

SXnet: A Practical Approach to Digital Video Networking—A Migration Path to Digital Video Distribution as Applied to the Broadcast News Operation

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The arrival of digital video equipment in the broadcast industry brought high expectations of increased efficiency and convenience in addition to improved picture quality. Many believed that video and audio material would be treated similarly to computer files for managing, processing, and transferring via computer networks and servers. This analogy to computer data systems—as used in office automation, for example—is too simplistic and cannot be applied directly to the demanding video and audio system architecture of a broadcast facility. Stringent requirements must be placed on broadcast A/V systems to deliver high volumes of data, in continuous streams, to a multitude of users. Realtime throughput and predictable delays are all essential for on-air applications. While many approaches are available, this paper discusses the concept and implementation of a novel peer-to-peer networking system that addresses the specific requirements of the news broadcast environment. The paper emphasizes the merit of a simple solution to manage A/V material between MPEG-2 4:2:2 MP@ML Betacam SX workstations.

The transition of the broadcast industry to an all-digital environment for television broadcast operations and news programming is creating a demand for high-performance, yet, cost-effective video and audio content handling systems. In newsroom operations where time is critical and flexibility is the byword, it is particularly challenging to satisfy these requirements.

Disk-based nonlinear editing systems, multifunction audio/video (A/V) servers, and high-speed serial A/V digital interfaces have brought important enhancements to the broadcast news operation already. To create an efficient workflow, any new system must incorporate the best of current digital compression technology and employ novel networked system concepts.

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However, for the new digital systems to be practical, careful consideration of overall system integration is required. Particular attention must be paid to compatibility with existing equipment, as well as future migration paths.

With these requirements in mind, this paper explores the advantages of a peer-to-peer networking solution that links the A/V workstations in the newsroom. It also explores Sony's SXnet—a practical system implementation that is designed to exploit the strengths of the MPEG-2 4:2:2 Main Profile at Main Level (MPEG-2 4:2:2 MP@ML) used in Sony Betacam SX products. (Fig. 1)

Why Peer-to-Peer Networking?

The production of a newscast requires the management and processing of a tremendous amount of video and audio information from feed acquisition to on-air playback with the ability to change any of the elements up to the moment that a story goes on-air.

In a peer-to-peer networked system, like Sony's SXnet, everyone can work independently without interfering with other processes. The A/V network facilitates the exchange of material by simply moving, that is, copying, the desired A/V elements between workstations as needed. This eliminates the search for the correct tape and the tedious task of searching for an essential piece of video on that tape.

This also results in significant time savings in bypassing the uploading and downloading of material between tape and disk. Copying video files between workstations is well suited to the newsroom environment considering the short length of a typical news story or one of its elements. It is even more attractive when the video can be moved at greater-than-realtime speed between each workstation.

A peer-to-peer system also offers flexibility because each workstation can be replaced or upgraded—for example, from an analog edit suite to a nonlinear editing system—without having to replace the entire architecture of the newsroom. This avoids the disruption of simultaneously having to retrain all users and reinventing the workflow. Migrating from an analog to digital environment with nonlinear capabilities is possible without having to redesign and rebuild the infrastructure of the current system.

As in any new digital facility, a component digital router is added to distribute the digital video throughout the system. A progressive approach may be implemented and still achieve the desired improvements of higher picture quality and speed of random access storage.

With the peer-to-peer networking system, the tasks and workflow can

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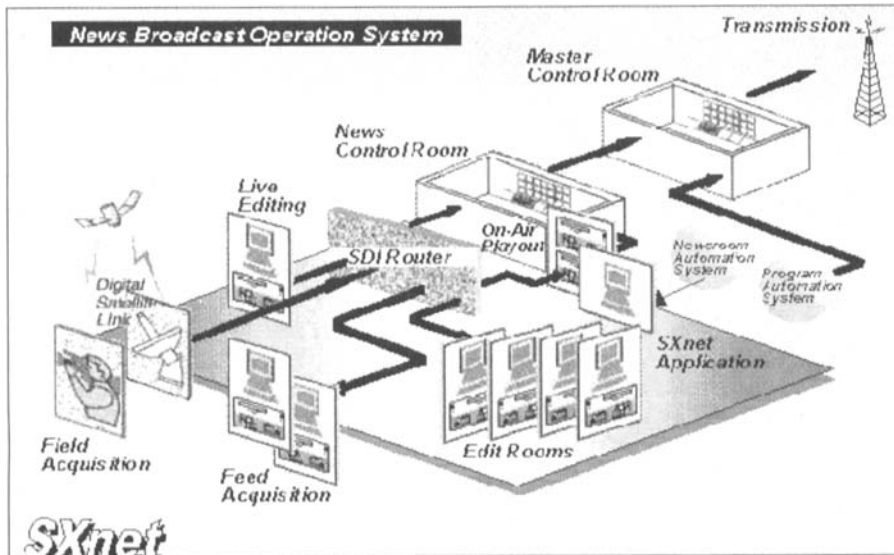


