Comparative Analysis Between Hard Disk Drive and Solid-State Drive

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Abstract. The resource of the contemporary computers are extremely good with one significant exception – HDD with spinning disks. The traditional spinning hard disk is primary nonvolatile information carrier of the computer. The information on it will not be lost upon powering off the system. SSD has the same functions as the hard drive but the information on it is stored on linked chips of flash memory, which protect the information even when it doesn't have electrical supply. These flash chips are different from USB drives and usually are faster and reliable. Our goal is to survey the pros and cons of both information providers.

Keywords: HDD, RAID, SSD.

1. INTRODUCTION

The computer technologies from the new century are developing too fast. Unfortunately, the transition from one generation processors to another provides fairly modest growth in overall performance of computers – usually within a few tens of percent, which can be hard to define like an expected improvement.

All storages in the computers appear in the beginning of the 70s from the twentieth century in the semiconductor industry. Solid-state memory – static RAM (SRAM), dynamic RAM (DRAM) and flash (originally EPROM) are based on storage of the transistors, while the mechanic memory – tape and hard disk (HDD) rely on magnetic storage. These two data carriers have a very long life.

2. HARD DISK DRIVE

Hard disk drives are energy-independent computer memory, they are relatively cheap and have a big capacity. HDD uses one or more disk plates around a common spindle, called disk package. Each plate is covered with a magnetic layer, onto which information is getting stored and read by a magnetic head. The data is stored onto concentric circles – lanes, which are numbered individually for each plate, starting from the outermost one towards the innermost one. The best reading and writing speed is close to the periphery of the discs, and reduces for recordings closer to the axis.

In addition to the low performance, HDD’s work is noisy and vibrational. They are very vulnerable to shifts and shocks during operation, and also lethal to them are the low temperatures. The spindle’s axis must always be horizontal or vertical, so that no forces can arise that could damage the bearings on the shaft itself.

HDDs in recent years have a very low reliability, especially those built into the notebooks, which are extremely slow.

The market now offers choice-oriented notebooks at the same price, e.g. 1TB HDD or 128GB SSD. Often, the large amount of information that can be stored on those devices is what attracts the user. Modern "thin" hard drives offer very unsatisfactory features, apart from the large capacity. Loading an operating system, for example, from such a disk is very slow.

Fragmentation. Because of rotating recorded surfaces, hard drives work best with large files that are located in adjacent (neighboring) blocks. This way, the disk head can begin and end its reading in a continuous motion. When the disc begins to fill up with information, large files can scatter across the disk - that's so-called fragmentation. While the read/write algorithms improve and the effect is reduced, HDDs can still be fragmented.

3. SOLID-STATE DRIVE

Several years ago, a new technology emerged that offered not just an increase but a dramatic leap forward in the performance of computers. It is called Solid-state drive (SSD).

SSDs are better in terms of speed, wear-resistance, shape, noise and fragmentation – namely the most important factors. They do not fragment the files because they lack read heads, which means that the information can be stored anywhere. This way, SSDs are much faster.

Speed. This is where the SSD really "shines". A PC with an SSD will boot up in less than a minute, often in seconds. The hard drive takes time to accelerate to its full potential, and will be slower than a normal SSD in normal operations.

Serious concern for users selecting SSDs for their machines is the feature of the number of possible records on that medium. The life of an SSD is measured in numbers of records done on the drive. Fortunately, this disadvantage is minimized thanks to Wear leveling technology. This technology, by controlling the controller, takes care of the even distribution of the records in the memory cells so that none is overloaded or left unused. The most advanced controllers also have built-in compression mechanisms before recording to less memory. For example, an SSD has been studied, and after 675 days of constant operation, and 6.21 TB of stored information, it remains 88% of life (Fig. 1).

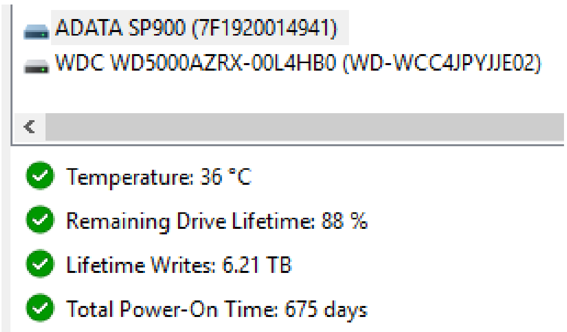

Fig. 1 Remaining drive lifetime

Due to the lack of moving and rotating parts, the SSDs are silent, but unfortunately we cannot enjoy the first step towards transitioning to SSDs because we expect the HDD to be included. The good news here is that if we do not constantly use an SSD, its put "asleep" by the operating system, that's important because we're actually progressing from HDD to SSD.

