The HyperDrive 4

The layout of the HyperDrive 4 is still a 5.25" unit that accepts up to eight DDR1 ECC DIMMs, and it still installs easily into any available drive bay. HyperOS added two 40 mm fans at the front of the drive, which are used to properly cool the device. We did not notice it getting really hot, but there is certainly nothing wrong with being careful. Unfortunately, the fans are more than noticeable, and will override your efforts to create a quiet system. While the HyperDrive 4 clearly targets the professional market and extreme enthusiasts, a solid state drive would obviously seem to be ideal for service in a no-noise environment. At least HyperOS mentions on the website that the next generation might be entirely quiet...

On the back side you will find a Molex connector, which the drive uses to get its power, and an UltraATA connector and a SATA port. Unlike the HyperDrive III, which was UltraATA/100, the fourth generation utilizes UltraATA/133. The SATA port is also limited to the theoretical maximum of 133 MB/s. It's a pity that it still doesn't support native SATA, but we understand that the step from UltraATA/100 to 133 was easier than and just as effective as going to SATA/150. A new HyperDrive with support for SATA/300 is in the works, and scheduled to launch in the first half of 2008.

It was very interesting to watch the SYSmark 2007 Preview results, because this application benchmark, which simulates popular applications, benefits considerably if the operating system and the benchmark are installed onto the HyperDrive 4. Clearly, the benchmark reflects that all the latencies we have to accept with conventional hard drives and even with Flash SSDs (write latency) are gone with the HyperDrive 4.

The only real drawback of the HyperDrive 4 seems to be its price: The bare product is currently priced at £1,195, which currently equals roughly $2,500 or €1,700. Typical users can almost buy a standard desktop PC *and* a notebook for that amount of money. If you want the version with up to 32 GB of memory, you'll have to fork out 50% more - and you still have to buy the memory! You can either buy DDR ECC memory at the retailer of your choice, or look at the HyperOS offerings: Eight 1 GB DIMMs cost £375 ($770 or €535), or you can go for eight 2 GB DIMMs for £995 ($2,040 or €1,420). The 32 GB memory package is a whopping five times more expensive! You might also want to add some money for the backup hard drive or Flash SDD, which is fairly cheap in contrast to the HyperDrive 4 and the memory.

HyperOS also offers a plethora of accessories, such as external eSATA models, drive cabinets and even bundles of multiple HyperDrives with memory and RAID controllers. The sky is the limit. We also want to make clear that HyperOS might not have much of an influence on memory cost. From this standpoint, we recommend switching to DDR2 memory, as this technology currently is cheaper than DDR1, even if ECC is required.

In the end, the HyperDrive 4 still left an excellent impression, as it works like any other hard drive and doesn't require drivers or any complicated installation, and its performance is stellar - both in terms of benchmark numbers and the subjective impression we got from using it.

There are two 40 mm fans in the front.

Inside The HyperDrive 4

The inside has changed a bit: the DIMM sockets have been moved to the sides, making room for an optional 2.5" UltraATA drive that is used as a permanent backup device in case of a power failure. The device automatically backs up the data onto an attached hard drive or Flash SSD, and it automatically starts restoring the data into the memory once power is restored. However, you should pay close attention to using a storage device that holds at least as much data as the memory, because the 16 GB Samsung Flash SSD we used had a net capacity of only 15.5 GB. Since our memory capacity was 16 GB, the total capacity was reduced to 15.5 GB.

We were able to mix memory modules of different capacities, but only as long as the same capacities were used within one bank. Each side inside the device represents a memory bank. We mixed four 512 MB DIMMs with four 1 GB DIMMs, which did not have an impact on performance, as there is no multi-channel operation. The good thing is that any ECC DDR1 memory can be used (DDR200, DDR333 or DDR400).

HyperOS states that the HyperDrive 4 requires 12 to 14 W, which is exactly what we measured (14.2 W max).

HyperDrive4 Performance Comparison

Process	Raptor	Raptor on Rocket RAID 2230	2 Raptors NVRAID0	2 Raptors on Rocket RAID 2230	4 Raptors NVRAID0	HD4
Boot XP from splash screen to Desktop (XP learns)	5-8s	11-13s	6s	11-13s	6s	3s
Make a Copy of a 1GB file on the Desktop	42s	29-32s	42s	29-32s	28s	17s
Rereference Windows Registry using Winmove	15s	14s	14s	14s	14s	7s
Sort a 12 million record file with Access	280s	246s	189s	200s	183s	140s
Search all the files in an XP Officesystem	4½s	4½s	4½s	4½s	4½s	1½- 2s
Resize an image to max resolution in Photoshop 7	280s	264s	195s	192s	137s	79s
Search through a large website in FrontPage	15s	15s	15s	15s	15s	15s
Compare two 2 million record files with Access	75s	75s	75s	75s	75s	75s
Open an image in Photoshop 7 (XP learns)	6-9s	6-8s	6-8s	6-8s	6-8s	3½s

Source: HyperOS.

Due to time constraints, we haven't verified all the statements that HyperOS makes in this table, and the results do vary between different systems, but we tried some of them during the testing. Please take the numbers as an indicator rather than given facts, as they're from the manufacturer. I decided to include this table simply because it provides a very good overview of what a RAM-based solid state hard drive can do outside of what we can explain by our standard benchmarks. Simply put, it cuts down latencies to a fraction of what we're used to; this is nothing that a Flash drive has been capable of.

Solid State Drive Comparison Table

Manufacturer	Hyperdrive 4	Samsung	SanDisk
Family	Hyperdrive 4	Solid State Flash Drive	Solid State Flash Drive
Model Number	Revision 3	-	SATA 5000
Capacity	16 GB	32 GB	32 GB
Rotational Speed (RPM)	RAM	Flash	Flash
Available Capacities	Depends on RAM	-	-
Geometry	8 x 2 GB ECC DDR1	16 x 32 Gbit	n/a
Interface	SATA/150 - PATA/133	UltraATA/66	SATA/150
Form Factor	5.25"	2.5"	2.5"
Cache (MB)	-	-	-
NV Cache Size	-	-	-
NCQ	-	-	-
Weight	900 g	46 g	94 g

Test Setup

... For Storage Benchmarks

System Hardware	
Processor(s)	2x Intel Xeon Processor (Nocona core) 3.6 GHz, FSB800, 1 MB L2 Cache
Platform	Asus NCL-DS (Socket 604) Intel E7520 Chipset, BIOS 1005
RAM	Corsair CM72DD512AR-400 (DDR2-400 ECC, reg.) 2 x 512 MB, CL3-3-3-10 Timings
System Hard Drive	Western Digital Caviar WD1200JB 120 GB, 7,200 RPM, 8 MB Cache, UltraATA/100
Mass Storage Controller(s)	Intel 82801EB UltraATA/100 Controller (ICH5) Promise SATA 300TX4 Areca ARC1280ML
Networking	Broadcom BCM5721 On-Board Gigabit Ethernet NIC
Graphics Subsystem	On-Board Graphics ATI RageXL, 8 MB

System Hardware	
Performance Measurement	c't h2benchw 3.6
PCMark05	V1.01
I/O-Performance	IOMeter 2003.05.10 Fileserver-Benchmark Webserver-Benchmark Database-Benchmark Workstation-Benchmark

System Software & Drivers	
OS	Microsoft Windows Server 2003 Enterprise Edition, Service Pack 1
Platform Driver	Intel Chipset Installation Utility 7.0.0.1025
Graphics Driver	Default Windows Graphics Driver

We used Areca's ARC1280ML controller for the storage benchmarks.