Figure 1. News broadcast operation system.

remain essentially the same as the ones in use today with the added benefit of better story/file management.

This distributed networked system has unique advantages because 1) each station operates independently, so there is no need to engineer redundancies; 2) single point of failure is minimized, which is a critical factor in the design of an integrated A/V server system; and 3) as costs continue to drop for storage devices and PC-based workstations, a common storage device can be used for easy replacement.

A Look into SXnet

SXnet is a simple network of workstations using Betacam SX Hybrid Recorders (HBR) for A/V local storage. Files can be managed and transferred between any of the devices attached to the network. The system has the advantage of nonlinear operation at each local workstation, for feed recording/triage, editing, narration track recording, and play-to-air. This streamlines the overall process and gives the ability to move A/V files [through serial digital interface (SDI) routing] from the disk of one workstation to the next.

In addition, to allow for the transfer of files between workstations, SXnet provides a simple play-to-air sequencing application for disk-based A/B style on-air playback of news run-downs.

A/V Networking

The A/V material is transferred between stations using serial digital interface/serial digital transmission interface (SDI/SDTI) interconnect.

This interface is compatible with the SMPTE 259M standard. Although SDI is used for realtime signals, SDTI allows for compressed video file transfer at speeds faster than realtime.

SDTI was also chosen so that simultaneous multipoint (or one-to-many) can be done, as compared with simple point-to-point computer networking. Additionally, there are no bandwidth and contention issues in SDTI as there are in standard computer networks.

All hybrid recorders are connected to an SDI/SDTI router that is under the control of the SXnet Server software application. When a transfer of material is needed, the request is made from any of the workstations to the SXnet Server software application. The SXnet Server sets up the path through the router and initiates the transfer.

SDI transport was chosen because it provides a time-tested synchronous, predictable transmission of signals throughout the broadcast facility using existing wiring. The proven track record also provides for compressed or uncompressed signals to coexist on the same infrastructure. It is important to maintain a synchronous transport capability for realtime broadcast application.

Control Networking

A 10/100 Base-T Ethernet network between workstations is used to exchange status, send commands, and allow for the browsing of the files stored in each local storage device, that is, the hybrid recorder (Fig. 2). Each workstation includes a PC running the local application and controlling the local storage device. The directory of A/V files in each of the local storage devices is published on the SXnet Server main application, which, in return, makes them available to all other workstations for browsing and transfer.

House time code is also fed to all

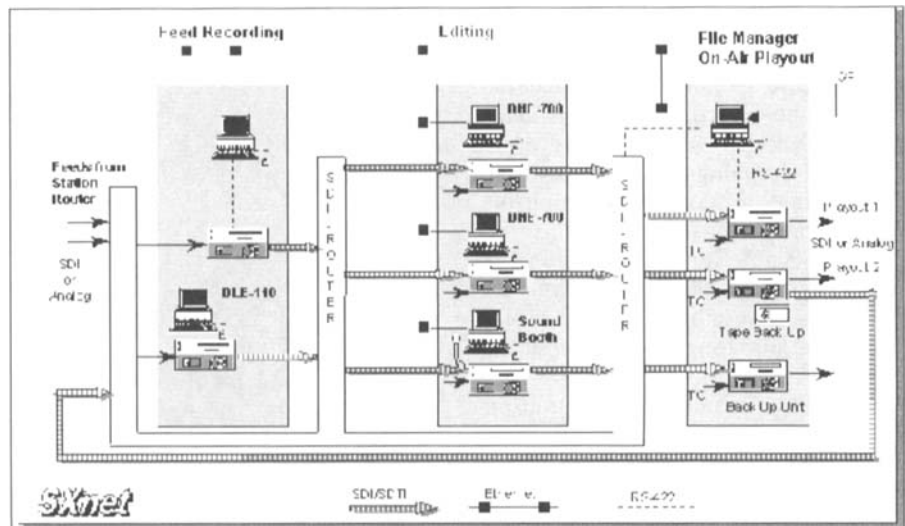


Figure 2. SXnet system configuration.

