189″ 853 x 480 cm		
Level 4 Ultra High Resolution	50°	30″ 76 cm	28″ x 16″ 71 x 41 cm	4096 x 2304	40
		108″ 274 cm	101″ x 57″ 257 x 145 cm		
		360″ 914 cm	336″ x 189″ 853 x 480 cm		



AVERAGE VIEWING DISTANCE

Distance	Applications
30″ 76 cm	Personal and Computer Displays
108″ 274 cm	Home Entertainment Systems
360″ 914 cm	Theatrical Display and Business Presentation

Figure 2. Example 16 x 9 Aspect Ratio

Figure 2 illustrates the relationships between display size, resolution and viewing distance, to deliver various levels of perceived resolution in different viewing applications.

For a new digital television system, the picture decoder should deliver images to a display buffer, optimized for the resolution of the local display and the typical viewing distance. Placing a scaling function, with properly designed filters, between the decoder and display buffers makes it possible to accommodate multiple formats with different levels of resolution and aspect ratios (see Figure 4 on page xx).

Decoupling also allows the viewer to choose between a cropped full-screen presentation of the content, with local pan & scan driven by coordinates embedded in the headers of the video bit stream, or letterbox presentation so that all of the information can be seen. It is also required if we want to use the display to present multiple objects or windows that are asynchronous to one another.

The Medium is the Message

The 1992 TFDIA Report set off a storm of controversy, identifying the critical issues that formed barriers to the convergence of video and computing. The advanced television process became a battleground, with numerous skirmishes, aimed at delaying the process and building barriers to the convergence of video and computing. Meanwhile, the Internet kept growing.

In response to Chairman Sikes' call for interoperability, the advisory committee created Working Party 4, to determine the extent to which each of the five systems that were undergoing testing, would be interoperable with computers. The WP4 review, published near the end of 1992, drove the final nail into the coffin for the analog HDTV system proposed by NHK. The four digital system proponents survived. After testing of the systems was completed in early 1993, ACATS reported that there was no clear winner. They suggested that the proponents consider working together, forming a "Grand Alliance" to develop a unified system proposal. In May 1993, the Grand Alliance was announced.

The Grand Alliance proposal borrowed from each of the proponent systems, creating a Chinese menu approach to digital television, with multiple formats, both interlaced and progressive scan, square and non-square pixels, and six frame rates. Many of the WP4 recommendations were ignored, while others were supported on a selective basis. The Grand Alliance claimed that they had accommodated the needs of the computer industry and quietly went back to work to develop the new system.

For the next 2 years the video industry traded barbs with the computer industry, while video equipment manufacturers tried to understand the implications of the Internet and the new computer-based tools that were gradually replacing traditional video production gear. In 1995, another controversy erupted as standard definition television video formats were added to the proposed DTV standard.

The computer industry had been advocating the use of a standard definition base-layer approach to video encoding, but the requests had fallen on deaf ears. The ACATS leadership claimed that they were only authorized to develop an HDTV standard. When several broadcast networks asked for the ability to transmit multiple SDTV programs in a single channel, however, the rules changed. Several SDTV formats were added to the proposed standard, bringing the total number of formats that a receiver would be expected to support to 17.

Meanwhile, the video compression technologies that enabled the dramatic shift to digital HDTV started showing up in the marketplace. The cable industry started testing interactive digital television networks, with video on-demand and home shopping. Industry leaders believed they were the heirs apparent to the convergence of video and the Internet, since they already had the best pipes into the home, and plans to build hybrid fiber/coax distribution networks. They had ambitions to become the gatekeepers of content for both television and the Internet, and their plans did not include HDTV.

Thompson, the French consumer electronics heavyweight (which sells televisions in the U.S. under the RCA name), had feet in multiple camps. A member of the Grand Alliance, Thompson teamed up with the Hughes subsidiary of General Motors for the launch of what would become the most successful new product in the history of the consumer electronics industry: a direct broadcast satellite (DBS) system called DirecTV.

