Memoright SSDs: The End of Hard Drives?

http://www.tomshardware.com/reviews/ssd-memoright,1926.html
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The HDD is Beaten

About six months ago, we reviewed Mtron's Flash SSDs (Solid State Drives), which were the fastest hard drives for desktop PCs until the launch of Western Digital's new VelociRaptor. Although the VelociRaptor is a conventional hard drive and therefore it cannot offer the extremely quick access times of transistor-based storage media, it is the best choice for most applications - and it offers almost 10 times the capacity at a fraction of the SSD drive's cost. However, we found an even better drive for the real enthusiast: the Memoright SSD MR25.2-032S, which leaves any other conventional hard drive in the dust as far as performance goes.

It has become difficult to keep track of the developments in the Flash SSD storage market. Flash SSDs look and behave like mechanical hard drives, except that flash memory devices store data in the same way that your motherboard's firmware device stores BIOS information. USB thumb drives use flash memory as well. Flash memory can offer good throughput and virtually zero access time, although write throughput and write access times can be clearly slower than the read values. While Flash memory doesn't generate as much heat as a hard drive spinning at high revolution speeds and it's also extremely robust, the media does not yet offer the capacities that PC hard drives are expected to have. A 2.5" notebook hard drive, for example, can store up to 500 GB and a 3.5" desktop drive's capacity can total up to 1000 GB.

However, flash-based drives can come in 3.5", 2.5", 1.8" or even smaller sizes. Remember that memory cards such as CompactFlash, SD or memory sticks are all based on flash memory. Flash memory typically requires much less power than a conventional hard drive does, and it withstands shocks, such as when a laptop is dropped, better than conventional drives. Flash SSD storage capacities have reached 128 GB, although only 32-GB flash SSDs have moved into a price range that can be considered affordable.

But why do we make such a big deal about SSDs in the first place? There are two simple reasons: performance and energy efficiency. While traditional hard drives do not directly accelerate processing performance for CPU-intensive tasks or graphics performance, they have a very noticeable impact whenever the operating system, applications or application data are launched or terminated. Once software can be executed or data can be accessed from within the system's main memory, the core components can show their potential. Until this is the case, data has to be loaded or stored from or to the hard drive, which is why we still have to wait seconds or even minutes for Windows or applications to start. Flash SSDs can significantly reduce user idle time by providing a good mix of quicker data access and good throughput. Lastly, flash memory devices can be more energy-efficient than conventional hard drives. However, an SSD's energy power consumption depends on the number of flash components the device has for its capacity. Flash memory's power consumption also can vary (MLC, SLC – see next page).

We already looked at various Flash SSD offerings from Samsung, Sandisk, Ridata and the Korean manufacturer Mtron, which has been offering the fastest flash SSD drives to date. Executives from SSD specialist DV Nation read our review of the Mtron drives and offered flash SSD from Memoright for our tests. A company representative said the devices would be an even better choice. He was right.

Flash SSD Tech Talk

There are two types of Flash memory: NOR and NAND. NOR provides an external address bus and can thus be directly addressed by storage controllers. Hence, it is possible to directly execute code from NOR flash memory, making it the proper choice for firmware applications. However, NOR also does not feature bad block management mechanisms. NAND flash can only be accessed in larger blocks, which are organized in so-called pages, in order to boost throughput. Thanks to this layout, the number of connections is smaller than with NOR. Also, NAND memory oftentimes comes with an integrated controller, which takes care of bad block management and wear leveling algorithms. This allows manufacturers to sell NAND Flash even if a few bad blocks are available. While this sounds like a disadvantage, it is actually an advantage for higher capacity storage, as it allows for production yields to be significantly increased and keeps flash memory prices low for current and upcoming memory densities.

But there is one more difference between flash memory devices, as flash cells can be designed to store either one or multiple bits. Single-level cell flash (SLC) stores a single voltage level, while multi-level cell flash (MLC) can store at least two bits. SLC chips hence are significantly faster and more energy efficient than their MLC brothers, and they typically sustain more write cycles than what MLC offers, although this should not be an issue for desktop users anymore.