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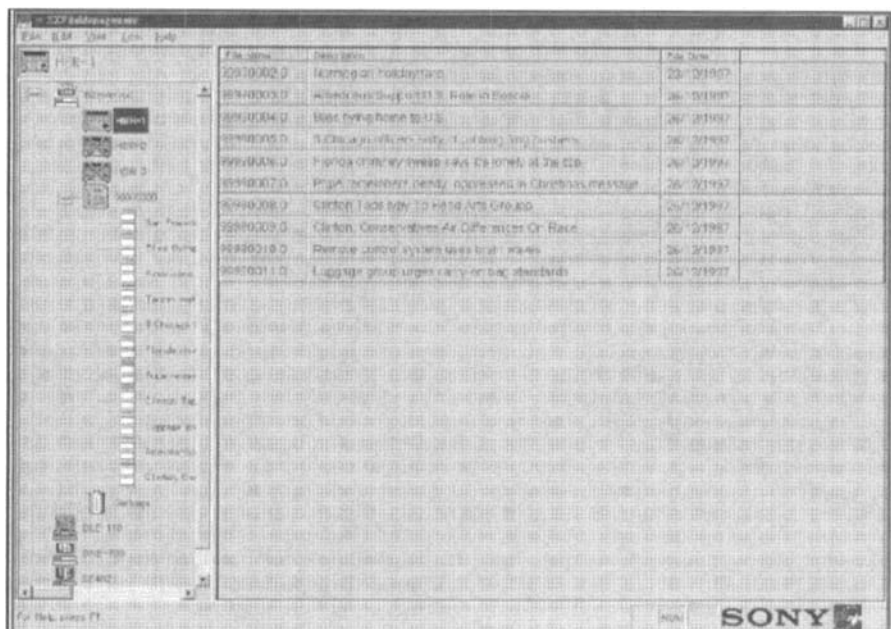


Figure 3. File manager screen.

workstations for synchronization of timeline functions.

SXnet File Manager

The SXnet File Manager application runs on an MS Windows NT 4.0 platform and is connected to each PC running the local application. The local applications include feed recording/highlight recording and nonlinear editing (Fig. 3)

The SXnet File Manager catalogs the files available on each hybrid recorder that is attached to each local workstation. From any of the local workstations, a file browser allows the user to view all available files posted on the SXnet File Manager. Deleting and renaming of files can be performed as required. When material needs to be copied, a request is made to the SXnet Server by simply dragging and dropping the original file to the destination icon representing the target workstation. (Fig. 4)

The SXnet Server manages the copy process by allocating the resources, assigning the router cross-point, and initiating the transfer at the proper time.

In addition to managing the transfer of files between the local workstations, SXnet also provides an on-air playout sequencing application designed for the broadcast news operation. The SXnet File Manager and

on-air playout control applications are integrated and are accessed from the same graphical user interface (GUI) windows. The on-air playout window directly controls up to three hybrid recorders for random-access playout, using the Sony 9-pin Hybrid Recorder Control Protocol. Additionally, the SXnet on-air playout application supports a host port to accept rundowns from the newsroom computer system by means of the commonly used Betacart host protocol. A typical

