Acquisition and Management of Digital Assets for the Transitioning Broadcast Facility

By Beth Rogozinski

Television stations and entertainment industries are becoming more reliant on digital tools for the acquisition, creation, and management of media assets. This trend will continue to rapidly expand as broadcasters around the world begin to transition their facilities to all-digital workplaces in preparation for all-digital transmission. While "all-digital" is still quite some time away for most broadcasters, it is inevitable that most, if not all, will need to replace aging analog equipment in order to maintain an edge in this increasingly competitive industry. This paper addresses the questions facing broadcasters wishing to upgrade their facilities with digital equipment, from an engineering and logistical perspective, as well as from a financial and business perspective: How will digital equipment work with existing analog equipment that doesn't have to be replaced yet? How might new digital solutions increase productivity in broadcast stations, thereby cutting costs? How might digital systems help to increase and retain the value of media assets? How will the digital solutions purchased today prepare broadcast stations for the future?

Most of the world's television stations are for-profit businesses that base their business models on the advertising fee system. While upgrading a television station to all-digital transmission might generate new income streams in the long run, immediate income from advertising fees is not likely to increase dramatically. (The historical example of the introduction of color attests to this hypothesis. Advertisers did not dramatically increase the amount of on-air fees they paid to television stations for the privilege of color.)

The lack of an immediate return on this significant investment in infrastructure will lead broadcasters to upgrade their facilities in various stages to amortize the associated costs over many quarters or even years. This situation is made additionally troublesome, as digital equipment simultaneously improves and decreases in cost on an average six-month cycle. Broadcasters are therefore forced to consider and plan the entire upgrade of their stations now, envisioning what the final result will be in three to five years.

Plans for immediate purchases must be based on traditional information technology and business considerations, such as cost and features. However, extensive care must also be taken when considering how well today's component purchases will serve as cornerstone and/or integrated systems into future scenarios. Flexible, scalable, open, maintainable—these are the descriptors of the digital systems that are the provident, economical, and sound business purchases for broadcast stations as they transition into the digital future.

Television Station Workflow Dynamic

Television stations operate as dynamic workflow environments (Fig. 1) where content is brought in via many means and methods; manipulated, edited, and enhanced by many people, sometimes simultaneously; then finally amassed, organized, and assembled, for final transmission. Digital solutions will not change this overall workflow edifice, but when properly structured, new digital solutions will facilitate these existing processes by increasing productivity and the residual value of media assets. The return on investment that broadcasters get immediately for installing digital solutions are these increases in productivity and media asset value. Over the long term, open and scalable digital equipment will offer broadcasters continued access to new digital tools which will further facilitate creation and distribution processes and a base environment that can grow and change with the facilities changing needs.

Current Broadcast Station Systems

The content origination element of broadcast station workflow involves creating and collecting recorded video footage, voice-over narratives, music and other audio enhancements, and static and motive graphical elements. In most broadcast stations today, all elements of content origination are analog, except for the creation of graphical elements, which is usually done digitally. The manipulation element of broadcast station workflow involves editing, enhancing, and compositing the four types of content assets to a complete ensemble piece. Manipulation of media assets needs to occur in realtime for immediate playout to air as well as in the more standard offline, post-production mode. Although some affiliate facilities and low-power television (LPTV) stations still do all manipulation on analog systems, most stations use some digital solutions in their manipulation processes.

In the distribution and transmission element of workflow, composited media content is either distributed to another internal workflow environment, transported to another facility,

Presented at the 139th SMPTE Technical Conference (paper no. 139-5), in New York, NY, November 21-24, 1997. Beth Rogozinski is with Silicon Graphics, Mountain View, CA 94043. An unedited version of this paper appears in *Film and Video Origination in the Era of DTV Broadcasting and Distribution*, SMPTE, 1997.

