

The Merging of Computers and Video: Using Ethernet and SCSI for Digital Video Input and Output

By Stephen Kilisky

As computer processing power increases and prices dramatically decrease, video facilities are looking to replace dedicated hardware with general-purpose computers running software tailored for video applications. This revolution in the computer industry has also led to the proliferation of 3-D computer graphics departments in most video facilities. Ethernet and SCSI greatly enhance the versatility and functionality of video peripherals connected to computers. Currently digital disk recorders are the most common video peripherals that use SCSI and Ethernet to integrate with computers. Ethernet and SCSI permit the disk recorder to take full advantage of the multiuser and multitasking UNIX operating system. In addition, Ethernet and SCSI are the simplest way to integrate video into a computer environment. This article helps to explain some of the technical issues involved in integrating computers with video.

Ethernet is a local area network (LAN) standard originally developed at Xerox's Palo Alto Research Center in 1973; the standard is detailed in IEEE 802.3. Ethernet interconnects a group of computers (Fig. 1). The transmission medium typically uses 50- Ω coaxial cable. Each computer is attached to the network using a device called a transceiver. The transceiver behaves like a traffic cop, routing all the data sent over the network to their proper destinations and controlling all activity on the network.

Data is passed serially at 10 MHz in the form of packets, having anywhere from 46 to 1,500 bytes of data. Each packet carries addressing information to show its source and destination. Unlike the public switched telephone system or a video routing matrix, the single Ethernet cable is shared by all the devices on the network, so there is a set of rules to determine when a node can access the cable. The technique is referred to as carrier sense multiple access with collision detection (CSMA-CD).

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Before transmitting, a node listens to confirm that nobody else is transmitting, then as it transmits it continues to monitor the cable in case another node starts transmitting at the same time. If two devices transmit simultaneously it is referred to as a collision, and both devices have to stop immediately and wait a random amount of time before attempting to retransmit.

Physical Integration of Ethernet

Installation on Ethernet is just a question of plugging the video peripheral

into a transceiver, which is a small box that provides an isolated interface to the Ethernet coaxial cable. In some instances (particularly in the case of Cheapernet) the transceiver can be part of the Ethernet interface board in the host computer or video peripheral. Remote transceivers can be up to 50 m away from the computer and typically come with a plug-in module to allow either a spike tap or BNC connectors to interface to the cable.

Cheapernet uses thin RG-58 50- Ω coax and BNC-style connectors. In this case the coaxial cable is "T"-d directly onto the Ethernet interface in the computer. Higher-level applications use better-quality thick cable and external transceivers that can attach to the cable with a spike-like tap. The primary advantage of a nonintrusive tap is that the transceiver can be removed without taking the network down.

The thick coax can be used for networks up to 100 nodes on 500 m of cable; the transceivers should be placed at multiples of 2.5 m on the cable, and Cheapernet is limited to 30

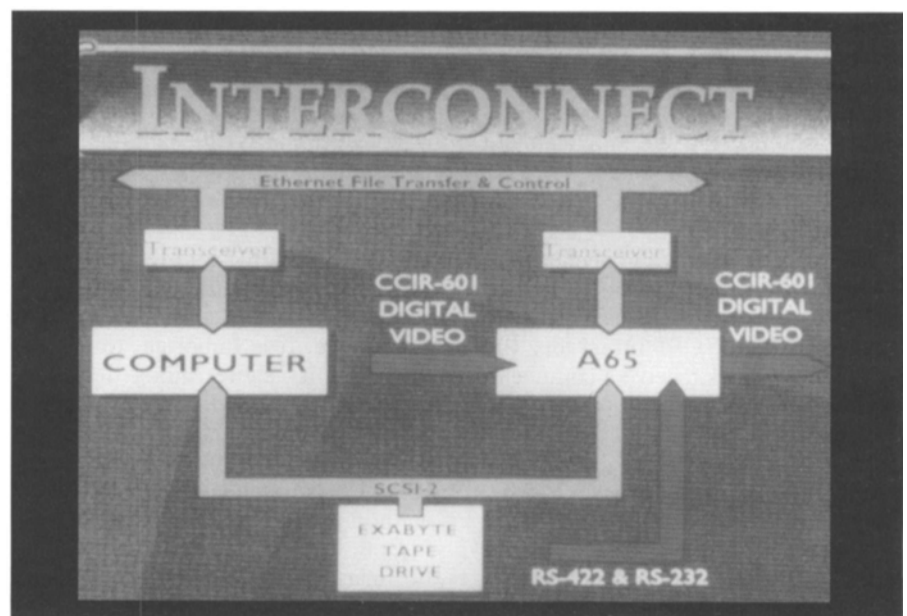


Figure 1. Diagram of computer interconnect.

nodes on 185 m of cable. Only two repeaters are allowed on a local network because of the propagation delays through them.

