HDD performance research

Sergey Nedev, Vladimir Kamenov
Technical University, Sofia, Bulgaria, e-mail: s_nedev@tu-sofia.bg, Technical University, Sofia, Bulgaria, e-mail: vladokamenov@tu-sofia.bg

Abstract: *Hard Disk Drive (HDD) is a non-volatile external memory for computers and other digital devices. The information is stored magnetically on specially coated discs made of aluminum alloys or glass ceramics. The purpose of the current paper is to determine the performance of several HDDs and compare the results obtained with the values given by the manufacturer for the respective devices. It is not the purpose of the paper to compare the devices against each other. The tests are made using two of the most popular software products developed for such tasks - HDTune Pro and Everest Disk Benchmark.*

Keywords: *HDD, HDD performance, transfer rate, testing.*

1. INTRODUCTION - HDD TECHNOLOGY

HDDs are a major component of any computer. They are non-volatile memory, with a large volume (up to about 10Tb), recording the information by magnetizing their work layer so that distinct areas with different direction of the magnetic moments are represented, representing 0 or 1 binary information. The information is recorded and read by a magnetic head. A typical hard drive consists of an axis (spindle) on which one or more flat discs, called plates forming the so-called disk package, are mounted.

The plates are made of non-magnetic material, usually aluminum alloys or glass ceramics, and are covered with a thin layer of magnetic material (10-20nm) and an outer layer of carbon to protect them. In modern disks, the magnetic layer is made up of cobalt-based alloys.

The data is recorded on concentric circles, which are called "tracks". The tracks are numbered for each plate individually, starting from zero (the outermost work track) to the last (the innermost one having the largest number). Normally there are several spare tracks after it. The tracks themselves are divided into smaller blocks of data called sectors. The sectors are numbered starting with 1, and are the smallest addressable blocks of data on disk drives.

The entire disk package rotates at a constant angular velocity (CAV) around its axis driven by an electric motor. In modern devices, the packet motor is most often miniature and flat, coupled directly to the spindle, and controlled by a dedicated controller that stabilizes its spin speed.

There is a separate head for each work surface of each plate. The block of magnetic heads is driven by an arm, performing the operation of positioning the heads by radial displacement. In most of the modern hard magnetic disc storage devices, the arm is rotated about an axis set out of the pack and parallel to its axis, whereby the tip of the arm and the heads attached there to perform circular arc motion oriented approximately on the radius of the disk package.

The recording is done by changing the orientation of the individual magnetic domains. By the end of the 20th century, the recording is done longitudinally - the orientation of the domains is along the paths, opposite or in the direction of rotation. The need to increase the recording density results in a transverse recording, with the orientation

of the domains left or right, across the track length, as well as perpendicular recording - perpendicular to the surface, in the depth of the magnetic layer, with the orientation of the domains up or down.

From the point of view of the optimization of the access to the data on the package in their physical organization, the term imaginary cylinder, which combines the tracks of the same diameter from all working surfaces, is introduced. The cylinders correspond to the number and numbering of the tracks on any surface.

2. HDD PERFORMANCE

HDD performance is determined by measuring the time for which a particular piece of data is found on the slates, and once found, how fast it can be read from the disk. The first parameter is called access time and the second is the transfer rate.

Access time is equal to the sum of average positioning time and latency. The average positioning time is the time required to move the magnetic head from the current cylinder to the other at an arbitrary distance from it. Measured in ms. This time is determined only by the characteristics of the magnetic head movement mechanism used in the particular HDD. Latency, in turn, is the average time it takes for a sector to be ready for access once the heads are positioned on the selected track. It depends on the speed of rotation and is equal to the time for which half a turn of the disk package is made.

The transfer rate may refer to raw or formatted information. The raw data transfer rate expresses the transfer rate of proprietary and user information to the buffer, and the formatted transfer rate of user information only. Typically, it is 2/3 of the raw speed. The formatted transfer rate is the one that is important to users. It depends on the recording density (number of track sectors) and the rotation speed. The higher the values of these two parameters, the higher the transfer rate. This is about transferring data from disk drives to the device buffer. This data is then transferred from the buffer to the motherboard. The rate of this transfer is determined solely by the speed of the interface used.

