Hitachi's Broadcast/Network Hybrid Digital Recorder

— A Whole New Way of Watching Media —

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OVERVIEW: In the market for video recorder units, DVD (digital versatile disk) recorders have seen explosive growth in recent years. HDD (hard disk drive)/DVD recorders in particular are predicted to enter households quickly, because of their convenience. The rapid increase of households connected to broadband networks has also caused an increase in the number of PCs and "information appliances" that can connect to networks and communicate from within the home. This has led this phenomenon to be referred to as a fusion of broadcast and communication within the home. With this concept in mind, Hitachi developed a new type of HDD/DVD recorder. In future, Hitachi will develop a hybrid digital recorder as the core of the home network, while expanding the capacity and features of the hard disk, the recorder's key component, and making it more quiet and energy efficient.

INTRODUCTION

DVD (digital versatile disk) recorders recently joined the ranks of flat panel plasma TVs and digital cameras as must-have digital gadgets, and all three items continue to be shipped in Japan in increasing volume. This is especially true of DVD recorders, 830,000 of which were shipped in Japan between January and August 2003, as they begin to enjoy real demand.

DVD recorders can be broadly divided into those with HDDs (hard disk drives) — we will call these "HDD/DVD recorders"— and those without. 70% of DVD recorders shipped are HDD/DVD recorders. From the point of view of users' needs, the major reasons for the popularity of HDD/DVDs can be surmised as follows.

(1) Technological developments
   (a) The increased specifications of DVD-R drives,
   (b) boosted hard drive performance and capacity,
   (c) advances in moving image digital recording technology;
   (d) integration of technology as a result of the shift from analog to digital,
   (e) increased network speed.
(2) User needs
   (a) The shift from stand-alone VTRs (video tape recorders) to DVD recorders due to more available DVD software,
   (b) consumer expectations for a clearer picture,
   (c) convenience not found in VTR units, such as the ability to play back a TV program while it is still being recorded ("time shifting"),
   (d) increasingly widespread broadband connections,
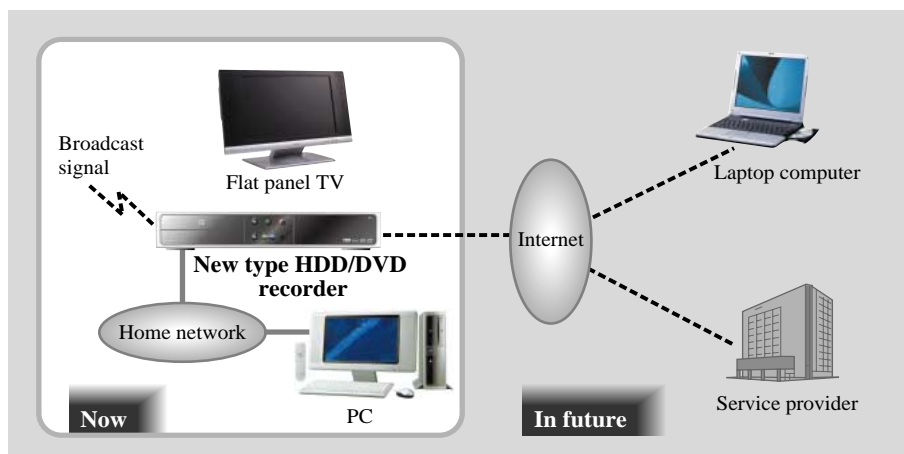   (e) the desire to be able to record for long periods.

