【OS】Day40

Class	Operating System: Three Easy Pieces
Date	@February 21, 2022

【Ch37】Hard Disk Drives

37.1 The Interface

The basic interface for all modern drives is straightforward. The drive consists of a large number of sectors(512-byte blocks), each of which can be read or written.

The sectors are numbered from 0 to n-1 on a disk with n sectors. Thus, we can view the disk as an array of sectors; 0 to n-1 is thus the address space of the drive.

Multi-sector operations are possible; indeed, many file systems will read or write 4KB at a time(or more).

However, when updating the disk, the only guarantee drive manufacturers make is that a single 512-byte write is atomic(i.e. It either complete in its entirety or don't complete at all). Thus, if untimely power loss occurs, only a portion of a large write may complete(sometimes called a torn write).

There are some assumptions most clients of disk drives make, but that are not specified directly in the interface:

- Accessing two blocks near one-another within the driver's address space will be faster than accessing two blocks that are far apart.
- Accessing blocks in a contiguous chunk(i.e. sequential read or write) is the fastest access mode, and usually much faster than any more random access pattern

37.2 Basic Geometry

Let's start to understand some of the components of a modern disk. We start with a platter, a circular hard surface on which data is stored persistently by inducing magnetic changes to it.

A disk may have one or more platters; each platter has 2 sides, each of which is called a surface.

The platters are all bound together around the spindle, which is connected to a motor that spins the platters around(while the drive is powered on) at a constant(fixed) rate. The rate of rotation is often measured in rotations per minute(RPM), and typical modern values are in the 7,200 RPM to 15,000RPM range.

Data is encoded on each surface in concentric circles of sectors; we call one such concentric circle a track. A single surface contains many thousands and thousands of tracks.

To read and write from the surface, we need a mechanism that allows us to either sense(i.e. read) the magnetic patterns on the disk or to induce a change in (i.e. write) them. This process of reading and writing is accomplished by the disk head. There is one such head per surface of the drive.

The disk head is attached to a single arm, which moves across the surface to position the head over the desired track.

37.3 A Simple Disk Drive

Assume we have a simple disk with a single track.

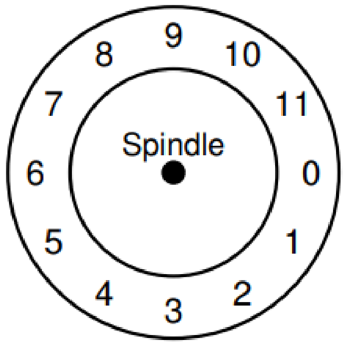

Figure 37.1: **A Disk With Just A Single Track**

This track has just 12 sectors, each of which is 512 bytes in size and addressed therefore by the numbers 0 through 11.

Single-track Latency: The Rotational Delay

If we receive a request to read block 0, how should the disk service this request?

The disk must just wait for the desired sector to rotate under the disk head. This wait happens often enough in modern drives, and is an important enough component of I/O service time, and it has a special name: rotational delay.

Multiple Tracks: Seek Time

Let’s look at a slightly more realistic disk:

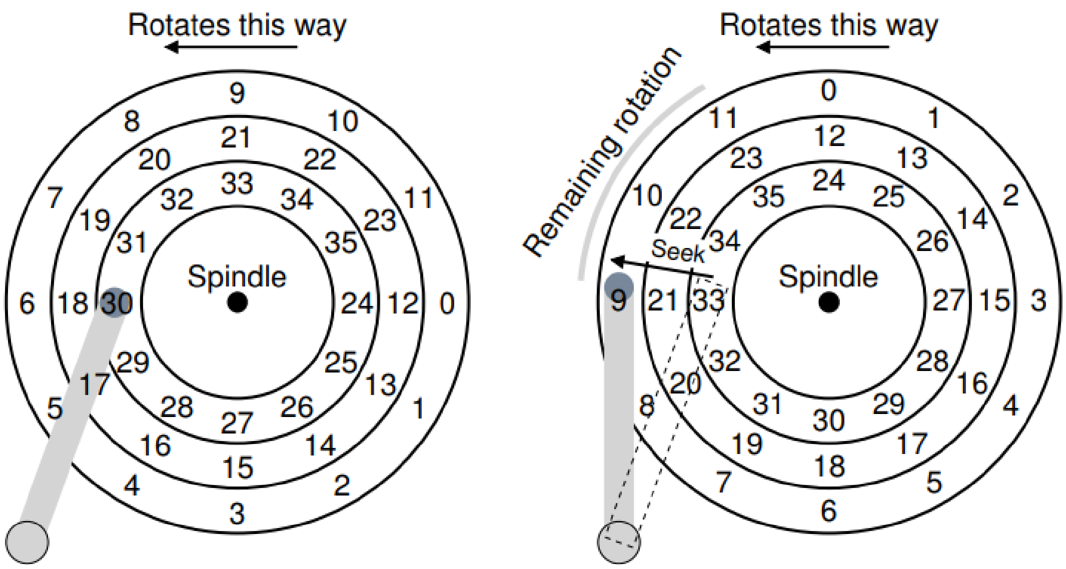

Figure 37.3: **Three Tracks Plus A Head (Right: With Seek)**

In this example, the head is currently positioned over the innermost track(24 through 35); the next track over contains the next set of sectors(12 though 23), and the outermost track contains the first sectors(0 through 11).

If we now receive a request to a distant sector, e.g. to sector 11, the drive has to first move the disk arm to the correct track(in this case, the outermost one), in a process known as a seek. Seeks, along with rotations, are one of the most costly disk operations.

The seek has many phases:

1. First an acceleration phase as the disk arm gets moving
2. Then coasting as the arm is moving at full speed
3. Then deceleration as the arm slows down
4. Finally settling as the head is carefully positioned over the correct track.

The settling time is often quite significant.

When sector 11 passes under the disk head, the final phase of I/O will take place, known as the transfer, where data is either read from or written to the surface.

Some Other Details

Many drives employ some kind of track skew to make sure that sequential reads can be properly serviced even when crossing track boundaries. This might appear as seen in the figure below.

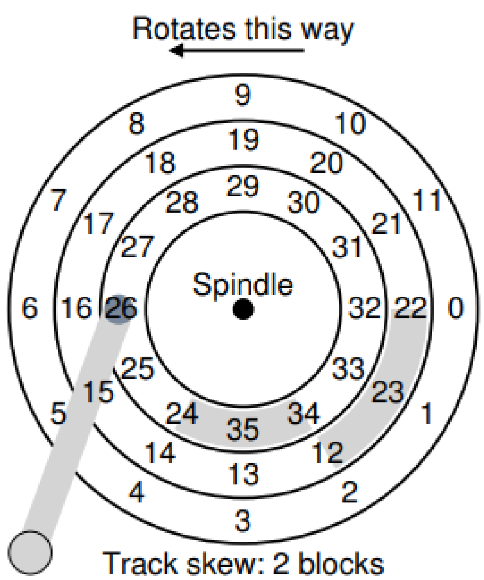

Figure 37.4: **Three Tracks: Track Skew Of 2**

Sectors are often skewed like this because when switching from one track to another, the disk needs time to reposition the head(even to neighbouring tracks). Without such skew, the head would be moved to the next track but the desired next block would have already rotated under the head, and thus the drive would have to wait almost the entire rotational delay to access the next block.

Another reality is that outer tracks tend to have more sectors than inner tracks, which is a result of geometry; there is simply more room out there. These tracks are often refereed to as multi-zoned disk drives, where the disk is organized into multiple zones, and where a zone is consecutive set of tracks on a surface.

Finally, an important part of any modern disk drive is its cache, for historical reasons sometimes called a track buffer. This cache is just some small amount of memory(usually around 8 or 16 MB) which the drive can use to hold data read from or written to the disk.