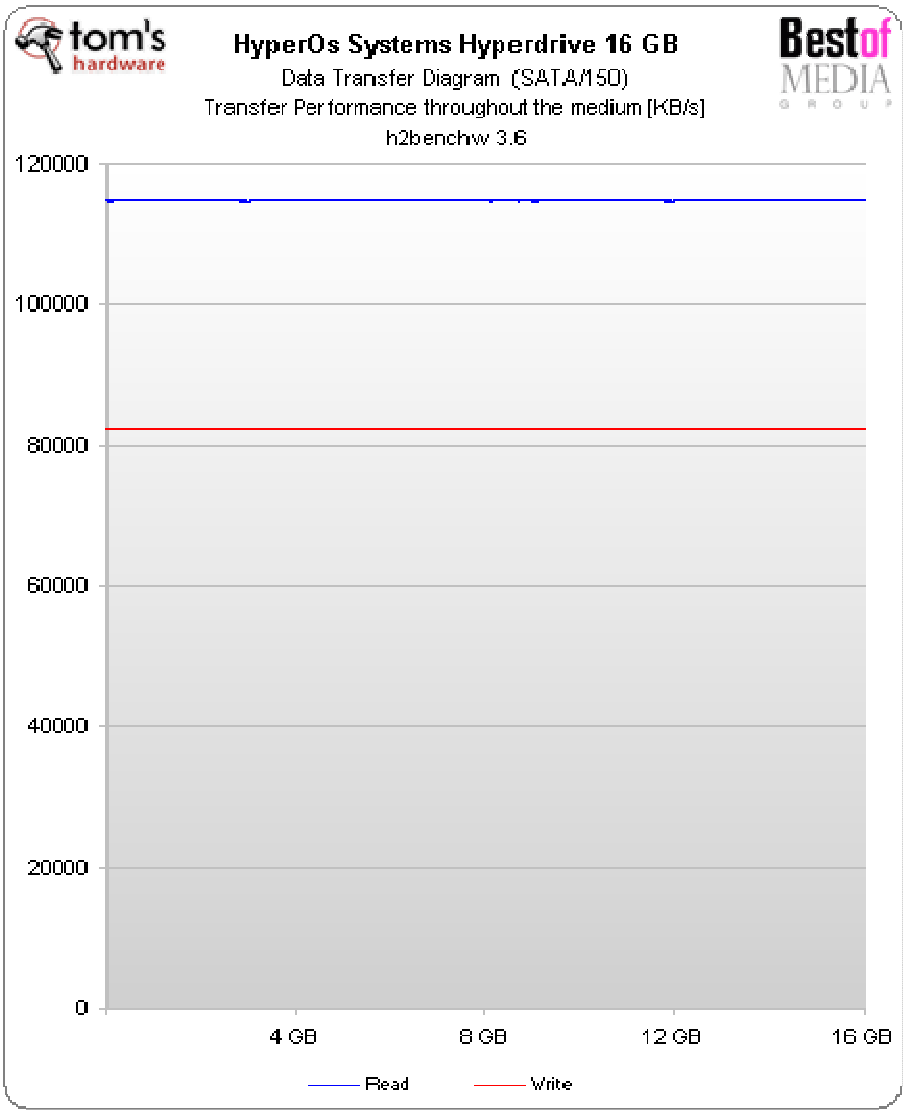
... For SYSmark 2007 Preview

Platform	
CPU III	Intel Core 2 Duo E6850 (65 nm; 3000 MHz, 4 MB L2 Cache)
Motherboard	ASUS Blitz Formula, Rev: 1.0 Chipset: Intel P35, BIOS 1101
RAM	Corsair CM2X1024-888C4D 2x 1024 MB DDR2-800 (CL 4-4-4-12 2T)
Hard Disk Drive I	Western Digital Raptor WD1500ADFD 150 GB, 10,000 RPM, 16 MB cache, SATA/150
Hard Disk Drive II	HyperOs Systems HyperDrive 4 16 GB, DDR333 ECC, SATA/150
Hard Disk Drive III	SanDisk SSD SATA 5000 32 GB, Flash, SATA/150
DVD-ROM	Samsung SH-S183
Graphics Card	Zotac Geforce 8800 GTS GPU: Geforce 8800 GTS (500 MHz) RAM: 320 MB GDDR3 (1600 MHz)
Sound Card	Integrated
Power Supply	Enermax EG565P-VE ATX 2.01, 510 Watt
System Software & Drivers	
OS	Windows XP Professional 5.10.2600, Service Pack 2
DirectX Version	9.0c (4.09.0000.0904)
Platform Drivers Intel	Version 8.3.1013
Graphics Drivers Nvidia	Forceware 162.18

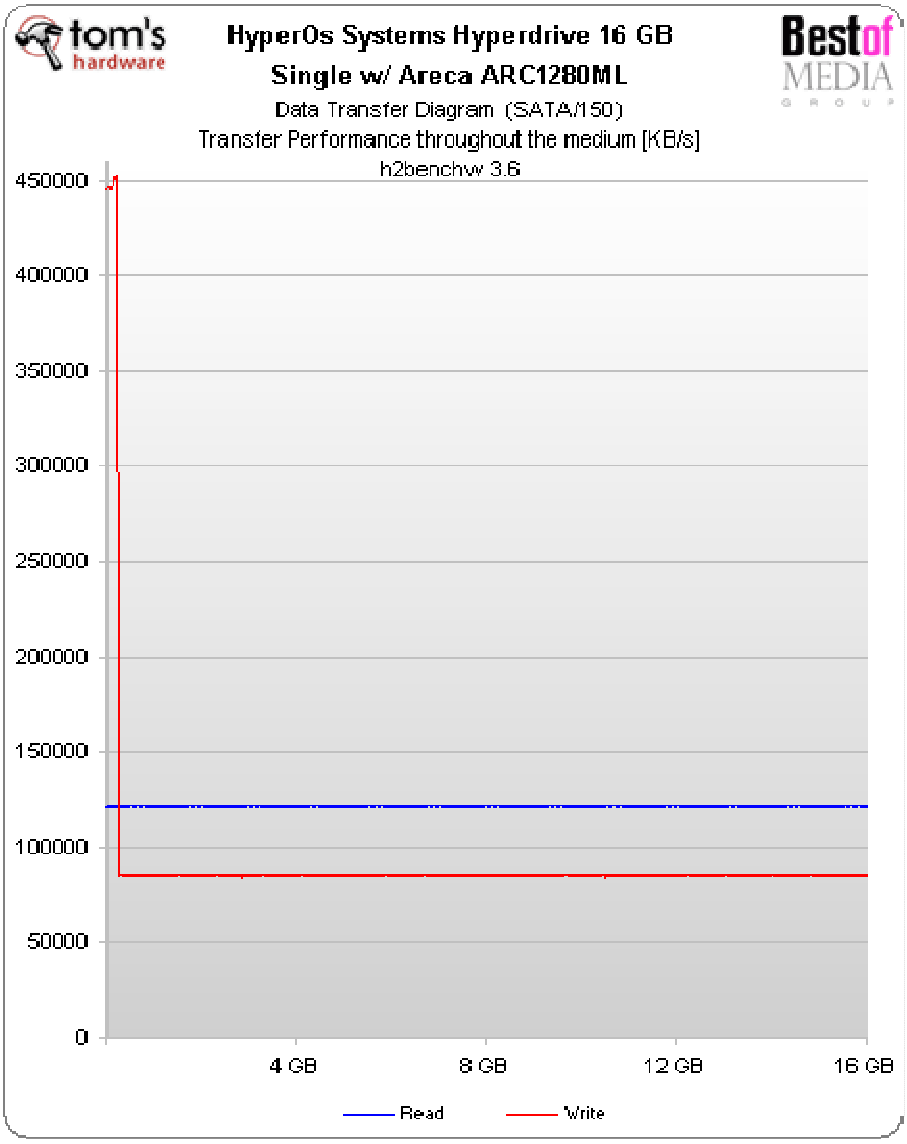
Storage Benchmark Results

We benchmarked the HyperDrive 4 as an individual hard drive using eight 2 GB DDR333 ECC DIMMs, and we also checked the performance on an Areca ARC1280ML RAID controller, both using only one HyperDrive 4, and using two of them in a RAID 0 array.

