

Network MPEG Video Distribution System

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OVERVIEW: A camera system is developed for delivering real-time video streams over corporate intranets, the Internet, and other networks. The system encompasses TCP/IP-compliant cameras that can be directly connected to networks, representative application software for the PC side, application-specific APIs, and an environment enabling customers to customize application software. The application software permits the video feed from any designated camera on the system to be monitored from a PC. Wide-ranging controls can be effected from the PC including switching between cameras, camera controls (pan, tilt, zoom), and the amount of video data can be adjusted.

INTRODUCTION

AGAINST the backdrop of growing crime rates, supermarkets and other businesses are showing increased interest in monitoring systems. Buoyed by favorable economic conditions, the US is witnessing a building boom in luxury hotels where there is a clear trend in casinos away from visual monitoring toward soft monitoring using dome cameras. Fueled by this development, the market for dome cameras has been expanding by 10 to 20 percent a year. Hitachi, Ltd.

has been providing zoom cameras for use as dome cameras on an OEM basis, and currently has a 60 percent share of the market.

Two areas of the monitoring market in particular are expected to yield high potential growth in the immediate years ahead: remote monitoring and outdoor monitoring. Digital remote monitoring in particular has excellent potential promise for implementing relatively low-cost monitoring systems over established intranet and Internet networks.

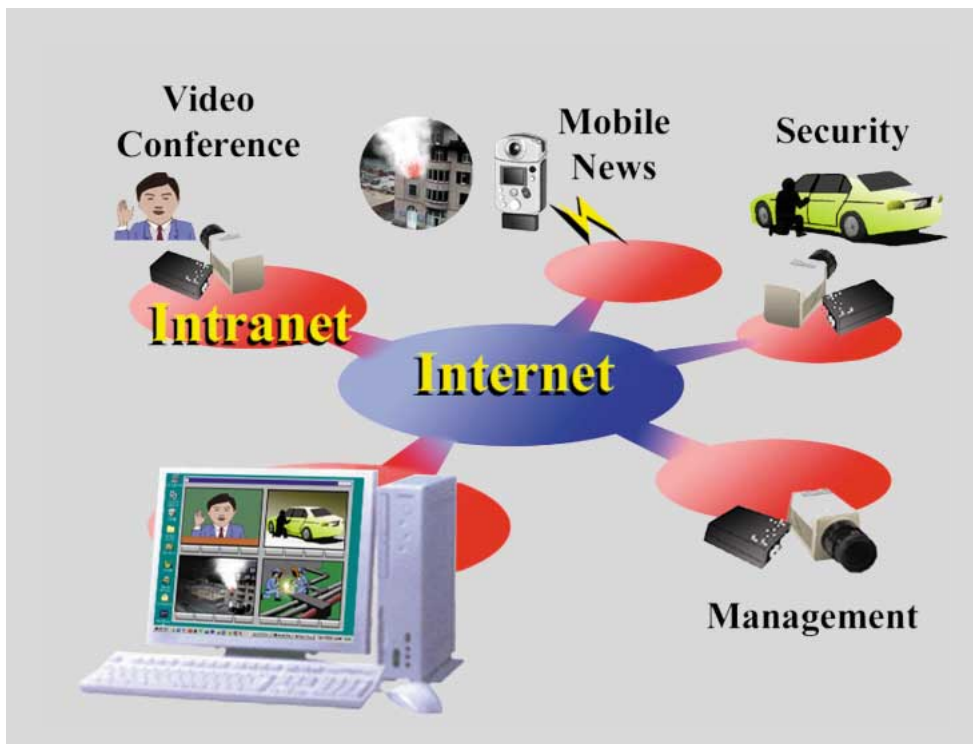


Fig. 1— Overview of the Network Camera System. Camera system provides real-time delivery of video over corporate intranets and the Internet. By specifying a camera's address, the video feed from any camera on the system can be monitored from a PC. Wide-ranging controls can be implemented from the PC including switching between cameras, controlling the camera itself (pan, tilt, zoom), and adjusting the quantity of video data to be transmitted.



Fig. 2— Application Software Example. The screen lets the user select feed from a specific camera, control the actions of the camera itself, and change the amount of data transmitted.