Manufacturers typically don't break down the technical details about what kind of flash memory that they offer in their data sheets for flash SSDs, although we think it would be good to know these specifics for a particular product. At the same time we have to emphasize that it's impossible to assess or even estimate a flash SSD's performance by only looking at the technical specifications. While manufacturers should be straightforward with throughput numbers and these are mostly reliable, a 2.5" Flash SSD's throughput can vary between 25 MB/s and 115 MB/s (like Memoright's SSDs).

Most flash SSDs were designed for 2.5" or 1.8" form factors, as flash-based hard drive are mostly interesting for mobile use given their robustness and lower power consumption. Also, the lower capacities of 16-128 GB can be sufficient in laptops, but hardly for desktop PCs. Should you still want to use a 2.5" Flash SSD in a desktop environment, then it would be easy to purchase a frame to install the 2.5" drive into a 3.5" bay. Western Digital has also gone down this road with its latest enthusiast-class hard drive, the VelociRaptor, which is a 2.5" hard drive at 10,000 RPM that is shipped with a 3.5" frame to cool the drive and allow installation in conventional desktop environments.

Lastly, flash drives provide a larger temperature range and better robustness for industrial applications. While hard drives may be operated at 5-55°C with few exceptions, most flash drives sustain temperatures of 70°C and industrial-grade drives can handle temperature ranges of -40°C to 85°C, which will work for car infotainment solutions geared for polar or desert climate zones.

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Memoright SSD MR25.2-032S

The Memoright Flash SSD MR25.2-032S is available in several capacities of 8, 16, 32, 64 and 128 GB. We received four 32-GB drives, which allowed us to do RAID 0 benchmarks, so we could see the potential of flash SSD when set up in RAID arrays. All of these come with a five-year warranty, which is comparable to other enterprise hard drives on the market. The warranty is also a sign of faith in flash SSD's reliability.

We found that the performance of the Memoright 32-GB flash SSD is awesome. The 0.1 ms access time is similar to what other Flash SSDs deliver, but the 115 MB/s read transfer rate is a new record for Flash SSDs. The cool part is that write performance is almost as high. Mtron's 32-GB flash SSD reached 95 MB/s read performance on our storage test system, but it was limited to 75 MB/s write performance. With the exception of the Webserver benchmark, all other I/O performance results are dominated by Memoright: 700-4,300 I/O operations per second are significant, which is approximately between 4x and 20x faster than a Western Digital WD1500 Raptor.

Although we found that the sequential throughput does not reach the interface bandwidth, the next SSD generation will certainly have to use SATA/300 instead of SATA/150 to avoid the interface becoming a bottleneck. When we compared four Memoright 32-GB flash SSDs to four Seagate Savvio 10K.2 2.5" SAS drives and four 3.5" WD1500 Raptor drives, we found the conventional drives don't stand a chance against the four Memoright device. A 0.2-ms access time is amazing for a RAID 0 array (vs. 7.4 ms for the Seagate Savvio 10K.2 and 8.5 ms for WD's Raptors). The Memoright flash SSDs also sustain a minimum write transfer rate of 323 MB/s in RAID 0, while the Savvios drop to 199 MB/s and the Raptors go down to 177 MB/s. The read throughput of 450 MB/s for the Mtron quartet is equally impressive.

The 128-GB version is priced at $3,500, which is way too much for the vast majority of us. A 64-GB version still costs slightly more than $2,000, but the 32-GB device is priced at $1,049, which is not out of reach for power users and enthusiasts. Other 32-GB flash SSDs may be much cheaper (DV Nation offers the Mtron device for $699), but they also aren't as fast. If you are a true hardcore user with a flexible budget then you should not hesitate. For everyone else I can only repeat the recommendation I made half a year ago: Capacities, performance and price points will only drop considerably over time.

Test Controller: Adaptec RAID 5805

Although DV Nation asked us to test the Memoright drives with an Areca controller because of their excellent throughput, we used Adaptec's new 5805 Unified Serial RAID controller, as it turned out to be the better product at this point in time. While the management software is more advanced, we found this product to deliver both excellent throughput and I/O performance (which hasn't always been the case with Adaptec's devices in the past).