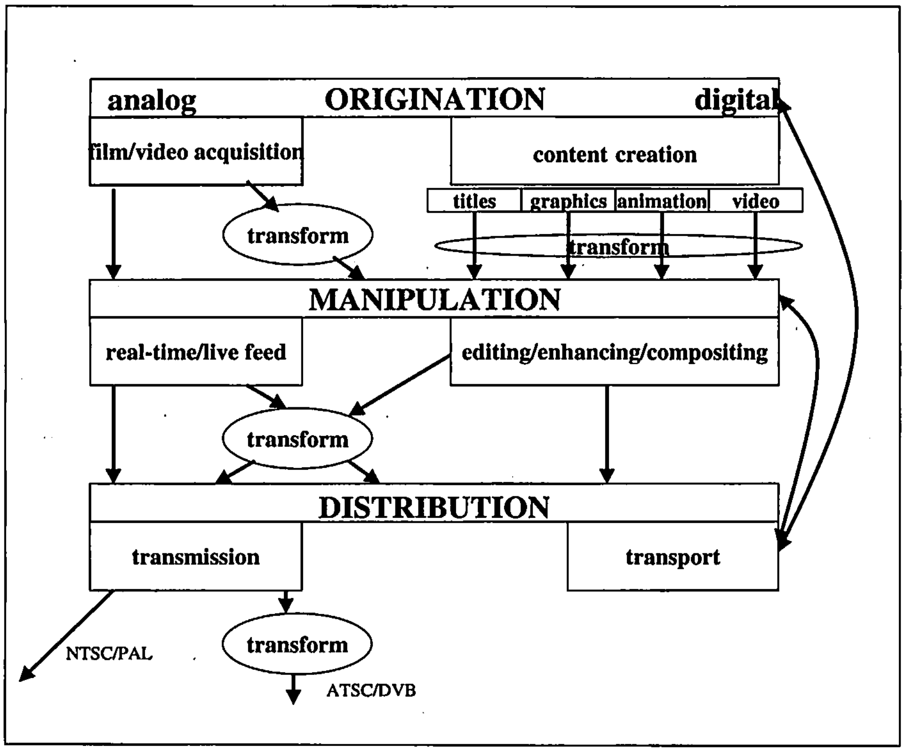

Figure 1. Broadcast station workflow.

or transmitted as playout to air. Transportation and distribution of processed content internally and externally is still mostly accomplished manually, and transmission conducted via analog methods.

Digital Broadcast Stations

The cornerstone system in a transitioning, and even a fully digital broadcast, environment will be the server system. In broadcast facilities, the digital server system will interface with all aspects of workflow, from content creation, to manipulation, to transport, and eventually will travel directly to air transmission. The server systems should also link production systems with business systems such as internal communications, billing, and revenue.

Although video servers will introduce a new level of complexity to the television station environment, they also promise significant operational improvements and increased productivity. In addition, digital servers can increase, extend, and maintain the value of created media assets by making them easier to find, access, work with, and retain original material integrity even after multiple uses. While video servers must have computational power, cost-effective servers for broadcast stations must focus as well on bus speed, input/output (I/O) bandwidth, scalability, flexibility and interoperability (Fig. 2).

An adaptable broadcast server provides broadcasters with a powerful, flexible, and scalable aggregation of tools that can be customized and configured to meet the needs of every growing broadcast station. The nucleus of the facility, the video server, must be an open, highly-scalable environment that supports a wide and growing range of software applications, high-definition television (HDTV)-capable graphics, high-speed networking, redundant array of inexpensive drives (RAID) storage, and additional video peripherals. In addition, the system must be able to combine video peripherals for digital asset management and media distribution.

Return on Investment (ROI) insurance for the future of this type of system would be its ability to handle multiple channels of uncompressed ITR-U 601 video I/O, dozens of channels of compressed video and audio I/O, all relevant disk I/O standards including small computer systems interface (SCSI), high-performance parallel interface (HiPPI), Serial HiPPI, and FibreChannel, local area network (LAN) and wide area network (WAN) networking standard protocol systems. With a scalable, flexible, and integratable digital video server system in place, the traditional workflow processes of broadcast stations can be supported while component systems are individually transitioned to digital.