The aspirations of the cable industry were dashed by the Internet phenomenon, specifically the World Wide Web. Cable moguls were developing proprietary interactive systems and trying to line up exclusive deals with content providers. They developed proprietary standards for delivering content, and expected to collect a toll for every transaction that took place on their networks. The content community vetoed that proposition, deciding instead to create content for the open standards of the Internet, such as HTML and Java.

What DirecTV demonstrated was that one could deliver more than 100 channels of video content, including near on-demand pay-per-view movies, to an 18-inch dish and digital set-top decoder. The success of DirecTV was a wake-up call for broadcasters, who realized that standard definition digital television was indeed a reality.

For the first time, there was a sense of urgency in the advanced television process. The success of DirecTV may help account for the desire of broadcasters to include SDTV formats in the DTV standard. They did not want to risk the chance that consumers might reject HDTV, opting instead for quantity over quality.

As if to add to the sense of urgency, broadcasters started to lose precious viewers to the net in significant numbers. Millions of consumers were spending their evenings in the den, watching the little screen of a computer and the growing content available through the Internet. To make matters worse, Microsoft, along with its allies, were beginning to get interested in turning that little screen into a big screen PC/TV.

Like the cable companies, Microsoft also had aspirations of becoming the gatekeeper of content, through their proprietary interface to the personal computer and stranglehold on PC market share. The Microsoft Network and MSNBC became visible signs that Bill Gates was not content with the domination of enterprise desktops and consumer multimedia PCs. The PC was approaching 40% penetration of the consumer market; televisions had 99.9% penetration, with multiple units in most homes.

Push = Broadcast

The Internet is much more than the physical servers and networks and appliances that draw information from it. The power of the Internet flows from a few fundamental concepts:

1. **Connections**: the ability to share information with anyone, anywhere, anytime, and the ability to route data through multiple paths to facilitate these connections and enhance reliability.

2. **Asynchronous communications**: the ability to forward information to one or many recipients, and store it for consumption at another time.

3. **Isochronous communications**: the ability to broadcast real-time events to anyone, anywhere, who wants to participate in the event.

Broadcasters are just awakening to the reality that with digital television they can leverage all of these important Internet concepts, and solve one of the biggest problems that plagues the Net today: inverse broadcasting. With DTV, the broadcaster can provide connections to a tidal wave of bits—18 megabits per second, 135 megabytes per minute, 8 gigabytes per hour. Compare that to what a 28.8Kbps modem can deliver.

Now think about the mess that the World Wide Web represents. A major content provider such the Wall Street Journal publishes an interactive edition. Millions of people try to connect to the Journal’s servers between 8 and 10 A.M. This is a paid service, so all of these people are subscribers. Wouldn’t it be easier to deliver the Wall Street Journal electronically, once, instead of having millions of people trying to come to the same newsstand?

Clearly, accessing the Internet and searching for information is also a critical part of the “message” of this new medium, as is the ability for individuals to become content creators. A huge amount of backbone traffic, however, could be eliminated by broadcasting content once to millions of subscribers.

There's no reason why digital television cannot provide the connections to deliver these bits.

Now think about the current infatuation with "push" technology and new standards like IP Multicast. This is pure broadcasting, the kind of bits that broadcasters could carry, with a big twist. DTV is the video-enabled Internet; at least the only one that many Americans are going to have access to in the foreseeable future.

To survive, broadcasters cannot afford to limit their vision to trying to deliver a marketable share of viewers. They must create a new business model based on delivering bits to the communities they serve. And they must become comfortable with the idea that they can receive compensation for bringing the people who buy and sell things together, even if this means that they might stop watching a program.

The business of digital television broadcasting will become the management of the data multiplex that feeds an 18 megabit per second channel, so as to maximize the revenue that can be produced at any given moment in time.

Some of these bits will carry traditional linear television programs. Occasionally a broadcaster may be able to maximize revenue by carrying one high resolution program. But most of the time they will be a common carrier of bits, an invaluable component of this concept we currently call the Internet.