Fig. 1—Concept behind Broadcast/ Network Combined Digital Recorder.
The digital recorder forms the core of a home network built on a concept of integrating broadcast and network communication.
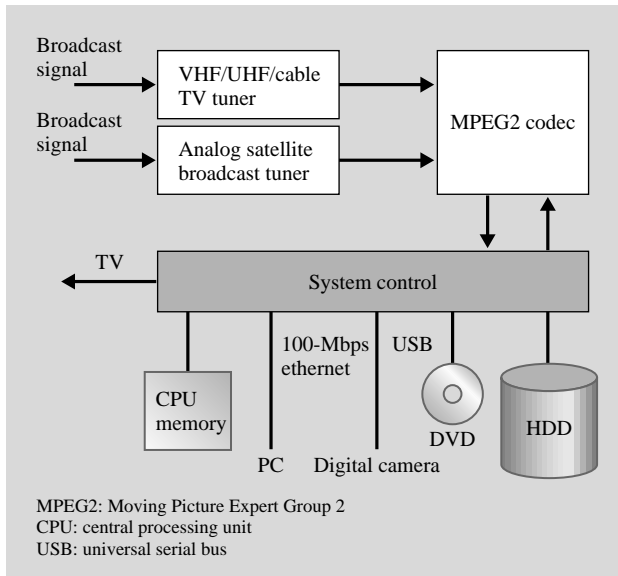
Simplicity
- Set timer record and search using the electronic program guide
- 120 Gbyte HDD for maximum recording time of approximately 120 hours
- Simple remote control using a crosshair cursor

Picture clarity
- Clear, easy-to-read GUIs and fonts
- 3D YC separation
- Digital TBC and digital NR

Convenience
- Streaming of recorded content
- DVD multidrive
- 1.5x playback with audio

GUI: graphical user interface   TBC: time base correction
YC: luminance/color signal   NR: noise reduction

Broadcast signal → VHF/UHF/cable TV tuner
Broadcast signal → Analog satellite broadcast tuner
→ MPEG2 codec
System control → TV
100-Mbps ethernet   USB
CPU memory   PC   Digital camera   DVD   HDD

MPEG2: Moving Picture Expert Group 2
CPU: central processing unit
USB: universal serial bus

Fig. 2—Overview of Hybrid Digital Recorder System.
As the digital recorder is connected with a high speed bus, it enables simultaneous recording and playback, time shifting, and streaming to a PC over a LAN (local area network).

Fig. 3—Hybrid Digital Recorder's Basic Concept.
The concept behind the recorder is "simple, clear and handy."

Broadband is also entering households rapidly, with 10.94 million broadband subscribers in Japan as at May 2003, a penetration into over 20 percent of Japan's 48 million homes.

It was in view of this situation that Hitachi produced a new type of HDD/DVD recorder that does more than simply replacing VTR units, aiming rather to integrate broadcast and network communication. Here, we will be discussing the development concept and features of the hybrid digital recorder, the features of its key component, the Hitachi Global Storage Technologies, Inc.'s HDD, and the future of integrated broadcast/network recorders.

OVERVIEW OF HYBRID DIGITAL RECORDER
Development Concept

The HDD/DVD recorder developed with the aim of integrating broadcast and network communication. It sports a 120 Gbyte hard disk, a DVD multi-drive [DVD-RAM (random access memory), DVD-R (recordable), and DVD-RW(rewritable)], 100 bps Ethernet*, USB 1.1, and a VHF/UHF/cable TV/ broadcast satellite tuner (see Fig. 2). The hybrid digital recorder's basic concepts are simplicity, picture clarity and convenience (see Fig. 3).

EPG (Electronic Program Guide)

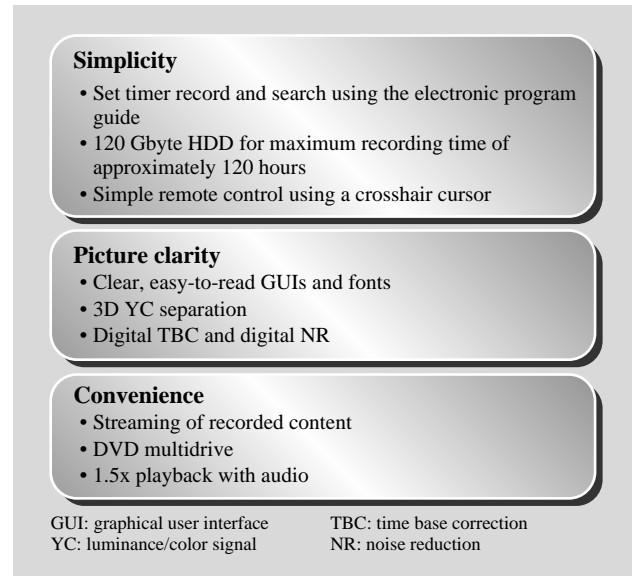One special characteristic of the hybrid digital