Adaptec's RAID 5805 is one of the fastest and most powerful Unified Serial RAID controllers (for SAS and SATA) available today.
Test HDDs: 2.5" Seagate Savvio 10K.2 and 3.5" WD Raptor WD1500

Seagate Savvio 10K.2: 10,000 RPM, 2.5" and a SAS interface. These are excellent server drives for high-density storage applications.
We decided to not only compare the Memoright flash SDD to the entire range of mechanical and flash-based competitors, but to also go one more step. We used four 2.5" Seagate Savvio 10K.2 enterprise SAS drives and four 3.5" Western Digital WD1500 Raptor drives, both of which can be considered as best in their class. The Raptor still is an excellent system drive for enthusiast systems (although its successor, the VelociRaptor, is considerably better) and Seagate's Savvio 10K.2 is a backbone for high-density storage servers. We compared four of each in a RAID 0 setup against four Memoright Flash SSDs in a RAID 0 setup to show the maximum performance potential.

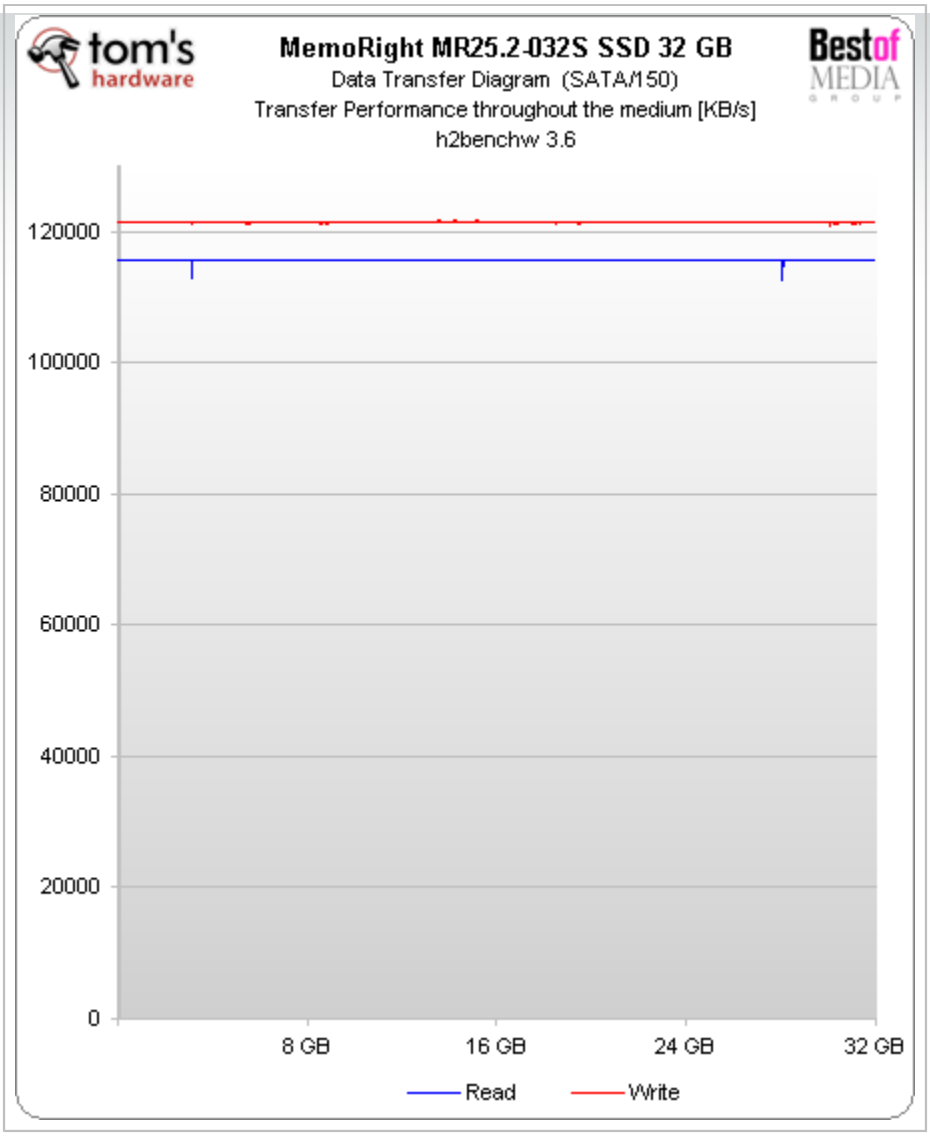
Although beaten by its predecessor, the good-old 3.5” Raptor by Western Digital still is a de-facto standard for enthusiasts and entry-level servers.