4. RAID ARRAY

For high-end PCs and server machines, it is highly recommended to use a group of storage devices logically related to each other. This array is called the Redundant Array of Independent Disks (RAID), a data virtualization technology that makes disc storage and increases productivity. When building a computer configuration, we need to know what we're looking for - just storage, just speed, or both together, and selecting the RAID level in Table 1.

TABLE 1. RAID level comparison.

Features	RAID 0	RAID 1	RAID 5	RAID 5EE	RAID 6	RAID 10
Minimum # Drives	2	2	3	4	4	4
Data Protection	No Protection	Single-drive failure	Single-drive failure	Single-drive failure	Two-drive failure	Up to one disk failure in each sub-array
Read Performance	High	High	High	High	High	High
Write Performance	High	Medium	Low	Low	Low	Medium

Capacity Utilization	100%	50%	67% - 94%	50% - 88%	50% - 88%	50%

For example, for our research, we've united six of the fastest HDDs in a RAID 0 array, as we are looking for maximum performance and we do not expect to be booked.

5. PURPOSE OF THE STUDY

The purpose of this study is to convince users of the benefits of SSD over HDD and to prevent the purchase of a new computer without such a fast data carrier. It is imperative to use disk arrays in more powerful machines. The market now offers choice-oriented notebooks at the same price, e.g. 1TB HDD or 128GB SSD. Often, the large amount of information that can be stored on those devices is what attracts the user. Modern "thin" hard drives offer very unsatisfactory features, apart from the large capacity. Loading an operating system, for example, from such a disk is very slow. Considering that a large volume SSD is too expensive, we suggest that the old HDD be retained as a second disk to store large volumes of information when a large PC upgrade, on average, it has a volume of 1 TB.

6. EXPERIMENTAL RESULTS

We match SSDs and HDDs running on one computer under the same conditions, and a computer running a HDD in a RAID 0 array.

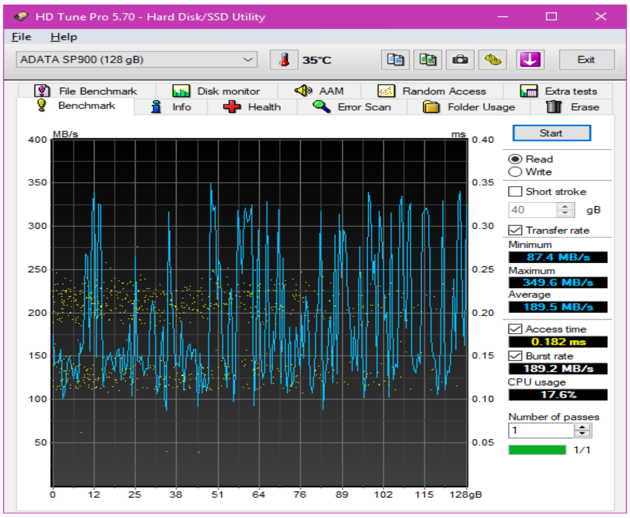

Fig. 2a Benchmark on SSD

For all experiments SATA3 controller has been used and the considered SSDs were Multi Level Cell (MLC) devices.

We start with Benchmark competition between SSD, HDD and RAID 0. Compare the characteristics on Fig. 2a, Fig. 2b and Fig. 2c.

The data transfer rate is measured across the entire disk surface or across the selected capacity. The X-axis shows the position in gigabytes (GB). The Y-axis shows the transfer speed in megabytes per second (MB/s). The best benchmark is achieved by RAID 0.

SSD has unmatched average access time, which is measured and displayed in milliseconds (ms). The measured access times are shown on the graph as the yellow dots.

