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Establishment of Controlling IEEE1394 devices over the network

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Abstract

This paper proposes the design and implementation of IEEE1394 device control over network. We have extended the wired connection between IEEE1394 device and computer into IP network, formerly connected with IEEE1394 interface. Implemented system could use all of the features which IEEE1394 device carries, via IP network.

Using implementation on IEEE1394 device control over IP network linked with DVTS which transports DV Data through IP network, we can construct radiowave broadcast transport system through IP network. Using implemented radiowave broadcast transport system, we can watch and store radiowave broadcast over IP network.

From this research we achieved extension of the connection between IEEE1394 device and computers to control IEEE1394 devices. By constructing a radiowave broadcast transport system, we have experimentally proved the availability of our implementation on IEEE1394 device control over IP network.

1 Introduction

Consumer AV appliances are being transformed from analog to digital technology. Digitalization of AV appliances made simpler interconnectivity between computers. IEEE1394[2, 5, 11] is a common interface connecting AV appliances and computers or other digital AV appliances. DV camcorders are the mainstream of AV appliances using IEEE1394 interface.

There are three reasons why IEEE1394 adopted in these kinds of AV appliances. 1) Fast transfer speed is indispensable for audio and video data. 2) Small connector is convenient to connect small devices. 3) Supports hot-swap connection. When new IEEE1394 device is connected or removed, IEEE1394 bus automatically reconfigures the new node.

There are two functionality on IEEE1394. 1) Controlling the device, and 2) transportation of the media.

Capability of IEEE1394 to control its connected device is due to the fact that IEEE1394 interface is not designed to connect only with computers. IEEE1394 are also designed to connect with consumer appliances. There are a few software implementations to control IEEE1394 devices.

There are two sample applications transporting IEEE1394 features through the network, 1) DVTS [9, 10](Digital Video Transport System), and 2) Video Transport System designed for MPEG2TS [3](MPEG2 Transport Stream). By using these applications, construction of internet broadcast system using IEEE1394 connected device and computer with Internet Protocol (IP) can be established in simple manners. These implementation are already in practical use for video conferencing and high quality streaming.

Comparing the feature of data transmission in implementation of IEEE1394 interface, there are only few softwares implementing the control mechanism of IEEE1394 connected device. However, there are no implementation to control devices over IP network. In some operating systems, Application Programming Interface (API) for controlling IEEE1394 device connected with IEEE1394 do exists.

There is specification for IEEE1394 device control for several types of devices. For example, VCR, TUNER and TAPE RECORDER. In spite of the existence of specification, there are many devices with out these implementation.

In this paper, we define “Radiowave Broadcast” for television broadcast which uses radiowave for transmission and “Internet Broadcast” for broadcast system which uses IP network for transmission.

1.1 Controlling the devices connected locally

Some IEEE1394 devices require vendor distributed applications for controlling the device. This paper implements controlling of these devices connected via IEEE1394. In this research, we designed and implemented IEEE1394 device control over IP network. IEEE1394 has platform capability to control devices locally. IEEE1394 has a limitation in its physical interface for the wire length of the controlling media. IEEE1394 cable connection has a restriction in length of 4.5 meters.

There are no implementation to extend controllability of the device from local cables to over IP network. For sample implementation of IEEE1394 device control over IP network, we designed and implemented “Radiowave Broadcast Transport System” linking with DVTS.

1.2 IEEE1394 Device drivers

Some Operating System (OS) supports API for IEEE1394 device control (Table 1).

Table 1. IEEE1394 API for several OS

OS	API
FreeBSD	Device file
Linux	Device file & Library
WindowsXP	Driver & Library

OHCI (Open Host Controller Interface) link chips are defacto standard for IEEE1394. OHCI chip cannot be placed in promiscuous mode. Therefore, monitoring the traffic through the interface is difficult. Before OHCI link layer appears, Texas Instruments PCI Lynx link chip has been used. This link chip could be placed in promiscuous mode.