From a close examination of today's average broadcast station, it is likely that the manipulation phase systems will be the first to be all-digital, while origination phase systems will likely be mixed for some time. Distribution systems will also be mixed for quite some time as digital

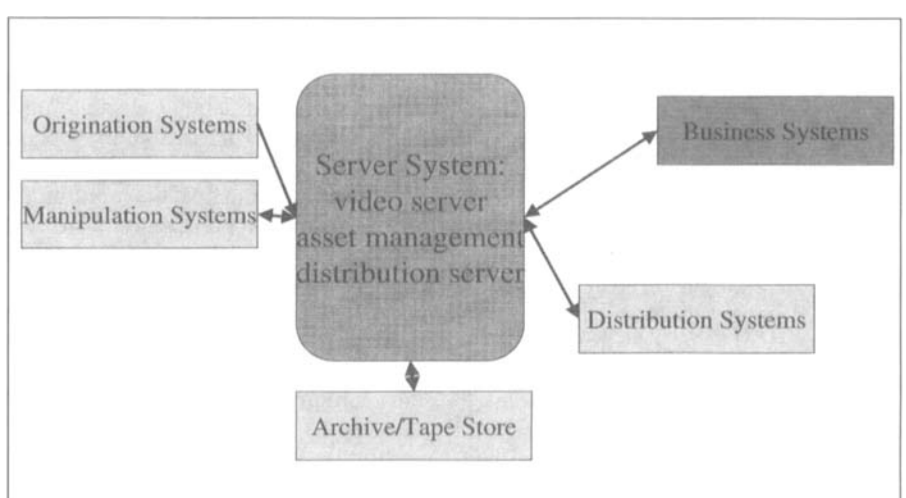

Figure 2. The broadcast server as the station nucleus.

distribution will begin internally immediately, but external distribution and transmission will be both analog and digital until the vast majority of consumers have digital receiving devices.

Digital Content Acquisition

Because of the transformative nature of the shift to digital broadcasting, economics require broadcasters to phase in digital technology that will be both compatible and befitting to analog means of gathering content. The creation of most graphic elements is currently a digital process, but the most prevalent media asset gathered is still analog video and most stored assets are either analog video or film. Some stations will quickly ramp up to the sole use of digital cameras and begin digitizing all media assets stores, however, most stations will require systems on site that can quickly and easily digitize media assets. This conversion will be required for mixing analog media with digital elements to facilitate collaborative working environments with digital distribution and transmission. Analog-to-digital conversion technology is already available and can support uncompressed digital media at film resolution. Digital cameras are also currently available, affording broadcasters manifold transition paths to the digital future.

Conversion and Workflow Concerns

One main concern of broadcast engineers and production managers when transitioning to digital systems is the perceived amount of time that is required to digitize or "load" analog footage into the digital systems. This is a viable concern, but if we examine the workflow time of traditional means of creating an edit decision list (EDL) or rough edit and compare it to working with digital video, we can clearly see that the time required is approximately the same, and digital video offers more reliability, flexibility, and potential quality. In addition, automated video cataloging systems, such as the Virage Video Cataloger, not only dramatically cut down on the amount of time required for logging incoming footage, but effectively database the assets, thereby increasing their potential value for versioning and archiving for future use.

Analog EDL/Rough Edit Process in a News Gathering Scenario:

1. Tape comes back from field and gets delivered to editor. Reporter goes off to finish writing voice over (VO).
2. Editor fast rewinds the tape, making mental notes regarding which scenes work and which scenes clearly do not work. Editor stops and plays at normal speed all interview and reporter talking head footage to check for usability.
3. Using only the "by memory" list of shots, the editor jogs the tape back and forth to create an EDL and rough of the final.
4. Reporter returns with final VO ready, records VO, and final coalition of media assets is made in the edit bay.

Digital EDL/Rough Edit Process in a News Gathering Scenario, using the Virage Video Cataloger:

1. Tape comes back from the field and is installed at digitizing station. Reporter goes off to finish writing VO.
2. Footage is digitized and simultaneously logged. A scene change template database is created with thumbnail images and time code.
3. EDL can be made using the visual and time code reference data, and EDL for various versions can be made consecutively.
4. Reporter records versions of the VO directly into digital format, and final coalition is made immediately with all versions ready to go out to air.

The two processes described here can take approximately the same time, although there is far less valuable staff time required with the digital system. In addition to cutting the amount of labor required to prepare the EDL, the digital system offers a definitive record of scene changes and timecode, instead of relying on the editor's memory. The catalog of scene changes can also quickly and easily be made into a number of EDLs for different versions to be used throughout the day and/or for localization. The digitized content, ready to be edited and composited with audio, titles, and other graphics, can also simultaneously be distributed via the web to internal end-users for further use, and/or it can be published to a web site for sale or distribution outside of the station.

