STAR Watch

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No Moving Parts:

Solid State Disk Drives Revisited

A little over two years ago, we wrote an article about Solid-State Disk Drives. At that time, we were optimistic about their future, but not ready to advocate for their use. A lot of questions needed to be answered about them – especially the issue of reliability. Fast forward to today. There is now large body of knowledge and user experience regarding these devices. Based on the information available, we feel it is time to revisit the topic.

A brief history…

The disk drive as we think of it now debuted in 1956. Marketed as the IBM 350 Disk Storage Unit (Model 1), it consisted of 50 24-inch magnetic disks, had a capacity of 5 million characters of data, and leased for $35,000 per year (in 1956 dollars). It had two independent read/write heads that moved up and down among the discs, then in and out to locate the desired data on one of the platters. Its average speed to locate and read a single 100 character data record was 6/10ths of a second. The almost 1 ton unit was 68" tall, 60" wide, and 29" deep.

Over the last 56 years, there have been a multitude of technical improvements that have decreased the size, decreased the cost, and increased the speed of disk drives. Now, for a few hundred dollars, anyone can buy a disk drive that can hold 600,000 times as much data and access any data record 80 times faster than the original drive. But even after all of these improvements, today's disk drive is fundamentally the same as that 1 ton monster from the days of yore.

In this issue…

Today…

Disk drives still have multiple disk platters – albeit much smaller in size and quantity. The 24 inch disks that spun around at the astounding speed of 1200 rpm, have been shrunk to 3.5, 2.5, or 1.8 inches and rotate at 5,400, 7,200, or 10,000 rpm. Instead of two read/write heads to travel around reading and writing data to/from 50 different discs, there is at least one read/write head dedicated to each of the discs. Those read/write heads still move in and out to locate, then read or write data to/from a specific location. Granted, things are phenomenally faster than they used to be, but in the near-term, there don't seem to be any new ideas in the works to improve the disk drive beyond current levels of performance.

Many people are under the impression that today's disk drives are blindingly fast because they read the manufacturers' ads that claim that drives with a "SATA III" interface can transfer data at up to 6 Megabytes per second. The manufacturers' claims are true, but omit an important piece of information: The data rate that they are referring to is the speed at which the data moves between the buffer in the disk drive controller and the computer's memory. It does not include the time needed to physically access the data on the disk drive itself. The rate at which data can actually be read or written to one of the magnetic platters in the drive is much slower – usually between 125 and 150 Megabytes/second. That is nowhere near the speed of the interface. How can this be?

An example…

If we filled a 5 gallon pail with water from the garden hose, the water in the garden hose flows at a rate of 5 gallons per minute. At that rate, the bucket could be completely filled in 1 minute. Once it is full, the water in the bucket could be emptied out in less than 1 second. While the rate of flow from the bucket is very high, it cannot be sustained because the bucket cannot be refilled quickly enough. So, what is the rate at which water empties from the bucket? Optimists will say that water empties from the bucket is 5 gallons/second. The pessimists will argue that the time it takes to fill the bucket must also be considered, so, the sustained rate at which the bucket empties is 5 gallons/minute. It all depends on how the answer is framed.

How fast (or slow) are disk drives?

While manufacturers are touting the interface speeds of their products, the numbers that actually matter are buried deep in a specification sheet that hardly anyone reads. For a traditional disk drive, the numbers that matter are:

- Average Seek time: As we stated earlier, the read/write heads must be moved to the desired location on the rotating disk inside the drive. This takes a finite amount of time to accomplish.
- Rotational Latency: Once the read/ write head is properly positioned, the drive must wait for the desired piece of

data to rotate around and end up under the read/write head. The laws of probability dictate that, on average, the target data is ½ a revolution away. The drive must wait for the data to end up under the read/write head. The rotational speed of the drive directly affects this value.

- I/O Operations per Second (IOPS): When operating in real-world conditions, disk drives are constantly performing reads and/or writes to multiple different files. Since each of the files occupies a different location on the disk, the read/write heads must move every time I/O operation is performed on a different file.

  IOPS is a direct calculation based on Average Seek Time and Rotational Latency. It indicates how many read or write operations could occur in 1 second when each of those I/O operations take the average amount of seek time and rotational latency.

  This number has a direct affect on the overall performance of the computer. It affects how quickly the computer can boot up, load programs, process data files, and shut down because all of these operations require disk I/O. When comparing the performance of several disk drives, this number is an excellent indicator of relative performance among them. For traditional disk drives on the market today, the IOPS is between 75 and 100 per second.

- Sustainable Transfer Rate: Under perfect conditions (no seek time and no rotational latency), this is the speed at which the drive could read or write data for an extended period of time. For most drives on the market today, the Sustainable Transfer Rate ranges between 125 and 150 Megabytes/sec.

Since its inception, there has been continued improvement in disk drive performance. Read/write heads are able to move much more quickly. Rotational speeds of disk drives normally found in personal computers have moved from 4200 and 5400 rpm to 7200 rpm. That proportionally decreased Rotational Latency. Changes in the storage capacity of drives has also proportionally increased Sustainable Transfer Rates. But, the traditional computer disk drive as we know it has little left that can be improved upon. There are certain laws of physics that make it difficult to significantly improve disk drive performance, keep the price affordable, and be reliable for a reasonable amount of time.

