Winchesters for multiuser/multitask applications

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ABSTRACT

The paper addresses the growing need for Winchester disk storage to handle multiuser/multitask applications. The paper reviews key elements necessary for achieving reliable performance, capacity, and fast access (e.g., linear voice coil actuation, closed-loop servo techniques, and processing/packaging methods). High-performance Winchester options for multitasking, how to evaluate them for specific applications, and what the future holds for Winchester technology are also discussed.
Winchester disk drives have been in use with large computers for years, but it is only recently that they have been adopted by manufacturers of small business systems, of word processors, and even of personal computers. Unlike large-system Winchesters, however, there is a bewildering variety of small-system Winchester storage products: three different disk sizes; two fundamentally different actuator systems; and a variety of interfaces, ranging from "dumb" to "smart."

In a multiuser/multitask environment, where reliability and performance are essential, Winchester disk drives that provide high capacities and low cost per megabyte are a logical choice. Once the decision to use a Winchester is made, decisions also need to be made regarding the specific type of Winchester and the interface type. These issues are discussed in the rest of this paper.

WHAT ARE THE WINCHESTER CHOICES?

Selecting the right Winchester starts by defining the system requirements. There are three fundamental system types: Single-User/Single-Task (SU/ST), Multi-User/Multi-Task (MU/MT), and Single-User/Multi-Task (SU/MT). Each of these fundamental system types has different basic mass storage requirements, as shown in Figure 1. Networks, or distributed processing, are typically hybrids of the two fundamental system types, and high-powered workstations—frequently part of a network—can be thought of as single-user/multitask (SU/MT) systems. In this system a single user may have several different programs (tasks) working in parallel (the concept of concurrency). These tasks might include performing word processing, compiling a BASIC program, plotting financial information, and sending or receiving an electronic mail message.

Six basic types of OEM Winchester disk drives serve these three system types. They are simply the combinations possible from the three main disk diameters currently available (14-inch, 8-inch, and 5¼-inch) and the two basic actuator systems (the low-performance, open-loop stepper motor and the high-performance, closed-loop voice coil motor). Typical capacity and access time range characteristics are shown in Figure 2. The complex procedure now begins to determine which one (or combination) of the six basic types of Winchester disk drives should be chosen for a particular type of system. The tradeoffs that the system designer makes during this selection process are also depicted in Figure 2.

A mapping of the fundamental system types into the basic drive types (see Figure 3) has been developed to assist in choosing an appropriate type of Winchester disk.

<table>
<thead>
<tr>
<th>SINGLE-USER/SINGLE-TASK</th>
<th>MULTI-USER/MULTI-TASK</th>
<th>SU/MT</th>
</tr>
</thead>
<tbody>
<tr>
<td>* DEDICATED DATABASE</td>
<td>* SHARED DATABASE</td>
<td>* DEDICATED/SHARED DATABASE</td>
</tr>
<tr>
<td>* UP TO 20 MEGABYTES (MB)</td>
<td>* 30 TO 400 MB</td>
<td>* 20 TO 50 MB</td>
</tr>
<tr>
<td>* LOW COST PER UNIT IS KEY</td>
<td>* LOW COST PER MB IS KEY</td>
<td>BOTH COST PER UNIT &amp; COST PER MB CONSIDERATIONS</td>
</tr>
<tr>
<td>* &quot;SLOW&quot; DATA ACCESS ACCEPTABLE</td>
<td>* &quot;FAST&quot; DATA ACCESS REQUIRED</td>
<td>* &quot;MODERATELY FAST&quot; DATA ACCESS REQUIRED</td>
</tr>
<tr>
<td>* LIGHT DUTY CYCLE IMPOSED ON ACTUATOR</td>
<td>* HEAVY DUTY CYCLE</td>
<td>* MODERATE DUTY CYCLE</td>
</tr>
<tr>
<td>* SMALL SIZE IS KEY; USED IN PORTABLE DESKTOP SYSTEMS, FLOPPY-DISC CAVITIES</td>
<td>* SMALL SIZE HELPFUL; USED IN PEDESTAL OR RACK MOUNT SYSTEMS</td>
<td>* SMALL SIZE IS KEY</td>
</tr>
</tbody>
</table>

Figure 1—Mass storage requirements for three popular system types
THE MAPPING OF THREE SYSTEM TYPES TO SIX DRIVE TYPES

The SU/ST storage requirements of small size and capacity, low cost, and light duty cycle fit the 5¼-inch stepper motor (SM) Winchester best. However, if the SU/ST system is planned to grow into an SUIMT system, the user needs to plan now for using a 5¼-inch voice coil motor (VCM) later. In early 1983, three years after low-capacity (under 10 MB) 5¼-inch drives were introduced, high-capacity 5¼-inch drives in the 40- to 55-MB range have now made their entrance.