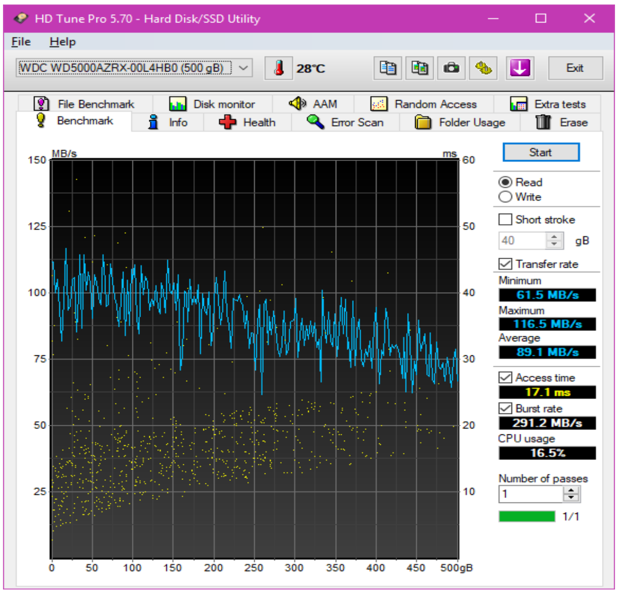

Fig. 2b Benchmark on HDD

In HDD and RAID 0 HDDs, the data density at the outer tracks of a hard drive is higher than at the inner tracks. Reading or writing at the outer tracks will be done at a higher speed because the rotation speed is constant. This can be seen in the transfer rate graph where the speed is the highest at the start of the test and decreases towards the end of the test. This does not apply to SSDs and other storage media.

Excellent Burst rate is in RAID 0. The burst rate is the highest speed (in megabytes per second) at which data can be transferred from the drive interface (IDE, SATA, SCSI, USB) to the operating system.

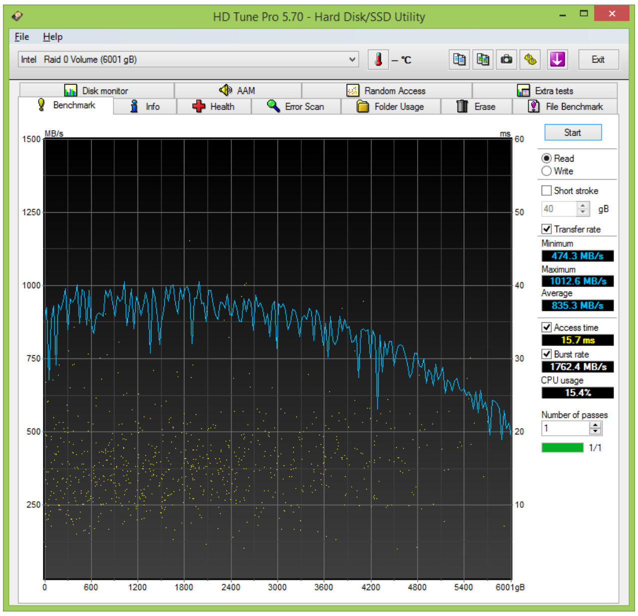

Fig. 2c Benchmark on RAID 0

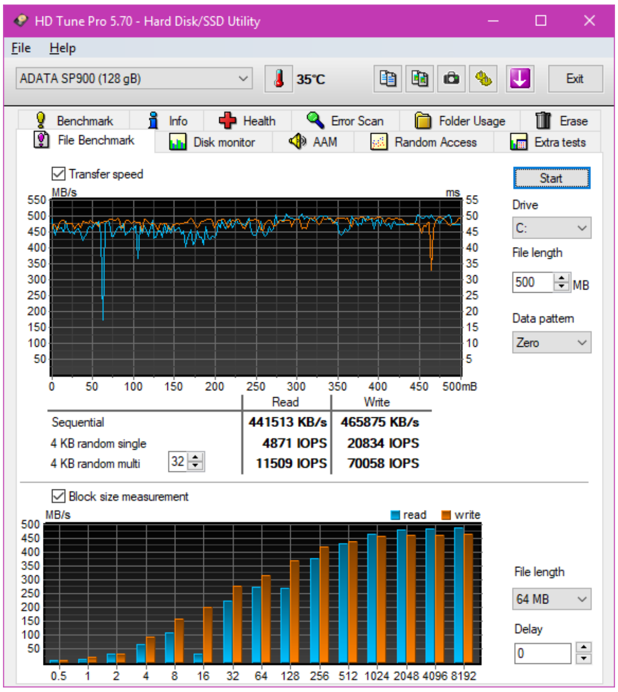

Fig. 3a File benchmark on SSD

The CPU usage parameter is roughly the same in all three cases and is therefore not subject to discussion on the purpose of the study. CPU usage shows how much CPU time (in %) the system needs to transfer data from the hard disk.