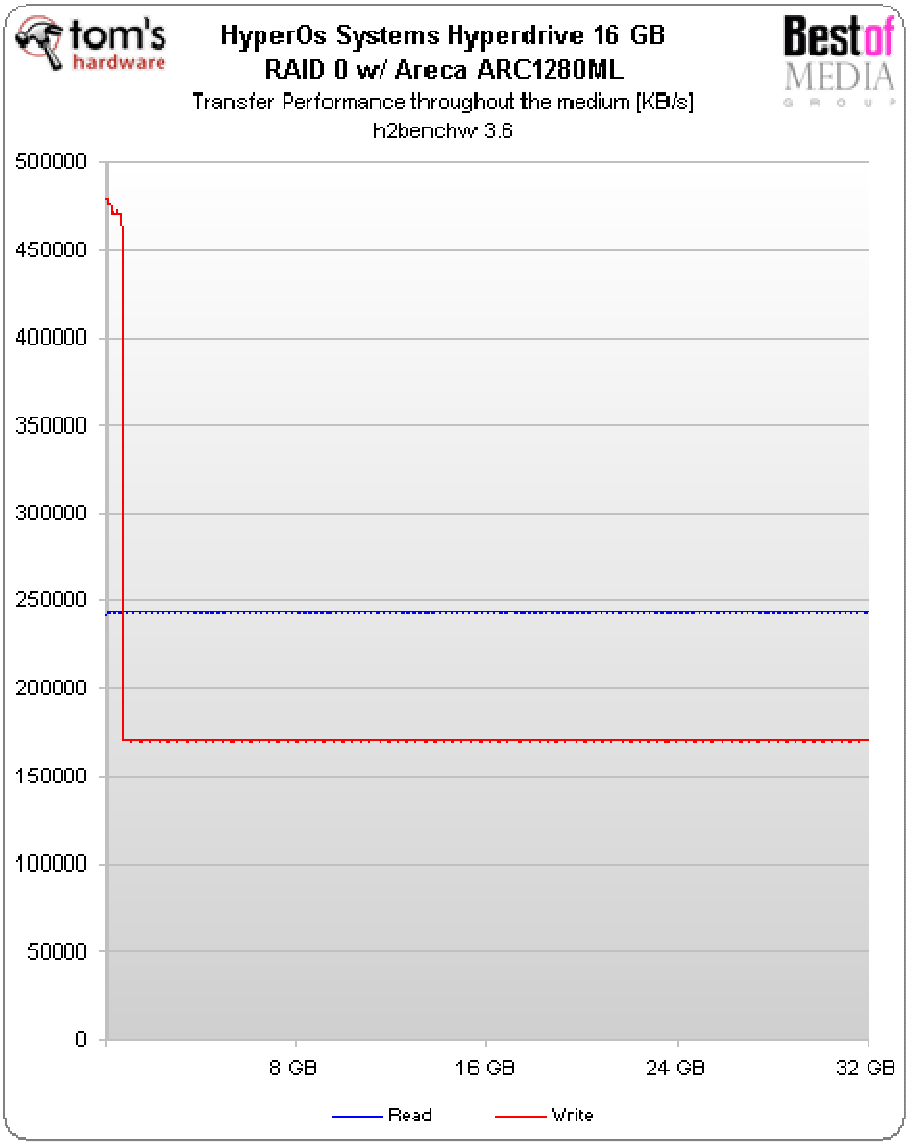
Data Transfer Diagrams



The HyperDrive 4 sustains a 114 MB/s read transfer rate and 82 MB/s write transfer rate across the entire 16 GB of storage. Both results are excellent; only the read results can be beaten, and only by the latest 15,000 RPM SAS drives.

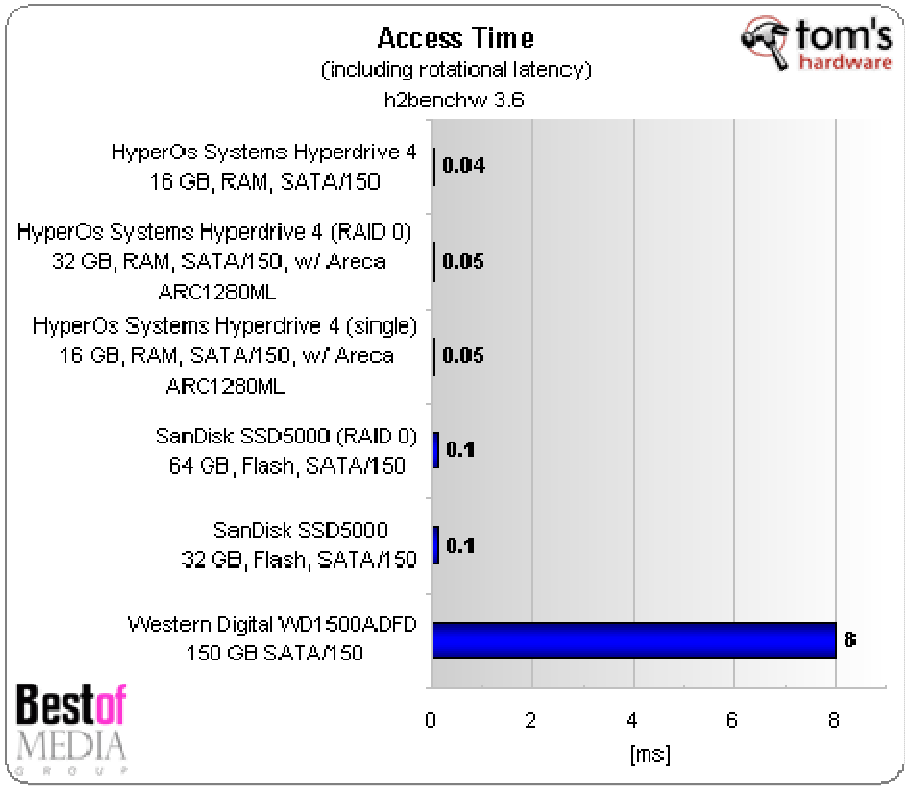


Running the HyperDrive 4 on the RAID controller with cache memory results in the same basic read and read throughput, but the controller's cache memory is extremely helpful for write operations: as you can see, the sequential throughput for writes skyrockets to 450 MB/s for the first 500 MB of data, because this is what the controller can store inside its DDR2 cache memory.



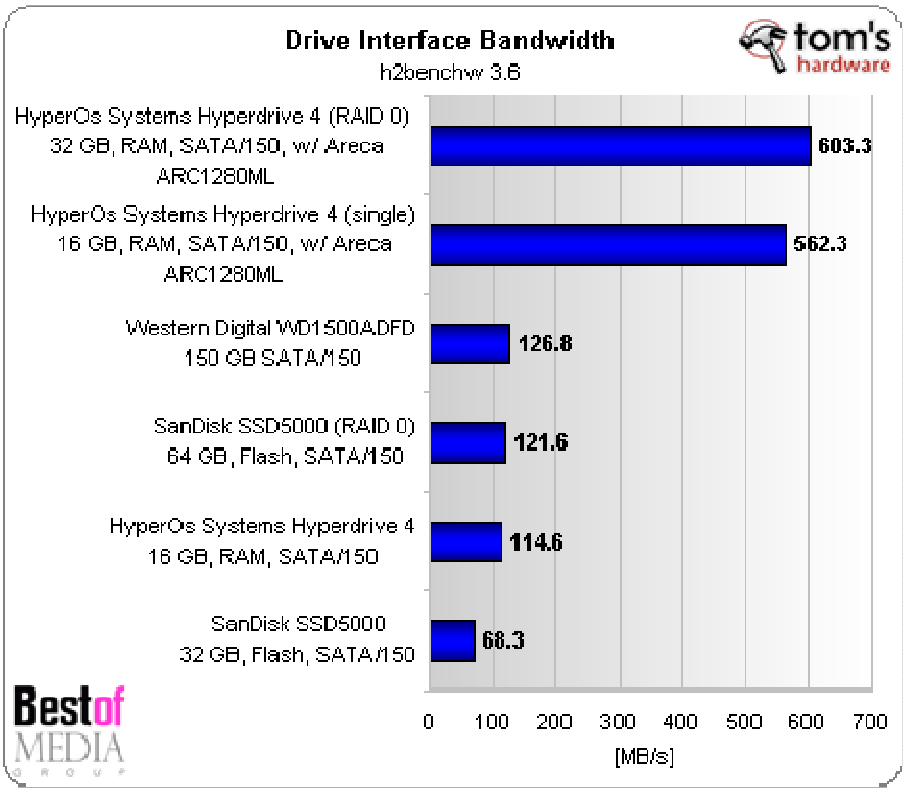
Running two HyperDrive 4s in RAID 0 results in almost twice the sequential throughput, for both reads and writes. The caching advantage of our Areca ARC1280ML RAID controller is also still there.