To meet the demand for this growing market, Hitachi, Ltd. has developed the network camera system that is illustrated in Fig. 1. It features MPEG cameras,^{1,2)} a TCP/IP-compliant MPEG encoder for monitoring,³⁾ application software for the system PC, and a robust application programming interface (API). Fig. 2 depicts a screen shot of the developed application software that enables the user to select any camera on the system, control the cameras on the system, and modify the amount of data carried by the system.

NETWORK CAMERA SYSTEM

The network camera system we have developed can be directly connected to corporate LANs, public switched telephone connections, and other kinds of data net facilities. Since the system delivers real-time video without requiring costly dedicated facilities, it can be used to implement a wide range of cost-effective surveillance, monitoring, and other management operations systems.

The video stream can be played or stored on a regular PC without any additional hardware, thus permitting users to remotely monitor the video feed from any camera on the system from their desktop computer in the office.

The system can also be readily adopted as a convenient solution for wireless applications handling video transmissions using a wireless LAN card or video streams from public network circuits. Now let us take a closer look at the main features of the network

camera system:

(1) TCP/IP-based LAN Connectivity

All of the cameras connected by the network camera system are centrally controlled by the TCP/IP communications protocol.

The initial figure shows a schematic overview of the system. Even if each camera on the network is used for a different purpose — monitoring, management and supervision — the video feed from each camera can be readily accessed as necessary by specifying the unique network address of the camera.

(2) Remote Control Functions

Every aspect of a camera's operation can be controlled by entering commands from the host: the video feed can be turned on and off, the bit rate and other transmission parameters can be set and changed, and the operation of the camera itself — zoom, tilt, and so on — can be controlled. This will be described in greater detail below, but the ability to adjust the transmission bit rate allows users to tailor the throughput of the system to the available bandwidth. This enables the system to be optimized to any network environment from the Internet to a LAN.

(3) Wireless Video Transmission

Using a wireless LAN card, the system can accommodate unlicensed video transmissions that are problematic for analog devices to handle. Certainly there are situations where the transmission distance is less than a mile due to limited signal strength or where the received signal is intermittent due to obstacles in

the signal path, but the system nevertheless provides an effective solution in situations where mobility is a priority.

(4) Transmission over Public-switched Network Facilities

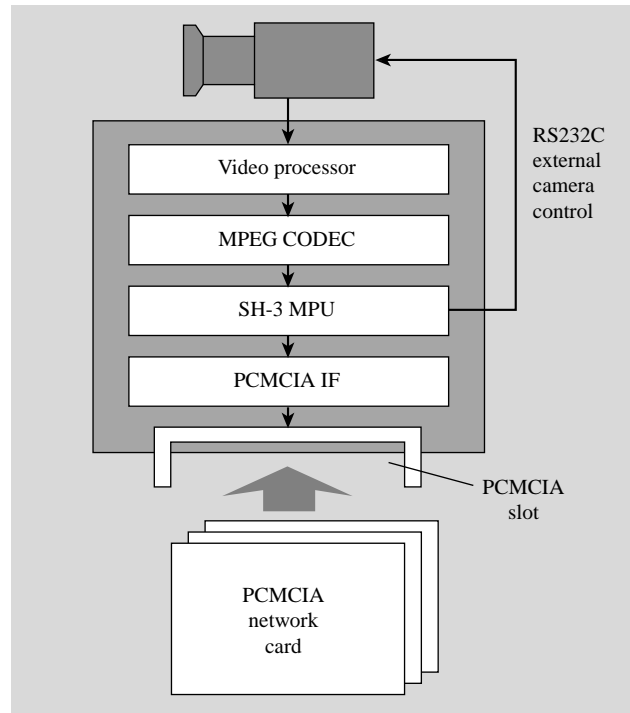
Video transmission can be readily handled over PSTN (public-switched telephone network) facilities using a modem card or a PHS (personal handyphone system) card. Although public networks can only currently support intermittent video transport due to bandwidth constraints, data can nevertheless be sent from virtually anywhere in the world.

NETWORK CAMERA CONFIGURATION

Overall Configuration

Fig. 3 is a schematic block diagram of the network camera. In this article we will be primarily concerned with the aspects relating to video transmission over networks, which will be treated in a later section.