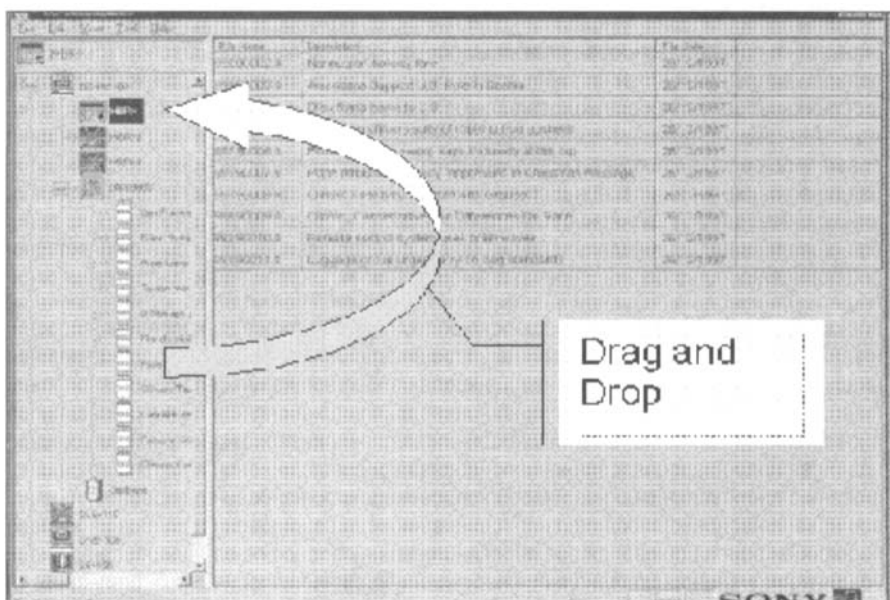


Figure 4. System drag and drop concept.

SXnet system is outlined in the following sections.

SXnet Feed Recording

Using the Sony DLE-110 controller, incoming feeds are recorded on the attached hybrid recorder. A start and stop time can be programmed in advance for automated recording of scheduled feeds.

Feed recording on the hybrid recorder is fail-safe because the material is recorded on both disk and tape simultaneously, giving the added protection of a built-in tape backup. In addition, all users are guaranteed to find the recorded feeds through the SXnet File Manager browser. This eliminates the tedious task of searching for that in-demand tape of a breaking news story.

Because the recording is made to disk, and the hybrid recorder's simultaneous record and playback capability, there is no need to wait until the end of the feed to use the incoming material. Moments after the recording of the feed has started, the material can be played out and transferred to the edit suite. This is an important factor in the case of a breaking story, and it is an improvement over today's operation where a second VTR (or more) would have to be started so that the tape with the beginning of the story can be pulled to start work immediately.

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Another application for the feed recording station is the preselection of sections of the feed before it even goes to the edit station. Good examples are that of a sports game or a lengthy press conference, where a quick sequence of highlights is put together on-the-fly from the Live Editor while the game or conference is still under way. The sequence can then be played back and routed to the on-air playout system even while the end of the feed is still being recorded.

Storage capacity for each of the hybrid recorders hard disk drives (HDD) is 45 or 90 min (depending on model) and can be optionally extended up to 6 hr. Recorded feeds on the HDD can be protected to prevent inadvertent erasing.

Nonlinear Editing

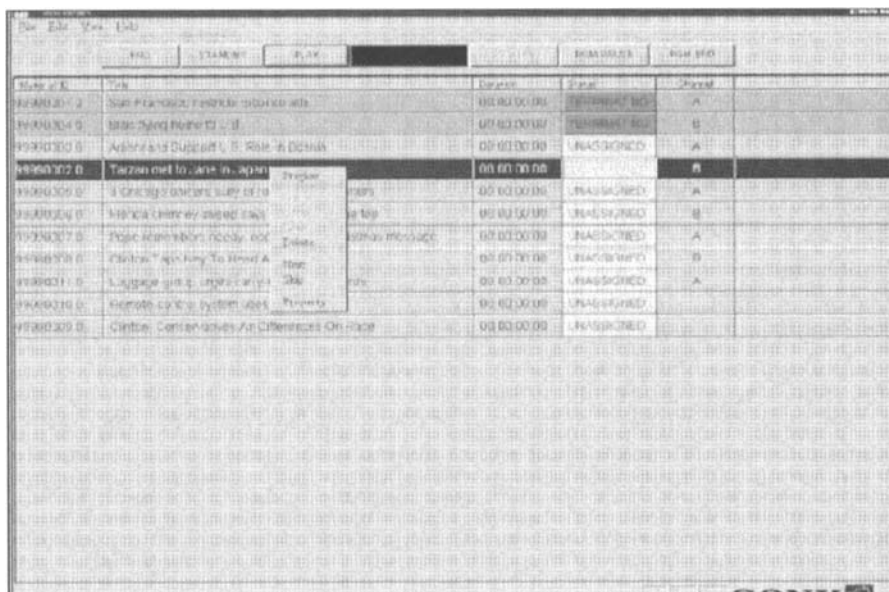
After the reporter has recorded a sound track on the sound booth hybrid recorder, the audio file is transferred to the editing workstation by using the SXnet File Manager client browser. All A/V files from any of the feed recordings or other editing workstations are available for browsing and transfer as well. Archives or locally shot video material on tape also may be loaded directly from the Hybrid Recorder's built-in tape transport.