Fig. 4—EPG Channel by Channel Display.
By periodically receiving broadcast data on TV programs, a variety of applications can be displayed. This screen shows the information for a particular channel.

recorder is the ability to process TV program information sent in the gaps between terrestrial TV broadcast signals. It uses this information to display an EPG, enabling simple timer recording of programs (see Fig. 4).

This function uses TV-Asahi Data Vision Corporation's EPG service. The EPG contains information on up to eight days of VHF (very high frequency), UHF (ultra high frequency) and analog BS (broadcasting satellite) programs (note that the EPG is not displayed in areas where there is no TV-Asahi Data Vision Corporation's EPG service).

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* Ethernet is a registered trademark of Xerox Corp.

Fig. 5—EPG Performer Display.
Performers appearing in programs are displayed in the order of the Japanese syllabary. Selecting a performer with the remote control and pressing "Execute" displays the programs that performer appears in.

Fig. 6—Streaming.
Images recorded on an MSP in the living room can be viewed on a PC in the library via a 100-Mbps LAN.

As well as showing the length of programs, the electronic program guide displays genre symbols, for example, sport, news, and drama. Details of programs are displayed at the bottom of the screen, and can be taken in at a glance. The program itself plays live in the bottom right corner of the screen, allowing the user to watch TV or record manually while viewing the EPG. The program guide can be displayed by channel or by genre, and there is even a search function where the user preprograms up to five favorite actors and singers and only programs starring these performers are displayed (see Fig. 5). Setting the record timer is very simple — one simply selects the desired program from the EPG and presses "Enter."

Streaming

Streaming is one of the new type digital recorder's functions that makes use of networks. Streaming enables data stored on a server to be played back sequentially while being downloaded. This function can be used to view moving images recorded on the recorder on a PC (see Fig. 6). Owners of Windows XP* PCs with LANs can achieve this by simply connecting the recorder to the PC with a 100-Mbps Ethernet. An overview of viewable programs stored on the recorder can be displayed on the PC, and programs can be played back easily by simply selecting them. Users can also skip directly to a desired point by using the progress bar display.

* Windows is a registered trademark of Microsoft Corporation in the U.S. and in other countries.
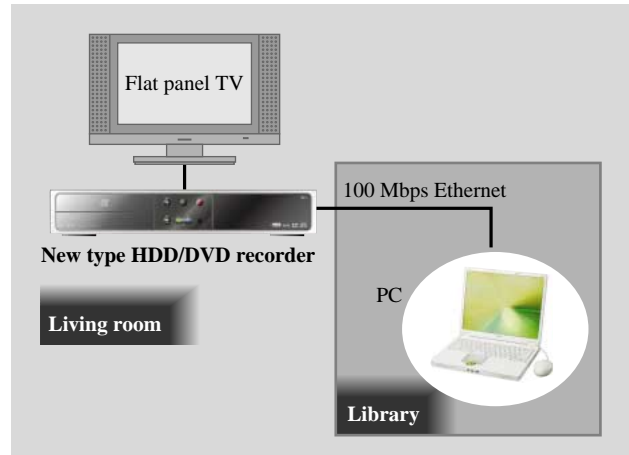
DVD Multidrive

The digital recorder features a DVD multidrive which enables reading/recording of DVD-RAM, DVD-R and DVD-RW, and can play DVDs recorded in the DVD-RW video recording format, and the DVD-R and DVD-RW video formats. It can also record on the DVD-RAM video recording format (possible with software updates), as well as the DVD-R and DVD-RW video formats. It is also possible to select desired programs from the high-capacity 120-Gbyte hard drive and dub onto DVD without any deterioration. Also, as it is possible to read DVD-RAMs through the UDF (universal disk format) being made popular by PCs, DVD-RAM disks recorded using this format can easily be exchanged between the new recorder and the PC.

