Magnetic Disks

- Magnetic disks provide the bulk of secondary storage for modern computer systems.
- Each disk platter has a flat circular shape, like a CD . The two surfaces of a platter are covered with a magnetic material.
- We store information by recording it magnetically on the platters.
- A read–write head “flies” just above each surface of every platter. The heads are attached to a disk arm that moves all the heads as a unit.
- The surface of a platter is logically divided into circular tracks, which are subdivided into sectors. The set of tracks that are at one arm position makes up a cylinder.
- There may be thousands of concentric cylinders in a disk drive, and each track may contain hundreds of sectors.
- The storage capacity of common disk drives is measured in gigabytes.

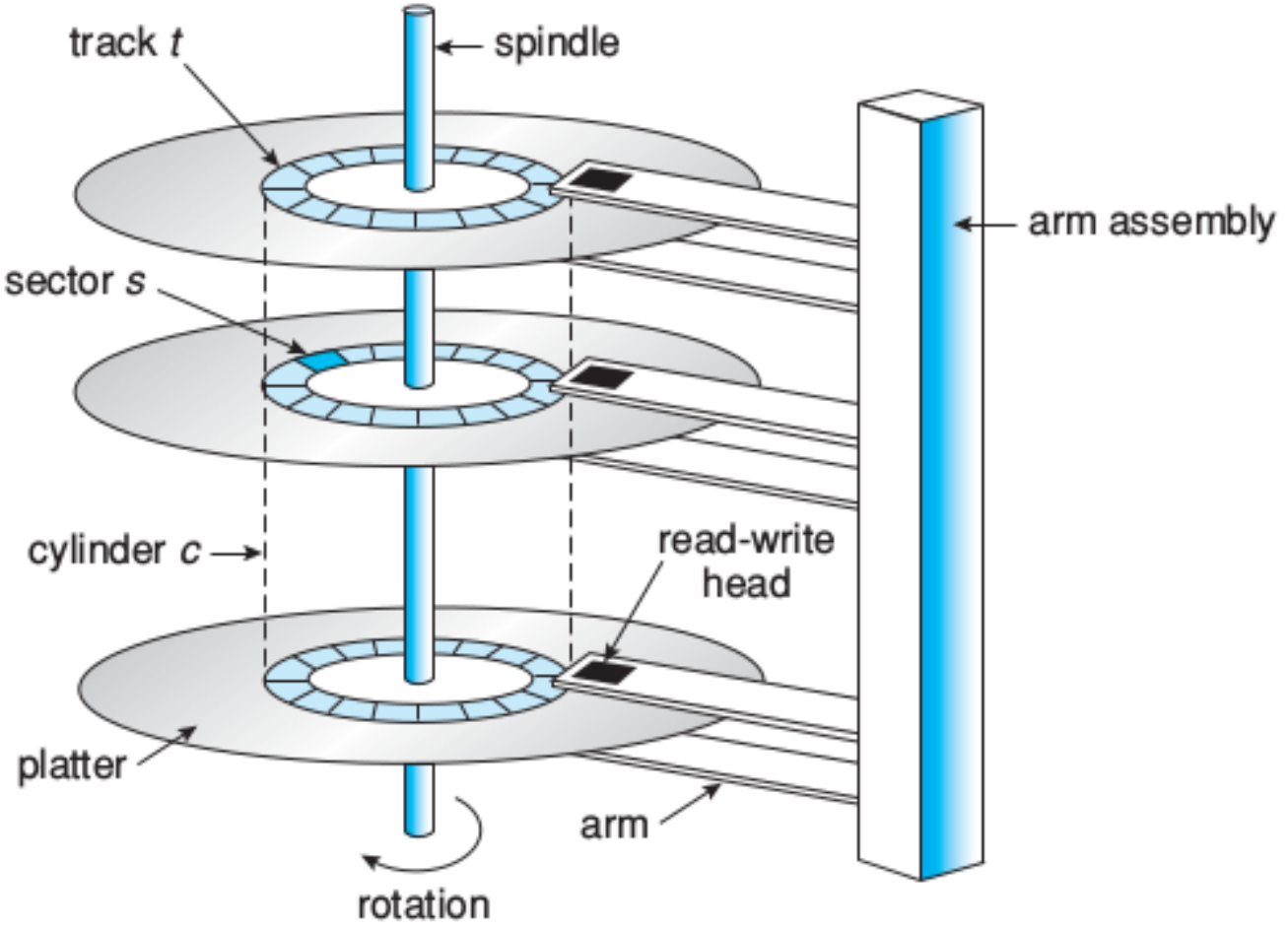

Figure 10.1 Moving-head disk mechanism.

- When the disk is in use, a drive motor spins it at high speed.