Once connected to the network, the system manager specifies an Internet (IP) address for the video peripheral. The other computers on the network can then use this IP address to access the services supported by the video peripheral. Typically the IP address is entered in the hosts file, which resides in the */etc* directory of the computer.

As an Ethernet device, the video peripheral should appear to be another node on the network. In the case of a disk recorder, image files can be transferred to or from the disk recorder using Ethernet. There is no need for a separate VTR animation controller, frame buffer, sync generator, or special software.

SCSI

SCSI stands for Small Computer Systems Interface. The SCSI-1 standard is documented in ANSI X3.131-1986, and the SCSI-2 standard is documented in ANSI X3.131-199X. SCSI has become one of the most popular methods for connecting peripherals in the computer industry.

Improvements in memory and central processing unit (CPU) products are shifting the processing bottleneck to the input/output (I/O) bus. SCSI is ideally suited for high-performance, single-user environments where maximum performance is required of peripheral devices. As users require additional data transfer rates and more functionality, SCSI-2 will be a more viable solution, yet will still maintain compatibility with SCSI-1.

Benefits of SCSI

SCSI has the following advantages:

- High data transfer rates.
- Disconnect/reconnect. To utilize the single-bus SCSI interface, the peripheral devices receive a command, then reconnect with the bus after data has been found and retrieved. This eliminates bus tie-ups by slower peripherals, such as tape drives.
- Cabling configuration. The 50-pin ribbon cable allows users to daisy-chain peripherals. Up to 7 peripherals can reside on the bus. Typical maximum cable length is 6 m; however, if

differential drivers are used, lengths up to 25 m are possible.

General SCSI-1 Specs

The general specifications of SCSI-1 include the following:

- 50-pin Centronics connector.
- 8-bit data path.
- 18 signal lines: 9 data (including parity), and 9 control lines.

Single-Ended vs. Differential SCSI

Single-ended hardware is the predominant configuration. It relies on a reference to ground, and the signal uses a single wire for each data and control line, varying the voltage for operation. The use of a ground produces some signal noise and ground shifts. This is why the single-ended specification limits the length of the bus to 6 m.

Differential bus lines are balanced. This eliminates the ground and uses a pair of wires for the "high" and "low" signals for each data and control line. The resultant cleaner signal allows for bus lengths up to 25 m.

Asynchronous vs. Synchronous

Asynchronous data transfers means the receiving device acknowledges receipt of each byte before the next byte can be sent. The data rate for asynchronous SCSI transfer is 1.5 Mb/Sec.

Synchronous data transfer allows blocks of data to be sent at a predetermined rate without receiving an acknowledgment for each byte. The peak synchronous transfer rate is 5 Mb/Sec. Please note that a peak rate is not necessarily the same as a sustained rate.

Installation Notes

Even though a cable may meet SCSI specs for twisting and shielding, SCSI allows for a wide range of impedance. It is important to use the same-quality cables along the entire bus to avoid impedance mismatches. The greater the mismatch, the more noise will be introduced onto the bus. It is also preferable that the cables be as short as possible.

Both ends of the SCSI bus should be terminated in the same manner. SCSI-2 specifies the use of an active terminator for fast single-ended buses.

Active termination uses a voltage regulator in the circuit to terminate the signal.

SCSI-2

General SCSI-2 Specs

The general specifications for SCSI-2 include the following:

- 50-pin micro-D connector.
- 8, 16, or 32-bit data path.
- Compatible with SCSI-1.
- Command queuing and the common command set (CCS)
 - Fast SCSI.
 - Wide SCSI.

Command Queuing and the Common Command Set (CCS)

Command queuing allows up to 256 commands from each initiator to each logical unit. The host can send several commands without waiting for acknowledgment. This allows for higher throughput.

Commands can be designated as ordered or unordered. Ordered commands are processed on a first-in, first-out (FIFO) basis; unordered commands are sorted by priority and executed in a sequence that achieves the fastest throughput.