If broadcasters adopt this business model, we can begin to think of a digital television receiver as a computer with an Internet address. It will be able to receive content customized for viewer preferences or to which a viewer subscribes, and the broadcaster will be paid to deliver this content. The digital media server in the family room will be able to filter information from the data multiplex and store it for later consumption.

The broadcaster will provide a variety of "on-demand" services to the community, both through the DTV channel and via back-channel connections to their Web server. News, election returns, sports scores, the local weather forecast, program guides, city directories, restaurant and movie guides — the server that feeds this information to the Web will also feed the DTV data multiplex, periodically updating information stored in a viewer's digital media server.

Imagine watching a commercial on the large screen display component of the digital media server in your family room. The video, audio, animation and graphic components of the linear commercial are also components of the 72-megabyte Web site just delivered to your server. These sites will become interactive brochures where you can manipulate photorealistic 3D renderings of products. For example, you could custom configure that new sports utility vehicle, then link to the Web to have a dealer bring one by for a test drive, set up financing, or deliver it.

Sadly, the standard for digital television developed through the ACATS process ignores most of this opportunity. The system designed by the Grand Alliance, approved by ACATS and documented by the Advanced Television Systems Committee, only defines the modulation and transport for the bits, the audio coding system, and 17 video formats optimized for the delivery of linear entertainment.

Fortunately, that's more than we need.

Let the Marketplace Decide

At the eleventh hour, the broadcast, computer, and consumer electronics industries agreed to a compromise that removed the video format requirements, allowing the marketplace to decide what digital television will look like in the future. The FCC adopted the proposed standard without the 17 video formats and without a mandate for HDTV broadcasts.

To help bring about this dramatic change, FCC Chairman Reed Hundt invited Microsoft to throw its weight around. Microsoft joined forces with Apple, Compaq, Cray, Dell, Hewlett Packard, Intel, Novell, Oracle, Silicon Graphics, and Tandem to form the Computer Industry Coalition on Advanced Television Service. Silicon Graphics did not play an active role and later indicated it was not part of CICATS.

When the FCC proposed adoption of the ATSC standard in a June 1996 Notice of Inquiry, CICATS, along with numerous other companies, filed extensive comments including a three-tier proposal:

1. Don't set any standard. Let the marketplace decide.

2. If the FCC must set a standard, approve only the modulation and data transport portions of the ATSC standard.

3. If the FCC felt a video format must be standardized, it should select the base-layer standard proposed by CICATS.

The base-layer proposal would have established a level of performance significantly higher than today's NTSC standard, using 480-line progressive scanning with the ability to deliver images with aspect ratios as wide as 2:1. Higher levels of resolution — up to 2 million pixel HDTV — would be supported via an augmentation bit stream that would only be decoded by HDTV receivers.

The broadcasters, and their consumer electronics industry partners, continued to support the ATSC standard, with its 17 formats. The FCC did not want to be put in the position of picking and choosing, so they asked all of the interested parties to try to work out a compromise.

Craig Mundie, Senior Vice President of Microsoft's Consumer Platform Group, played a pivotal role in these negotiations, essentially telling the broadcasters and consumer electronics manufacturers that they would become irrelevant if they chose to move ahead with a system optimized only for linear entertainment applications. The computer industry was prepared to help them with the DTV transition, but only if they would support the computer industry base-layer proposal.

On November 24, 1996 a compromise was announced, removing the requirement to use the 17 video formats of the ATSC standard. The standard, and this table can be downloaded as Adobe Acrobat .pdf files at <www.atsc.org>.

The FCC adopted the ATSC standard, without mandated video formats, in December 1996, and allocated DTV channels and established the rules of the transition on April 3rd, 1997. The full text of the 4th, 5th and 6th Report and Order in the ATV proceeding are available at the FCC's site <www.fcc.gov/mmb/dtv/dtv.html> .

