21ST CENTURY TECH

CHAPTER 19 How Storage Will Work

The death of hard drives has been predicted for just about long as there have been hard drives. After all, the disk drives that act as the main repository of programs and data for all PCs are confronted with disadvantages and perils. Except for the floppy and CD-ROM drives, which only get occasional use, the hard drive is the slowest part of your computer. It has mechanical parts that move from one point to another, making the hard drive considerably slower than the electricity zipping among solid-state components—those without moving parts. If your PC seems sluggish, chances are it's because of the hard drive. And the days of a hard drive's life are numbered. The same mechanics that make it slow also make it mortal, more so than microchips that don't experience anywhere near the physical wear and tear. The most dreaded PC experience you can have is a physical disk crash, in which the read/write heads hovering less than a hair's breath above the surface of the disks suddenly nose-dive onto a platter, destroying the drive and your data at the same time.

So why are hard disks still standard, even essential parts of a computer? Why haven't they been replaced with mass quantities of steady, virtually infallible RAM? Because hard drives are cheap and getting cheaper.

At the same time, hard drives are getting better. Their capacity has been increasing at a rate of 60 percent a year, and they're faster and more dependable, although not to the point that you can forget about backing them up. By the start of the new century, the cost of hard drive storage had fallen in just 10 years from $35 a megabyte to a penny, at the same time cramming 256 volumes of the Encyclopedia Britannica into the same space that used to hold only two.

Such progress, in the main, hasn't been because of wondrously new tech breakthroughs. Instead, most of the progress has been incremental. The magnetic coatings that cover the platters have been made denser at the same time the magnetic fields from the read/write heads have been intensified.

Together, the two improvements have made it possible to pack more and more data into increasingly smaller areas on the surfaces of the disks. For example, *near-field recording*, works similarly to a magneto-optical (MO) drive. A laser beam heats a small dot on the platter's surface to the Curie point, a temperature at which the coating is loosened enough to affected by a relatively weak magnetic field. A special lens focuses a laser beam more tightly than an MO drive can manage. The result should eventually yield 15 to 50 gigabytes of data per square inch. When you reach that density, however, something called the superparamagnetic limit starts to click in. A platter begins to lose data because bits are packed so closely their own minute magnetic fields can have an effect on each other. Quinta Corp., a subsidiary of the long-time drive manufacturer Seagate, plans to combat superparamagnetic limits with a technology it calls optically assisted Winchester (OAW) drives. OAW, as do MO drives and near-field recording, uses a combination of magnetism and optics, but in a clever way that limits the effects of stray magnetic waves. Usually drives have only one read/write head for each side of a platter. But OAW uses laser light to select among various heads within the drive.

A laser beam is focused on the surface of a platter and uses the Kerr effect, where polarized light that is bounced off a magnetized surface performs a twist. The light then passes through a second polarizing filter. Whether the beam has a twist or not determines the intensity of the light as it leaves the second filter and can be read as either a 0 or 1 bit.

Writing data with OAW is similar to the method used with MO drives. But where magneto-optical drives require one pass to read an area and a second pass to actually write a bit to the same area, OAW accomplishes this all in one pass. This method of writing requires less power from the laser so the heating effect that can loosen magnetized spots on the platter is minimal and there's less chance of data corruption. To accomplish this, OAW uses mirrors and lenses, no bigger than the head of a pin created with the same techniques that chip makers use to etch minute circuits on semiconductors. A micromachined, motorized mirror and a tiny lens focus the laser very accurately on the smallest area possible. Laser light is carried to the head via a fiber optic strand rather than being flashed through the air with cumbersome mirrors as a conventional MO drive works. As a result, the head and arm take up less space, allowing the drive to use multiple heads that are optimized for writing to different sectors of the platters.

The first fundamental change in mass storage will come sometime during the first decade of the next century—holographic storage. Holograms, those flat pictures that seem to move or pop out in three dimensions, are created by recording light differently. Instead of making a record of light hitting the surface of the hologram, the technology makes a record of the interference patterns created when the ordered light waves of one laser beam that is turned on and off to represent data bits has they pass through the waves of a second laser beam. During reading, the reaction of the reference laser beam and the stored interference pattern in the medium recreates the original data beam, which is then detected by an array of photosensitive cells.

These records are stored not simply on the surface of a material, but within the material itself, adding a third dimension to data storage. Plus, changing the angle at which the laser beams cross paths changes the interference patterns. In traditional holography, the different patterns are used to present different viewing angles of the same object. With holographic storage, the different patterns allow different "pages" of information to coexist within the same 3D space. It raises the possibility that storage will abandon the platter configuration to instead record data within a cube of optically sensitive crystal. The method has no moving parts, virtually eliminating the type of unrecoverable head crashes that plague conventional drives. And the lack of mechanical parts also eliminates the accompanying slowness that is inherent where physical movement is involved. IBM has already demonstrated the technique, recording 1GB of data in a crystal the size of a sugar cube, with fantastic data access rates of one trillion bits a second. Translated to the form size of a typical hard drive, holographic storage capacity grows to 280GB—enough for 1,500 1GB holographic vacation photos.

The catch? It's not rewritable. Any data written to holographic storage is permanent. It can't be erased or changed. While research is under way to make holographic storage rewritable, the permanence of holography isn't necessarily a problem. Storage is capacious enough and cheap enough that software can keep track of new versions of a same file so that previous versions are accessed only when there's a need to. And for archiving and storage that requires an unalterable audit trail, holography is a natural.

In the next century—certainly in the next millennium——the most difficult challenge will be not new methods of data storage. It will be old forms. Already countless megabytes of data reside on outdated floppy disks, hard drives, and tape storage that can no longer be read by modern disk and tape drives. In relying so heavily on the efficient, compact storage that computing offers we have assigned vast realms of data to a black hole from which they may never escape.