Stream Manager—Targeting High-functionality AV Equipment at Low Cost

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OVERVIEW: With the popularization of AV equipment incorporating HDDs, DVD/HDD recorders, plasma TVs with built-in HDDs, broadband PCs, etc., "time shift viewing"—where recorded pictures are viewed off the hard disk—is becoming commonplace. In contrast to recording media like videotape, an HDD allows read and write operations to be executed simultaneously. Accordingly, recorded programs can be watched while being recorded, and multiple programs can be recorded simultaneously. From now onwards, applications for enjoying recorded programs over networks will also become more popular. Hitachi has developed and is commercializing two middleware solutions that provide applications with hard-disk utilization adapted to the features of high-definition-image content: (1) a stream manager for enabling simultaneous handling of continuous flows of data ("streams") between various hardware components and HDDs, and (2) an "AV-use File System" for assuring data transfer rate of image contents. Applying these two middleware solutions enables HDTV images to be handed simultaneously, reduces the processing cost of AV equipment, and offers high functionality.

INTRODUCTION

AS a result of the digitization of contents such as music and images, AV (audio-visual) equipment fitted with storage, namely, flash memory and HDDs (hard disk drives), is becoming more popular. Moreover, thanks to improved quality and resolution of music and images, the volume of contents is tending to grow ever bigger, and HDDs are becoming indispensable for AV equipment, particularly devices handling image contents.

Under these circumstances, focusing on capability of AV equipment and features of image contents, Hitachi is making efforts to provide middleware applications for HDDs (see Fig. 1). As regards AV equipment handling image contents, simultaneous recording of multiple programs and simultaneous handling of high-definition images (such as normal playback and "trick play" during program recording) are necessary. In addition, high-definition images have a high bit rate that is three times that of normal images on conventional DVDs (digital versatile disks), and it is difficult to secure the rate for each access during simultaneous access to an HDD.

As for these challenges, by means of processing

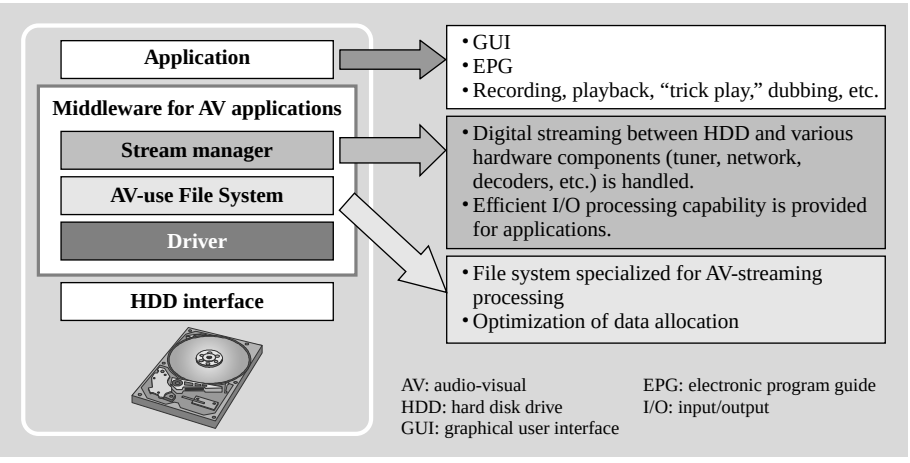


Fig. 1—AV Middleware for Handling Features of Image Content.
In AV equipment mounted with a hard disk, simultaneous operation (i.e. recording, playback, and transmission) is required. For efficiently handling "high-definition" images with hard disks, development and commercialization of middleware for AV applications of the stream manager and "AV-use File System" are continuing.

modeling, optimization of I/O (input/output) processing as well as addition, modification, and reuse of functions can be made easy, and a stream manager (located in middleware for simultaneous handling of high-definition images) and an "AV-use File System" (for assuring data-transfer rate in accordance with the high bit rate of image contents) are being proposed.

In the rest of this article, the stream manager is overviewed, and its application to broadband PCs is described.

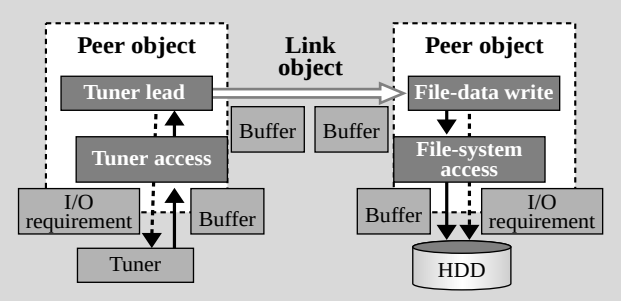


Fig. 2—Streaming Model.
Flow (i.e. "stream") of continuous data is composed of "peer objects" and "link objects."

OVERVIEW OF STREAM MANAGER

Configuration

Realizing the capability of recording and playback on AV equipment adds up to controlling the flow of continuous data at the core of an HDD, namely, "to HDD from tuner" and "to decoder from HDD." This continuous data flow is referred to as "streaming."