Analog-to-Digital Conversion Devices

Three common analog-to-digital conversion systems are telecine, datacine, and film scanners. Because most broadcast facilities will require only video transfer on a regular basis, it is likely that most will opt to purchase a telecine device and forego the more expensive datacine and film scanning devices. (This type of digitization will likely be outsourced to post-house facilities and new facilities that are forming to meet this increasing need.) Regardless of the resolution of the system that broadcasters choose, key evaluation concerns for analog-to-digital conversion systems are centrally involved in the computer system specification. These include bandwidth capabilities of the system I/O boards and cards; internal throughput and processing power; the availability of appropriate and powerful software solutions; and the ability of the system to interface with all other production systems.

Telecine systems, such as those from Eastman Kodak and Philips, which interface with Silicon Graphics desktop systems O2 and/or OCTANE, as well as dedicated, internal video capture and compression boards, afford broadcast stations the ability to quickly and cleanly digitize media footage, create a log of the incoming footage, and quickly and easily network the digital video to content creation seats for amalgamation and digital video effects (DVE) systems for editing and enhancement. If and when a broadcast station upgrades their facilities to all-digital cameras, the central processing unit (CPU) and networking components of the digitizing system can be converted to either additional DVE or digital content creation seats (Fig. 3).

Direct-to-Digital Acquisition

Most video footage generated by affiliate stations is remotely captured news and weather. Therefore, it seems likely that the first direct to digital acquisition systems will be remote

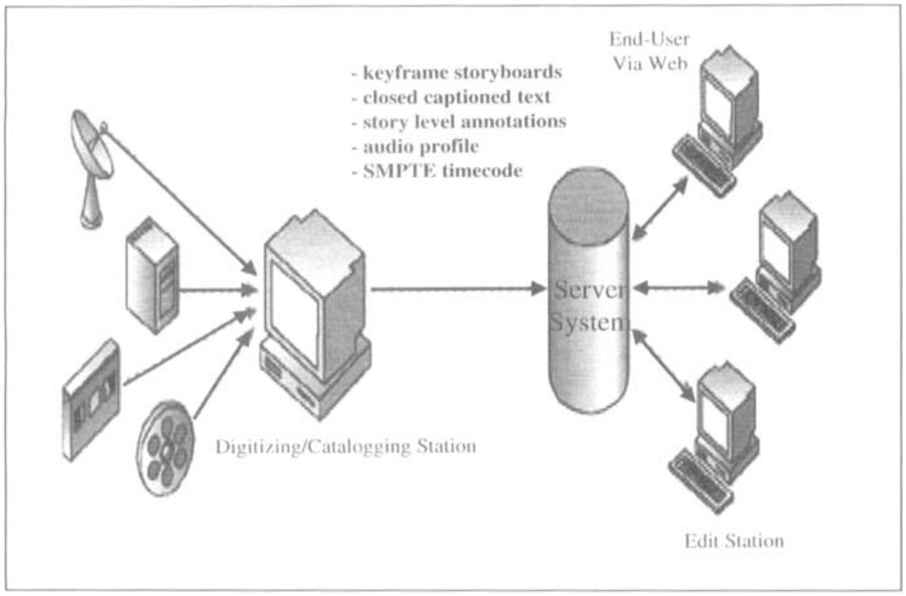

Figure 3. Analog-to-digital conversion workflow.

capture/field cameras. These digital cameras must be light, durable and able to hold large stores of content. Additionally, these systems must easily interface with in-house studio cameras, digital content creation workstations, and media asset servers.

There are a growing number of digital cameras available for broadcasters to evaluate based on size and weight of camera equipment, size and resolution of the CCD, and price. Interfacing digital cameras with computer manipulation and management systems is a fairly straightforward proposition that concerns the broadcaster in two primary areas: networking connections/throughput, and compression compliance between systems.

Networking digital camera systems to video servers requires the computer systems to have realtime capabilities and as many I/O pathways as possible. Current trends are to input/output digital video through the Peripheral Component Interface (PCI) bus. Although the latest advancement in PCI technology, the PCI 64 bus, has a theoretical bandwidth of 266 Mbytes/sec, it has typically been limited to three to four slots in the computer.