The detailed operation of a nonlinear editing system is beyond the focus of this paper and a large amount of information is already available on these systems. Once all of the elements have been edited into the story and the piece is completed, the edited story can be forwarded or "pushed" to the on-air playout system.

SXnet On-Air Playback Sequencing Application

A simple application is used to manage and arrange the order of news stories for on-air playout in a desired sequence. The ability to bring the stories together in sequence by drag and drop operation, and reorder the sequence on-the-fly until the last moment is done with the random-access disk playback on the local hybrid recorders.

The on-air playout window is shown on the same Microsoft Windows NT computer that runs the



Item	Title	Duration	Status	Priority
1199021.0	San Francisco Giants vs. Yankees	01:00:00.00	ASSIGNED	A
1199024.0	San Francisco Giants vs. Yankees	01:00:00.00	ASSIGNED	B
1199025.0	San Francisco Giants vs. Yankees	01:00:00.00	ASSIGNED	A
1199027.0	Tennis net to catch in Japan	00:01:00.00	ASSIGNED	A
1199028.0	1. Chicago Bears Super Bowl	05:00:00.00	ASSIGNED	A
1199029.0	1. Chicago Bears Super Bowl	05:00:00.00	ASSIGNED	B
1199030.0	Police officers in riot gear	01:00:00.00	ASSIGNED	A
1199031.0	Police officers in riot gear	01:00:00.00	ASSIGNED	B
1199032.0	Police officers in riot gear	01:00:00.00	ASSIGNED	A
1199033.0	Police officers in riot gear	01:00:00.00	ASSIGNED	B
1199034.0	Police officers in riot gear	01:00:00.00	ASSIGNED	A
1199035.0	Police officers in riot gear	01:00:00.00	ASSIGNED	B
1199036.0	Police officers in riot gear	01:00:00.00	ASSIGNED	A
1199037.0	Police officers in riot gear	01:00:00.00	ASSIGNED	B
1199038.0	Police officers in riot gear	01:00:00.00	ASSIGNED	A
1199039.0	Police officers in riot gear	01:00:00.00	ASSIGNED	B
1199040.0	Police officers in riot gear	01:00:00.00	ASSIGNED	A

Figure 5. Playlist.

SXnet Server application. The application controls two hybrid recorders by way of Sony 9-pin Hybrid Recorder Control Protocol with all of the stories recorded on each HBR's internal hard disk drive simultaneously. This configuration allows for A/B transition during playout or last minute reordering with no concern for continuous A-B-A transition. A third hybrid recorder may be added in parallel to run as a backup. (Fig. 5)

Even at crunch time when the newscast has started, the material can still be filed to the playback hybrid recorders, thanks to simultaneous record and playback capability. Once the edited programs have been transferred to the on-air playout system, a new start point (mark in) and stop point (mark out) or duration may be used for each story.

Integration with the newsroom computer system is accomplished by importing rundowns via the host port (using the existing Betacart protocol) that predetermines the playback sequence to air.

Stories not yet filed in the SXnet On-Air Playout system are flagged and can be monitored to confirm status before time to air. During the newscast, as the order of the stories is rearranged, the on-air playout system readjusts the file sequence as needed, based on an updated rundown from the newsroom computer system or by

simply dragging the desired file icon displayed on the SXnet's GUI window.

Disk-based playback for the newscast is particularly beneficial for managing video sequences that are used repeatedly during the show, like show intro, bumpers, promos, etc. Disk storage capacity on the hybrid recorder of 45 or 90 min is ample, based on the model, and can be extended up to 6 hr with an optional external disk storage unit.