The techno-political battle to protect the government-supported broadcast franchise has now become a marketplace battle.

The Shift to Data Broadcasting

The traditional assumption that television broadcasting is a one-way medium, incapable of delivering interactive services is been rendered meaningless by the shift to digital technology. Instead of dumb terminals, the digital television receiver has the potential to become a new kind of information appliance that leverages the power of both the Internet and digital broadcasting.

The debate has now evolved from digital television broadcasting to data broadcasting, using open standards from the computer industry. First and foremost among these standards is HTML. The development of HTML has proven to be the enabling technology for an entirely new form of electronic publishing, the World Wide Web.

At a fundamental level, HTML provides our first glimpse at several important concepts, which are now beginning to affect expectations for DTV:

- The ability to link a variety of media objects in a manner that permits the objects to be delivered and composed at the viewers location, as they are consumed. The flexible nature of HTML permits the local information appliance to present these objects in a manner appropriate for the local display and viewing conditions;

- The ability to continuously extend the capabilities of the standard and devices that support it, to facilitate new features and services.

Additionally, the Java programming language has emerged as a model for interoperability and extensibility of services that will be delivered via the Internet. The Java concepts can be extended to digital television. Java is based on two critical concepts:

- The virtual machine, and

- The ability to deliver data and the program required to consume it, by compiling the program to run on the local virtual machine.

Consumers may have several back-channel options for interacting with television broadcasts: telco, cable and wireless. More important, however, they may not need or want any back channel to consume interactive services delivered through the DTV channel. The ability to store broadcast data locally, in an information appliance, makes it possible to deliver interactive applications in much the same way that the Internet currently broadcasts data to servers all over the world.

Perhaps the most important implication of DTV, however, is that broadcasters will have sufficient bandwidth to deliver high quality audio and video along with these new interactive services. Equally important, they can do this in a totally non-invasive manner. Viewers can choose whether they want to send any information back, essentially building a privacy firewall between the viewer and the service provider. This level of privacy does not currently exist when a consumer connects to an Internet Web site.

Network Computers (NC) might play a role in the transition to digital television as the ideal DTV receiver. By definition, an NC draws much of its power from the network and the servers to which it is connected. But the server to which these NCs are connected is likely to be in the home, with a firewall between the server and the outside world.

There are many potential advantages to an in-home network architecture that uses a media server connected to low cost NCs. The server can deal with connections to various service providers — telcos, cable, DBS and DTV — routing the desired streams to information appliances optimized for specific applications: the big screen in the family room and personal workstations in the den, bedrooms, and kitchen. Portable information appliances may be optimized to decode only certain services carried by a digital broadcaster, such as paging and messaging systems, or a stock quotation service.

To better understand the data broadcasting opportunity, we must first understand the potential sources of data that will feed the DTV channel multiplex. There are three general categories of data that will feed the multiplex, as illustrated in Figure 3.

Programmed data looks the most familiar. These are bits that a broadcaster contracts to deliver at a given point in time: for example, a free-and-clear program, perhaps simulcast on an NTSC channel, provided to meet the broadcaster’s public service commitment. Programmed data is real-time. These packets must arrive on time or they are useless.

Unlike the isochronous nature of video programs, periodic data can be delivered in an asychronous manner—when it can be fit in. A good example of periodic data is the Teletext service that is delivered in the vertical interval of PAL broadcasts in France.