Most broadcasters will require systems that can simultaneously handle I/O of 20+ streams of digital data. While it is possible for PCI cards to be stacked to this level, the result would likely be bus congestion into and out of the central processing or storage systems—even with a dedicated bus manager. By using multiple systems, broadcasters can skirt the bus congestion issues, but this type of system will quickly fall short for systems beyond 20 streams.

For moving more streams, several developing proprietary systems currently exist that are effective for increasing the possible number of I/O ports. However, these "switched-fabric" systems are not scalable, and cannot handle data rates sufficient to move large-scale files such as those associated with HDTV. Additionally, I/O bandwidth requirement of media must be addressed by all components of the computer system. High I/O capacity of a single interface is insufficient if the internal I/O bandwidth or CPU processing of the system cannot support the required sustained and/or concurrent requirements of the overall system.

Although many groups are currently working on various solution sets for I/O of large video and data files, broadcasters need to ascertain the scalability and flexibility of any and all solutions purchased. Large-scale solutions tailored to meet the current and growing needs of broadcasters, while initially appearing more costly, can actually result in significant savings because they can be adapted over the years instead of being completely replaced. A recent development in the I/O arena is the XIO bus which has a theoretical throughput of 1.6 Gbytes and, in the high-end server systems such as the Origin 2000, can scale up to 24 simultaneous streams in and out. This level of throughput means that broadcasters can push 24 channels of 601 video, or 2 channels of HDTV, across the systems at the same time.

For even larger systems, beyond 20 streams of 601 or a few streams of HDTV, the capabilities of even the most advanced I/O buses available today will be reached. In this range it is important to use a video server architecture that does not rely on a single backplane for memory access nor a single I/O bus. The Origin 2000 line is one example of a system that employs a Non-Uniform Memory Architecture (NUMA), and CPU in addition to I/O node boards that can be expanded in an almost unlimited way. NUMAs can scale to hundreds of processors, while maintaining a single address space. These types of system architectures allow for the configuration of very large servers that can scale up for handling large numbers of media streams of very high media rates, such as 720I and 1080I HDTV. A NUMA coupled with independent CPU and I/O nodes eliminates any single point as a bottleneck for I/O bandwidth. (Table 1.)

Asset Management Systems

For broadcasters, asset management is an essential business requirement. The bulk of expenses for broadcasters revolves around creation, storage, and access to media assets. In the analog world, the "storage of and access to" parts of this equation are largely inadequate and leave broadcasters unable

Table — I/O Bus Comparisons

Card/Board	PCI-32	PCI-64	XIO
Theoretical Throughput	133 Mbytes/sec	266 Mbytes/sec	1.6 Gbytes/sec