2 Design of radiowave broadcast transport system

Radiowave broadcasting is limited in its strength of radiowave resulting limitation of coverage for reception. To establish enhancement of coverage, we need to set radiowave broadcast receiver inside the coverage to transport audio and video data to the client. Coverage of radiowave broadcasts are limited due to power and degradation of radio signals. A method to control radiowave broadcast receiver is required to establish similar operation as the situation inside the coverage. Also, storing the broadcast is required for recording matters.

By using audio and video transport application with IEEE1394 device including a tuner for radiowave broadcast, constructing a radiowave broadcast transport system using IP network is possible. In addition, using IEEE1394 device with function to record, radiowave broadcast can be recorded to a local IEEE1394 device. Another method is to record to DV format file. From both of these method, storing mechanism can be implemented.

2.1 Design outline

System irrespective to location and time is required to realize this system. To construct the system irrespective to location, we must control the radiowave broadcast receiver remotely. To construct the system irrespective to time, we must have a method to store the radiowave broadcast.

This system is constructed in 2 parts, server module and client module. Via IEEE1394 interface, server module controls IEEE1394 devices and receives DV data. It transmits DV data over IP network. Client module sends control request to server module.

DV converter and D-VHS deck (Digital VHS) for IEEE1394 devices is used in this system. DV converter can convert radiowave broadcast from antenna and analog inputs of video and audio data into DV format. D-VHS deck is used for storing the broadcast into D-VHS tape. By controlling DV converter via IP network remotely, it is possible to transport radiowave broadcast outside the coverage.

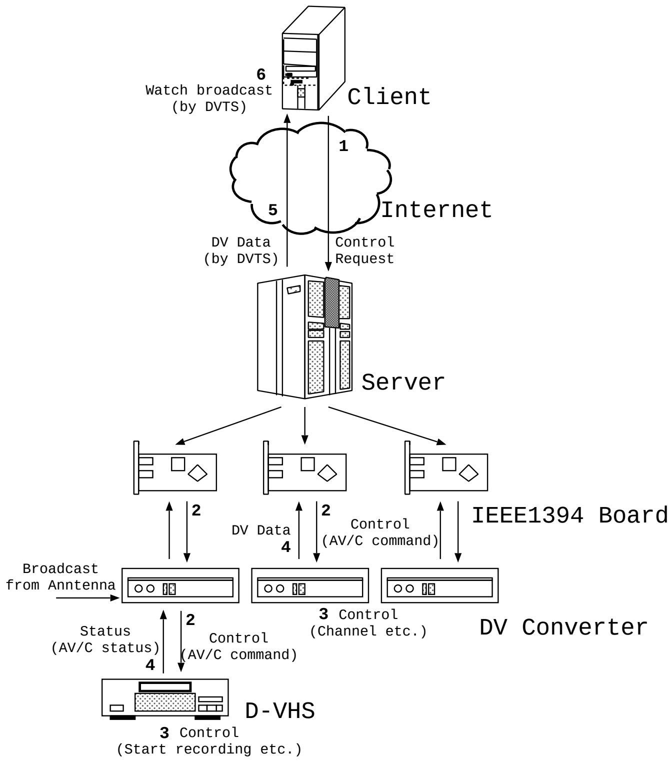

Figure 1. Overview

Figure 1 shows the overview of this system. There are 6 steps in its sequence.

1. Client sends control command transmission request to the server by using web interface.

2. Server sends control command to IEEE1394 devices (DV converter or D-VHS).

3. IEEE1394 devices accept the command and change the channels, start recording to D-VHS tape, etc.

4. Selected broadcasts DV stream is send to server via IEEE1394 to server.

5. Server sends DV stream through Internet by DVTS to client
6. Client receives the selected broadcast with DVTS.

Using this implementation, radiowave broadcast can be transported outside of a coverage area and can be stored to D-VHS tape and into DV format files.

2.2 Server module

Server module consists of 3 parts. Former part sends control commands to IEEE1394 devices via IEEE1394 interface and receives response. Second part receives DV data from IEEE1394 device via IEEE1394 interface and sends DV data via IP network using DVTS. Third part receives DV data from IEEE1394 device via IEEE1394 interface and records into DV format files.

2.2.1 Transaction type in IEEE1394

IEEE1394 is used for audio and video data transmission and device control. Both usage have a specialized transaction mode to send data and receive response.