Access Time



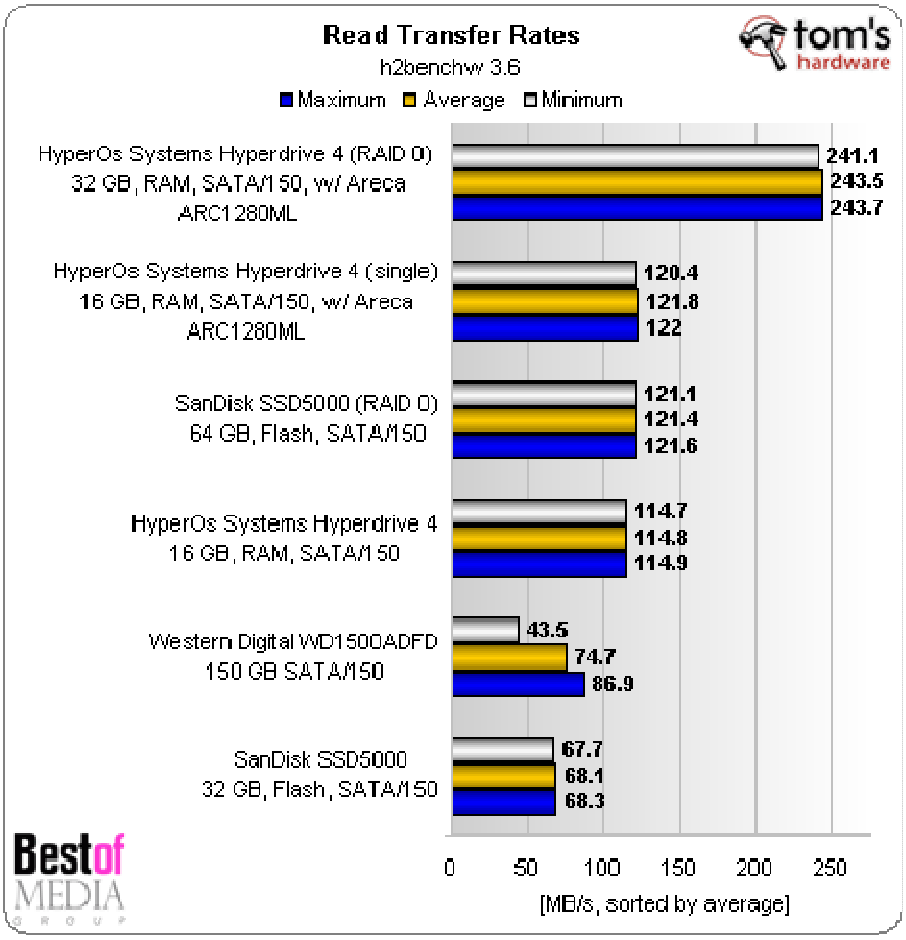
HyperOS claims an 1,100 ns read seek time and 250 nm write seek time. The total access time, measured by c't magazine's h2benchw benchmark, was 0.04 ms. In any case, access time can be considered effectively eliminated here. The SanDisk Flash SSD5000 takes roughly twice as long to access read data.

Interface Bandwidth



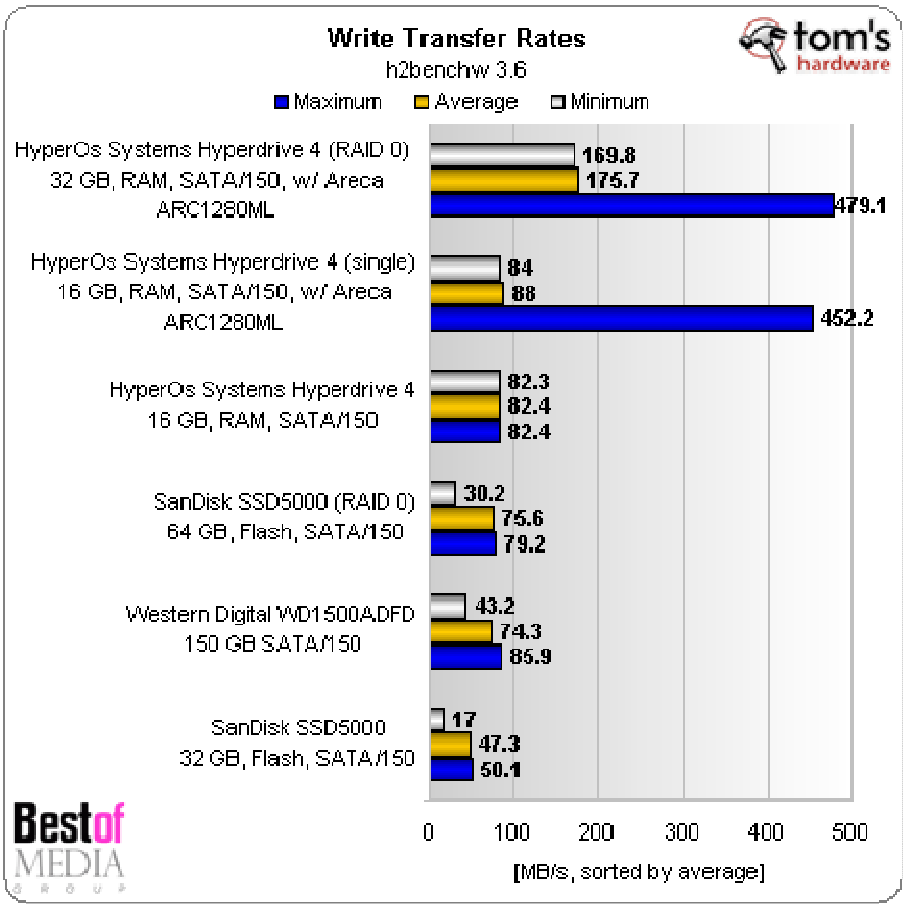
These results really are impressive: Using the Areca ARC1280ML controller with its cache memory, the total bandwidth is 562 MB/s for a single HyperDrive 4 and 603 MB/s for a RAID 0 that consists of two HyperDrive 4s. A WD Raptor WD1500 seems to outperform a single HyperDrive 4, but this is only because the interface bandwidth test reads directly out of the hard drive's cache memory, which of course saturates the SATA/150's bandwidth. The interface bandwidth of the HyperDrive 4 actually represents its sequential throughput.