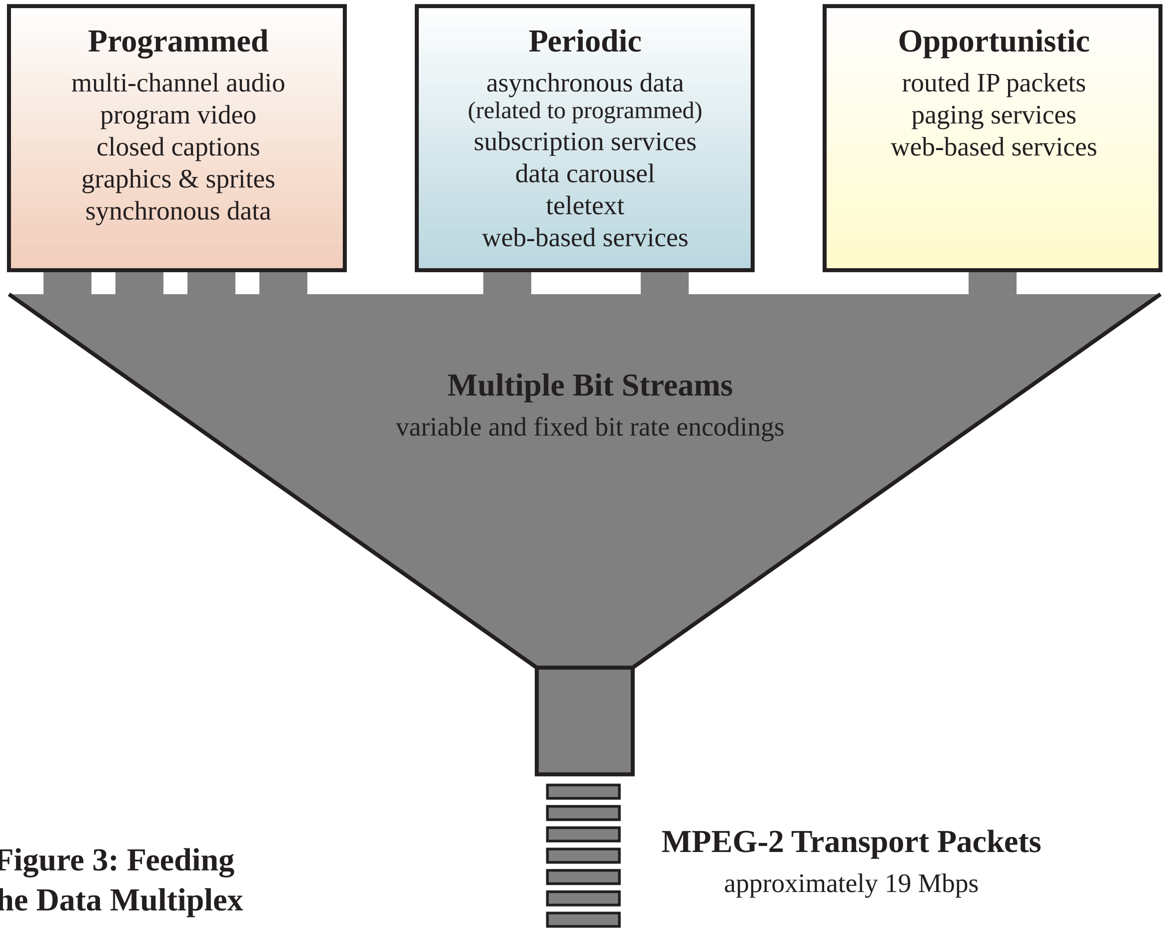


Figure 3: Feeding the Data Multiplex

Assume a broadcaster chooses to provide advertiser supported news headlines, sports scores, weather maps and forecasts to viewers through a web site and their DTV channel. When a DTV receiver tunes to the channel, it will receive a program map that indicates all of the services feeding the data multiplex. The receiver can set up a memory buffer to accept periodic data identified in this program map. This data is inserted in the multiplex periodically to update information and serve new customers who are acquiring the channel. Once in memory, this information will be available to viewers on demand (full screen), or it can be displayed continuously on an unused portion of the screen (a window), or as a program overlay.

Periodic data can also be used to provide other new revenue streams. For example, a broadcaster could deliver movie guides for local theaters, restaurant guides and printable coupons. Like programmed data, periodic data can be sold and scheduled, however, due to its asynchronous nature there is some flexibility in delivery time.