Recording and Playback

The digital recorder lets users playback programs that are still being recorded, with the time shifting function. Also, if the phone rings or a visitor arrives while the viewer is watching TV, a press of the "Wait" button automatically starts time shift mode recording. When the viewer is free again, he/she can replay the program from the missed scene simply by pressing "Play." There is also a 1.5× playback mode with audio, which is handy when the user does not have much time to watch a certain prerecorded program, and which can also be used to get an overview of the news. The digital camera still-frame replay function is also useful when viewing still images taken with a digital camera on TV.

Table 1. New HDD/DVD Recorder's Main Features
The digital recorder has a UHF/VHF/cable TV tuner and a tuner for analog broadcast, and features an electronic program guide, a high capacity HDD, a DVD multidrive and network-routed streaming.

Recordable disks	HDD, DVD-RAM, DVD-R, DVD-RW
Recording method	MPEG2/MPEG 1 layer 2
Recording time (120-Gbyte HDD)	LP: approx. 120 h, SP: approx. 60 h, HQ: approx. 30 h
Recording time (DVD)	LP: approx. 4 h, SP: approx. 2 h, HQ: approx. 1 h
Recording DVD formats	DVD-VR*: DVD-RAM, DVD-video: DVD-R, DVD-RW, MPEG2 data: DVD-RAM
Playback media	DVD-RAM (VR*, MPEG2 data, still images) DVD-R (video), DVD-RW (video, VR), DVD-video, Video CD, Audio CD, CD-R/CD-RW (video, audio, still images)
Network	100 Mbps Ethernet (streaming), USB 1.1 (digital camera)
Tuner	Terrestrial (VHF: channels 1-12 / UHF channels 13-62 / CATV: channels C13-C38) × 1, analog BS (channels 1,3,5,7,9,11,13,15) × 1
Output interface	Composite × 2, S-video × 2, component × 1, D1 jack × 1, analog audio × 2, fibre optic digital sound × 1
Input interface	Composite × 3, S-video × 3, analog audio × 3, BS decoder input × 1
EPG	ADAMS-EPG
Dimensions (mm)	430 (W) × 352 (D) × 75 (H)

LP: long playing   HQ: high quality
SP: standard playing   VR: video recording
* uses software updates

The digital recorder's main specifications are shown in Table 1.

HITACHI GLOBAL STORAGE TECHNOLOGIES, INC.'S HDD
HDD as Image Recording Device

While most hard drives currently mass produced are designed and developed as data storage for PCs, this is beginning to change. Domestic HDD/DVD recorders as exemplified by the digital recorder are predicted to become a big market in future, making appropriate hard disk design necessary. Of the various benefits offered by using hard disk drives in HDD/DVD recorders, most important is their high speed, followed by their large recording capacity. While these special characteristics are also the reason HDDs are in wide use as recording devices for computers, the characteristics required by DVD recorders are slightly different.

Fig. 7—Hitachi Global Storage Technologies, Inc.'s HDD. The 120-Gbyte HDD used in the new digital recorder. Achieves high-speed reading performance by spinning a 3.5 inch disk at 7,200 rpm.

Speed

While we tend to refer to them both as being "high speed," there is in fact a significant difference between the information devices exemplified by PCs, and HDD/DVD recorders. For example, data reading/writing from a PC to an HDD is often highly random, with hard disks reading from totally different places from one access to the next. As one can easily imagine, however, reading and writing of data is usually conducted in sequence in the case of moving image recordings. A drive's performance in sequential reading and writing is dictated by the rate of data transfer from the disk, and the caching technology, which stores the data in DRAM (dynamic random access memory) within the HDD.