Test Setup

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.) 2x 512 MB, CL3-3-3-10 Timings
System Hard Drive	Western Digital Caviar WD1200JB 120 GB, 7,200 rpm, 8 MB Cache, UltraATA/100
Test Hard Drives (4x) I	MemoRight MR25.2-032S 32 GB, Flash SSD, SATA
Test Hard Drives (4x) II	Western Digital Raptor WD1500ADFD 150 GB, 10,000 RPM 16 MB Cache, SATA
Test Hard Drives (4x) III	Seagate Savvio 10K.2 73 GB, 10,000 RPM 16 MB Cache, SAS
Mass Storage Controller(s)	Intel 82801EB UltraATA/100 Controller (ICH5) Adaptec RAID 5805
Networking	Broadcom BCM5721 On-Board Gigabit Ethernet NIC
Graphics Card	On-Board Graphics ATI RageXL, 8 MB
System Hardware	
Performance Measurements	c't h2benchw 3.6 PCMark05 V1.01
I/O Performance	IOMeter 2003.05.10 Fileserver-Benchmark Webserver-Benchmark Database-Benchmark Workstation-Benchmark Streaming Read and Write Benchmarks
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

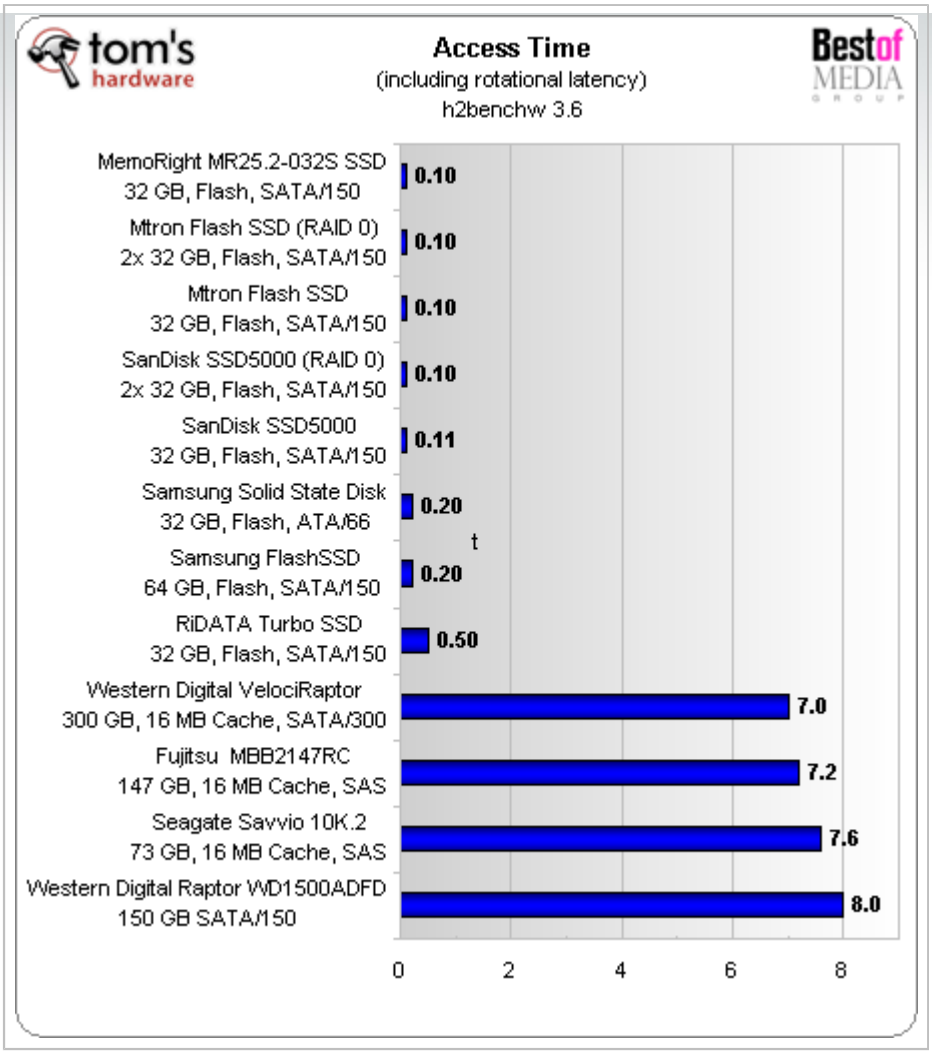
Memoright SDD Benchmark Results

Data Transfer Diagram



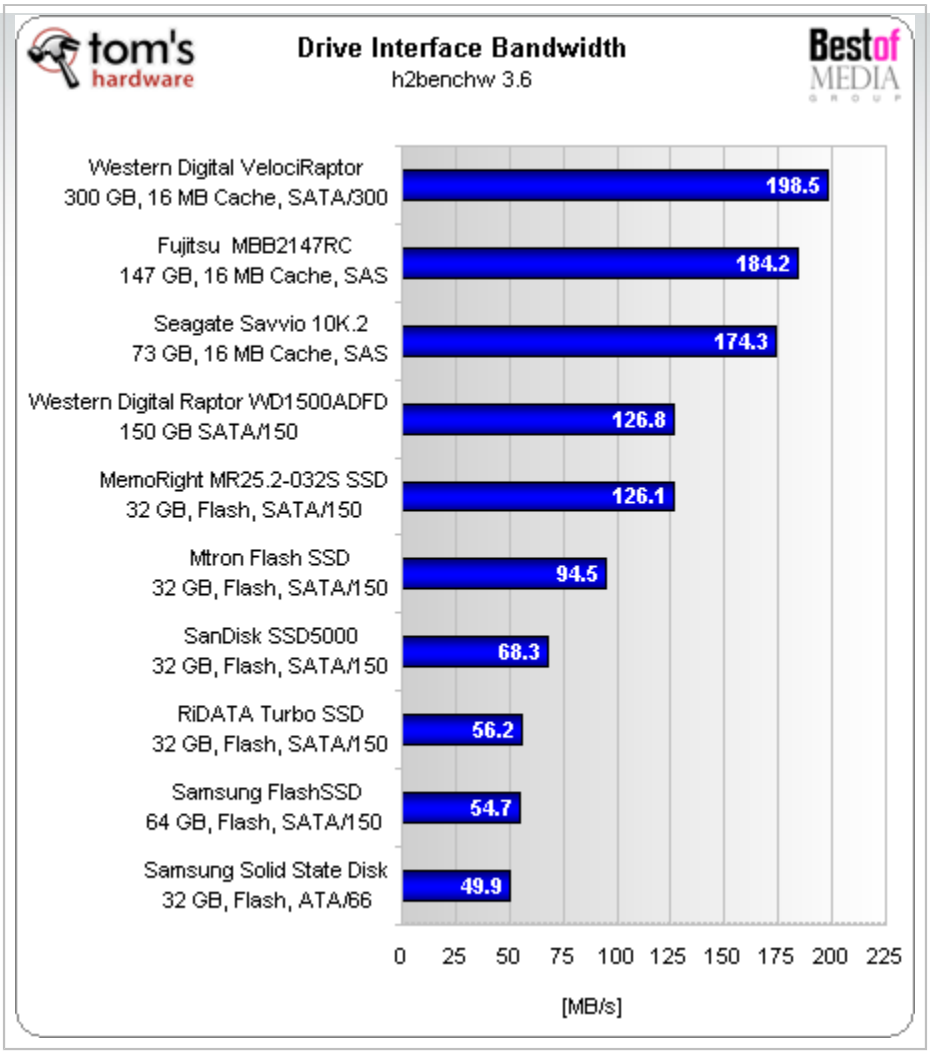
This is a perfect transfer diagram; both the read and write performance are sustained across the entire medium.

