“Contents on Demand” Architecture and Technologies of Lui

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Abstract

NEC Personal Products, Ltd. has developed Home Server PC “Lui SX”, which is a PC incorporating a large-capacity HDD and capable of unified management of digital contents and distribution of them to PCs in a home network or to network (DLNA)-capable TV sets. This paper introduces the technologies supporting the Home Server PC “Lui SX”, including “high-reliability design” for 24-hour stable operation and “Multi Record Casting Technology” for recording/distribution of two digital broadcast programs simultaneously as well as the usability of these technologies.

Keywords

digital broadcast, DLNA, DTCP-IP, file system, cooling/noise reduction, user interface

1. Introduction

Recent PCs feature improved digital content handling capabilities, such as digital broadcast recording/viewing functions and the content distribution function based on the DLNA (Digital Living Network Alliance) standard. However, they are still insufficient for use as a server implementing “Contents on Demand”, because (1) the digital broadcast recording is interrupted when the OS is restarted, and (2) the user interface gets sometimes unsmooth due to the CPU load imposed by content distribution processing in the background.

This paper will introduce the technologies for implementing “Contents on Demand”, including “high-reliability design” for 24-hour stable operation and “Multi Record Casting Technology” for recording/distribution of two digital broadcast programs simultaneously as well as the usability of these technologies.

2. High–Reliability Design

2.1 PC/Recorder Independent Architecture and Monitoring Mechanism

To ensure stable recording that is not affected by PC applications and power saving during the period PC functions are not used, we adopted hardware (HW) architecture separating the PC system implementing PC functions and the recorder system recording digital broadcasts, as shown in **Fig. 1** .

The PC system can run applications on Windows Vista

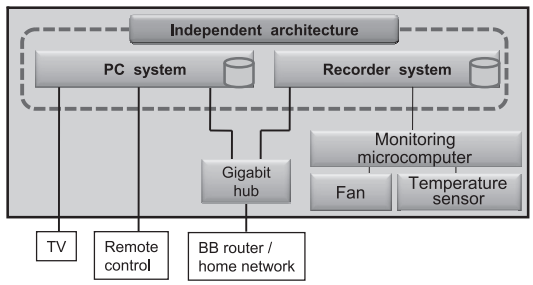

Fig. 1 PC/Recorder Independent Architecture and monitoring mechanism.

Home Premium at the same level as other NEC PCs, and supports HDMI (High-Definition Multimedia Interface) connection and remote control input, assuming installation in a living room. Its power is supplied independently from the recorder system for a power saving structure, with which only the PC system can be powered off when PC functions are not required. On the other hand, the recorder system is a system in which two digital broadcast tuners and recording HDD(s), with max. 1TB capacity, are implemented. The two systems are connected in a LAN through the gigabit hub, so that the recorder system can function independently even when the PC system is powered off. To ensure communications without dependence on the network environment, we adopted IPv6, which is capable of automatic IP address setting even when a DHCP server is not present in the home network environment.

For the system monitoring mechanism to support 24-hour continuous operation, we provided (1) a watchdog timer function enabling auto-recovery from stalling due to software faults, etc., and (2) a monitoring microcomputer capable of

automatic shutdown based on detection of fan troubles or abnormal temperature.

2.2 Cooling/Noise Reduction Technology

Since the home server PC is connected to a large-screen TV in the living room, it is necessary to reduce acrostic noise to a level that will not disturb users. However, the acrostic noise reduction measures must be very powerful when the PC is provided with versatile functions and large recording capacity that can meet user needs. Therefore, in collaboration with the System Jisso Research Labs, NEC Corporation adopted an air cooling system featuring easy size reduction, and established a technology for providing both cooling and acrostic noise reduction through the following four steps:

(1) Study of Element Technologies

To reduce noise in the limited unit size, we evaluated the effect and tuning method of each element technology (see **Table**) and adopted low-noise fans, fan speed control, separated location of the air intake hole and noise sources, placement of devices with low heat resistance in upwind locations, etc.

Table Element technologies for noise reduction and their effects.

Element	Effect	Tuning Method
Noise	Generated noise reduction	• Use of low-noise fans
Cooling air	Air volume increase	• Decrease of fan speed
Sound insulation	Noise insulating structure	• Wind noise reduction by optimization of distances of parts before and after the fan
Sound absorption	Volume attenuating materials	
Vibration reduction	Vibration attenuating materials/structure	
Sound leak	Aperture position/direction control	

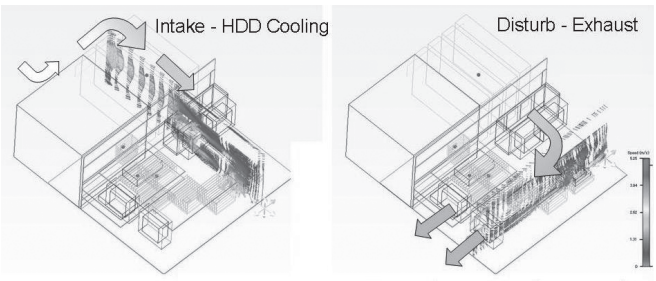

Fig. 2 Thermal fluid simulation of the interior of home server PC.