For audio and video data transmission, Isochronous Transaction is used. Isochronous transaction is similar to UDP in IP network. Data is divided into packets. The divided packets are send in ordered interval. Data are not sent to specific node, but to a channel in the bus which every node connected to IEEE1394 bus receives. The node receiving the data does not send a acknowledge packet to the originated node. Isochronous transaction is specialized in real-time aware data transmission. Isochronous channel is used to determine each audio and video data stream in one transaction. Mainly consumer IEEE devices uses 63 for Isochronous channel value which is broadcast channel.

Asynchronous Transaction is used in device control. In asynchronous transaction, data are not sent in ordered interval. The data are sent to a specific node connected to IEEE1394 bus. Node which received the data sends acknowledge packet to the originated node. In addition, there are 2 formats to write in asynchronous transaction. Quadlet (4 byte = 1 quadlet) write and Block (More than quadlet) write.

There are several command formats in asynchronous transaction. Example for the command format is AV/C (Audio Visual Control) including FCP [7](Function Control Protocol) and SBP-2 [8](SCSI-3 Serial Bus Protocol). AV/C is used for controlling consumer AV digital devices. SBP-2 is used for serial transfer which uses same command set as SCSI (Small Computer Systems Interface). SBP-2 is used for devices like HDD (Hard Disk Drives).

This system uses asynchronous transaction using AV/C for transmission between IEEE1394 devices and the server. When the data transfer finishes correctly, acknowledge packet will return to the server.

Node ID are used to resolve each IEEE1394 device to send command using asynchronous transaction. IEEE1394 uses 64 bits of address space. High 16 bits consists from Node ID and Bus ID. High 10 bits shows Bus ID and low 6 bits shows Node ID.

2.2.2 AV/C protocol frame, FCP frame

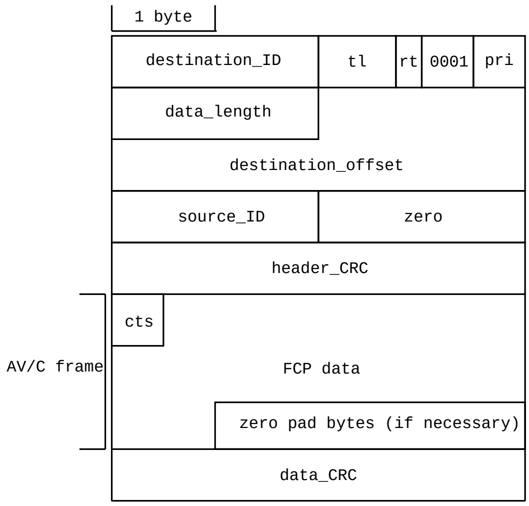

Figure 2. FCP Frame

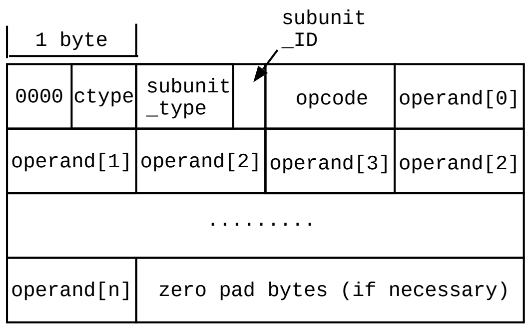

Figure 3. AV/C Protocol Frame

AV/C (Audio Video Control) protocol regulates digital interface for consumer AV devices on IEEE1394. AV/C commands are used according to the specification of IEEE1394 device. Encapsulation of AV/C frame to lower protocol, FCP (Function Control Protocol) is required.

FCP encapsulate commands and responses with "asynchronous block write transaction" in IEEE1394. FCP frame is shown in Fig 2. "cts" field is regulated in FCP. AV/C protocol uses 0 for this field meaning control. "destination_ID" regulates node ID of device to control. Control node transmits commands to FCP_COMMAND register in target node. Target node transmits response to FCP_RESPONSE register in control node.

