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資源管理機構を用いたビデオインターネットワーキングの設計

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あらまし　近年、ネットワークの広帯域化や QoS 技術の向上により高品質で実用的なビデオネットワークの構築が行われている。ビデオネットワークで用いられる技術はビデオ伝送の目的やネットワークの帯域、端末となる機器の性能に依存し、その管理方法もそれぞれ特化されたものとなっている。そこで本論文ではこれらのビデオネットワークの相互接続を実現し、単一のインターフェースで操作可能となるビデオインターネットワーキングを提案する。ビデオインターネットワーキングシステムは端末であるビデオ機器をコントロールするデバイスコントローラ、ビデオ機器などの資源管理を行うリソースマネージャからなる。最後に、実際に稼働しているシステムにおける実装について考察する。
キーワード　ビデオネットワーク, 資源管理, 相互接続, ゲートウェイ, シグナリング

A design of Video Internetworking System using resource managers

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Abstract　As the deployment of the broadband network infrastructure and the development of the QoS technologies progresses, it is regarded to be practical to construct high quality video transfer systems today. But, existing Video networks use specific technologies depending on their original purpose, available network bandwidth, and performance of terminal devices. Most of them also have their own management system which are not interoperable with each other. In this paper, we propose a new system called Video Internetworking System where interconnection between several video networks and unified operation interface are provided. This system consists of Device Controllers and Resource Manager, and some implementation issues are also discussed in this paper.
Key words　video network, resource management, interconnection, gateway, signaling

1. Introduction

Recently, a trend in computer network toward broadband is hitting not only specific place like schools and offices but also access lines connecting common family. As the effect of this, systems and applications sending high quality video data including MPEG2 and DV have been introduced and used.

ATM is a base technology of the wide area network system and IEEE1394 [1] is used to build relatively small networks as in a family. These network are absolutely effective to transport video data, because the networks can constantly guarantee to keep the maximum jitter and minimal data rate under specific value which are necessary for quality of service enabled network. On the other hand, there are some project in the Internet to develop technolog like IntServe and DiffServe making the network guaranteed quality of service. These technologies make it possible to build QoS guaranteed video network.

There are several sorts of video networks based on networks mentioned here. They tend to have a specific target area and unique management style to get higher profit from the network. But on the other hand, They are too specific to have interoperability.

If the interoperability with video network systems is achieved, every video network can send and receive video

data over the border, and if this system has a integrated interface to control the system, we can operate this network system as just one system. To realize this system we must introduce a unified interface to make video network systems connect each other.

In this paper, we propose Video Internetworking System under which existing video networks work almost same as how they have served. We introduce a new resource manager in each video network to manage and control all video devices there and cooperate with external resource managers, and any connection between video devices in different video networks is accomplished in same way.

2. Video network

Video network system is a system which transport video data over a network or networks. Videophone and internet broadcasting are examples of these systems. These network have different target area where they should be used effectively. The bandwidth of the network and terminal performance also affect what kind of video format the system employs.

3. Overview of Video Internetworking System

In this chapter, we discuss about the features which must be implemented to construct proposed Video Internetworking System, which interconnects existing video networks each other.

3.1 Connection between two video networks

There must be a kind of system which has connections between two video network systems and forward video data from a video network to other. We call a system which has this role Video Gateway in this paper. Furthermore, distinct video network systems are supposed to use different signaling scheme to connect between video devices there. Because being unique for each video network systems and only available locally, these are not usable to interconnect local video device to external one directly. This results that Video Gateways are required to understand two sorts of signaling scheme used in directly connected video networks. In the case of several video formats are used, Video Gateway may also be supposed to have ability to transform the format.

3.2 Device management in Video Internetworking System

To accomplish a connection between video devices in a video-network, we must collect device information needed to do in advance. Targeted video devices and their information are usually managed by specific way in their video network. Some small video networks might not have these information permanently, and they could be just collected using broadcasting or other methods when needed. Users decide which devices must get connect to do what they want to do by checking the collected information. On the other hand there is another option to collect device information. There is a centralized information manager which has all information about devices in the video network, and what users must do is to query to the manager. The collecting information procedure could be dynamic or static. In case of dynamic, every video device attached must register itself to the manager. In case of static, the information in the manager are written by hand and video devices couldn't change these. This management form can't follow what devices are really available there.