Creating a faster data storage device…

What would be required to turn a traditional disk drive into a significantly faster storage device? We could start by getting rid of the things that impede performance:

- The read/write heads that move in and out to access data are a big time waster. Whenever they are moving, they are not transferring data – They have to go.
- The magnetic disks that store the data must also go away. The drive is wasting too much time waiting for the

data on the disk to end up under the read/write head.

In place of the magnetic disks that stored the data, we could use the same type of memory that is used in a USB thumb drive. Once data is stored in it, the data is not lost when the power is turned off. Data access on a thumb drive is pretty quick, but it could be sped up by using a faster interface, like SATA. After all this is done, what would we have? It would be a Solid State Disk (SSD).

Good news!

We don't have to do the work. Many companies are already marketing SSDs. There are literally hundreds of makes and models to choose from. But, are they that good? In a word: Yes.

While it is true that SSDs cost more than traditional drives, every SSD on the market outperforms even the best disk drive. Let's compare the two big performance numbers. As we stated earlier, a traditional disk drive can perform 125 – 150 I/O Operations per second. A solid-state drive that was designed to replace a traditional disk drive handles 5,000 – 60,000 IOPS. That is up to 400 times faster (at a minimum, it is 40 times faster).

When it comes to Sustained Transfer Rate, almost all SSDs exceed 200 MB/sec, but most can handle greater than 500 MB/sec. Compared to a traditional disk drive, every SSD outperforms a traditional disk drive.

And, because an SSD has such a high IOPS rate, the amount of data that it can transfer in 1 second will be much closer to its Sustainable Transfer Rate than a traditional disk drive.

Other than speed, what else?

Start up time. SSDs are ready to begin work within 2 seconds of power up. A traditional disk drive takes 4 – 21 seconds.

Noise. There are no moving parts. SSDs are silent.

Power. SSDs use 25% (or less) of the power needed for a traditional disk drive.

Fragmentation. Absolutely irrelevant to an SSD. Regardless of where the data is stored, the amount of time required to access it is the same.

Reliability. There are no moving parts. There is nothing mechanical to wear out. The warranty period on SSDs go up to 5 years, depending on make & model.

Who are SSDs best suited for?

Road Warriors. With an SSD installed in a laptop, it will boot up & shut down faster, it will load programs faster, it will extend battery life, and it is mostly immune to bangs and bumps that could damage a traditional disk drive.

Speed Demons. SSDs are fast. Very fast.

Audiophiles. These are very fussy people who get annoyed when the flow of the music is interrupted by other computer operations needing disk I/O.

Web sites. Many of the big names in web sites (Google, Facebook, Amazon) are having their online content moved to

SSDs. The increased performance allows the websites to handle more transactions per second.

Some people say that the memory used in an SSD can "wear out". Is that true?

It is true, but really needs further explanation. In order to make a device that would not lose all the data stored on it when the power is turned off, manufacturers of SSDs were forced to use a type of memory that is physically changed when data is stored in it. Every time the data in a memory location is changed, its ability to retain data is diminished by a very tiny amount. Eventually, after the data in a specific location in memory has been changed an excessive number of times, that location loses its ability to store data.

Every SSD manufacturer has addressed this issue. In order to reduce wear and tear on a specific location, the controller on the SSD keeps track of the number of writes to each storage location and stores new data into less used storage areas. This "wear leveling" tends to balance the usage and extend the life of the SSD.

Let's get more specific about how much use it would take to "wear out" an SSD: In order to "wear out" a 240GB SSD in 5 years, it would require the user to write (reading doesn't wear out the memory) 82.5GB of data to the drive every single day of that 5 year period. According to a study (by Toshiba), the average computer user stores 2.4 GB of data every day and a heavy user stores 9.2GB. The likelihood that the SSD will wear out before the computer is retired is extremely remote – even less likely than having a traditional disk drive fail in that period of time.

In addition to wear leveling, every drive has more storage capacity than it admits to. These areas are kept in reserve for occasions when one of the storage areas becomes defective. When the controller determines that a data area can no longer reliably store data, that space is flagged as unusable and some of the reserve space is used.

Is there anything that people might not like about SSDs?

Right now, the price of SSDs may scare some people away. We recently purchased an Intel 520 Series 240GB SSD for one of our laptops. The price was around $325 (Amazon.com).

While there are some exceptions, the cost of a reasonably good SSD ends up being $1.25 - $1.50 per Gigabyte of storage capacity. A traditional disk drive is around half the cost.

But, are SSDs worth the price?

Yes! It was very easy for us to do performance comparisons on our laptop by swapping the old drive with the new SSD, run a few tests, swap drives and re-run the test: With the SSD installed, the laptop boots up in less than 1 minute (It used to take more than 2 minutes). It shuts down in 40 seconds (about ½ the time). The rate at which it is able to render video files (lots of huge files) has increased 30-35%. It's almost like getting a new computer.

WNYLC Web Statistics For May 2012

Total Hits…..…1,679,438
Number of Pages Viewed.....…..…...456,179
Total Visitors.....…163,058
Average Hits/Day…….....…..……54,174
Average Pages /Day……..…...14,714
Top Web Browsers Used:
Internet Explorer 9.x…….…….....16%
Internet Explorer 8.x…….…….....21%
Internet Explorer 7.x…….…….....11%
Firefox.....…..……...……15%
Safari.....…..……...……7%
Google Chrome.....6%

Top Operating Systems Used:
Windows 7…..…..29%
Windows Vista.....…….……...8%
Windows XP.....……32%
Mac OS.....…….……....….4%
Linux.....<1%
iPad.....…1%

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