Opportunistic data has similar characteristics to periodic data. The major difference is that it may not be something that can be scheduled, or it may be data with a lower priority and thus may be sold at a lower rate. In either case, it will be delivered on a space available basis.

A good example of opportunistic data would be a paging service. The message size is small and thus easy to squeeze into the limited residual packets that are left over, and there is some latitude in delivery time. Another good example is the delivery of routed data packets to wireless information appliances, for Internet type services. An appliance of this type may use a back channel to request data packets, or it may simply filter the data carried in a DTV channel, looking for information to which it subscribes.

A new business model for digital broadcasting can be supported using the concepts outlined previously. Clearly, the broadcaster can deliver almost any type of service by delivering bits to a data broadcast enabled DTV receiver. There are, however, some problems with using terrestrial broadcast channels for applications where the integrity of the data is critical.

The absence of a back channel to request retransmission of packets that are lost or that contain errors makes it difficult to guarantee the integrity of data in applications that depend on error-free transmission, like a Java applet that will be compiled and run on the local processor. The MPEG-2 transport protocol, upon which the new DTV is based, does not assume error-free transmission. Instead, it depends on error concealment to hide the effects of lost data packets.

There are several ways to deal with this limitation in data broadcast applications.

- Add an error correction layer to the data transmissions, at the expense of a portion of the available bandwidth;
- Use periodic data updates to recover from earlier errors;
- Transmit data on multiple channels with time offsets.

Improved error correction may prove to be a viable option for certain applications. The nature of the errors that have been measured in field tests of the DTV modulation system tend to be of short duration, often the result of impulse noise. Error correction routines designed to deal with these burst errors could be implemented at the expense of channel bandwidth.

Periodic updates may provide a viable error correction solution in applications where data is being stored in the receiver for demand-based information services. If a packet is lost, it can be refreshed at the next periodic update.

In applications where streams of data require error-free delivery, time offsets within the same channel or on two channels can be used to provide error correction, at the obvious expense of channel bandwidth.

In certain applications, the service provider may want to deliver a data service to multiple channels within the same market, so as reach the maximum number of viewers. The data can be delivered to different channels with time offsets; information in the packet headers can indicate when this data will be delivered again and on what channel(s). Assuming that a digital media server in the home might be equipped with two or more demodulators, it could tune to another channel to capture packets lost in the original transmission.

This technique might also prove viable for applications where DTV channels are used to deliver large amounts of data to consumers or businesses in time periods when DTV channels might otherwise be underutilized (e.g. 1:00 - 6:00 a.m.). Dual-channel broadcasts with a small time offset could provide nearly real-time error correction.

Multiplexing Objects for Local Composition

For a number of years, this author and others have suggested that digital media content will be delivered in a variety of new ways. These techniques provide potential solutions to deal with the realities of accommodating program content with variable aspect ratios — including 4:3 and 16:9 — as well as a variety of new services, which can be delivered using data broadcasting techniques.

With the introduction of set-top computers optimized for the presentation of Internet web-based services, it is clear that capabilities for local, object-based, image composition will be desirable in many of the information appliances that will exist in the future. This includes PCs, NCs, and DTV receivers that will display video programs and information from data broadcasts. It is appropriate to think of these appliances as being nearly identical with respect to image and data processing components, but optimized for the applications and viewing environments in which they are used.

