sided disk). The expansion digital versatile disk is also used in place of digital ideo disk, since DVDs can hold any digital data, not just video data. Data are stored optically on a disk, and are read by a laser.

The optical disks used in read-only compact disks (CD-ROM) or read-only digital video disk (DVD-ROM) cannot be written, but are supplied with data prerecorded. There are also “record-once" versions of compact disk (called CD-R) and digital video disk (called DVD-R and DVD+R), which can be written only once; siich disks are also called write-once, read-many (WORM) disks. There are also “multiple-write" versions of compact disk (called CD-RW) and digital video disk (DVD-RW, DVD+RW, and DVD-RAM), which can be written multiple times.

Optical disk jukebox systems contatn a few drives and numerous disks that can be loaded into one of the drives automatically (by a robot arm) on demand.

e Tape storage. Tape storage is used primarily for backup and archival data. Although magnetic tape is cheaper than disks, access to data is much slower, because the tape must be accessed sequentially from the beginning. For this reason, tape storage is referred to as sequential-access storage. In contrast, disk storage is referred to as direct-access storage because it is possible to read data from any location on disk.

Tapes have a high capacity (40- to 300-gigabyte tapes are currently available), and can be removed from the tape drive, so they are well suited to cheap archival storage. Tape libraries (jukeboxes) are used to hold exceptionally large collections of data such as data from satellites, which could include as much as hundreds of terabytes (1 terabyte = 10'* bytes), or even multiple petabytes (1 petabyte = 101° bytes) of data in a few-cases.

The various storage media can be organized ina hierarchy (Figure 11.1) according to their speed and their cost. The higher levels are expensive, but are fast. As we move down the hierarchy, the cost per bit decreases, whereas the access time increases. This trade-off is reasonable; if a given storage system were both faster and less expensive than another—other properties being the same—then there would be No reason to use the slower, more expensive memory. In fact, many early storage devices, including paper tape and core memories, are relegated to museums now that magnetic tee

and semiconductor memory have become faster and cheaper. Magnetic tapes themselves were used to store active data back when disks were expensive and had = Storage capacity. Today, almost all active data are stored on disks, except in very ra

i ical jukeboxes.

cases where they are stored on tape or in optical ju . 2

The fastest os media—for example, cache and main memory —are referred

'0as primary storage. The media in the next level in the hierarchy—for example,

ic di e, or on line storage. The media

Magnetic disks—are referred to as secondary aboteg one SE ree

N the lowest level in the hierarchy —for examp Bye ears

pos = 2te relegred to.2s EE a storage systems, there is also the

In addition to the speed and cost of the vario Sern the power to the

© of storage volatility. Volatile storage loses its conten’