An added benefit of using a Betacam SX Hybrid Recorder is the flexibility to use tape media with the built-in tape transport. Compatibility with current analog tape archives is also available when using the analog compatible model that accepts any Betacam SX, Betacam (Oxide), or Betacam SP tapes. In case there is no time to load the story onto the disk, the story can be cued and played directly from tape in the same manner as it is done today.

During the newscast, the sequence of stories may be played, based on a predetermined time schedule including breaks, or each event may be manually triggered using a general purpose interface (GPI) port of the SXnet control computer.

The multipurpose hybrid recorders used at different workstations provide combined local disk storage, tape input or output, and archive playback

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capability. This is an efficient way to maximize the utilization of the equipment because any hybrid recorder can easily be moved or swapped and then reassigned as more resources are needed. By using an individual deck instead of a single server, single point failures are greatly minimized.

Conclusion

The introduction of the MPEG-2 4:2:2 Main Profile@Main Level video compression standard for broadcast applications brings the quality of digital video and the efficiency of random access to broadcast operations. To be practical, the newly designed equipment must be integrated into a system that improves the overall workflow and minimizes the impact of creating a new environment.

The SXnet peer-to-peer networked system builds on the technology used in the Betacam SX family, and its versatility, to improve the workflow in the newsroom. By adding cost-effective Ethernet and SDI/SDTI connectivity, this simple and elegant approach affords easy exchange and sharing of material with minimum departure from today's operational workflow. This approach allows a progressive transition to a digital infrastructure in the newsroom.

Furthermore, it is possible to envision a similar system beyond the confines of a single newsroom site, although this functionality is not a part of the SXnet system described in this paper. SXnet can be used over wide area networks (WAN) to move files conveniently. Because the SXnet

directories of files and related data can be published as HTML web pages, content information could be accessible to any client connected to the WAN, and browsing of file data could occur even at remote locations. Then, using an MPEG transport for the A/V material, an A/V file could be transferred nonsynchronously at the rate allowed by the available data link. A standard video transport method, like satellite or telco link, could also be used.

In summary, SXnet is a simple and efficient implementation of a peer-to-peer networking system that allows broadcasters to migrate to the digital future, in stages, and cost-effectively. The transition is easy because the SXnet system architecture maintains the workflow in use today.

Chris Golson has 15 years of experience at Sony Electronics. At the helm of Broadcast and Production National Sales Management, he is responsible for establishing sales strategies for key applications and/or sales channels, in collaboration with marketing applications teams and product and systems groups in the areas of broadcast and production.

Prior to his current position, Golson served as vice-president for Broadcast and Production Systems Storage Marketing for eight years, where, among other accomplishments, he was key in the success of the Betacam, Betacam SP, and Digital Betacam product lines as well as the launch of the Betacam SX family of products. During his tenure at Sony, Golson has held positions as product manager for monitors and manager for marketing development.

Golson has a B.A. degree from Tufts University in Massachusetts. He is a member of the Society of Broadcast Engineers and SMPTE.

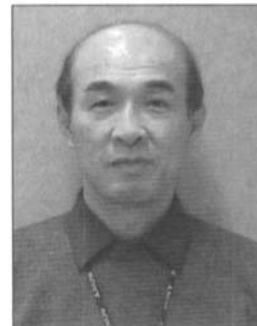
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Sony for 24 years and has held a variety of positions. He started out in Consumer Services and joined the Broadcast Division at its inception. Tansek worked as a field engineer until his product development activities brought him to California as a software engineer. He later became engineering manager of Switcher, DME, Editor, and Audio Products.

Tansek received a B.A. degree from Wayne State University in Detroit, MI. He is a member of SMPTE.

Nobuaki Sato graduated from the Fukui National Polytechnic School in 1971 with a degree in electrical engineering. He then joined Sony, where he worked in the VTR design group,

for six years, until he was dispatched to work as the VTR product manager with Sony sales and marketing companies abroad. Since returning to Japan, Sato has been working in the Product Planning Department for Broadcast Applications.

Hajime Takeuchi received a degree in electronics engineering from Osaka University in 1971. Since then, he has been engaged in designing Broadcast equipment. He joined Sony in 1979 and has been involved in developing VTRs, cart machines, and other application systems for the Broadcast industry. Takeuchi works in the Sony Product Planning Department for Broadcast Applications.