Read Transfer Rates



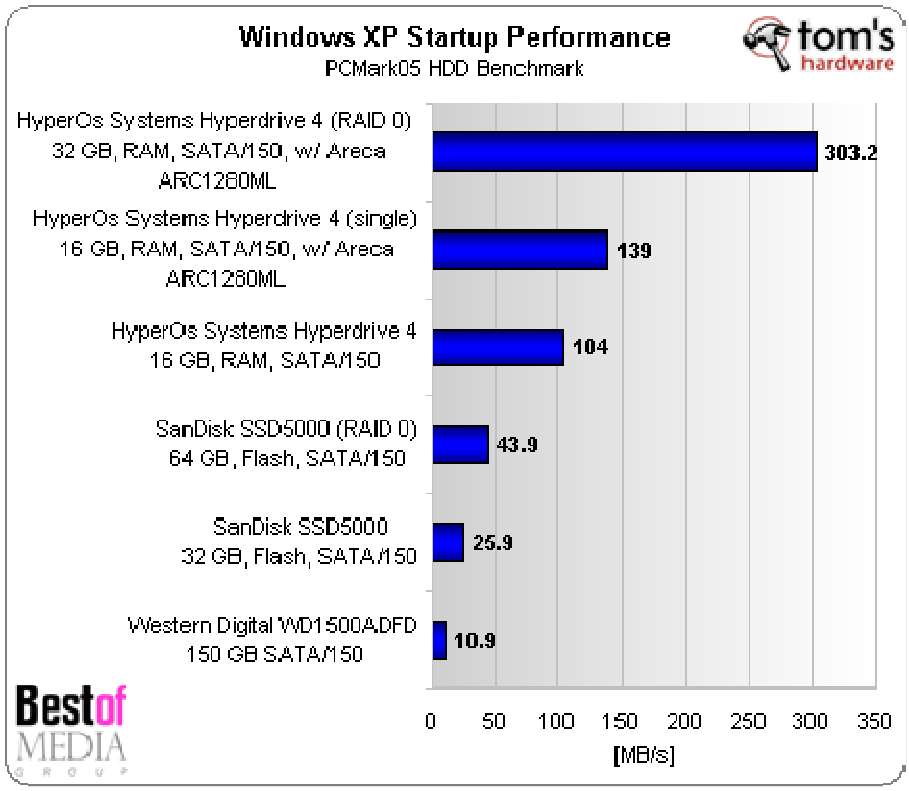
The results here couldn't be more obvious. A single HyperDrive 4 is as fast as two SanDisk SSD5000 Flash-based solid state drives in a RAID 0 configurations. Putting two HyperDrive 4 modules into a RAID 0 results in double the sequential read performance: 243 MB/s. And this result is sustained across the entire capacity of the HyperOS drive.

Write Transfer Rates



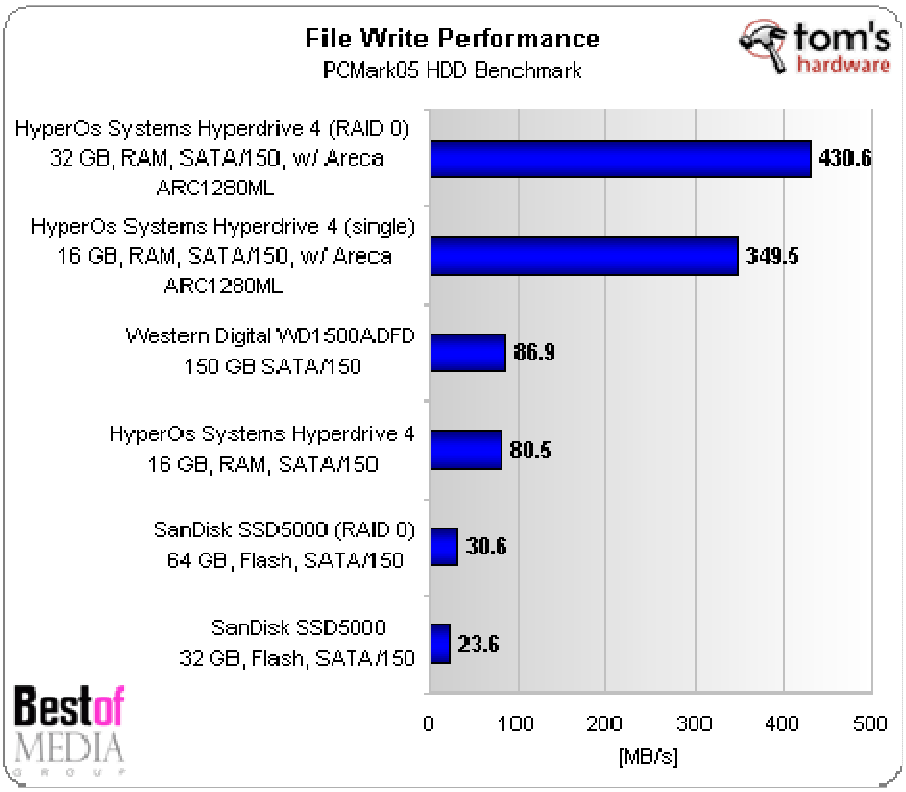
The write transfer performance looks similar, but none of the drives can sustain the excellent read results. You will notice the high maximum write throughput for the results we received with the Areca RAID controller: once again, this happened because the controller caches the writes, and thus provides a tremendous performance with initial writes. Look at the average and minimum performance to see how fast the HyperDrive 4 really is when writing directly into its DDR memory.

Windows XP Startup Performance (PCMark05)



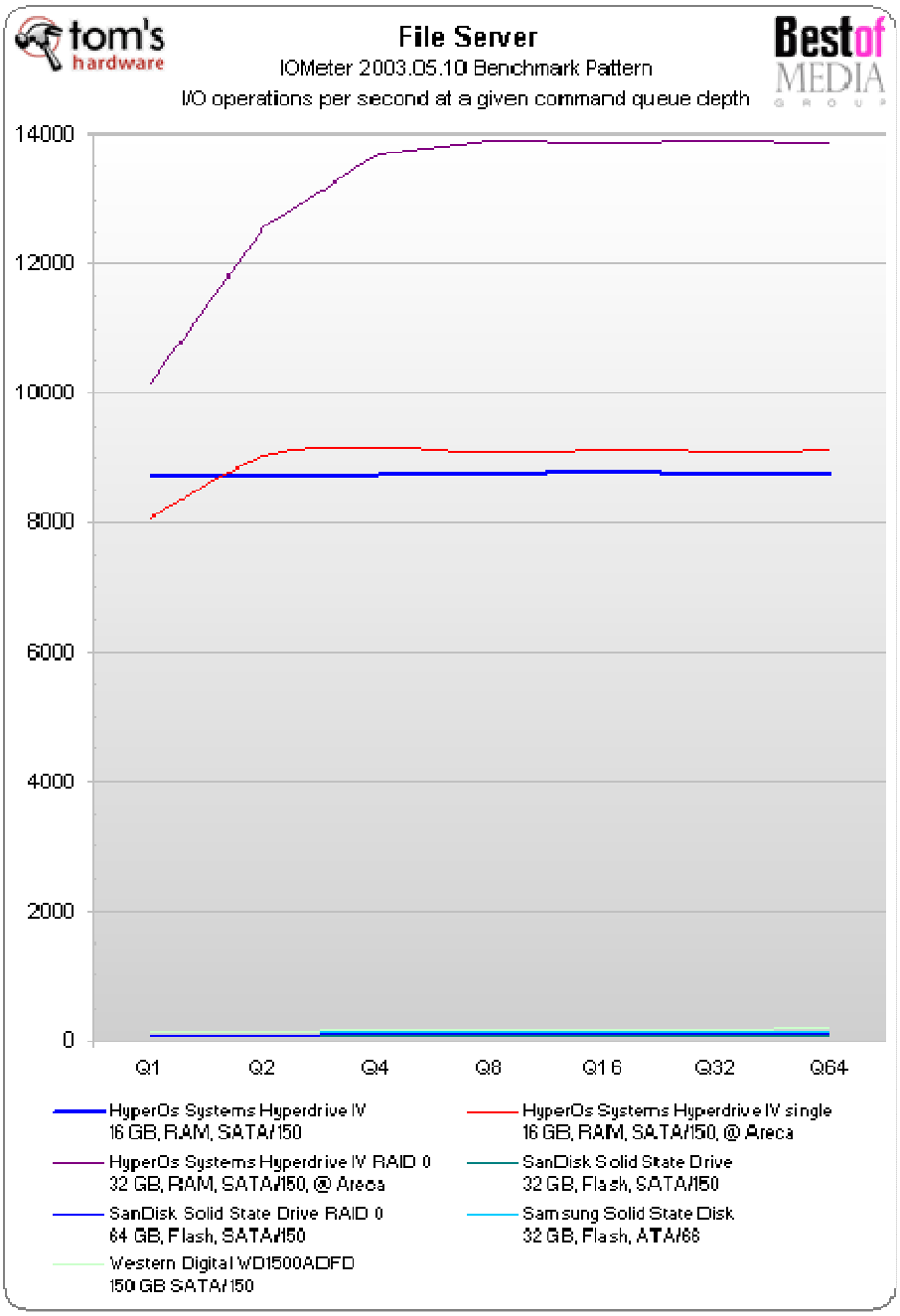
These results make clear why the HyperDrive 4 only takes a few seconds to boot Windows, while any other hard drive takes 10-20 seconds, depending on the system setup. The results of the PCMark05 Windows XP startup benchmark are displayed in megabytes per second.