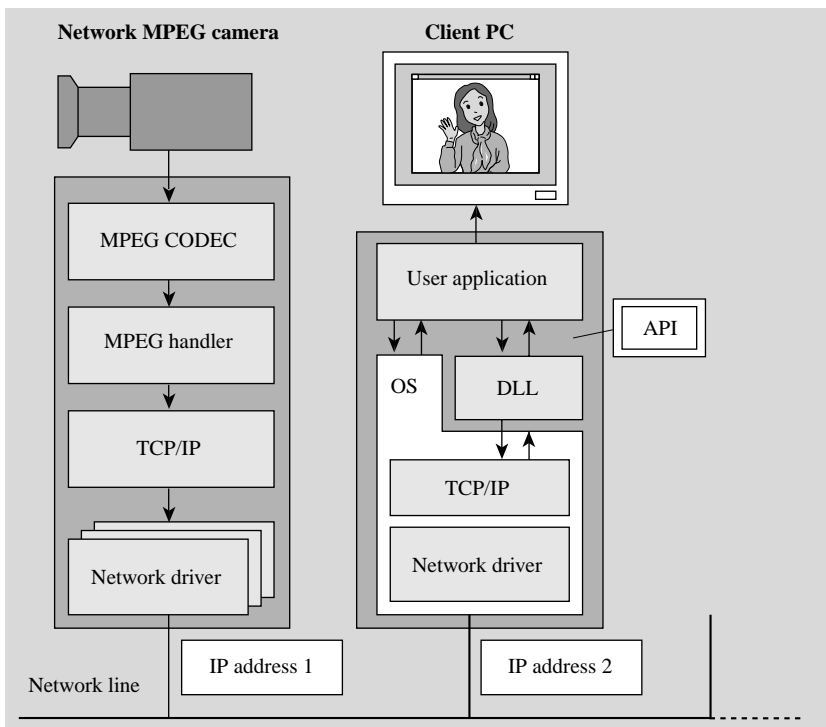
Fig. 4 shows a schematic of the various software layers involved from the network camera to the client's PC where the video is played back. Certainly the video data received by the client's PC can be displayed or stored depending on its intended purpose using the software that was developed for this project. In addition, middleware in the form of a dynamic linking library (DLL) has also been developed so users or third-party developers can create applications tailored to their own specific needs.



IF: interface
 MPEG: Moving Picture Expert Group
 PCMCIA: Personal Computer Memory Card International Association

Fig. 3— Network Camera Configuration.

The network camera consists of a real-time MPEG/JPEG encoder, and an SH-based processor for implementing communications and external camera control. The camera can be directly interfaced to various types of data networks by installing an appropriate network card — LAN card, modem card, etc. — in the system's PCMCIA slot.



OS: operating system
 IP: Internet protocol
 API: application program interface
 DLL: dynamic-linking library

Fig. 4— Software Layers.

Image data from a network camera is received by the TCP/IP module integrated in a PC operating system, then displayed or stored using application software. DLL-based middleware is also being developed to permit a large number of developers to create their own application software. Specific application interfaces are also being readied.

MPEG Handler

The network cameras have been built to accommodate transmission rates ranging from 30 kbit/s to 2 Mbit/s in order to support video transmission across a diverse range of network facilities from public-switched circuits to dedicated LANs.

At the same time, the MPEG standard specifies 30 frames a second in order to achieve smooth playback of video streams. It is very difficult to support the compression needed to satisfy this standard at low bit rates of less than 300 to 400 kbit/s.

A solution was found by varying inter-frame compression ratio and playback frame rate in accordance with the transmission rate. This enables us to obtain video playback in which the picture quality and the playback frame rate are always in balance. The MPEG handler implements this variable control by adjusting the picture inter-frame compression ratio and the playback frame rate per unit time to match the transmission rate. Fig. 5 shows the transmission rate versus the playback frame rate per second.

(1) When the Transmission Rate is Above 384 kbit/s

In this case, 30 frames a second are encoded using all three IPB types (intra, predicted, and bidirectional) of frames in full compliance with the MPEG standard mandated compression scheme.

(2) When the Transmission Rate is Below 384 kbit/s

In this bit-rate domain, B frames are skipped. Video streams are encoded IPPPPIPP..., and video is played back at a frame rate of 10 frames per second. Simply dropping certain frames, however, would make the stream no longer compliant with the MPEG1 standard, which would mean that it couldn't be played on standard decoders. For this reason, we have inserted a skip frame code wherever a frame has been omitted. The skip frame code tells the decoder that "this frame is identical to the preceding I or P frame," thus making the stream compliant with MPEG specifications.