- The **transfer rate** is the rate at which data flow between the drive and the computer.
- The **positioning time**, or **random-access time**, consists of two parts: the time necessary to move the disk arm to the desired cylinder, called the **seek time**, and the time necessary for the desired sector to rotate to the disk head, called the **rotational latency**.
- Because the disk head flies on an extremely thin cushion of air (measured in microns), there is a danger that the head will make contact with the disk surface.
- Although the disk platters are coated with a thin protective layer, the head will sometimes damage the magnetic surface. This accident is called a **head crash**.
- A head crash normally cannot be repaired; the entire disk must be replaced.

- A disk drive is attached to a computer by a set of wires called an I/O bus.

Solid-State Disks

- An SSD is nonvolatile memory that is used like a hard drive.
- SSDs have the same characteristics as traditional hard disks but can be more reliable because they have no moving parts and faster because they have no seek time or latency.
- In addition, they consume less power.
- However, they are more expensive per megabyte than traditional hard disks, have less capacity than the larger hard disks, and may have shorter life spans than hard disks, so their uses are somewhat limited.
- SSD s are used in some laptop computers to make them smaller, faster, and more energy-efficient.

Magnetic Tape

- Magnetic tape was used as an early secondary-storage medium.
- Although it is relatively permanent and can hold large quantities of data, its access time is slow compared with that of main memory and magnetic disk.
- In addition, random access to magnetic tape is about a thousand times slower than random access to magnetic disk, so tapes are not very useful for secondary storage.
- Tapes are used mainly for backup, for storage of infrequently used information, and as a medium for transferring information from one system to another.
- Moving to the correct spot on a tape can take minutes, but once positioned, tape drives can write data at speeds comparable to disk drives.

Disk Structure

- Modern magnetic disk drives are addressed as large one-dimensional arrays of logical blocks, where the logical block is the smallest unit of transfer.
- The size of a logical block is usually 512 bytes, although some disks can be low-level formatted to have a different logical block size, such as 1,024 bytes.
- The one-dimensional array of logical blocks is mapped onto the sectors of the disk sequentially.
- Sector 0 is the first sector of the first track on the outermost cylinder. The mapping proceeds in order through that track, then through the rest of the tracks in that cylinder, and then through the rest of the cylinders from outermost to innermost.

- We can convert a logical block number into an old-style disk address that consists of a cylinder number, a track number within that cylinder, and a sector number within that track.
- It is difficult to perform this translation, for two reasons. First, most disks have some defective sectors, but the mapping hides this by substituting spare sectors from elsewhere on the disk.
- Second, the number of sectors per track is not a constant on some drives. On media that use **constant linear velocity (CLV)**, the density of bits per track is uniform.
- The farther a track is from the center of the disk, the greater its length, so the more sectors it can hold. As we move from outer zones to inner zones, the number of sectors per track decreases.
- The drive increases its rotation speed as the head moves from the outer to the inner tracks to keep the same rate of data moving under the head.

- This method is used in CD-ROM and DVD-ROM drives.
- Alternatively, the disk rotation speed can stay constant; in this case, the density of bits decreases from inner tracks to outer tracks to keep the data rate constant.
- This method is used in hard disks and is known as **constant angular velocity (CAV)**.

Disk Attachment

- Computers access disk storage in two ways. One way is via I/O ports (or **host-attached storage**); this is common on small systems.
- The other way is via a remote host in a distributed file system; this is referred to as **network-attached storage**.

1. Host-Attached Storage

- Host-attached storage is storage accessed through local I/O ports. These ports use several technologies.
- The typical desktop PC uses an I/O bus architecture which supports a maximum of two drives per I/O bus.
- A wide variety of storage devices are suitable for use as host-attached storage such as hard disk drives, and CD , DVD , and tape drives.
- The I/O commands that initiate data transfers to a host-attached storage device are reads and writes of logical data blocks directed to specifically identified storage units

2. Network-Attached Storage

- A network-attached storage (NAS) device is a special-purpose storage system that is accessed remotely over a data network.
- Clients access network-attached storage via a remote-procedure-call interface.
- The remote procedure calls (RPC s) are carried via TCP or UDP over an IP network—usually the same local- area network (LAN) that carries all data traffic to the clients.
- Network-attached storage provides a convenient way for all the computers on a LAN to share a pool of storage with the same ease of naming and access enjoyed with local host-attached storage.
- However, it tends to be less efficient and have lower performance than some direct-attached storage options.