The CCS is now standardized and fully documented. It also includes support of more types of peripherals than SCSI-1. The CCS includes four levels of commands: mandatory, extended, optional, and vendor-unique.

Fast SCSI

Fast synchronous SCSI doubles the sustained data rate to 10 MBytes/sec using an 8-bit bus. Fast SCSI is an optional mode; both the host and target must be equipped for it.

Wide SCSI

Wide SCSI allows for 16 and 32-bit data paths. When combined with fast SCSI, sustained data rates of up to 40 MBytes/sec are achievable. Thirty-two bit wide SCSI requires two 16-bit connectors and cables. The "B" cable uses a 68-pin connector.

SCSI-3

Multiple fast SCSI-2 devices can clog a network. The pending SCSI-3 proposal attempts to address this issue. SCSI-3 will use a layered approach. Single-ended and differential tech-

niques will be supplemented by two new layered approaches known as P1394 and SSA. A minimum 20-Mbit bandwidth will be possible. SCSI-3 will also remove the limitations on distance and increase the number of peripheral devices that can be linked together.

SCSI-3 will be referred to as the Interlocked Protocol. Another layer that will be added on a software level is the Common Access Method 2 (CAM-2). CAM-2 will allow users to write device drivers that will run on different operating systems with few or no changes. Finally, SCSI-3 will document and standardize the specifications of termination methods.

Applications

The key benefit of Ethernet on a video peripheral is to take advantage of the multiuser capabilities commonly available in a computer environment. Ideally, multiple users should be able to access the video peripheral simultaneously. The primary video application of Ethernet and SCSI is digital image file transfer.

Ethernet Digital Image File Transfer

The simplest method to transfer images digitally between computers and video peripherals is to use standard computer Ethernet remote file transfer utilities. Most of these utilities are based on the UNIX operating system.

The UNIX operating system was developed in 1969 by Bell Laboratories and is used by over 100 computer manufacturers. The basic operating system has spawned many implementations. An implementation is nothing more than a customized version, usually for a specific brand of computer. Some of the more common implementations of UNIX are: System V, Berkeley (BSD 4.X), SGI Irix, and PC/TCP.

The UNIX *rcp* command is one way to transfer files between the video peripheral and other computers on the network. For non-UNIX computers, the official ARPA file transfer and remote log-in utilities called FTP (file transfer protocol) and Telnet are used. These are specifically intended to work between different computer

architectures and operating systems.

Typically users transfer files to or from the video peripheral in the CCIR Rec. 601 file format or as RGB files. Other common file formats, such as TIFF, TGA, and PICT, require a format conversion before they can be stored on the video peripheral. File transfers should be bidirectional, meaning that images can be transferred to or from the video peripheral.

SCSI Digital Image File Transfer

Historically, the primary use of SCSI has been as a digital archive medium. Common archive devices are 1/4-in. streaming tape drives, 8-mm Exabyte drives, and 4-mm DAT drives. In addition, with increases in SCSI transfer speeds, SCSI has become an attractive medium for direct file transfer between a single host computer and video peripherals. SCSI file transfer is significantly faster than Ethernet; however, SCSI does not offer the networking support that Ethernet provides, and it has a fairly limited bus length when compared to Ethernet.

Ideally, the computer and video peripheral should be able to share the same archive device. This requires that all the devices coexist on the same SCSI bus. It also means that they use a common SCSI file format. The standard UNIX tar file format is the most common SCSI archive format. The key benefit of video peripheral support for the tar file format is that users can then generate tar tapes on their computer that can be read directly by the video peripheral. In addition, tar tapes generated on the video peripheral can be read directly into the workstation.

Direct SCSI image file transfer between a single host computer and a video peripheral is known as SCSI target. In SCSI target mode, a computer becomes the master and the video peripheral is controlled by the computer. The peripheral is now a target device that the computer can transfer files to or from. An SCSI driver for each video peripheral must be written and installed on the host computer. The SCSI driver is simply an implementation of the SCSI common command set.

Conclusion

Ethernet and SCSI are standard computer industry interfaces available for a multitude of computer platforms. Including these interfaces in video peripherals provides two key benefits. First, it simplifies the task of integrating computer hardware with video hardware. Second, it increases user productivity by taking advantage of a multiuser networked environment.

Glossary of Terms

ARP

Address Resolution Protocol — used to obtain Internet to Ethernet address mappings when they are needed rather than maintain a static list on each host.