File Write Performance (PCMark05)

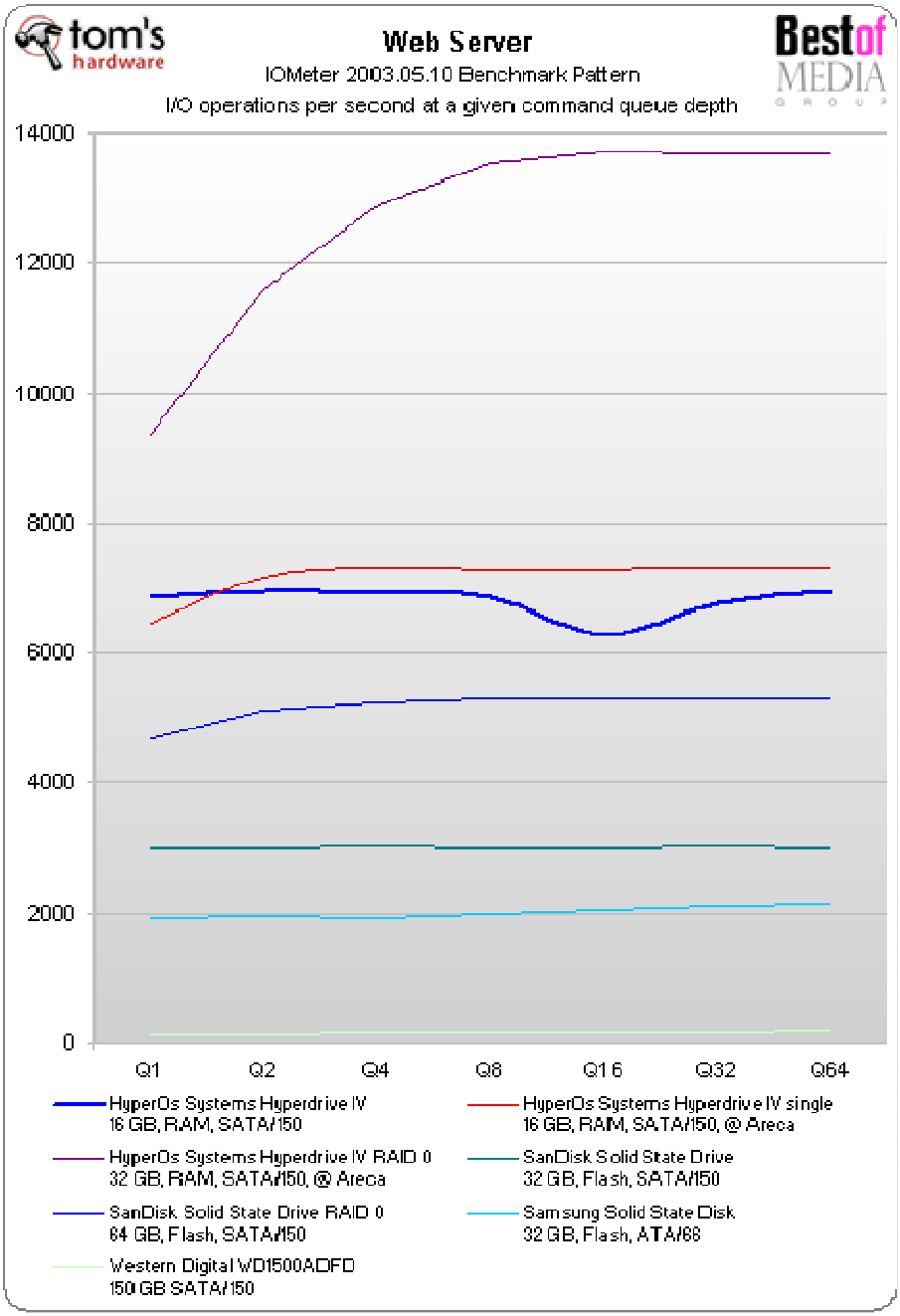


The write performance again benefits from the RAID controller's optional DDR2 cache memory. The 80.5 MB/s using the default SATA controller represents the net performance without any caches. Removing the cache memory from the Areca controller results in a maximum of 155 MB/s in RAID 0.