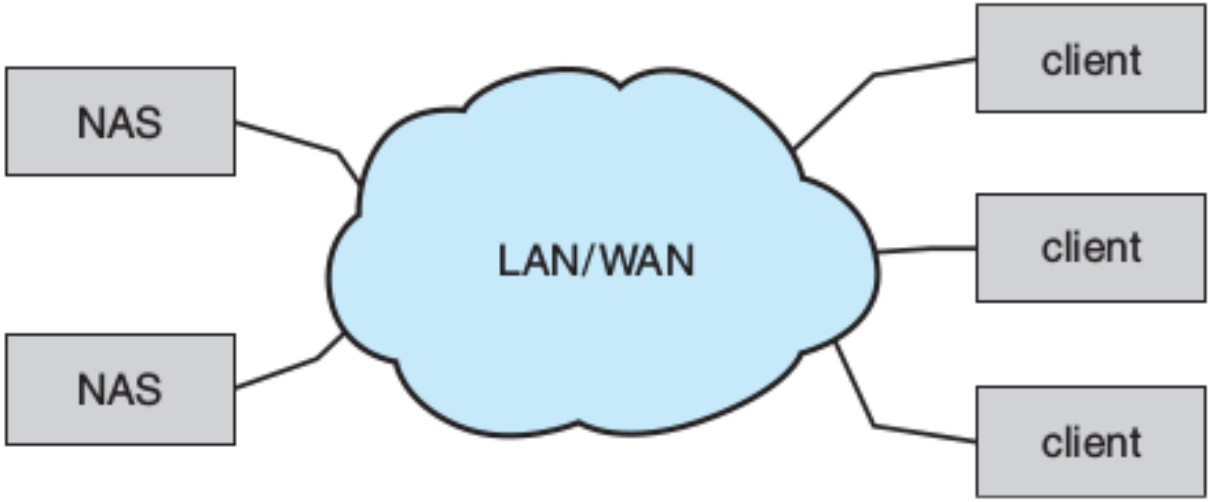

Figure 10.2 Network-attached storage.

- One drawback of network-attached storage systems is that the storage I/O operations consume bandwidth on the data network, thereby increasing the latency of network communication.
- This problem can be particularly acute in large client–server installations—the communication between servers and clients competes for bandwidth with the communication among servers and storage devices.

A **storage-area network (SAN)** is a private network (using storage protocols rather than networking protocols) connecting servers and storage units.

- The power of a SAN lies in its flexibility. Multiple hosts and multiple storage arrays can attach to the same SAN , and storage can be dynamically allocated to hosts.
- As one example, if a host is running low on disk space, the SAN can be configured to allocate more storage to that host.

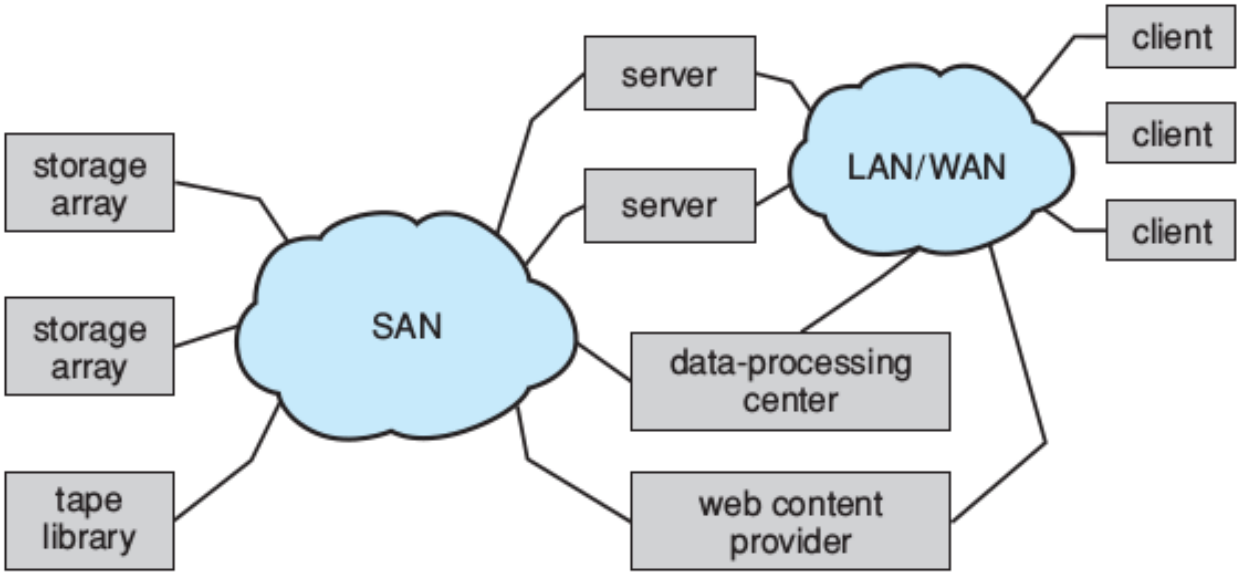

Figure 10.3 Storage-area network.