(3) When the Transmission Rate is Below 192 kbit/s

In this bit-rate domain, the number of frames per unit of time is further reduced by inserting 5 skip frame codes between each frame. Five frames are played back per second.

(4) When the Transmission Rate is Below 128 kbit/s

In this bit-rate domain, one frame is sent at a time, and skip frame codes are inserted as dictated by circuit conditions.

TCP/IP Protocol Stack

The system employs a 54-MHz SH-3 processor for the MPU, and this is where the TCP/IP protocol stack

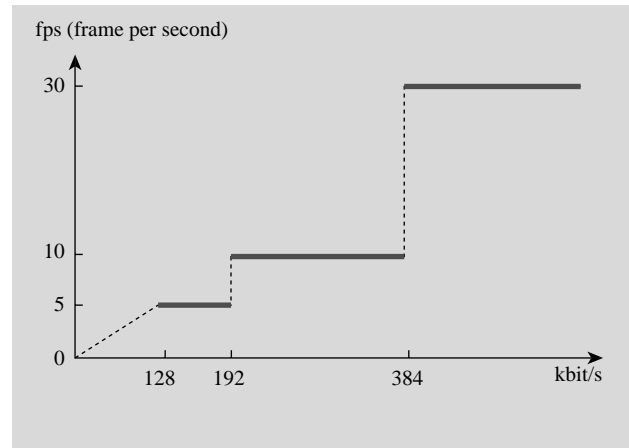


Fig. 5— Bit Rate Versus Frame Rate.

The frame rate is incrementally changed according to the transmission rate to balance the picture quality and frame rate. MPEG format is preserved by inserting skip frame codes between valid frames.

is implemented.

What is generally referred to as the TCP/IP protocol encompasses multiple modules. At the present stage, not all the modules encompassed by the protocol stack are required for video transmission, so not all of the modules have been implemented. Gradually, however, the number of modules is increasing as additional functions are added.

Table 1 lists the protocols that have been implemented so far. One can see from the table that, in addition to the IP and TCP protocols, the UDP, ARP, ICMP, and a number of other protocols have already been implemented.

The primary function of the protocols listed in the lower part of the table is to dynamically acquire IP addresses from servers that allocate IP addresses over the network. In our system, IP address and subnet mask values are set by way of the serial port and stored in the system's internal flash memory.

Network Card Drivers

Three types of network card drivers have been fabricated, that enable the system to interconnect with the following three kinds of networks. These three types of drivers are available for purchase as peripheral devices for use with any kind of computer.

Wire-line connection

- * LAN card driver

Wireless connection

- * Wireless LAN card driver

- * PHS card driver

TABLE 1. TCP/IP Protocol Stack

This series of protocols is implemented in the camera (the MPEG encoder), enabling the camera to be controlled remotely over the network.

Module		Function
IP	Internet protocol	IP address management
TCP	Transmission control protocol	Connection-oriented data transmission control
UDP	User data-gram protocol	Connectionless data transmission control
ARP	Address resolution protocol	IP address to physical address messages
ICMP	Internet control message protocol	Transmission state, error messages
RARP	Reverse address resolution protocol	Physical address to IP address messages
BOOTP	Bootstrap protocol	Transmits device start-up program
DHCP	Dynamic host configuration protocol	IP address dynamic supply
FTP	File transfer protocol	File transfer management

CONCLUSIONS

This article has given an overview of a camera system developed by Hitachi, Ltd. for delivering video images over networks. Application software and interfaces for the system were also briefly described.

Commercial services for delivering video on demand over networks is gradually beginning to emerge, but the availability of only limited bandwidth still prevents the unrestrained flow of video streams and the emergence of large-scale businesses. In the meantime, to promote near-term business expansion in this area, Hitachi is focusing efforts on a number of stop-gap solutions such as combining smaller video images with larger still images. Once the capabilities are in place, it is certain that the range of applications for video delivery will be very extensive. Hitachi is thus concentrating its efforts on demonstrating new and enticing technologies that can be used across an extensive range of applications.

REFERENCES

- (1) T. Ima-ide et al., "An MPEG Camera with Tapeless Video Recording," IEEE ICCE Digest, June (1997).
- (2) T. Imaide et al., "PC Data-Compatible MPEG Camera," *Hitachi Review* **46**, No. 5 (October 1997) pp. 227- 230.
- (3) H. Kami et al., "A Network MPEG Camera," IEEE ICCE Digest, June (1999).

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