The HDD from Hitachi Global Storage Technologies, Inc. achieves the fastest media transfer rate in its class at 87 Mbyte/s, and a 56 Mbyte/s sequential reading speed (at the perimeter of the disk) (see Fig. 7). It also uses a data caching algorithm geared toward time shift mode. During time shift, the image being broadcast at the time is recorded on the HDD, while earlier images are being replayed. While the data involved all constitutes one mass of image data, this operation requires the HDD to alternately write and read. Conventional PC-oriented HDDs did not have to concern themselves with data sequentiality in these kinds of scenarios. When performing time shift
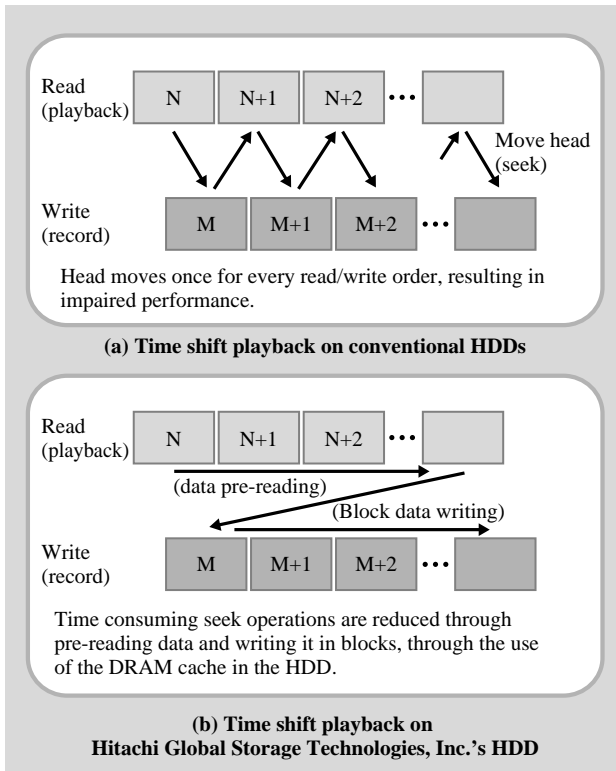
Fig. 8—Hitachi Global Storage Technologies, Inc.'s HDD Operation During "Time Shift" Playback.
Allows data to be read in a manner suitable for time shift playback.

playback on an HDD/DVD recorder, however, a read command following a write command will start from the position where the last read command left off. In this situation, existing caching algorithms are virtually unable to pre-read data in a manner that is effective during sequential reading, and are very inefficient. Hitachi Global Storage Technologies, Inc.'s HDD, used in the new digital device, pays particular attention to this problem in using an algorithm that will not halt pre-reading on receipt of a write command. This reduces losses in transfer speed during time shift playback (see Fig. 8).

High Capacity

HDD recording density has increased by 1.5 to 2 times every year since the HDD's inception, as computer applications using HDDs have demanded this increased performance. Since a few years ago, however, we have been approaching a point where the technology amply satisfies any demands. As one will appreciate when actually using a computer, there are very few situations in which the several hundred Gbyte capacity of modern computers is actually required. While new applications will continue to be invented

TABLE 2. Comparison of AV and Network Recorders
Recorders can be broadly divided into those of the AV and network variety. Network recorders are, in other words, integrated digital recorders which fuse broadcast and network communication.

Recorder Type	AV recorder	Network recorder (fusion of broadcast and network)
Property	Broadcast	Broadcast and broadband network (multistream, bi-directional)
	1:1 connection	N:N connection, remote connection
	Conventional appliance	Evolving appliance (software upgrades, databases, etc)
	Video and audio content	Varied content (moving images, audio, data)
Target market	VTR units	Core device of the home network (new market creation)

AV: audio-visual

and the storage capacity they require is forecast to increase, this seems unlikely to be decisive in determining PC performance and new possibilities.