In the stream manager, the stream is modeled in the way described as follows. Processing points in the stream are defined as "peer objects," which are connected by "link objects" as shown in Fig. 2. By modeling in this way, it is possible to simply actualize the stream inside AV equipment. This, for example, makes it easy to increase the number of simultaneous recordings and supplement the distribution capability to a network. Incorporating such a stream model, the configuration of the stream manager is shown in Fig. 3.

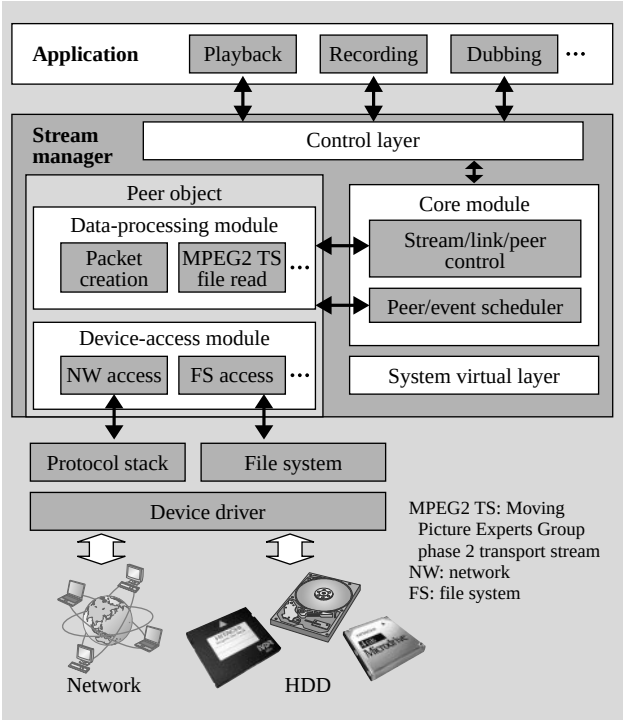


Fig. 3—Software Configuration of Stream Manager.
In correspondence with applications like playback and recording, streaming control platform, optimized I/O processing, and real-time processing are provided.

Features

The features of the stream manager are summarized as follows:

(1) Control function with modeled stream processing

Peer processing is executed by stream-link-peer control and peer scheduling (time scheduling and I/O event scheduling).

(2) Function enabling optimization of I/O processing

A function for incisive I/O control enabling asynchronous I/O processing and a buffer control function enabling "zero copy" I/O processing are provided.

(3) Real-time processing

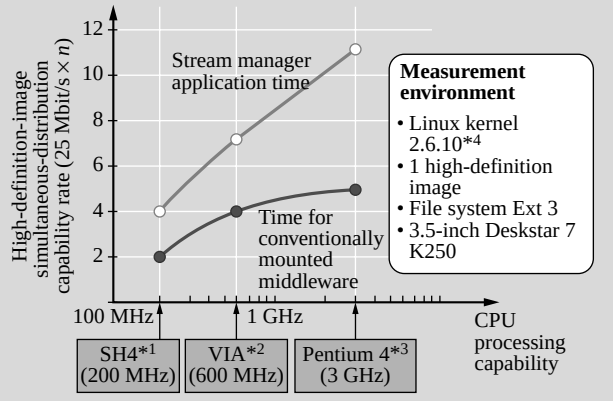
Processing of "real-time peers" is executed by means of thread control, peer scheduling, and CPU (central processing unit)-load reduction. As for peers, by controlling the required number of I/O and I/O size according to device load, processing in accord with real-time load is made possible.

(4) High interchangeability and high expandability

Concealment of OS (operating system)-dependent sections is improved by means of a system's virtual layer, and software productivity is improved by modulization of functional units.

Effectiveness Evaluation

The stream manager was used to realize a distribution-server capability. For different CPU clock frequencies, the number of simultaneous distributions in the case of network distribution of HDTV (high-definition TV) images at 25 Mbit/s is shown in Fig. 4. Regardless of the type of processor, compared with a conventionally packaged middleware manager for



CPU: central processing unit
*1 SH is a registered trademark of Renesas Technology Corporation.
*2 VIA is a registered trademark of VIA Technologies, Inc.
*3 Pentium is a registered trademark of Intel Corporation.
*4 Linux is a registered trademark of Linus Torvalds.

Fig. 4—Effectiveness of Stream Manager.
By utilization of a stream manager, the number of high-definition images that can be handled simultaneously can be increased by about two times.

realizing delivery capability by applications, the stream manager can improve the distribution number by about two times (under the condition of no file fragmentation on the HDD).

APPLICATION TO "HIGH-VISION AV-PC"

Hitachi launched a broadband PC—called "high-vision AV-PC" in October 2005—fitted with an analog/digital tuner. High-vision AV-PC is installed with Hitachi's own image-processing LSI. As regards this AV-PC, it must be possible to operate the PC smoothly during both viewing and recording of HDTV broadcasts. Considering reduction and equalization of I/O processing load on an HDD as well as simplicity of function expandability in the future, Hitachi is applying the stream manager to control of streaming during recording and playback of HDTV broadcasts.