The SU/MT storage requirements of moderate capacity and performance with very small size fit the 5¼-inch voice coil motor Winchester best. However, production quantities of these drives are not available, and the product and vendors still need to be field-proved (remember the “8-inch fever” in 1979 and 1980). So those who need capacity and performance in a small package size in 1983 (maybe even 1984) should stick with the 8-inch voice coil motor.

The MU/MT storage requirements of high capacity, low cost per megabyte, and heavy duty cycle fit the 14-inch voice coil motor Winchester best. The main exception occurs when size is more important than large storage capacity. In that case the user should consider the 8-inch voice coil motor.

Figure 2—Six basic types of Winchester disk drives: Tradeoff matrix

in mind that most 14-inch drives include space for a power supply but 8-inch drives do not. The drive power supply must be considered in space planning if an 8-inch drive is chosen.

Growing capacity needs of the SU/ST and SUIMT applications are reaching into and beyond the range of capacity available in 5¼-inch drives today. However, if the capacity of 5¼-inch drives reaches what is currently projected, and if these drives become available in volume, 5¼-inch drives will eventually replace some of the 8-inch drives in newly designed systems. This will happen first and most furiously at the low-end (open-loop stepper motor) segment of the 8-inch market. Conversely, the portion of large existing MU/MT applications that are becoming size-sensitive will probably grow, leading to the increased use of compact 14-inch voice coil motor, and floppy size 8-inch VCM Winchesters.

Future system storage requirements no longer map directly onto the 8-inch and 14-inch stepper motor Winchesters. This is because the physical size of the Winchesters suits the MU/MT system best, but their access time, duty cycle, and storage capabilities fit them to SU/ST systems best. Thus they map to neither system type, and their use by systems designers will be declining rapidly.

Particular attention needs to be paid to the capacity growth path implications of the device chosen. On the one hand,
there are lateral growth paths, where the physical size of the device remains the same. These are relatively easy to implement without changing interface or systems packaging. On the other hand, vertical growth paths in the same system enclosure, where the physical size of the drive changes, will occur less frequently, because of the capacity increases promised in the 5¼- and 8-inch disk sizes. Nevertheless, these growth paths are important, because of the increasing propensity of systems manufacturers to repackaging successful systems for appeal to different markets: Standalones are souped up to serve multiuser markets, and multiuser systems are downsized to serve desktop markets. In these cases, travel along a growth path where the drive interface is common is much easier than if interface, power, and software changes are required.

OTHER CONSIDERATIONS FOR THE MULTIUSER/MULTITASK APPLICATION

Several other issues need to be addressed in the evaluation of high-performance Winchester disk drives: system architecture, system integration, reliability, vendor viability, and total cost of ownership, to name a few.

System Architecture

System architecture can affect drive performance. In MU/MT applications, performance is the key ingredient. It is possible for total system performance to be drastically affected by apparently small changes in disk drive specifications or system timing requirements. For example, a change of a few microseconds in the time required to switch heads could be very significant if it precludes reading the next sector, causing tens of milliseconds to be added to a multisector operation. Similarly, an increase in data rate could cause sectors to be missed because of a suboptimal interleaving factor, again adding tens of milliseconds to each operation.

In evaluating system performance with different Winchester disk drives it is important to verify that the disk is not artificially constrained by a system parameter (like interleave factors) that you, as the system's designer, would be willing to change.

In most disk drive applications a significant part of the total transfer time is spent seeking and waiting. In a well-designed system these times are overlapped and minimized as much as possible. Many variations have minimal effect. When a boundary is approached, however, performance often changes suddenly and drastically.

System Integration

Choosing the Winchester is just the first step. Making it work in a prototype and then in production systems is next. The key to this task is the selection of an interface.

If the system design is brand-new, more decisions are required than if a current model is being enhanced or redefined. In either case, evaluation of the interface options on the basis of functional integrity, specific application requirements (perhaps emulation), controller availability, and the projected longevity of the interface is required.

In today's rapidly changing storage market, choosing the disk drive interface may be a longer-standing commitment than choosing a particular drive capacity level. Projecting the disk requirements for the future of the product line is an important factor. Will the interface choice still be appropriate? In the long term, a high-level interface generally makes the most sense; floppylike, external data separators make the least. In addition, because the market is changing so rapidly, the user should review the possibility of purchasing an intelligent controller, or even a memory subsystem, to accelerate the product to production.

The higher-level interfaces have technical advantages in that they all contain data separators. In truly high-performance products the data separator is a key component in the determination of data integrity. As such, it is to the
OEM's advantage to have the disk vendor responsible for an appropriate data separator design. Another advantage of the higher-level interface is its ability to deliver diagnostic status information.

Interfaces start from very simple and unsophisticated levels that approximate the control capabilities of floppy disk drives. They improve in stages in capability and intelligence until the drive with its interface actually constitutes a disk subsystem in which many sophisticated disk controller functions are added to the data storage capability of the drive. This range is briefly summarized below.