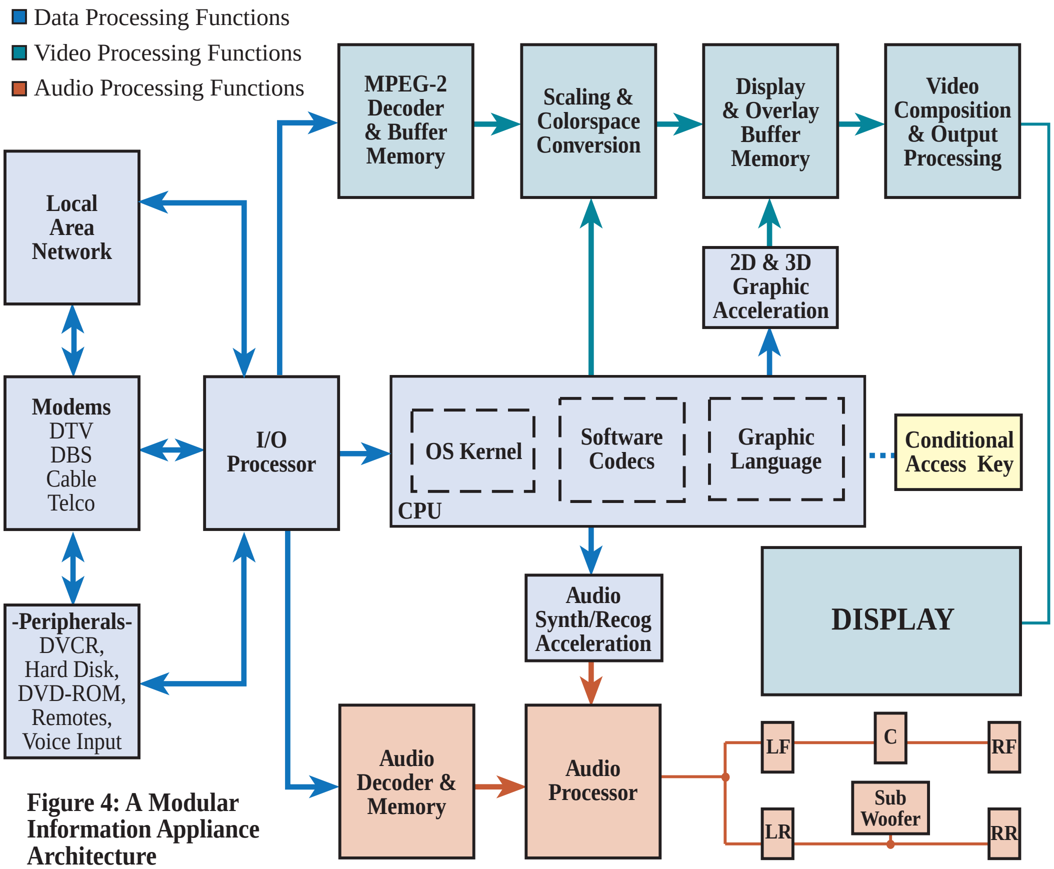


Figure 4: A Modular Information Appliance Architecture

Figure 4 provides a generalized view of the modular components that are likely to be found in these information appliances. Appliances that offer the kinds of processing capabilities identified in this figure are likely to emerge in the next generation of multimedia PCs or NCs and in set-top boxes designed for DTV, DBS and digital cable applications. These appliances will be capable of processing digital media files that may contain some or all of the following information tracks:

- a raster image background;
- raster image inserts for graphic sprites, picture-in-picture and picture-out-of-picture;
- ancillary data for locally synthesized text, graphics, 3D objects and print output;
- natural sound and music;
- dialog and narration.

Appropriate tracks may be selected from a broadcast transmission or in an interactive network transaction.

As described in Figure 4, modular appliances may support a variety of techniques for decoding, synthesis, and display of these tracks:

• packets are routed to the appropriate processing components after demodulation;

• the MPEG-2 decoder buffer can be used for the program raster(s) and to decode visual objects;

• objects carried in more compact representations such as 2D and 3D vector based graphic formats can be processed by the CPU or dedicated acceleration hardware;

• the display and overlay buffer memory supports double buffering of decoded image streams to permit synchronization with the local display refresh rate; these buffers can be used to facilitate local composition by feeding blocks of pixels to the image composition module;

• similar capabilities exist for the audio processing modules of the appliance or media server;

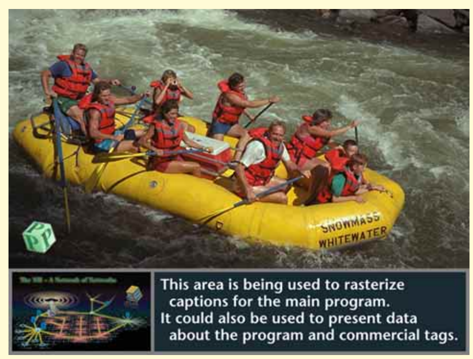
• finally, a composition syntax is required to put all the pieces together.