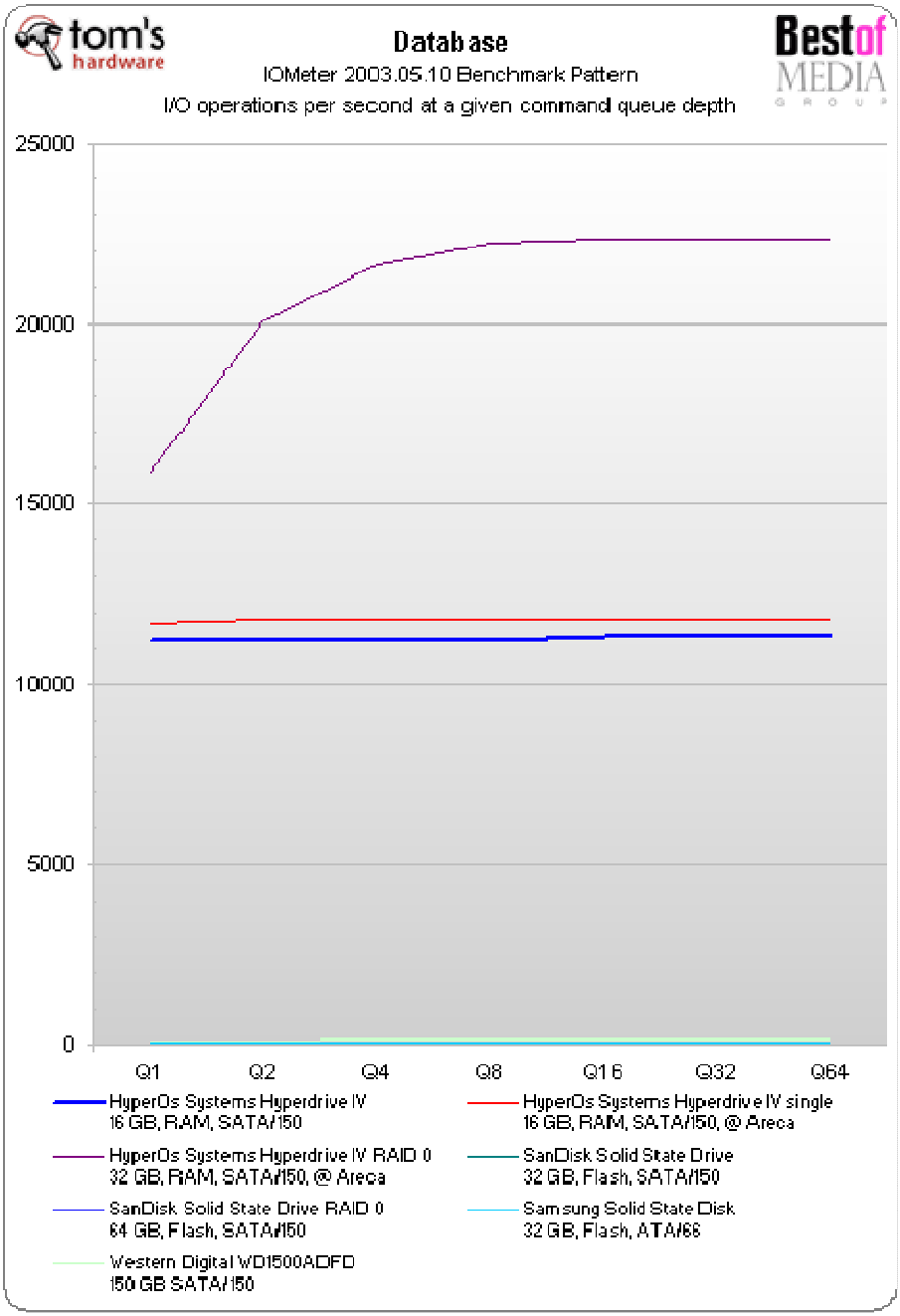
I/O Performance



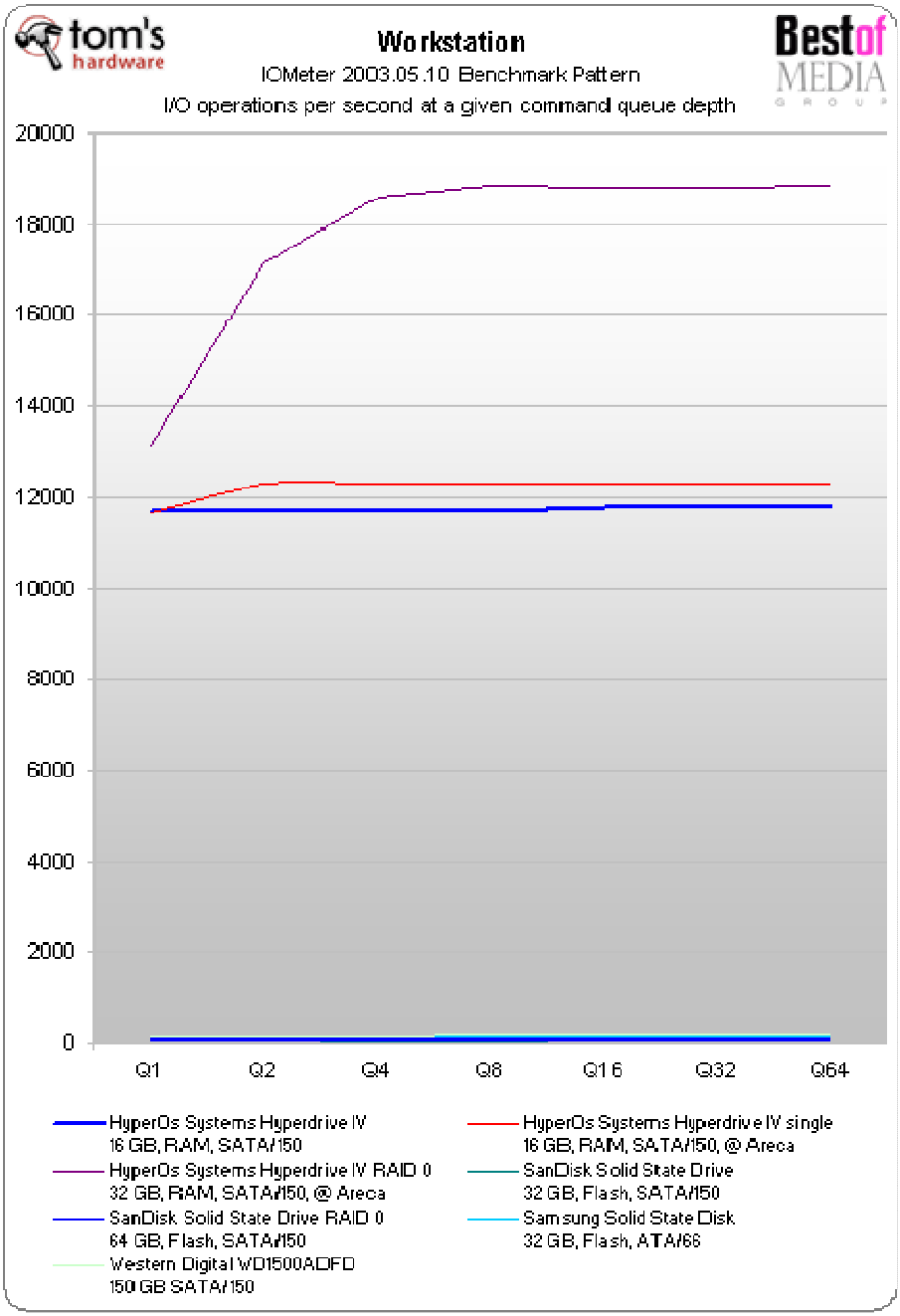
Here is proof for HyperOS's statements about several hundred or thousands of times better performance of the HyperDrive 4 versus conventional hard drives or RAID arrays. Even the single HyperDrive 4 provides almost 8,800 I/O operations per second using the fileserver benchmark pattern, and this goes up to as much as 13,800 I/Os per second in a RAID 0 with two HyperDrive 4 units. Even the fastest hard drives max out at approximately 200 I/O operations per second. The WD Raptor WD1500, which you can find on the very bottom of the diagram, is between 123 and 174 I/Os per second.



Web servers typically require few write operations, which is why the Flash-based hard drives from SanDisk make their comeback in this benchmark. Once again, the HyperDrive 4 delivers ~7,000 I/Os per second.



Database access involves lots of random access and usually only small blocks. Here the I/O performance of the RAM SSD is stellar again: roughly 12,000 I/O operations per second for the single HyperDrive 4 or up to 23,000 for a RAID 0 setup is nothing any RAID configuration of conventional hard drives could ever beat.

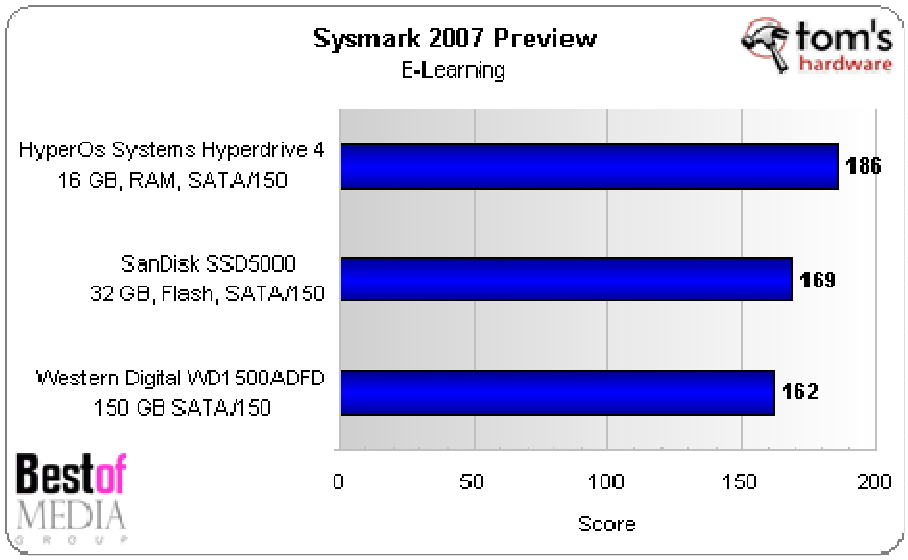


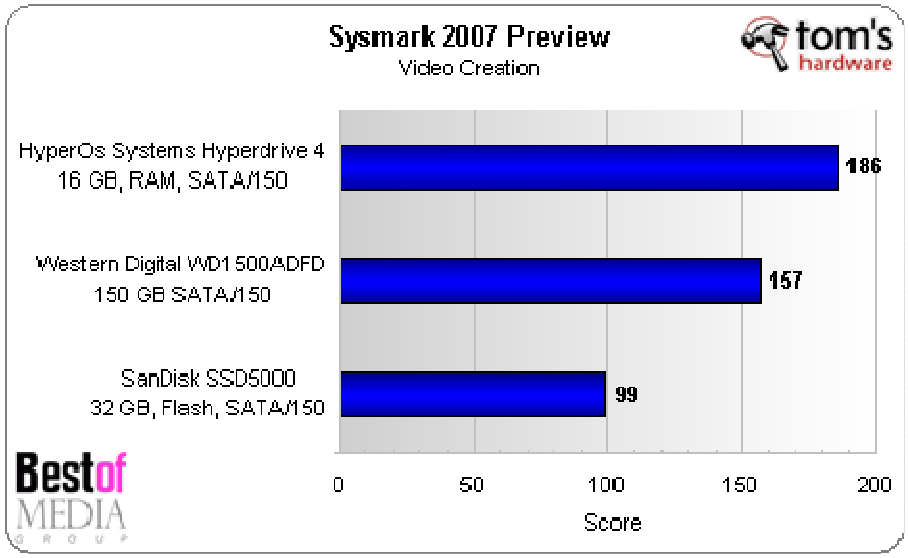
No changes also in the workstation benchmark. The HyperDrive 4 clearly dominates Flash hard drives and the WD Raptor WD1500.