The transfer rate of modern HDDs is not a constant magnitude. This is due, on the one hand, to the fact that the plates are rotating with a constant angular velocity, and on the other hand, the number of sectors of the external tracks is greater than that of the inner ones due to their greater length.

3. RESEARCH OBJECTIVES AND METHODS

The objective of this research is to determine the transfer rate and access time of four specific HDDs, as well as compare the actual values obtained with the manufacturer's device specifications. The tests are made using two of the most popular software products in this field: HDTune Pro and Everest Disk Benchmark [1], [2], [3]. The HDDs are not compared to each other. The choice of the selected hard drives for research is influenced by their popularity in the computers used currently by the users in our country, which are predominantly secondhand high - business class laptops and desktops. The research is structured in the following way:

- A benchmark test with HDTune Pro using HDD data reading, which determines the minimum, average and maximum read transfer rate and processor load. The process is visualized graphically.
- Using HDTune Pro the average access time is calculated.
- Using the Everest Disk Benchmark, the transfer rate and access time are tested again in order to verify the accuracy of the data received.

The following four HDDs were tested:

- Hitachi HDP725025GLAT80
- Hitachi HDP725050GLA360
- Hitachi HTS545016B9A300
- WDC WD3200BEVT-22ZCT0

Their characteristics are given in Tables 1-4.

Tab. 1: Hitachi HDP725025GLAT80 [4]

Manufacturer	Hitachi	Physical dimensions	147 x 101.6 x 26.1 mm
Family	Deskstar P7K500	Maximum weight	550 g
Form factor	3.5"	Latency	4.17 ms
Formatted volume	250 GB	Speed of rotation	7200 RPM
Discs	1	Transfer rate (internal)	1138 Mb/s (142.25 MB/s)
Heads	2	Access time	12 ms
Recorded surfaces	2	Interface	Ultra-ATA/133
Volume of Buffer	8 MB	Transfer rate (external)	133 MB/s

Tab. 2: Hitachi HDP725050GLA360 [5]

Manufacturer	Hitachi	Physical dimensions	147 x 101.6 x 26.1 mm
Family	Deskstar P7K500	Maximum weight	550 g
Form factor	3.5"	Latency	4.17 ms
Formatted volume	500 GB	Speed of rotation	7200 RPM
Discs	2	Transfer rate (internal)	1138 Mb/s (142.25 MB/s)
Heads	4	Access time	12 ms
Recorded surfaces	4	Interface	SATA-II
Volume of Buffer	16 MB	Transfer rate (external)	300 MB/s

Tab. 3: Hitachi HTS545016B9A300 [6]

Manufacturer	Hitachi	Physical dimensions	100 x 70 x 9.5 mm
Family	Travelstar 5K500.B	Maximum weight	95 g
Form factor	2.5"	Latency	5.5 ms
Formatted volume	160 GB	Speed of rotation	5400 RPM
Discs	1	Transfer rate (internal)	875 Mb/s (109.375 MB/s)
Heads	2	Access time	12 ms
Recorded surfaces	2	Interface	SATA-II
Volume of Buffer	8 MB	Transfer rate (external)	300 MB/s

Tab. 4: WDC WD3200BEVT-22ZCT0 [7]

Manufacturer	Western Digital	Physical dimensions	100 x 70 x 9.5 mm
Family	WD Scorpio Blue	Maximum weight	117 g
Form factor	2.5"	Latency	5.5 ms
Formatted volume	320 GB	Speed of rotation	5400 RPM
Discs	2	Transfer rate (internal)	875 Mb/s (109.375 MB/s)
Heads	4	Access time	12 ms
Recorded surfaces	4	Interface	SATA-II
Volume of Buffer	8 MB	Transfer rate (external)	300 MB/s

4. TEST RESULTS

The data obtained are shown in Figures 1-8:

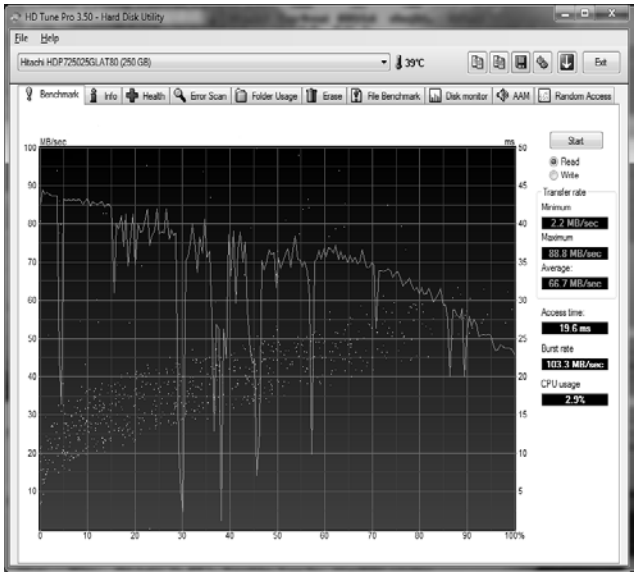

Fig. 1: Hitachi HDP725025GLAT80

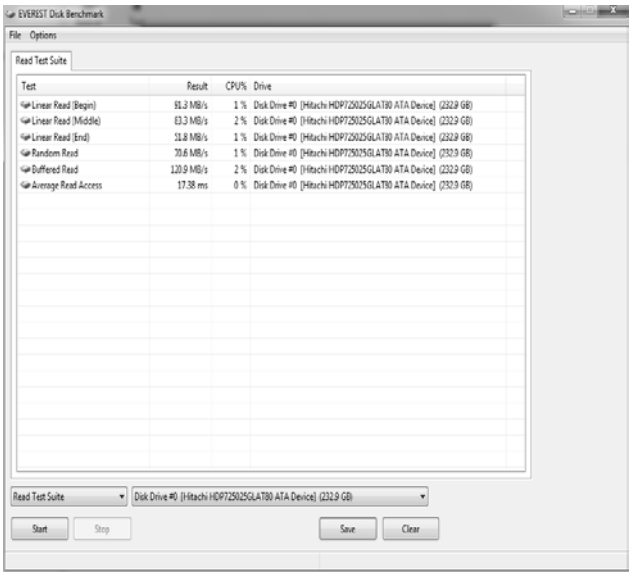

Fig. 2: Hitachi HDP725025GLAT80

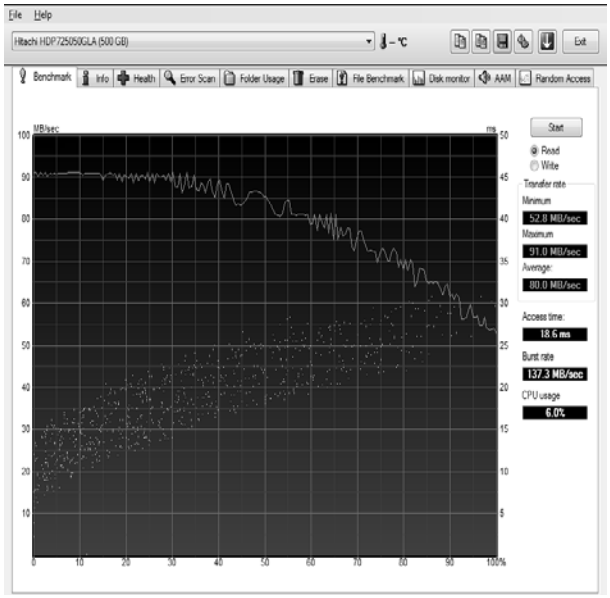

Fig. 3: Hitachi HDP725050GLA360

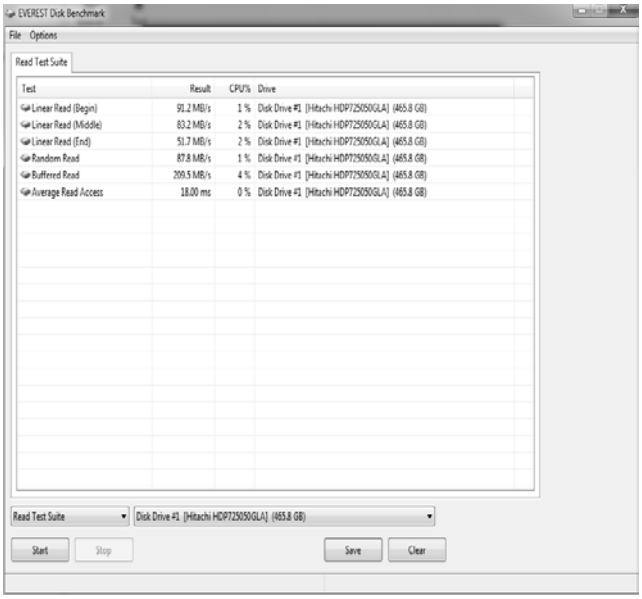

Fig. 4: Hitachi HDP725050GLA360

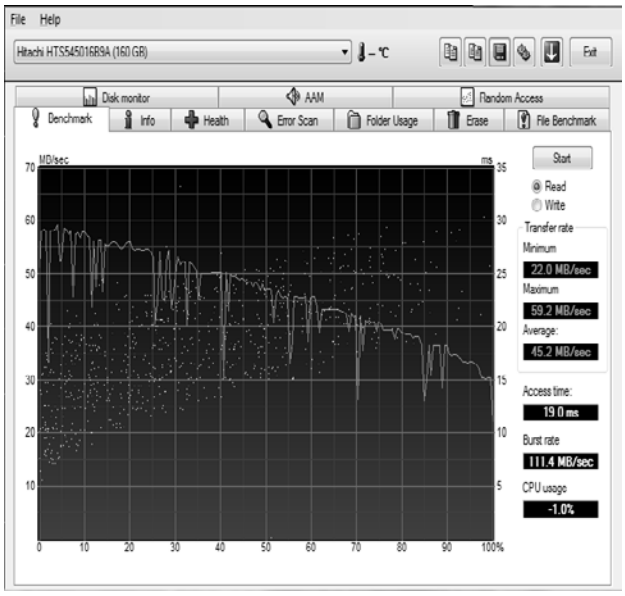

Fig. 5: Hitachi HTS545016B9A300

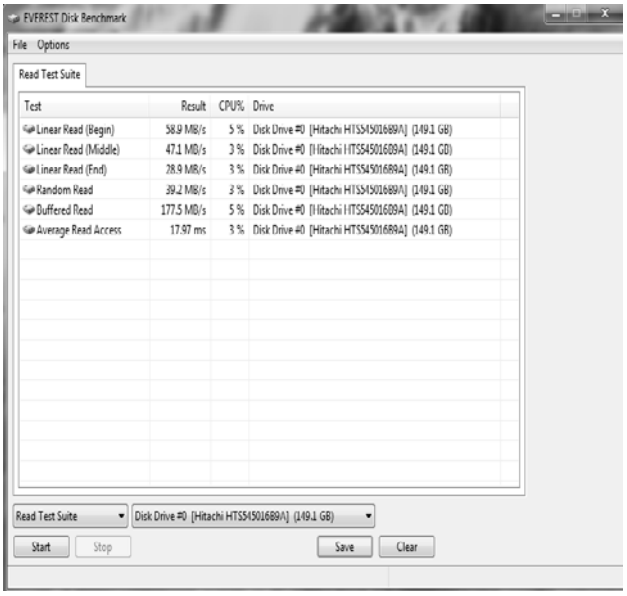

Fig. 6: Hitachi HTS545016B9A300

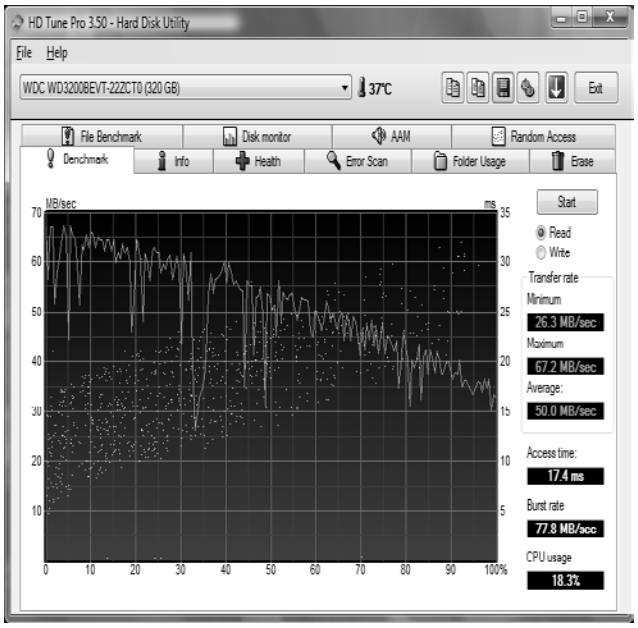

Fig. 7: WDC WD3200BEVT-22ZCT0

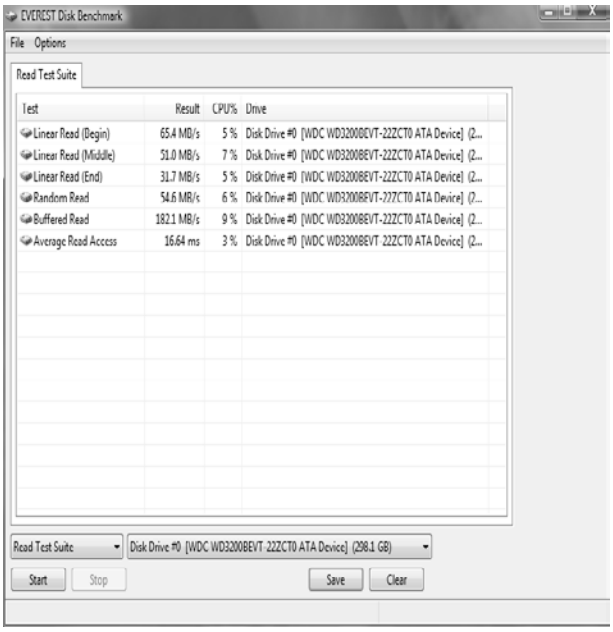

Fig. 8: WDC WD3200BEVT-22ZCT0

- The data obtained from the two test programs are relatively commensurate, which implies their reliability. Big differences are only reported at the external transfer rate, but they are not essential because they are far from the capabilities of the interface.
- The significant reduction of the transfer speed of the HDD when reading from the internal tracks of the devices is clearly visible from figures 1 - 8. The rate is reduced approximately twice.