**Low Cost/Low Function Interface:** Provides the user MFM data- and bit-oriented command and status information. This interface is the most difficult to use, but the most economical from a drive point of view. Therefore it may be attractive to the SU/ST, large-volume, cost-sensitive user with substantial engineering and manufacturing resources capable of designing, testing, and controlling the difficult data separation circuitry required to process MFM data and higher and higher data rates.

**Early OEM Disk Interface:** This interface provides NRZ data; that is, data separation is performed on board the drive. Commands are byte-oriented, but status is bit-oriented. Control Data Corporation's SMD interface, developed in the early 1970s, has become a standard interface for larger systems. Though most designers consider it technically obsolete, since it is cumbersome to use and costly to implement, the wide range of disk drives available with the SMD interface contribute to its continuing popularity with systems designers.

**Modern Disk Bus:** This interface has an NRZ data stream like its predecessor; but both command and status are byte-oriented, and the interface is typically microprocessor-driven. The modern disk bus interface costs a little more than the low-cost/low-function interface; but is substantially easier for the system designer to use, and it provides better data integrity, since the data separator circuitry is on board the drive and controlled by the disk drive supplier. Examples of this interface include the ANSI standard and PRIAM interfaces.

**Intelligent Bus:** Intelligent bus interfaces such as IS1, SCSI, and SMART are indicative of the trend toward dispersing intelligence to components of computer systems and making disk drives easier for system designers to use.

Using a microprocessor to provide broad control capability at low cost, the intelligent bus type of interface is completely byte-oriented and is designed to adapt readily to commonly used microprocessor I/O busses. High-level versions of the intelligent bus include disk formatting and defect mapping, implied seek, daisy-chaining capabilities, selectable sector sizes, automatic alternate sector and track assignment, overlapped commands, data buffering, ECC, nonbuffered data transfers at disk speed, interleaved formats, backup device support, and logical or physical sector addressing.

When the systems OEM uses this last type of interface, integration problems are substantially reduced and data integrity is likewise improved. Moreover, the OEM gets the system running and into production 3 to 4 times as fast and with substantially less resources. And with the economies of scale available through volume manufacture of intelligent interfaces, the disk manufacturer can bring this type of product to the systems manufacturer very cost-effectively.

**Reliability**

Reliability is the key attribute of Winchester technology. Some supporting areas need to be considered as well, since Winchester has grown to be a very general term. Remember the key technology ingredients of the original Winchester technology of the IBM 3350: low mass, low force heads with contact start/stop capability, fixed media, and a sealed environment.

Today, disks and heads are permanently enclosed in most Winchester drives being manufactured. This is a characteristic vital to the improved reliability that Winchester drives provide. The most common causes of failure in pre-Winchester disk drives were improper handling of the packs and cartridges by computer operators and exposure of disk packs and cartridges to hostile environments (which includes the office environment).

The more traditional issues of electromechanical designs need evaluation. Look for fail-safe locking mechanisms for both carriages and spindles. As Winchester find their way into more portable systems, exposure to sustained vibration and repeated shocks will put excessive demands on them.

The terms high performance and stepper motor are almost mutually exclusive. Stepper motors typically have shorter lives in the heavy duty-cycle applications of MU/MT systems, whereas voice coil motors, being designed for this kind of use, last longer. Moreover, data recovery is not as affected by temperature or vibration in drives using closed-loop servoed voice coil positioners, while open-loop systems are more sensitive to the effects of temperature change and external vibration. Sampled data systems usually take care of temperature effects, but not the instantaneous effects of shock or vibration, which may be induced by simply bumping a desktop system, or the effects of nonrepeatable spindle runout.

**Vendor Viability**

Analyzing a vendor's track record before committing considerable resources to that firm is an important consideration. The vendor must be able to support the prototype systems that will be put in place. Evaluate the manufacturer's technical support staff. They are the key to providing application assistance and servicing the disk drive products that are being brought to market.

The vendor must be able to support the follow-on production. Does the vendor have a record confirming its ability to ship in volume?

Does it have the financial strength to survive, as well as maintain the R&D expenditures necessary to insure continued innovation?

**Cost of Ownership**

Though some drives may cost more in the beginning, they may be more inherently reliable and thus require fewer service calls or repairs. Therefore, the higher initial cost may in fact result in a lower life cost of ownership.

It is predicted that improvements to disk drive technology will vastly increase disk data density (see Figure 4). By the end of the 1980s, storage of up to 60 million bits per square inch of
Figure 4—Disk drive capacity growth through technology

disk surface is anticipated through the use of plated or sputtered disk surfaces, new recording techniques, and thin-film heads. This potential for improvement to sealed disk drive technology makes it certain that disk drives will provide for the foreseeable future the most economical and reliable means of storing and retrieving large amounts of data.