In order to be managed by a integrated operation, Video Internetwoking System has a unique protocol and format to accept queries about device information. Any video networks in Video Internetworking System must response to these queries and have databases. The built databases might be completely new one or already existing one.

Every video device has a unique number called address which identify devices in the video network. In this paper, this address is referred as a specific address. Even though these addresses identify video devices correctly, this is not suitable to Video Internetworking System because every video network uses different addressing system. In order to solve this problem Video Internetwoking System must use new addressing system which is supported by all video network. We call addresses assigned by the new system Video Address. Video Address consists of two parts. One part identifies which network the device joins, and the other part shows which video device it is in the local network. We call the former Video Network Address and the latter Local Video Address respectively. The limitation of that video devices can't deal with Video Address demands a method finding specific address corresponding to Video Address.

3.3 Exchange Routing information

Users are supposed to know no information about a topology of a video internetwork and how video networks to be connected each other. Existing video networks also do not care the connection between different video networks because they are not designed for interconnection of the networks. After these observation, we conclude that introducing new mechanism is necessary to manage interconnection states and keep topology information up to date. Every video network must have this mechanism monitoring whether neighbor video networks are in operation and to which video network Video Gateways located in local video network are connected.

These mechanism enable video networks to gather how to be connected to neighbor video networks, and these informa-

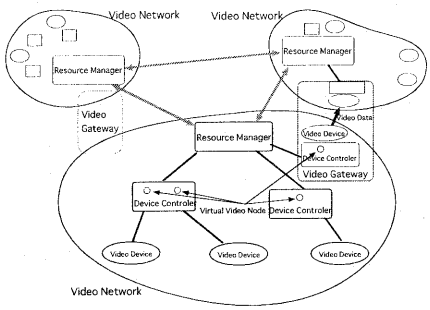

図 1 全体構成
Fig. 1 System outline

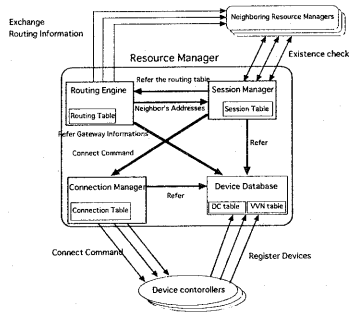

図 2 リソースマネージャ
Fig. 2 Resource Manager

tion are exchanged with neighbor. Using these collected and stored information, each video networks can calculate routes of video data to directly and indirectly connected video network. Routers in the Internet have similar mechanism called In the Internet, the similar situation is solved by cooperation of routers. Some routers are exchanging the routing information between the Autonomous System or organization to form the internetworking between networks, and others are used to determine a route inside the organizations, each of them uses a specific routing protocol for that purpose.

4. Video Internetworking System

This chapter proposes the Video Internetworking System which will provides the features discussed in the previous chapter.

4.1 System outline

Figure 1 shows the outline of the proposed system.

The system composed of three major components. A Resource Manager is located in each video networks, and manages the information of the video devices available in its video network, and issues connection commands to Device Controller. This component also maintains the address mappings between local video address and specific address to provide an address translation service on the request from other components.

Device Controller manages the video equipments in a video internet as Virtual Video Nodes, which are abstract video equipments. This enables Resource Manager treats only the Virtual Video Nodes rather than specific video equipments. Device Controller also abstracts the signaling, so Resource Manager does not have to depend on a specific singling system. These functions make different video networks can use a single Resource Manager architecture.

Video Gateway is the group of special device controllers and video equipments which forward video data stream between video networks.

4.1.1 Resource Manager

Resource manager has four main components as shown in Figure 2.