ARPA

Advance Research Projects Agency — U.S. Government agency responsible for developing the TCP/IP family of protocols.

AUI

Attachment Unit Interface — the long way of saying transceiver cable. Normally limited to 50 m, it carries twisted pair differential signals for transmit, receive, and collision detection. The AUI cable also carries 12-V power for the transceiver.

Bridge

Bridges are generally connections between networks of the same type at the data link layer.

Broadcast Packet

Ethernet packet carrying the address FF:FF:FF:FF:FF:FF, which will be received by all the hosts on the network.

Cheapernet

An alternative form of Ethernet that uses thin RG58 50-V cable with BNC connectors and "T" pieces at the transceivers rather than that normally used for Ethernet. This cable suffers from greater loss and the cable run is typically limited to 185m. In all other respects it is electrically compatible with "normal" Ethernet.

Client

The consuming (user) end of a client-server relationship.

Connection

The link between two specific ports on two Internet hosts analogous to a telephone call being set up between two phones on a network.

CRC

Cyclic Redundancy Check — a sort of serial check sum that assures the integrity of a serial data stream by using some sort of polynomial feedback.

CSMA-CD

Collision Sense Multiple Access with Collision Detection — describes the mechanism that allows several devices to share the single Ethernet cable.

Domain Names

A name addressing scheme that uses a hierarchy of domain names to describe the address of a remote computer in a similar way to a mailing address, e.g., simon@master.abekas.com.

Ethernet V1 and V2

The original Ethernet standard was developed by Xerox and published jointly with DEC and Intel.

Ethernet Address

A 48-bit address conventionally written as 6 hex bytes separated by colons. Vendors typically ship equipment with the Ethernet address contained in a small bipolar ROM.

Fragments

Subdivisions of Internet packets — sometimes necessary if different networks have varying maximum packet lengths.

FTP

File Transfer Protocol.

Gateway

Gateways allow interconnection of different networks at the network layer.

IEEE 802.3

The IEEE standard for CSMA/CD networks, forms part of the 802.x family of standards for local area network (LAN) interfaces and protocols.

Internet Address

A 4-byte number representing the

address of a host on the Internet.

Jabber

A condition detected by a transceiver to prevent locking up the network. If the output is active for more than 1/10 sec, the transceiver should latch up and prevent further transmissions until the transmit signal is inactive for at least 1/4 sec.

Jam

A collision signal generated by a repeater so that the cable segments on both sides of it are aware that a collision has occurred.

Heartbeat

See SQE.

Host

A computer that is a node on a network.

Hostname

The name by which a particular machine is known at the user interface level normally associated with a network address.

NFS

Network File System (developed by Sun Microsystems).

NIC

Network Information Center — the central repository for all information regarding the development of the ARPAnet.

OSI Layered Model

Open Systems Interconnection — the abstract model for the seven-layer hierarchy of network protocols issued by ISO, the international standards body.

Ping

Program that uses the ICMP Echo Request facility to verify the connections between two machines. Note that this only verifies correct operation up to and including the network layer or Internet Protocol.

Port Number

An addressing scheme within a host computer that allows more than one simultaneous connection to that computer.

Repeaters

Repeaters interconnect or buffer two sections of the same network with very little intelligent signal processing.

Server

A host or node on the network that provides a service; e.g., a file server provides a file system for diskless nodes.

SQE

Signal Quality Error — some Ethernet transceivers generate a collision signal immediately after each transmission. This permits the Ethernet interface to verify that its collision detection circuitry is functioning correctly.

Socket

A socket is an abstraction in BSD UNIX for the interprocess communications primitive known as the pipe. A socket can be opened in much the same way as a file would be opened.

Telnet

ARPA remote terminal/login program.

10BASE5 and 10BASE2

IEEE names for Ethernet and Cheapernet respectively, abbreviated from 10-MHz baseband 500-m and 200-m maximum length.

Thin-LAN or Thin-net

See Cheapernet.

Transceiver

The box that attaches the host computers' Ethernet Interface to the cable. The best ones use a spike arrangement to nonintrusively attach to the cable (without cutting it). The transmit and receive signals are coupled onto the cable through isolating transformers. The transceiver is also responsible for detection collisions.

X25

Public Wide Area Packet Switched Network Standard.

Yellow Pages

The Yellow Pages is a network service that provides network-wide password and system information from a single data base. It was written by Sun Microsystems but is available on many systems