The video modules can be designed to support a single display refresh rate, or to vary the rate when being used with a multi-synchronous display. In addition, the display buffer can have multiple outputs, making it possible to simultaneously feed both an existing interlaced television receiver and new displays that provide higher levels of resolution.

Using memory addressing techniques, visual objects can be moved within a composition to support simple path based animation and the scrolling of text. Positions can be updated on a frame-by-frame basis to support motion path scripting. Color replacement and alpha channel blending techniques can be offered to provide high quality overlays with full support for antialiasing and transparency (see Figure 5).

The recent DTV compromise leaves us with the market driven approach, and the potential for chaos. To take full advantage of the market driven approach to DTV, we should define minimum standards for local image synthesis to support local image composition, interactivity, and navigation. These features can be implemented on receiving devices at an appropriate

Video streams and graphic objects are scaled and placed into the display buffer



Composition on 4:3 display

Composition on 16:9 display

Figure 5 - Local Object Composition
Local stream and object composition provides support for enhanced features including interactive applications, and the ability to compose objects to accomodate the presentation of video streams and graphics on displays with different aspect ratios.

level of performance. Low cost receivers may provide minimal capabilities and no options for extensibility, while digital media servers may provide higher levels of performance and the ability to upgrade modules as standards evolve.

By establishing only the minimal requirements for compatibility with the standard, consumers and manufacturers could choose the level of performance desirable for specific applications. For example, a caption might be included in a media file or broadcast transmission as ASCII text data with timing references to link the caption to the program content. In a similar manner, a localized commercial tag could be transmitted as ASCII text data referenced to specific ZIP codes; the address of the decoder would be used to select the appropriate tag from the text file.

The DTV Team

On April 7,1997, much of this framework was proposed at the National Association of Broadcasters convention by Microsoft, Intel and Compaq under the banner of The DTV Team <www.dtv.org>. What they proposed is the addition of support for a base-layer DTV standard in the PC98 specifications developed by these companies. Calling these specs a “de facto” standard for the computer industry, the DTV Team claimed that they would ship 30-50 million DTV-enabled PCs by the time the consumer electronics industry ships 1 million DTV receivers based on the ATSC formats.

With this latest move, the DTV Team has abandoned its partners in CICATS, who fought for many years to help them earn a seat at the bargaining table. The broadcasters, who started this decade-long process to fend off potential competition from the telecommunications industry, now face an even more formidable foe.

Perhaps this move may help align the interests of competitors to force a more open approach to the development of a base-layer standard. Perhaps it’s the shot across the bow, signaling the beginning of a long and costly war, that the broadcasters cannot hope to win.

The debate about video formats and encoding technology for DTV still hinges on the display scalability issue: whether to optimize the system for the most demanding HDTV applications, or the more affordable mass market applications.

The proponents of the ATSC formats have argued that delivering two-million pixel HDTV is critical to the success of their system, and that current encoding technology does not permit the use of layered encoding techniques that support multiple levels of resolution. The computer industry has argued that the layered coding is required to deliver the benefits of DTV to everyone, at prices that will permit this new medium to succeed; they advocate the use of an enhanced resolution base-layer, optimized for interoperability with computer displays.

The next few months may be the most critical in the entire digital television process. This time, the medium really is the message. The social implications of the shift to digital television will be far more profound than a sharper image and 3D sound. This is an entirely new medium. It will leverage other communications infrastructures to provide the consumer with something that was missing from our first attempt at a visual mass medium: the ability to control the vision, rather than being manipulated by it.