In AV/C protocol frame field shown in Fig 3, "ctype" represents command type. CONTROL and STATUS for this field are used in this implementation. "subunit_type" represents type of the IEEE1394 device. D-VHS decks format used in this implementation is included in SUB UNIT TYPE VCR. DV converter doesn't follow the proper specification which should be SUBUNIT TYPE TUNER for this field. DV converter were using SUB UNIT TYPE UNIT in "subunit_type" for vendor dependent implementation. "opcode" field represents command category for each commands for each subunit type. "operand" represents the actual command.

Source packet length of AV/C protocol is fixed by various IEEE1394 devices. Source packet of control node is divided into 1, 2, 4 or 8 data blocks. These data blocks are needed to be assembled by target node. Encapsulated AV/C commands are sent to IEEE1394 device with asynchronous transaction.

2.3 Client module

This system is designed to be location independent. Furthermore, this system is not designed for a specific user. For this, this system must be independent to the user's computing environment as much as possible.

By using web interface for user interface, dependency to users computing environment could be made low. Therefore web interface is used for client module.

3 Implementation of radiowave broadcast transport system

The software environment of this implementation is shown in Table 2.

Table 2. Software environment of implementation

OS	Linux (Kernel 2.4.20)
Programming language	C language / PHP
Library	libraw1394 0.9.0 libavc1394 0.4.1
Compiler	gcc3.2.2

The IEEE1394 devices used in this implementation is shown in Table 3.

All IEEE1394 devices are capable to control with AV/C protocol. D-VHS deck is correctly implemented to the AV/C specification. Both DV converter are incorrectly implemented to the AV/C specification. It uses vender dependent command set.

Table 3. List of IEEE1394 device used

Device type	Vendor	Product name
DV Converter	IO-DATA	GV-1394TV
DV Converter	Canopus	ADVC-200TV
D-VHS	Victor	HM-DH30000
D-VHS	Victor	HM-DR10000

3.1 Server module

Linux has a several API to access IEEE1394. The IEEE1394 access map is shown in Figure 4.

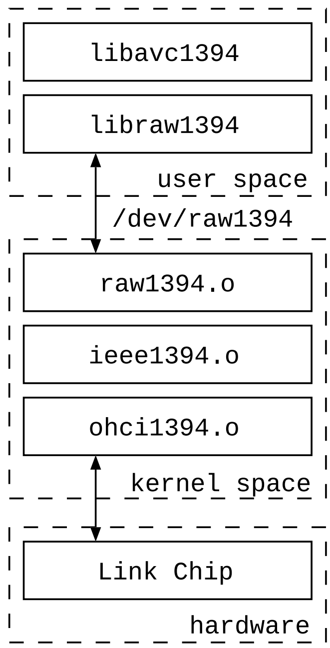

Figure 4. IEEE1394 API for Linux

Driver which access OHCI link chip is **ohci1394.o**. **ieee1394.o** is required to access IEEE1394 transaction administration. **raw1394.o** is required to access IEEE1394 in raw mode. **/dev/raw1394** is a device file, which connects kernel space and user space. **/dev/raw1394** could be used from user space with libraw1394. libavc1394 requires libraw1394 to send command to control IEEE1394 devices.

libavc1394 is a library file for using AV/C protocol. Using libavc1394, controlling IEEE1394 devices which implements AV/C protocol is possible. There are many devices do not follow IEEE1394 specification for device control. From this reason, we need a method to control these incorrectly implemented IEEE1394 devices. As we described before, D-VHS deck is correctly implemented but DV converter is incorrectly implemented to the AV/C specification. We dumped the AV/C command to solve this problem.

OHCI link chips cannot be placed in promiscuous mode.

From this reason, dumping packets of command from other node is impossible.

Dumping the command locally originated from application included with DV converter is required. Software named "wdm sniffer"[1] is used to dump the data which go through certain application to WDM (Windows Driver Module). We have achieved to dump the command sent from Windows application. By analyzing number of commands, speculation of the DV converter command set is possible. This method could be used for any IEEE1394 device includes Windows application, which is the most case in consumer IEEE1394 device.

