1. Introduction
We have developed home network technologies for interoperability among audio video (AV) appliances. The newly developed high-speed and stable delivery algorithm has achieved a high-quality image display for random access playback without fluctuations in the image display intervals. We have also developed a remote control technology that enables high-speed control of AV appliances linked through a comfortable user interface.

2. AV Appliance Interoperability
AV appliance interoperability refers to the ability of multiple appliances interconnected on a home network to share/control contents, and is roughly divided into “AV device interoperability” and “mobile device interoperability.” AV device interoperability makes it possible to enjoy video contents that have been recorded in the living room, on the LCD TV in the bedroom, while mobile device interoperability allows AV devices to be controlled from a mobile device (Fig. 1).

3. Technologies for AV Device Interoperability
3.1 Basic sequence of video delivery process
This time, we have built a video delivery middleware system for embedded devices based on the Digital Living Network Alliance (DLNA) guideline. Figure 2 shows the basic operation sequence of this system. Once the video delivery device is connected to the home network, interconnection between AV devices is automatically established. The user retrieves a list of stored video contents from the video display device, and selects the desired content. Once selected, the video display device uses the HTTP GET method to instruct the video delivery device to start playback of the selected content. Subsequently, the video delivery device sends a ‘playback started’ response as an HTTP response to the video display device, followed by the transmission of AV streams as HTTP response packets. The video display device decodes the received AV streams to play the AV content.

3.2 Video delivery algorithm
3.2.1 Current issues
For video delivery over the network, it takes a long time to execute the sequence of playback start-up processes, from “delivery start instruction” to “video stream delivery.” For the random access playback such as fast forwarding and fast backward, the playback start-up processes are repeatedly executed, and thus the number of displayable video frames per unit time is reduced, and smooth video display is disrupted. In addition, in some rare cases of delivery contents that have a special data rate, it takes a longer time than usual to start the video stream delivery, leading to fluctuations in the image display intervals and possible degradation of the display quality.
3.2.2 Automatic adjustment of transfer buffer size

This time, we have developed a dynamic video delivery control algorithm for the random access playback mode, where the status of the display device is estimated, and the transfer rate from the delivery buffer is controlled based on the estimated playback status and the data rate of the delivery content. With this control, video data is provided to the video display device at an appropriate transfer rate and timing for the playback status even in the random access playback, no fluctuations occur in the displayed image and a high-speed, stable video stream delivery can be achieved. Figure 3 shows the display intervals measured at the video display device before and after the application of this control method.

The data in Fig. 3 is the switching intervals between two consecutive images measured on each test sample in the random access playback mode. A larger display interval means a less smooth video playback, and a larger up/down variance or fluctuation of the display interval means a lower display quality.

As shown in Fig. 3, applying this algorithm to the random access playback reduces the video delivery time by about 25% in terms of the average display interval, as well as the standard deviation of the display intervals from 0.18 to 0.06. As such, it has been demonstrated that the application of this system reduces the fluctuation in the display intervals and achieves a high-quality image display.

4. Technologies for Mobile Device Interoperability

4.1 Remote control technology

Mobile devices such as smart phones and tablet devices can be intuitively and easily operated using a touch panel. Recently, we have been receiving requests for the capability to control AV devices in a similar manner to mobile devices. However, a TV’s processing capacity is lower than that of mobile devices, and thus it has been difficult to ensure the same operational performance as mobile devices. Accordingly, we have built a remote control system that requires no modification of TV hardware and provides the users with satisfactory TV control capability by using a mobile device.

Figure 4 illustrates the block diagram of the newly developed software architecture.

A new application program for the interoperability is installed in both the mobile device and TV set. The application is used to control intercommunication using the communication library. When the control from the mobile device is started, mutual interface specifications are exchanged to determine the functional compatibility. When a control command is executed, the mobile device uses the abovementioned interface specifications to transmit the command to the TV, which is then interpreted by the TV/Video recording application program. In this manner, channel selection, volume and image quality adjustment, and other functions are remotely controlled from the mobile device.

4.2 Speed-up of response process

In order to improve the response speed between the system modules, we have developed a method to reduce the waiting time between those modules. First, when a control command from the mobile device and a conventional TV software program are executed in parallel, the priority between the command and the TV program is determined to ensure the functionality of the TV. Second, given that various types of control commands from the mobile device require different processing times, an appropriate waiting time sufficient for each command type is determined, by not simply setting the same response waiting time to all operation commands. This modification has reduced the response time between modules and improved the speed of the response process. To evaluate the performance of this method, the response waiting time of the mobile device was examined (refer to Table 1).

As shown in Table 1, it has been confirmed that this method provides the mobile device with a response waiting time equivalent to that of the conventional infrared remote controller (0.02 s on average).
Table 1 Measurement results for response waiting time of mobile device

<table>
<thead>
<tr>
<th>Action</th>
<th>Response waiting time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request for connection</td>
<td>0.02</td>
</tr>
<tr>
<td>Disconnection</td>
<td>0.02</td>
</tr>
<tr>
<td>Audio volume change</td>
<td>0.02</td>
</tr>
<tr>
<td>Channel change</td>
<td>0.02</td>
</tr>
<tr>
<td>Input change</td>
<td>0.02</td>
</tr>
<tr>
<td>Timer recording setup</td>
<td>0.23</td>
</tr>
<tr>
<td>Retrieval of a program list of timer recording</td>
<td>0.37</td>
</tr>
</tbody>
</table>

5. Conclusion

We have developed a middleware system for embedded devices to realize AV appliance interoperability. We intend to enhance the home network functionality as well as to develop new functions to improve the convenience of users.

References