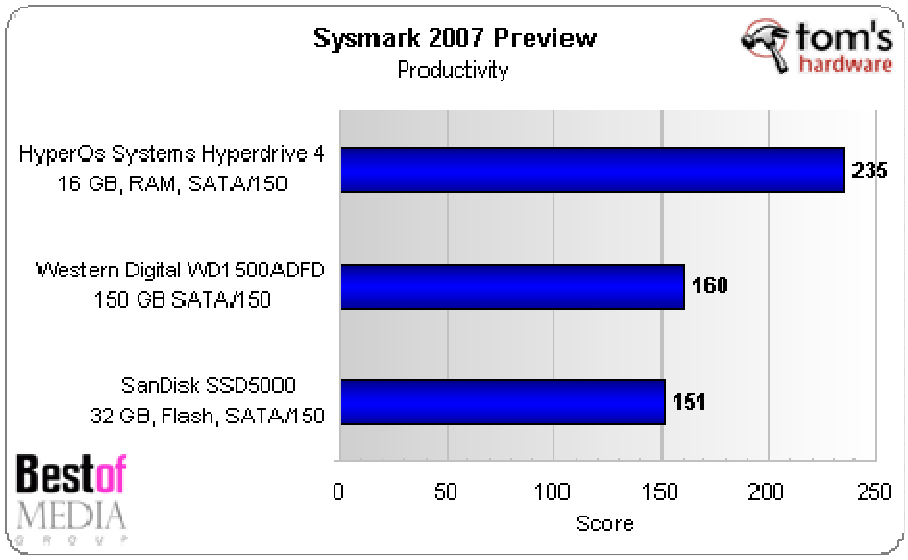
Application Benchmark Results

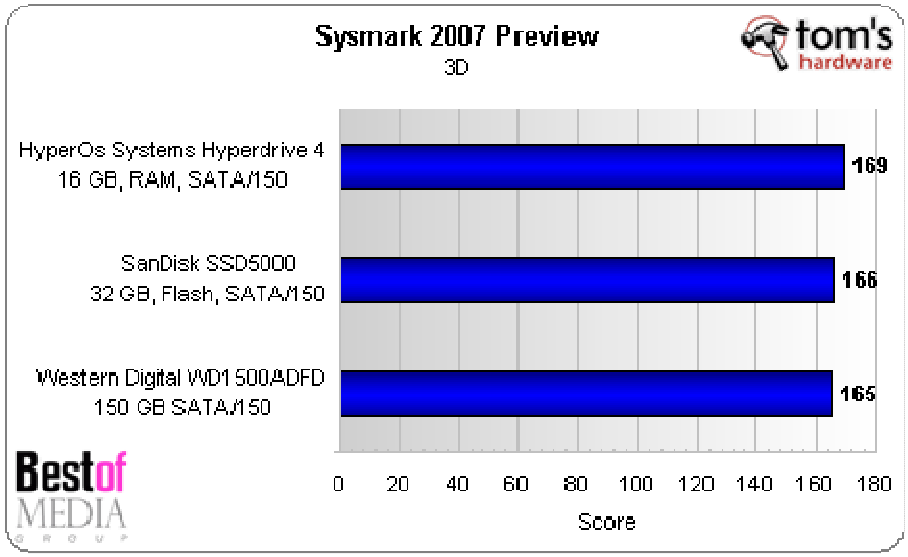
We used a Core 2 Duo E6850 on an Asus Blitz Formula motherboard for the application benchmark, since this is a more realistic environment for the application benchmark suite than our aged dual Xeon storage reference test system.

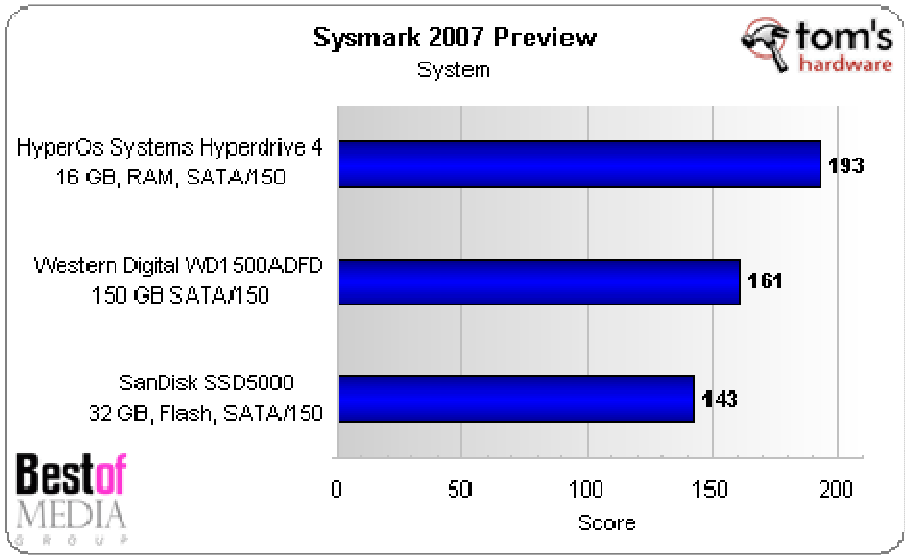
SYSmark 2007 Preview











The performance benefits of the HyperDrive 4 when compared to SanDisk's Flash SSD5000 or the WD Raptor WD1500 are tremendous, and we did not even dare running it in a RAID 0 setup using the Areca controller. These results were produced on a typical Core 2 Duo system on a P35 motherboard, rather than on our storage test system. The fascinating thing about the results is the performance boost, which is larger than any CPU or platform upgrade could ever hope to achieve.

Conclusion: HyperDrive 4 The Fastest Of Its Kind

The claim of the HyperDrive 4 being the "fastest hard disk in the world" sounds like just more marketing hyperbole, but it's indeed true. HyperDrive 4 provides excellent throughput of up to 114 MB/s and virtually nonexistent read and write access times, which results in amazing real world performance. And it doesn't matter whether you run it with 2 GB of memory or with 16 GB.

The benchmark results, which the latest product by HyperOS / Accelerated Logic dominates at will, reflect this. And there is a more impressive side of performance, which is not sufficiently illustrated by the benchmark results, but that you experience when using the HyperDrive 4. Simply put, system responsiveness increases more than with any other hardware upgrade, and the delays you're familiar with (such as when launching a mighty application such as Adobe Photoshop) are almost gone. Not even the step from single core to dual core, or similar technology advances, were capable of introducing performance gains of this magnitude.

I'd love to recommend a HyperDrive to any real enthusiast, but the pricing certainly is out of range for the vast majority of us. Despite the impressive performance and the noticeable performance gains, I would not spend $2,500 (or much more, depending on how much memory you want) on such a product. Professional users who can turn performance into value they use to make money, or folks like database administrators, should not hesitate, as this product is what you want. Compared to earlier RAM-based solid state drives, it even swaps data onto a physical hard drive to prevent any data loss.

Speaking for anyone else, though, I have to put the brakes on: there will be more and better Flash SSDs within the next few months, and there will be a SATA/300 version of the HyperDrive by next year. Even so, I love the idea of making SDRAM the main memory technology for the operating system to work from: it would be beneficial if memory prices finally decreased in the same way Flash prices have declined over time. If I think about how the idea of a RAM drive could be used best, I would like to run my operating system off a hybrid hard drive to boot up quickly, and offload the entire operating system data as well as application data to the main memory. If only it were possible to equip PCs with 16 GB or 32 GB of RAM. Someday, maybe