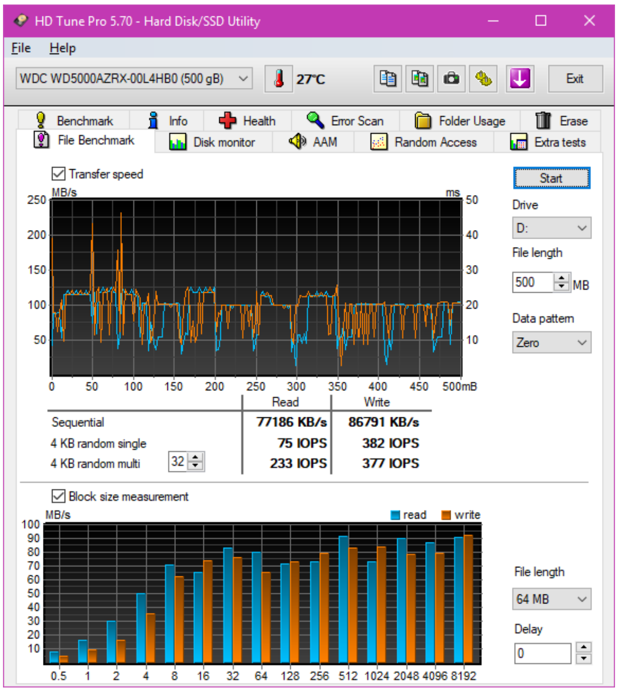

Fig. 3b File benchmark on HDD

We analyze the results of the File Benchmark Test, which consists of two parts: the transfer speed test and block size test (Fig. 3a, Fig. 3b and Fig. 3c).The transfer rate test measures three different parameters for both reading and writing:

- *Sequential:* the sequential speed is measured and shown on the graph. Ideally the transfer speed line should be straight and smooth. When the test is completed the average transfer speed is shown.
- *4 KB random single:* this test measures the performance of I/O operations of 4096 byte blocks. This is the most common I/O operation on a typical system. Especially the 4 KB write speed is an important indication of general system performance.
- *4 KB random multi:* this test is similar to the 4 KB random single test except that multiple requests are sent simultaneously to the device. The number of operations can be specified and can be a value between 2 and 64.

The transfer rate test is performed on a file which is created on the selected partition.

A larger test file size will give more accurate results.

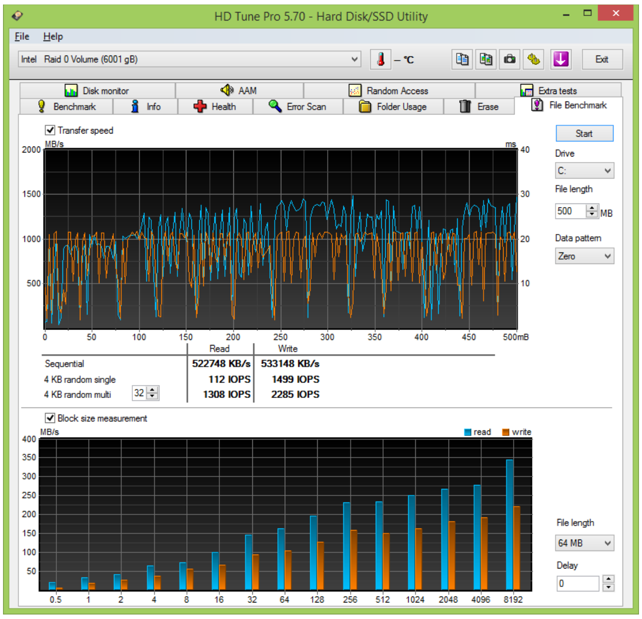

Fig. 3c File benchmark on RAID 0

The file benchmark measures the performance for reading and writing files to the selected hard disk partition with different block sizes ranging from 0.5 KB to 8192 KB (X-axis). The length of the test files can be set. For accurate results a large size is recommended. If the file length is too small the hard disk may be able to cache the entire file. In that case the cache speed will be measured instead of the hard disk throughput. The results for the single SSD were again not satisfactory.

CONCLUSIONS

From the comparisons made under the same conditions on both discs and RAID 0, we can get a solid reason to place SSDs for system drives on desktops and laptops. Naturally, high-end RAID 0 comprised of SSDs will have much better results.

Therefore, the goal of the study was achieved by demonstrating the outstanding advantages of SSD. We do not respond in any way if you come across an SSD that is worse and/or shorter. The discs mentioned are no longer in retail outlets, so branding and modeling should not be considered advertising.

REFERENCES

HD Tune Pro manual version 5.70, EFD Software, 2017.

URL: http://www.harddrivebenchmark.net/