(2) Cooling Capacity Evaluation and Simulation-based Packaging Design

Based on the power consumption and tolerable temperature of each device built into the unit, we calculated the cooling capacity required at maximum load using a special designed tool and obtained the approximate amount of necessary air volume. Then, based on it, we fabricated a thermal fluid digital mockup using 3D CAD, and simulated the air paths inside the cabinet, and the temperature rise of each device (**Fig. 2**), for eventually designing the optimum packaging that can meet the cooling condition requirements.

(3) Prototype Evaluation

Concurrently with the simulation, we also measured the unit's internal temperature and noise level at maximum load using a prototype. We fed the results back into the simulation in (2) above and finally decided on the use of two 60mm square fans for each of the internal cooling and external exhaust systems.

(4) System Control Adjustments

We installed temperature sensors in proximity to key devices such as the CPU and HDD, and control fan speeds in multiple steps to further reduce noise during low load conditions.

As a result of the above, we succeeded in achieving library-level quietness of about 30dB(A) (25°C environment), even under maximum load, using air cooling system alone.

3. Multi Record Casting Technology

To execute PC applications smoothly while processing the recording/distribution of two digital broadcast programs, reducing the CPU load for distribution, and securing the performance of the recording HDD(s), where four write and read streams are concentrated, become important issues. In this section, we will describe the architecture providing digital broadcast recording/playback functions by focusing on the technologies used for solving the above issues.

3.1 Digital Broadcast Recording/Playback Architecture

Fig. 3 shows the architecture used for the recording and playback of digital broadcasts.

The recording function is processed by the digital broadcast recording components running on the recorder system, and the video streams extracted from the two digital broadcast tuners are installed in the video HDD using an original

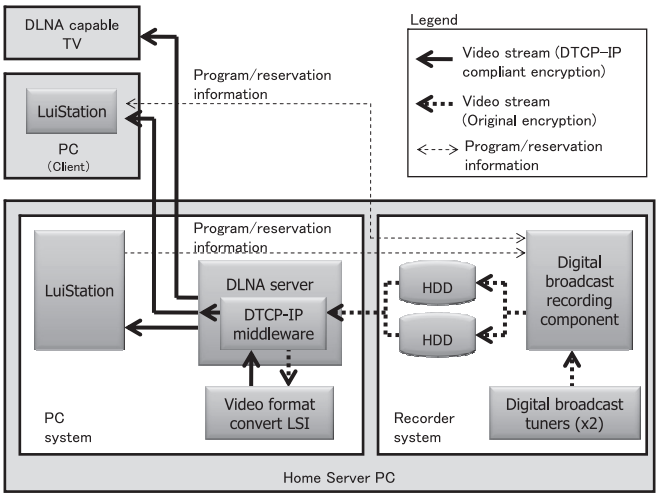

Fig. 3 Recording/playback architecture.

encryption format. The recorder system has two HDDs (with the upper model), and data is written alternately by switching the HDDs every 12 hours, to distribute HDD access load and ensure durability.

On the other hand, the playback function is implemented by the video distribution function from the DLNA server running on the PC system. The video streams stored in the recorder system using the original encryption format are converted into the DTCP-IP (Digital Transmission Content Protection over Internet Protocol)-compliant encryption format by the newly developed Video Format Convert LSI. Implementation of this encryption conversion processing, which imposes an especially heavy load on distribution processing, in the hardware has made it possible to reduce the CPU load for distribution of two HDTV signals to 20% to 30%, thereby enabling the simultaneous operation of distribution processing and PC application execution.

The video distribution from the DLNA server can be received and viewed with the digital broadcast recording/viewing application “LuiStation”, with built-in DLNA client function, or with any network (DLNA)-capable TV. When LuiStation is used, the standard program information provided by the DLNA, as well as the information under unified management of the digital broadcast recording component, can be used to implement (1) the recording reservation function, which is unavailable with ordinary DLNA clients, and (2) the program management function unique to the Home Server PC. For example, using the “continued playback function” makes it possible to resume playback from the last played program or

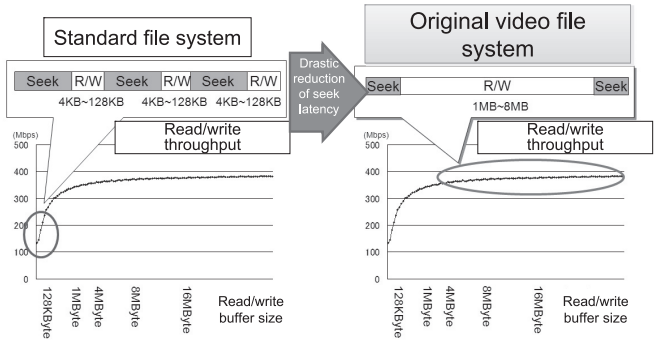

Fig. 4 Relationship between buffer size and throughput.

the last playback stop position, managed by the digital broadcast recording component. This makes it possible to continue viewing with a simple operation even when the user moves from the living room to a bedroom in the middle of viewing.