Requirements for Stream Manager

Simultaneous operation

Terrestrial digital HDTV images have a bit rate of about 25 Mbit/s. In the case of normal playback and recording at the same time, read-write access is at 50 Mbit/s. Moreover, in the case of playback at 1.3-times faster speed, read access must be at about 33 Mbit/s, so read and write access needs 58 Mbit/s.

During execution of this kind of HDD access (for example, even when the Internet is being accessed), to allow HDD operation without incident, the following two points must be considered:
(1) Average CPU utilization rate should be reduced as much as possible, and its maximum value should be suppressed.
(2) Memory utilization budget used for recording and playback should be equalized as much as possible.

TABLE 1. Overview of Control Library
An interface for easily using recording and playback applications of high-definition broadcasts is provided as a "library," and the streaming model is concealed from the applications.

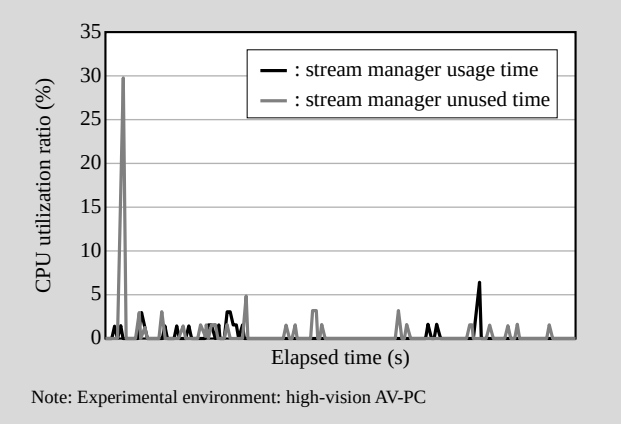
Library name	Overview
initialize	Initialization
finalize	Finalize
play	Play
jump	Switching of playback location
change-speed	Switching of playback speed
get-play-stat	Acquirement of present playback location
pause-on	Pause playback
pause-off	Restart of paused playback
record	Recording
get-rec-stat	Acquirement of present recording time
stop	Stop playback or recording

Applications and their interfaces

Interfaces that provide the stream manager need a sequence that creates peers, joins them together with links, generates a stream, and performs initialization. For the sake of easily controlling the stream manager from various applications, it is necessary to provide a user-friendly interface like "recording" and "playback." To meet this requirement, a "control library" is implemented on the stream manager (see Table 1). Moreover, an interface for notifying applications about the playback-position information is also provided.

Application Results

As results in the case that the stream manager was applied for controlling streaming during recording and playback, CPU utilization ratio during execution of recording of one program of HDTV images and playback at 1.3-times speed is plotted in Fig. 5. The case that file read/write was executed by applications and recording/playback processing was executed virtually with using the stream manager was compared with the case without the stream manager. In the case without using the stream manager, CPU utilization rate reaches a maximum of 30%; in contrast, with the stream manager, it is maintained around 7% at all



Note: Experimental environment: high-vision AV-PC

Fig. 5—CPU Utilization Ratio Resulting from Use of Stream Manager.
By use of the stream manager, CPU utilization ratio is equalized.

times. As a consequence, by means of the application of the stream manager, other software can be assured of enough, stable CPU resources for operating.

In the case that the stream manager is not applied, typically, other applications start to use memory, so memory utilization amount varies. However, in the case that the stream manager is applied, the specification ensures that a fixed amount of memory is used for processing and direct I/O is used; consequently, even in the case that another application is operating, the memory utilization amount does not increase. Applying the stream manager thus enables other software to utilize a stable memory range enough for its operation.

FUTURE DEVELOPMENTS

Applying the stream manager makes it possible to reduce and equalize CPU-utilization amount and to equalize memory-utilization amount. Furthermore, the stream manager enables twice the number of HDTV images to be handled simultaneously. As a consequence of these features, in the case of AV equipment incorporating HDDs, the hardware specifications required for processing HDTV images can be relaxed, so AV equipment can be made at a reasonable price. Making full use of the advantages of the stream manager, Hitachi will investigate its application to HDD-built-in devices such as broadband PCs (AV-PCs), plasma TVs with built-in HDDs, HDD recorders, and STBs (set-top boxes) as well as to streaming servers and file servers for handling large volumes of data.

CONCLUSIONS

In this article, the stream manager—middleware for enabling multiple HDTV images to be handled simultaneously—was overviewed, and its application to a broadband PC, as well as its effectiveness, was described. With the application of the stream manager, twice the number of HDTV images can be handled simultaneously, thereby reducing processing cost and increasing functionality. From now onwards, Hitachi will develop solutions aiming at a wide range of equipment fitted with HDDs, such as in-car and mobile devices.

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