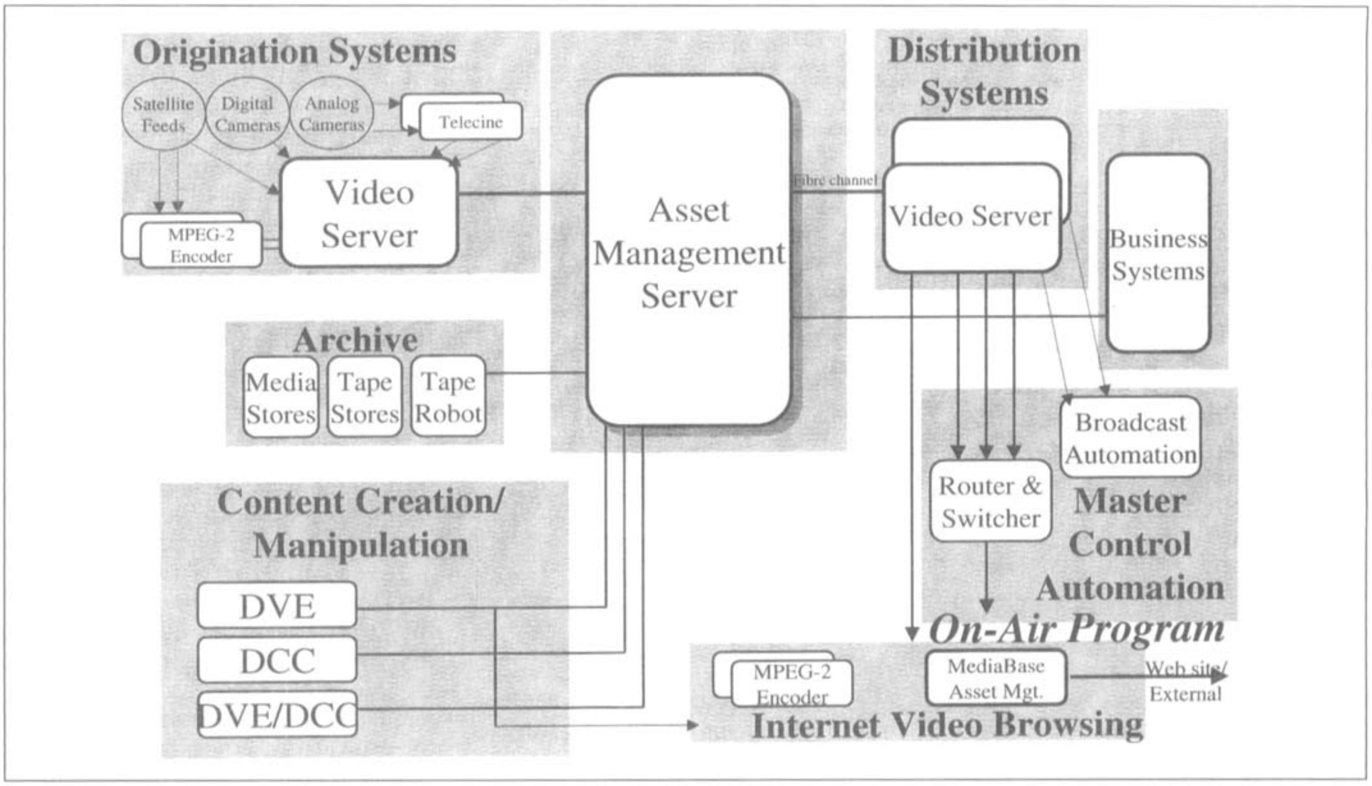

Figure 4. Digital asset management workflow.

to fully take advantage of the assets they have accumulated. Transitioning to digital asset management creates a new systemization that requires internal training and set-up time, but the benefits of digital asset management are countless. The return on investment in terms of work hours saved and the increase and retention of asset value will be seen almost immediately.

Current Systems of Asset Management

Asset management in most broadcast stations today consists of a number of ways and places to keep different media assets and files. Digitally created graphics and animation are kept on individual workstations and/or backed up onto some form of removable storage media, such as magneto-optical disks or digital audio tape (DAT) (both of which have definite drawbacks and problems inherent in their designs). Video footage, audio clips and voice overs, text documents, and print images are kept in one or more asset libraries, often placing certain assets quite a distance from the production work areas. All of these assets are stored in their original-read noncompatible and time degenerating formats, that, when and if found, have to be converted and cleaned before they can be used.

Digital Asset Management

A digital asset management system allows broadcasters to combine all of the station's assets onto a central storage facility with various levels of access via multiple access paths. The effective digital asset management system handles the input of all types of digital assets, accommodates various formats of digital media (i.e., graphics image format (GIF), Joint Photographers Engineer's Group, (JPEG), tagged image format (TIFF), encapsulated post script (EPS), Motion Picture Engineer's Group (MPEG) and Quicktime) and various resolutions for input and output, (i.e., film resolution, HDTV, NTSC, PAL, thumbnails, etc.).

In addition to accommodating all formats and resolutions, to be truly effective, the system must support format conversions, file-type recognition, creation of assets with multiple resolutions, as well as the capacity to group together all formats and resolutions of the same asset. An asset management server system with these capabilities increases productivity by decreasing the amount of time required to find a given asset. This decreases the time to convert an asset to appropriate format and resolution, facilitating versioning of assets for playout to air. This type of system will also help to retain and even increase the value of stored media assets by making them more accessible, and easier to find and use. A ready-to-use video clip that can be found in 30 sec, by the person who needs it, is far more valuable than one that requires research by the producer or editor, searching shelves and stores by support staff, and preparation by production staff.

