Hardware and operating system perspectives on CD-ROM

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INTRODUCTION

This paper discusses the particular steps that take place in the integration of a CD-ROM player to a computer. The computer can treat the CD-ROM player like any other external data storage device, however, a CD-ROM has a low data transfer rate as well as a low access time. The minimum data transfer rate for a CD-ROM player to a host computer is 176Kb/sec as compared with 625Kb/sec for a hard disk. Access time to the information is around one second compared to 0.15 second for the hard disk. To improve performance special software or hardware is needed.

One way to compensate for the slow data transfer rate is to use a Small Computer Systems Interface (SCSI). Most of the SCSI configurations are single-initiator, single-target systems, with the CPU being the initiator and the CD-ROM player the target. The SCSI bus allows quick transfers of information and commands to I/O devices via a standard command protocol. This protocol sends command-description messages to target processors that process the commands. To improve the operation, the CD-ROM drive needs to provide an interim storage space for the data between the disc and the CPU. A single-ported cache buffer can provide this capability. RAM buffers are placed in the SCSI controller to allow faster data collection. Using DMA the transfer rate between devices is increased. The current CD-I standard calls for 2 DMA channels in the microprocessor. This eliminates disc to CPU transfer time by loading the process directly into DMA.

A LOOK AT DIRECT MEMORY ACCESS (DMA)

The function of the DMA controller is to transfer a series of operands (data) between the system memory and a peripheral device. Operands can be in the form of bytes, words or long words (32 bit). With cycle stealing, the data is transferred in a single cycle. In a burst mode, the transfer is up to 64 kbytes per burst.

When the DMA controller receives a valid request for data transfer from a peripheral device, it arbitrates for and obtains ownership of the system bus. By asserting its Bus Request line (BR), it indicates that it desires to be the bus master. The processor is at a lower priority level than external devices. After completing the last cycle it had started, the processor will give control to the controller. Then, it puts the bus up for arbitration through its own Bus Grant output (BG). When a device enables the BG input, it becomes the bus master.

The controller will then wait until the Address Strobe (AS), Data Transfer Acknowledge (DTACK), and the Bus Grant Acknowledge (BGACK) signals become inactive before assuming command of the bus again. Next, the controller activates its BG line and proceeds to transfer data. At the completion of this phase, it gives back ownership of the bus by de-activating its BGACK output.

SMALL COMPUTER SYSTEM INTERFACE (SCSI)

SCSI adds flexibility and performance to many design concepts. The SCSI bus supports a maximum of 8 units. This limitation can be overcome by the use of a LAN. In addition, each SCSI device can support seven additional logical units, plus one master. Because SCSI serves as its own “traffic cop,” the user’s only concern is the management of the data at the host adapter.

Most SCSI devices are in the 12-MHz range. This is about 1.5 megabytes per second. This range can be increased to about 32 MHz at distances of 50 feet. The rate then would be around 4 Mbytes/sec. SCSI also provides a rich set of commands and defined bus structures. The SCSI standard calls for eight command-description byte (CDB) groups. Groups 0, 1, and 5 are reserved for general purpose instructions, groups 2, 3, and 4 are reserved by the National Bureau of Standards, and groups 6 and 7 are vendor specific.

A computer equipped with a SCSI bus requires a few commands to retrieve the information from the CD-ROM player. The computer has a key to the desired record and the logical block starting address of the file. The host adapter acquires control of the bus and sends a Search Data Equal command to the player. This provides the logical address for the file.

The player automatically moves the laser beam that reads the information from the compact disc. This is done through the SCSI based disc controller that locates the proper physical address on the disc. The CD-ROM player then signals the end of search to the source by sending a status byte with the Condition Met bit set. This is then followed by a Linked Command Complete message. The host adapter sends the disc controller a Read command which contains the number of blocks to be read and a logical block offset address. The controller then transfers the data to the host adapter. If the search for the key fails, the Condition Met bit is cleared in the status byte which is sent to the host adapter. This is followed by a Command Complete message, and the Read command waiting in the host adapter is purged and not set to the target.