- The real-time access time is about 50% higher than the one set by the manufacturers.
- The speed of the interface used in no way limits the transfer rate of the devices tested.

The summarized results are shown in Table 5:

Tab. 5: Summarized results

HDD	**Official Internal Speed** MB/s	**Official External Speed** MB/s	**Average Internal Speed** MB/s		**Average External Speed** MB/s		**Official Access Time** ms	**Average Access Time** ms	
			HD Tune	**Ever-est**	**HD Tune**	**Ever-est**		**HD Tune**	**Ever-est**
Hitachi 250	142.25	133	66.7	83.3	103.3	120.9	12	19.6	17.38
Hitachi 500	142.25	300	80.0	83.2	137.3	209.5	12	18.6	18.0
Hitachi 160	109.38	300	45.2	47.1	111.4	177.5	12	19.0	17.97
WDC 320	109.38	300	50.0	51.0	77.8	182.1	12	17.4	16.64

5. CONCLUSIONS

From the results obtained, the following conclusions can be drawn:

- For all tested devices, the actually measured transfer rate is significantly smaller than that given by manufacturers - by about 40-50%. Even the reported maximum transfer rates (Fig. 1-8) of the test software are far smaller than given by manufacturers. The reasons for this are disc wear, operating conditions, disposition of data on the disc, etc. Last but not least, it is also the desire of manufacturers to present their products in the best possible light. In fact, the speed given by the manufacturer is impossible not only to reach, but even to get closer.

6. REFERENCES

[1] http://www.hdtune.com – HD Tune Benchmark software.
[2] http://www.lavalys.com – Everest Benchmark software.
[3] http://www.wdc.com – Western Digital site
[4] https://www.cnet.com/products/hgst-deskstar-p7k500-hdp725025glat80-hard-drive-250-gb-ata-133-series/specs/
[5] https://www.cnet.com/products/hgst-deskstar-p7k500-hdp725050gla360-hard-drive-500-gb-sata-300-series/specs/
[6] https://www.cnet.com/products/hgst-travelstar-5k500-b-hts545016b9a300-hard-drive-160-gb-sata-300-series/specs/
[7] https://www.cnet.com/products/wd-blue-wd3200bevt-hard-drive-320-gb-sata-300-series/specs/