Digital asset management also adds value, by making assets simultaneously available to many users and making them trackable. The continuing problem of "lost" or between-shelves assets is completely removed with a digital system. In addition, there is no danger of generation loss or of compromising the original asset in a digital system, as the true original is only ever virtually accessed and manipulated. Saved versions of each manipulation and use are always associated with the original asset set, thereby adding further value to the media store.

A digital asset management system requires large amounts of digital storage capacity at online or near-line status, with secure backup and redundancy built in. Depending on the size of the facility being served, the asset management system can also serve as a playout to air server, but in most larger facilities, these two server systems will more likely be separate, with separate RAID stores, but connected via high-speed networking lines. The asset management system should be future-proof with faculties to create complex object hierarchies, have seamless publishing and subscribing procedures, track the usage of assets, and send out bulletins to end-users.

The two other main systems' requirements for effective asset management systems are the interoperability of the system with other facility systems, and the creation of consistent metadata fields. Because the asset management system must be able to work with all other information systems in the broadcast facility, including business systems, the environment must run on all existing installed platforms, and integrate with other software infrastructure, such as different types of file systems, other business systems, content creation, and manipulation systems, etc. (Fig. 4).

Content and Metadata

The main principle underlying the management of assets is the separation of metadata and content. An asset has contents and metadata-data about the asset. A video clip is an example of contents. The information that the image is DVCPro25 file, V1, 60 sec, is an example of metadata. Metadata is typically stored in a database system (RDBMS—relational database management system; ORDBMS—object relational database management system; or even an OODBMS—object-oriented database management system). Content is typically stored directly in a file system, but these file systems may be spread out across an installation's network. Furthermore, the file systems may be tuned for the type of content that they store. In some cases, content may need to be stored in application- specific formats to enable realtime streaming, recording, or automated playback.

The asset management system must facilitate the use of a wide variety of content stores as well as maintain the association of metadata and content. Although most file servers and object-oriented relational databases currently perform search and retrieve functions on metadata, a digital asset management file system must also use metadata to retrieve assets, open appropriate applications by icon-clicking, create a summary statement of media that is in the bank, and be "intelligent" enough to automatically link and code new versions of an asset with appropriate information.

As the exchange of digital assets and their metadata becomes more widespread, the need for common metadata definitions and wrapper formats is becoming critical. There are several groups and organizations working to establish standards in this area. The Metadata Coalition (http://207.33.3.206/welcome.html) has been pursuing the standardization of metadata for enterprise and government science and defense systems. The European Broadcasting Union (EBU) and SMPTE have formed a task force for the Harmonization of Standards for the Exchange of Program Material as Bit Streams (http://www.ebu.ch/pmc_es_tf.html and http://www.smpte.org/engr/ebumeet1.html) to provide recommendations for metadata definitions and wrapper formats pertinent to digital assets in the broadcast environment.

In addition, the SMPTE/EBU Task Force is studying file transfer, asset streaming, compression, and systems issues as well. To date, the metadata standards committees have received full cooperation from a wide range of concerned parties (broadcasters, content creators, software and hardware vendors) to ensure that standards are set and adhered to within the realm of digital media asset management.

Asset Management Environments

As asset management continues to grow as a central business concern for broadcasters, the asset management system that they choose must be open, customizable, and scalable to meet current and growing needs. In pursuit of such an environment, four years ago, Silicon Graphics began the development of StudioCentral, an asset management framework, that can be likened to a "software bus." Connected to this bus are industrial-strength databases such as Oracle and Informix, and content storage servers such as RAID and hierarchical storage management (HSM) systems. The open architecture of the system provides "plug-in" access to many content creation applications (such as Avid, Adobe, etc.) and asset and workflow management applications (such as Bulldog).

The advantage of the "software bus" approach is that components can be added to the bus as the system scales. Providing an open framework that supports content creation, management, and delivery of digital assets, this environment allows content creation tools, asset management applications, databases, and storage devices to work together through a common interface.

The StudioCentral environment consists of three main layers, the Applications Layer, the Foundation Layer and the Asset Bank Layer. Developed in close association with the needs and desires of entertainment customers, this layered environment provides an industry perspective on the digital media asset management requirements for the entertainment industries.