- Device Database

This component manages information of devices in a video network. This includes information of Virtual Video Nodes in the video network and information in Device Controller. These information can be static, or dynamic by receiving info from Device Controller to register them in the database. Database for devices are like follows:

Device Controller ID	Local Video Address
1	15923
2	13243
3	6323

Data Direction	Format	Specific Address
IN	DV	172.21.49.21
IN	DV	172.21.11.38
OUT	DV	172.21.11.5

Node Type	Type Information
NORMAL	NONE
NORMAL	NONE
GATEWAY	PEER 3 5323

Device Controller ID is a number which is uniquely assigned for a Device Controller in Resource Manager. Local Video Address is used to identify a Virtual Video Node in a video network, and the Video Data Direction is the orientation of the stream which is allowed to the Virtual Video Node. This information is used when a connection is made not to connect the same type. Specific Address is a video network specific address, and is IP address in this example. Node Type identifies the type of the Virtual Video Node, and is "NORMAL" for ordinary Virtual Video Node. Video Gateways have a value of "GATEWAY" in this field, and Type Information carries an additional information which indicates what Virtual Video Node in what network is connected to that gateway by using Video Address.

Information about Device Controller is as follows:

Device Controller ID	IP Address	Port Number
1	172.21.49.21	10232
2	172.21.11.38	13627
3	172.21.11.5	31945

Device Controller ID is an identification number given by Resource Manager and is used for a Virtual Video Node information database. IP Address and Port Number are required to connect the Device Controller.

- Connection Manager

This component manages connections between Virtual Video Nodes in a video network. When a connection request from a user or a Session Manager arrives, it checks the device information in the Device Database, and determine which Device Controller the connecting device belongs, and then issue a command to the Device Controller to make a connection. After the successful connection operation, it stores the information about the established connection into the database. The database contains following information.

Connection ID	Sender Device Controller ID
1	1

Sender Local Video Address	Receiver Device Controller ID
15923	3

Receiver Local Video Address
6323

- Session Manager

This component makes and manages connections to the devices which locate in external video networks. Session Manager has information about the adjacent Session Managers. A connection which was made by single or plural Session Managers in cooperation is called a Session. Session Manager can make up a data path for video stream using plural video networks connected by Video Gateways, and the resulting Session can consist of plural connections. Database for adjacent Session Manager is as follows.

Video Network Address	IP Address	Operation Status
1	172.21.53.1	LOCAL
2	172.21.118.21	STOPPING
3	172.21.54.47	SERVING

Video Network Address is assigned for each video network itself, and IP address is the address of the Resource Manager in that video network. Operation Status tells whether the video network is working or not, and "LOCAL" entry means the video network which the Session Manager itself belongs.

Session Information has following fields.

Session ID	Connection ID	Sender Video Network
100001	1	1

Receiver Video Network
3

Session ID has a unique value in the whole video internet, and identifies a Session. Connection ID contains an ID of connection which is locally established for that Session. This

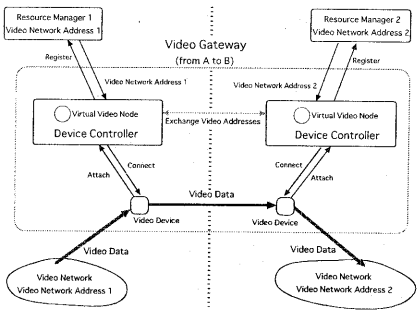

図 3 ビデオゲートウェイモデル
Fig. 3 A Video Gateway Model

database carries the source and destination video network ID as in a form of Video Network Address. When the peer of the connection is not a Video Gateway, the Video Network Address of the video network which Session Manager belongs is stored.

- Routing engine

This component computes the route between Virtual Video Nodes for a Session in the video internetwork using the external video network information. This enables Session Manager to determine the route from the source to the destination of the video stream in the video internetwork. It is possible to determine whether a video stream can be sent to adjacent video network by retrieving the information of the Video Gateway from the Device Database. It is also possible to determine whether a video data stream can be forwarded to the external video network by retrieving the information from the Routing Engine in the Resource Manager in the adjacent video network. The acquired information are transferred to the Routing Engine in the adjacent video networks.

4.1.2 Device controller

A Device Controller monitors the connection between devices and registers that information to its Device Database. It also has a role to issue commands to devices when it receives a connect request from Connection Manager, to make a signaling which practically set up a connection between the devices. This operation depends on the technology used in each video network, so no concrete operation is defined. Examples of Device Controller implementation with DVTS [2] and JAIST VideoLAN [3] [4] [5] will be shown in the next chapter.