3.2 Video–dedicated File System

To implement the function of recording/distribution of two digital broadcast programs, we developed a video-dedicated file system based on an original buffer management method, and incorporated it into the recording HDDs of the recorder system.

With a general-purpose file system that handles files of various sizes, the capacity can be used more efficiently by decreasing the size of the file read/write buffers. In this case, however, large files tend to be placed physically discontinuously, so the resulting increase in the head seek degrade the read/write rate (**Fig. 4**). Meanwhile, since the recording-dedicated file system handles only digital broadcast files of a few gigabytes, it does not degrade the HDD utilization efficiency even when the buffer size is increased, so it allows read/write performance to be improved by setting a large buffer size.

This file system is implemented as middleware working in the user space because it implements a unique buffer control method, and the one of OS-standard buffer mechanism is used as the bypassing-capable low-level HDD access API. We set the read/write buffer size to 4MB to implement high-speed access that is not affected by the head seek operation as well as to attenuate the performance due to file segmentation that results from repeated recording and erasure.

4. Usability

4.1 User Interface Suitable for Living Room

(1) Improved Visibility from Distant Locations

To improve visibility at a distance of 10 feet from the TV screen, we adopted larger icons than normal PC applications, which are usually viewed from a distance of 2 feet, for LuiStation (**Fig. 5** (a)). We also placed LEDs indicating unit operation status in a circular shape with angles, so that identification of lighting LED(s) is easier than with a layout in which LEDs are placed side by side (Fig. 5(b)).

(a) Top menu of LuiStation (b) Operation status indicator LEDs

Fig. 5 Visibility improvement measures for living room use.

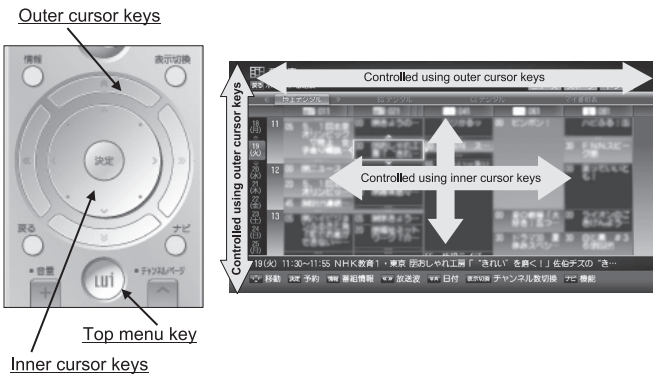

Fig. 6 GUI operation using double cursor keys.

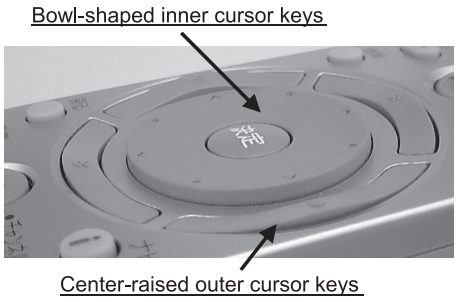

Fig. 7 Design of double cursor keys.

(2) Improved Remote Control Operability

We developed a new remote control unit that gathers the double cursor keys and major buttons in the center, so that the remote can be operated without changing hand posture. We also designed a GUI display matching the usage of the remote control unit (**Fig. 6**). For example, with the EPG (Electrical Programming Guide) listing, the broadcast type (terrestrial digital, broadcast satellite and communications satellite) and date are selected using the outer cursor keys, while the channel and broadcast time are selected using the inner cursor keys. The inner cursor keys are laid out in a bowl shape, and the centers of the outer cursor keys are raised, as shown in **Fig. 7** , to enable identification of the inner and outer keys of the double cursor keys without looking at the remote.

4.2 Improvement of Content Search Efficiency

To facilitate the finding of a desired program from a large number of digital broadcast programs, the following search functions are supported, in addition to the ordinary EPG list and the per-channel/per-genre/per-folder program lists/recorded program lists.

- Auto-selected program list: This function searches for and displays programs that match the keywords and genres registered by the user, and it is also capable of automatically recording the selected programs. Since the program search takes time, the search processing is performed at the same time the EPG list is updated, in the middle of the night, to ensure quick response when the user actually operates this function.
- Recommended program list: This function picks up the programs recommendable for the user according to the user's viewing history (programs, genres and broadcast time zone) and the program information. As this function does not need previous setup, it allows the user to find programs easily and efficiently when the user does not have a specific desired program in mind.

5. Conclusion

This paper explained the architecture and implementation technology of the digital broadcast recording/playback function of Home Server PC "Lui SX" and its usability. In the

future, we will enable multichannel simultaneous recording, and enhance the linkage with home video recorders, to promote the concept of “Contents on Demand” further.

*Windows Vista Home Premium is a trademark or registered trademark of Microsoft Corporation in the United States and other countries.

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