There are problems in IEEE1394 devices used in this implementation. Most of the consumer IEEE1394 devices does not implement selection of isochronous channel which is fixed to 63 (Broadcast channel). This causes the video and audio stream to be mixed up if we connect two or more devices to single IEEE1394 board. D-VHS deck were able to select isochronous channel but not with DV converters. Therefore, multiple IEEE1394 boards are used as in Fig 1. This made possible to store multiple radiowave broadcast at once using multiple IEEE1394 devices.

Software which sends AV/C command to IEEE1394 device via IEEE1394 interface are named **gv1394tv_ctrl**, **advc200tv_ctrl** and **dvhs_rec**.

gv1394_ctrl and **advc200tv_ctrl** is software to control DV converter. Figure 5 shows the usage of **gv1394tv_ctrl**. Function for **advc200tv_ctrl** are about the same as **gv1394_ctrl**. Table 4 shows optional variables for **gv1394tv_ctrl**.

```
./gv1394tv_ctrl [node_id]
             [channel_selection]
             [frequency_adjustment]
             [audio_selection]
```

Figure 5. How to perform gv1394tv_ctrl

Table 4. Optional variable for gv1394tv_ctrl

Optional variable	Function
node_id	Set node ID to send
channel_selection	Select channel to watch
frequency_adjustment	Fine adjust the frequency
audio_selection	Select audio format

dvhs_rec is the software to control D-VHS. Figure 6 shows usage of **dvhs_rec**. Table 5 shows optional variable for **dvhs_rec**.

```
./dvhs_rec [node_id]
           [command]
```

Figure 6. How to perform dvhs_rec

Table 5. Optional variable for dvhs_rec

Optional variable	Function
node_id	Set node ID to send
rec(command)	Start recording D-VHS
chkrec(command)	Check if D-VHS is recording
stoprec(command)	Stop recording D-VHS

3.2 Client module

Client module uses PHP for web interface. Web interface is built from simple forms and buttons. These forms and buttons get the request from client and send it to the server. In order of steps of procedure, client module's function are explained below.

Start DVTS Using PHP environmental variable, it reclaims client IP address automatically and start DVTS to transmit audio and video data to the client in 1 button procedure. As an option, discarding video frame to handle network bandwith in flexibility is available.

Controlling DV converter
Using PHP system function, as described in Figure 5, executes **gv1394tv_ctrl** or **advc200tv_ctrl** in server side. Optional variable for **gv1394tv_ctrl** or **advc200tv_ctrl** is obtained from the form input, correspondingly.

Controlling D-VHS
Using PHP system function, as described in Figure 6, executes **dvhs_rec** in server side. Optional variable for **dvhs_rec** is obtained from the corresponding form input.

Show DVTS and D-VHS status
IP address, DVTS is sending audio and video data, and status for D-VHS is displayed. Status for D-VHS is obtained by getting AV/C response from D-VHS by sending AV/C command for status request. Both of status are updated at each operation.

Stop DVTS
Using PHP system function, stops DVTS.

4 Evaluation

We compared Windows application comes with DV converter for local feature with our implementation for remote feature. Comparison of the local features and remote features is shown in Table 6.

Table 6. Comparison of local and remote features

	Local	Remote
Channel selection	Supported	Supported
Audio selection	Supported	Supported
Frequency adjustment	Supported	Supported

Feature of locally connected with IEEE1394 cable has been satisfied in remotely connected with IP network. All of the feature IEEE1394 device carries could be used from remote with no limitation in length.

5 Conclusion

We have constructed practical sample implementation for IEEE1394 device control over IP network. Our method to control IEEE1394 device over IP network has been confirmed. Our implementation of IEEE1394 device control over the IP network can extend the connection between IEEE1394 device and computers on the IP network.

Using our method, both IEEE1394 devices following the AV/C specification and IEEE1394 devices which doesn't follow the AV/C specification can be controlled over IP network. Functions IEEE1394 device carries can be used from over IP network and could work on more advanced application.

Using this implementation with existing audio and video transport system, we have designed and implemented audio and video transport system using the network. Using this system, client can watch the radiowave broadcast outside the coverage and store the radiowave broadcast to D-VHS tape and into DV files.

In future work, we will assort each type of device to construct framework for IEEE1394 device control over IP network.

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