If we take a look at the image storage of HDD/ DVD recorders, however, we will see that their demands for storage capacity are much higher. Hitachi Global Storage Technologies, Inc.'s HDD, featured in the new digital recorder, realizes a high, 60 Gbyte per side, storage density, achieving 120 Gbytes with two disks. Advanced compression technology means it can record up to 120 hours worth of images at a speed equivalent to VHS (video home system). In future, however, HDTV (high-definition television) broadcasts and the transmission of images of even higher resolution will probably create demand for even larger storage capacity.

Hitachi Global Storage Technologies, Inc. has begun mass production and shipment of an even higher density version, and plans to commercialize a unit of still higher density with a capacity of over 500 Gbyte in the near future. Hitachi is preparing for future demand for super-long recording time and the high-definition video recording needed for HDTV.

DIRECTIONS IN HYBRID BROADCAST/ NETWORK DIGITAL RECORDERS

Table 2 shows a comparison between the network-type recorder envisaged by Hitachi (integrated broadcast/network) and conventional AV-type recorders. We will go on to discuss the features of network recorders described.

Broadcast and Broadband

AV recorders were developed to be devices to

receive and record TV transmissions, and many HDD/DVD recorders released by the various manufacturers are intended as replacements for existing VTRs. The integrated broadcast/network hybrid digital recorder, however, is able not only to receive and record from broadcast signals, but to receive programs over a broadband connection. In future, when a variety of content will be sent over FTTH (fiber to the home), expected to become the main type of broadband connection, there will be a need to handle multiple streams of content, i.e. content broadcast over TV broadcast signals and content broadcast over networks. This will require a high performance processor and memory, as well as a high-performance bus and HDD. In anticipation of these kinds of future developments, the new digital recorder architecture incorporates AV functions, based on a PC architecture which easily allows the aforementioned configuration.

N:N and Remote Mode Linkup

As AV recorders lack networking functionality, they inherently have 1:1 connectivity. However, integrated broadcast/network type hybrid digital recorders which feature network functionality as standard allow not only 1:1 but also *N:N* linkup. For example, in cases where there are several computers, combination broadcast/network hybrid digital recorders and networked TVs in a house, all fitted with broadcast tuners, networks and HDDs, the user is unlikely to mind which device programs are recorded or played back on. The user will also not want to worry about remaining hard disk space. Users simply want to be able to record the programs they want to watch, and play them back when they want to. All this can be achieved by using a network to turn the various device resources into a virtual resource. It will also become possible to view content stored in the broadcast/network hybrid digital recorder from laptop computers, PDAs (personal digital assistants) and mobile phones connected over broadband networks, as well as using the recorder as a storage space for videos and data.

Evolving Appliance

In general, the features of existing AV devices have remained the same from the time they are bought to the end of their lives. The rapid advance of software technology, however, has led to a general philosophy of using software upgrades to prevent purchased devices from becoming outdated. By applying this philosophy, broadcast/network hybrid digital recorders, are able to improve their features and performance through software upgrades. In future, storing and making use of information on users' tastes and ways of using the technology will enable the realization of a function that automatically records programs and gives advice.

Varied Content

AV recorders process audio and video data. However, the broadcast/network hybrid digital recorder, the future core of the in-home network, will process not only video and audio data, but also business and voice data. It will be possible to handle/process all these types of data simultaneously using broadband networks and LANs.

CONCLUSIONS

Here we have discussed Hitachi's broadcast/network hybrid digital recorder and its core component, Hitachi Global Storage Technologies, Inc.'s HDD, as well as future directions in broadcast/network hybrid digital recorders.

Hitachi intends to continue developing the recorder to make it a core home network component deserving of the name broadcast/network hybrid digital recorder.

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