4.1.3 Video Gateway

Video Gateway is a combination of a forwarding device which interconnects video networks in different types and forwards video streaming data, and a Device Controller which

manages information of devices and controls the device as shown in Figure 3. Internally it consists of two device controllers and a data path for video data. This device differs from other Device Controllers also in its operation: it acquires its video network address first which uniquely indicates the video network system it belongs. This make possible that when two video devices which provides a data path of video streams are attached and their virtual nodes are made, each of the virtual devices can get a valid video address. Two Device Controllers then tell that information each other and they can determine what video network the Virtual Video Nodes belongs. This information is also required to register the Virtual Video Nodes to Resource Manager.

4.2 Details of signaling

The signaling of this system is composed of the signaling in the abstract video networks which is common to all video networks, and the real signaling which depends on the technology of each video network to practically work. As for the former one, when Session Manager receives a connection request, it uses a Routing Engine to select a route, then issues a connection request to Device Controller through Connection Manager. This operation is common to all kinds of video networks. The latter signaling is technology dependent, and is differ for each video networks. For example, in case of some video networks which use ATM or RSVP [6] on IP for QoS control, Device Controller can use these signaling system to make connections between devices. It is also possible to use higher layer signaling system like SIP which is popular in VoIP systems to handle in more abstract information layer such as names rather than addresses.

4.3 Operation of the system

The proposed video internetworking system has two operation phase: registration of devices and connection request. This section describes the brief outline of each phase.

4.3.1 Registration of devices

Device Controllers must be registered to the Resource Manager before the Virtual Video Nodes are registered to Resource Manager. A Device Controller in the video network registers itself to the Resource Manager first, then wait the video equipments to be connected by monitoring the video network. When a video equipment is connected, a Virtual Video Node is created and a local video address is assigned. This phase ends by registering the Virtual Video Node to Resource Manager.

4.3.2 Connection request

Figure 4 shows the time sequence for the session establishment after the connection request from a user. Figure 4 represents a connection from an AV equipment in Network1 to a device in Network2. In this figure, the video data stream is passed among the Device Controllers, but actual

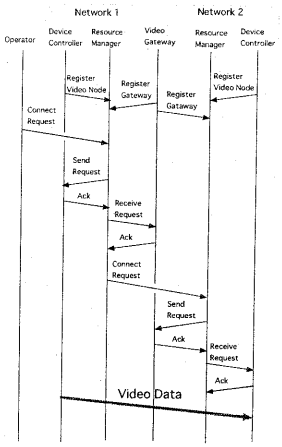

図 4 コネクションの流れ
Fig. 4 Sequence of Connection

data streams are transmitted between two video equipments in the connection. If Device Controller is implemented inside the AV equipments, the stream is transfered just like Figure 4.

5. Implementation

5.1 Implementation on JAIST VideoLAN

JAIST VideoLAN is a DV video transfer system which delivers DV data stream from the AV devices on IEEE1394 over long distance ATM communication line. Figure 5 shows the overview of the system. There are gateways called Terminal System between IEEE1394 frontend network and ATM core network, and they manages the connections between AV equipments. Resource Management Agent (RMA) is located in the core network and is managing the information on AV equipments connected to Terminal Systems in a centralized manner.

To implement a video internetworking system, there are two possible alternatives described below.

- Implementation of the new components

Resource Manager and Device Controller are implemented independently from existing component. Device Controller retrieves device information from RMA and delegate connection command or signaling to RMA.

- Modification of existing system

RMA in JAIST VideoLAN and Resource Manager in proposed system have almost the same role. Similarly, Terminal System can be regarded as a device controller which also have a gateway function. This implies that it is not so difficult to realize the video internetworking system based on the ex-

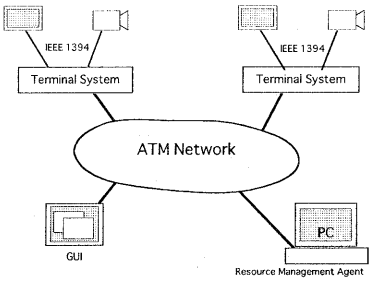

図 5 JAIST VideoLAN の構成
Fig. 5 JAIST VideoLAN

isting JAIST VideoLAN components. The most important component that JAIST VideoLAN lacks is Session Manager, because interconnection with other networking system is not considered in the design of original JAIST VideoLAN. A Session Manager is implemented in RMA to enable the interconnection with other video network systems.

