

drive has to wait an average of 0.004167 second for the data to arrive at the read/write head.

Let's put that into perspective by comparing it to the typical clock speed of a modern CPU. CPUs typically purr along with clock speeds ranging from 2.0 GHz to 3.5 GHz; we'll pick 2.0 GHz to keep the math simple. That's two billion clock ticks *per second*. In the 0.004167 second it takes for the disk drive to wait for data to arrive, the CPU clock will have ticked more than 8 million times. Thus, the CPU can do 8 million other things while it waits for data to spin around the disk.

Here's an even better way to get a perspective on how slow disk drives are: Imagine that you could slow both the CPU clock and the disk drive down to where the CPU clock ticked once per second. Snap your fingers and count *one one thousand, two one thousand* to get this mental exercise going. At that pace, you would have to wait more than three months for the data to spin around to the point where it can be read by the read/write heads.

For the fun of it, let's go back a moment to Step 1 in the process, in which the read/write head moved to the track that contains the sector to be accessed. In most disk drives, this move can take anywhere from a single revolution to three full revolutions to accomplish. In our one-click-per-second illustration, we had to wait on average six months before we could even start to wait for the data. So now we've waited a total of nine months, on average, just to be in position to read the data.

3. And we're still not done: When the data has arrived at the read/write head, the head is activated to either read or write the data. And then, the read/write head can only read the data at the speed that it passes under the read/write head. Figuring out the amount of time it takes for the data to fly under the head is a much more complicated task than accounting for moving the read/write heads and waiting for the data to arrive. Let's just figure that it will take a few additional days or weeks to actually read the data.

That was fun, wasn't it? The whole point of this detailed discussion is to illustrate why disk storage is one of the most troublesome bottlenecks when it comes to the overall performance of your network.

To be fair, disk drive manufacturers go to great lengths to minimize the impact of the inherent slowness of disk technology. For example, all disk drives include a relatively large amount of internal storage that is used as a *cache*, which stores the most recently read data in fast memory so that it can quickly be read again if it's needed. Even so, cache memory can only marginally improve disk performance. What's needed is an inherently faster storage technology, which is where solid state drives come in.