The development of SCSI drivers can be very complicated. The user must have a good understanding of the device and its

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operating system. Problems are compounded by the makers of SCSI busses. They are insisting on system and device-specific device drivers.

In order to understand what the player is actually reading, it is important to learn the data structure format of a CD-ROM sector. One sector contains 2352 bytes. The first 12K bytes are used for synchronization purposes. The next 4 bytes contain header information. The first 3 bytes of the header are reserved for sector addressing and the 4th byte denotes the mode. The next 2K bytes are user data, then 4 bytes for error detection code, 8 bytes of space, 172 bytes of P-parity and 104 Q-parity error correction code.

The mode byte describes the nature of the user data. Mode 1 is used in applications which require maximum data integrity. Mode 2 is used for applications where the integrity is not an important issue (home or consumer applications). Mode 2 provides 288 bytes of additional user data.

After accounting for the synchronization header, and error detection and correction bytes, one disc contains 270K blocks of user data at 2048 bytes per sector yielding about 540 mbytes of usable data space. With the use of a sophisticated data search routine, the user can search the disc for a particular pattern or patterns. Each section can be encoded with an address bit which is then linked to a search pattern algorithm and the beginning of the disc. This algorithm would be placed in RAM for maximum execution speed. If the pattern is found, the program supplies the address byte sector information so the laser beam can move to the exact location. If the pattern is not found, the program notes this and exits. This reduces the wasted search time normally taken to search on hard or floppy disks.

BASIC COMPONENTS OF A CD-ROM SYSTEM

As in any computer system integration procedure, it is important to keep in mind the various components used. Design procedures require a study of the long and short term goals of the proposed system. In designing a computer system, there are six basic elements to be considered. These elements apply to CD-ROM system integration as well.

Capture

Where is the data coming from? In what form is it stored? These are important questions to answer, since without data, the system is useless. Recent developments in laser technology enable input data to be received from a number of sources. Optical Character Readers (OCR) can digitize a page and allow editing on the screen. Other digitizers allow pictures and diagrams to be digitized. These are frequently useful for CD-ROM applications.

Manipulation

Once the data are available, editing may be necessary. Recent advancements in desktop publishing software provide extensive cut-and-paste capabilities. A wide variety of editors can be used to modify textual information.

Storage

In order to maximize access time, careful thought must be given to the data storage techniques. During this process, the information is identified by name, size, and location. An indexing scheme is used to “tag” the information. There is no set procedure for this process since it is dependent on the application and retrieval software.

Of concern also is the “disc geographical layout.” This refers to the physical layout of the data on the disc. Geographical location greatly affects the speed with which an application can access and display the data. Storage methods include contiguous or sequential files, mapped files (as on a hard disk), and interleaved files (files broken into 2K blocks and stored in spiral fashion). Interleaving is practical for reducing access time between related files. For instance, a file containing a database can be interleaved with a file containing its indices.

The data then needs to be compressed. This is accomplished by eliminating empty space and repetitive areas. Several data compression schemes are available for both text and video. One of the techniques is “Entropy Reduction.” This method reduces data by replacing repetitive items with a short code.

Retrieval

This element is the software that determines the location of the desired information on the CD. Specialized retrieval software is necessary for particular applications. Because of the large amounts of data that can be stored on CD and the current limitations of transfer rates, careful design of the retrieval software is essential.

For most CD-ROM applications, the retrieval software will behave similarly to a database management system. The program requires a stand-alone indexing scheme to remember where each piece of information is stored.

Transmission

Some applications may call for users to access information from on-line databases. Several companies are setting up such systems. Again, careful thought must be given to the type of data to be transmitted, the transmission rate, and primarily to the type of error detection and correction techniques to be established.

Display

Depending on the application, this software can be complex or relatively simple. Display software represents a large variable in CD-ROM system design. Resolution, aspect ratios, and pixel configurations all play important roles in the selection and installation of a display system.

All of these elements play an important role in the integration of any computer system. They apply equally to CD-ROM. The design process must be laid out properly and appropriately from application to application.