5.2 Implementation on DVTS

DVTS is a video transfer system over IP networks. A DVTS sender receives a DV data stream from an IEEE1394 port of a PC and sends that data stream over the IP network to the DVTS receiver which reproduces the DV stream on a IEEE1394 port. The sender and receiver only uses their IP address to make the connection, and no information on the DV equipments are maintained, so new Device Controller for DVTS is required in a PC which runs DVTS, to manage the DV devices on the IEEE1394 bus and controls the DVTS program. Figure 6 shows the structure of the processes in a PC. Because the Resource Manager is designed to be portable, same code as in the JAIST VideoLAN can be used for this case.

5.3 Implementation of a Video Gateway between JAIST VideoLAN and DVTS

Gateways are required to interconnect JAIST VideoLAN and DVTS. Considering the latency of the gateway it is preferable to implement in a single device, but we are implementing using a design shown in Figure 7. In this design, two components which run terminal system and DVTS respectively are connected using an IEEE1394 serial bus, which allow us to use existing code and systems.

The left half is a video network using DVTS, and the right half is based on the JAIST VideoLAN. A Device Controller is added in the JAIST VideoLAN to manage the Gateway, enabling the exchange of the video addresses with the Device Controller in the DVTS side. This mechanism enables the both system to recognize the virtual video node addresses, and it is possible to register the gateway to the Resource Manager.

6. Conclusion

This paper proposed a Video Internetworking System which interconnects existing video networks, each of which emerges because of the development of broadband networking and QoS control technologies. In the proposed system, a device called Resource Manager manages the resource in the video network, and communicates with Resource Managers in the adjacent video networks to exchange the information they manage. To exchange the video streams between different video networks, Video Gateways which multi-homes to plural video networks are used. The gateways enable the communication between video equipments in the remote video networks.

We are now examining the practical connection method of video networks and designing a routing engine to be implemented. Some applications are also under development based on the proposed networking system.

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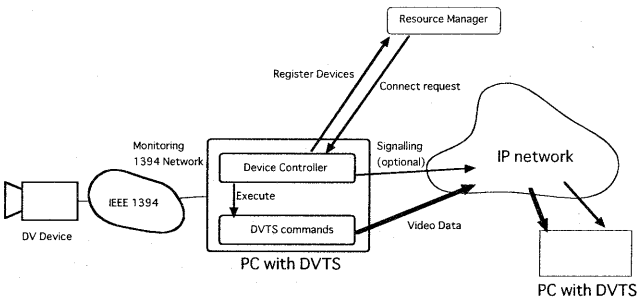

図 6　DVTS におけるデバイスコントローラの構成
Fig. 6　A component of Device Controller with DVTS

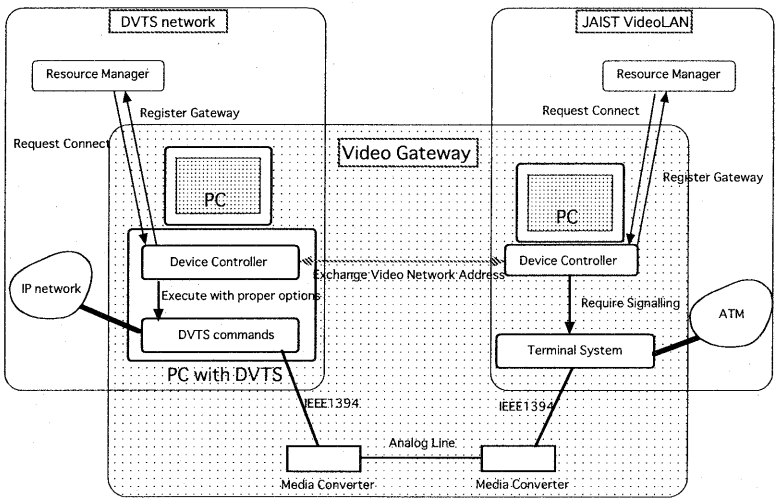

図 7　ビデオゲートウェイの構成
Fig. 7　Components of a Video Gateway