The Application Layer contains tools and applications developed by Silicon Graphics' software partners as well as third party value added resellers (VARs). Tools for cataloging, archiving, browsing, and plug-ins that enable content creation applications (editing, cel animations, and compositing applications) make up this layer. Applications (and plug-ins) interface with StudioCentral using various means such as native C++ libraries, Java, Perl or HTML templates.

The Foundation Layer provides a warehouse for metadata, content, and workflow management. In this layer, developers can create objects (such as voice over, video, and script) that contain metadata for the assets. With customized objects in place, developers then perform operations on the warehouse repository to store, retrieve, and query the metadata and the content on the newly standardized metadata object attributes. Creation of these objects is easily accomplished using the "data-modeling" capabilities built into the package. In addition, the Foundation Layer also provides for content management and tracking, event notification for enabling workflow routing and project management, plug-in support for connecting with legacy databases and other applications, and access control and Java libraries for accessing this repository from any platform.

The Asset Bank Layer consists of a set of customizable and adaptable metadata and content stores for caching a digital asset's metadata and content. Metadata stores are implemented using RDBMS (such as Oracle and Informix OnLineServer) or ORDBS (such as Informix Universal Server) that support indexing and query features. Content stores are implemented using file system volumes in various content servers, possibly in different machines on the network.

Interoperability of Digital and Analog Asset Management and Storage

Although digital asset management is now a viable and affordable alternative to tape storage, most stations will retain analog tape and offline systems for storage and archiving. The prime considerations for integrated server/tape systems are that the asset management systems can record and track analog and/or offline digital assets and that automation systems can interface with the server. A key component of digital asset management environments, is that they track all types of assets and can be programmed to read bar code data for checking off-line assets in and out, so that assets don't get "lost" when they are pulled out for production uses. The systems also must have the capability to communicate with hardware control devices, such as the Avalon Archive Manager and the Emass hardware control peripheral made by Amass.

All broadcast facilities today are beginning evaluations of digital solutions. Integral to their success in the pursuit of a smooth transition to a digital broadcast facility is the interoperability of digital and analog equipment, new and legacy databases, and traditional and modern methods for acquiring, manipulating, and distributing media. The business of television is one in which content is produced to inform, educate, and entertain the masses. The industry of television is a substantial and successful one that has refined the process of information dissemination.

As television transitions to its use of new digital solutions, it is critical that the analog systems that work, are regarded as integral components of the immediate future. All digital solutions must conform to the sound idea of interoperability with analog systems. Although it is *de rigeur* for digital solutions to be scalable and upgradable, they also must be optimized for today by being able to take advantage of the capacity of existing analog systems. Because the amount and level of digital equipment now available is insufficient to replace analog systems, analog systems must be integrated, or the show will not go on. Since the cost of much digital equipment is exceptional, analog systems must be integrated, or the business will not go on.

Conclusion

While the transition to becoming a digital studio will be a multiyear process for most broadcast stations, planning for the all-digital station should begin before new digital equipment is installed, to ensure that each component system will work within the final, ultimate digital facility. Broadcast stations should anticipate being in a digital transition phase for at least three to five years, therefore systems purchased today must be able to withstand the transitional period, in addition to the anticipated needs for HDTV. All new digital systems that are put in place must be able to seamlessly and easily interface with the remaining analog systems as well as being capable of scaling to meet future needs.

The key to a successful transition to a digital facility in both business and technical terms is first to replace aging analog equipment in order to create a strong foundation on which the digital facility can grow and flourish. The foundation of all transitioning and ultimate digital broadcast facilities will be the server system's capability of running a comprehensive asset management application. The asset management server system will act as I-beam support for the digital facility and will promote communication between all business and production systems and provide for the free transfer of information and assets in a seamless, expeditious manner. The central server systems and all component digital solutions must increase workflow productivity, media asset value, and revenue potential.

THE AUTHOR

Beth Rogozinski is the market development manager for Silicon Graphics' new Intel/NT workstations. Prior to shifting focus to low-end desktop systems, she served as a strategist for the Advancement Entertainment Systems group at SGI. Rogozinski has over ten years experience as a consultant in the media technology industry, developing strategies for hardware, software, government, and end user groups. She has taught media technology at SDFSU, has published many articles and white papers, and is the author of the book, *Introduction to Interactive Multimedia.*