Access Time



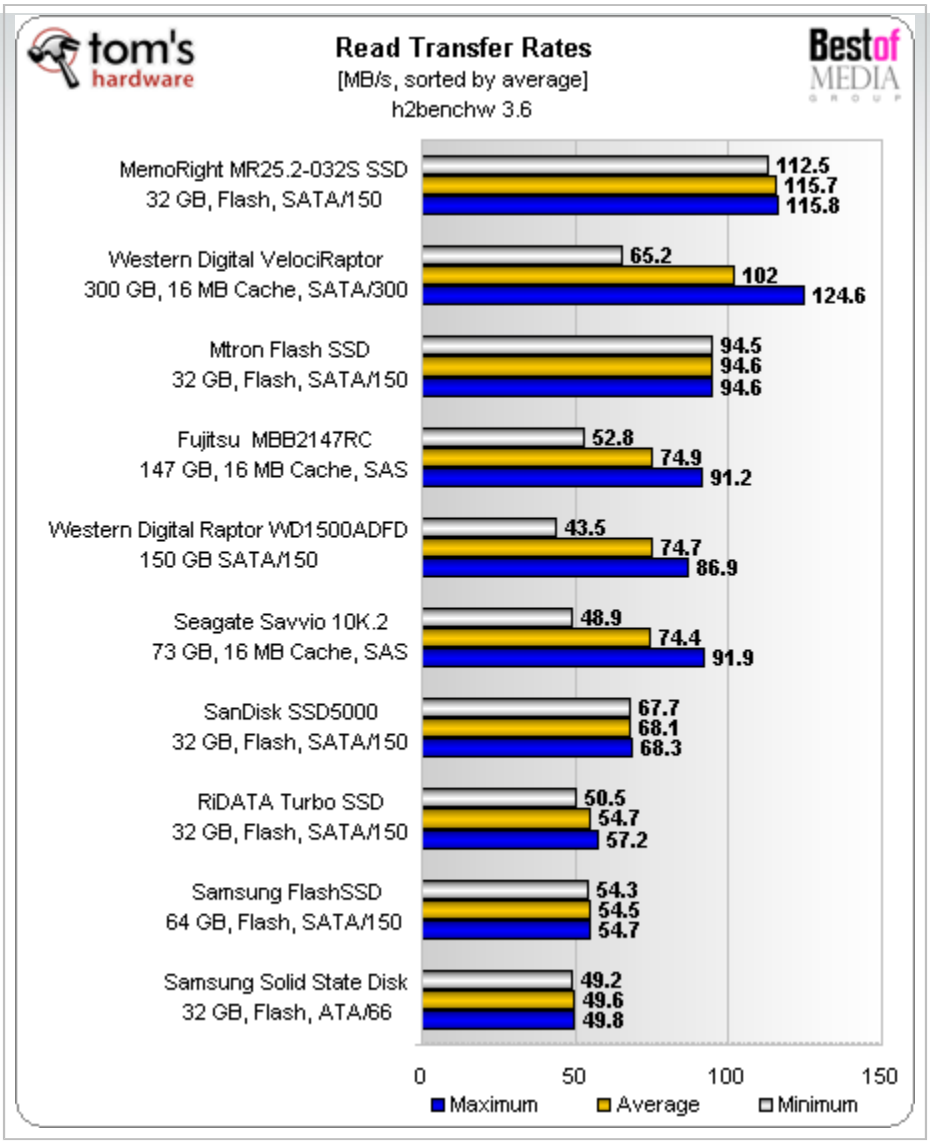
Like with other Flash SSDs, access time is virtually non-existent.

Interface Performance



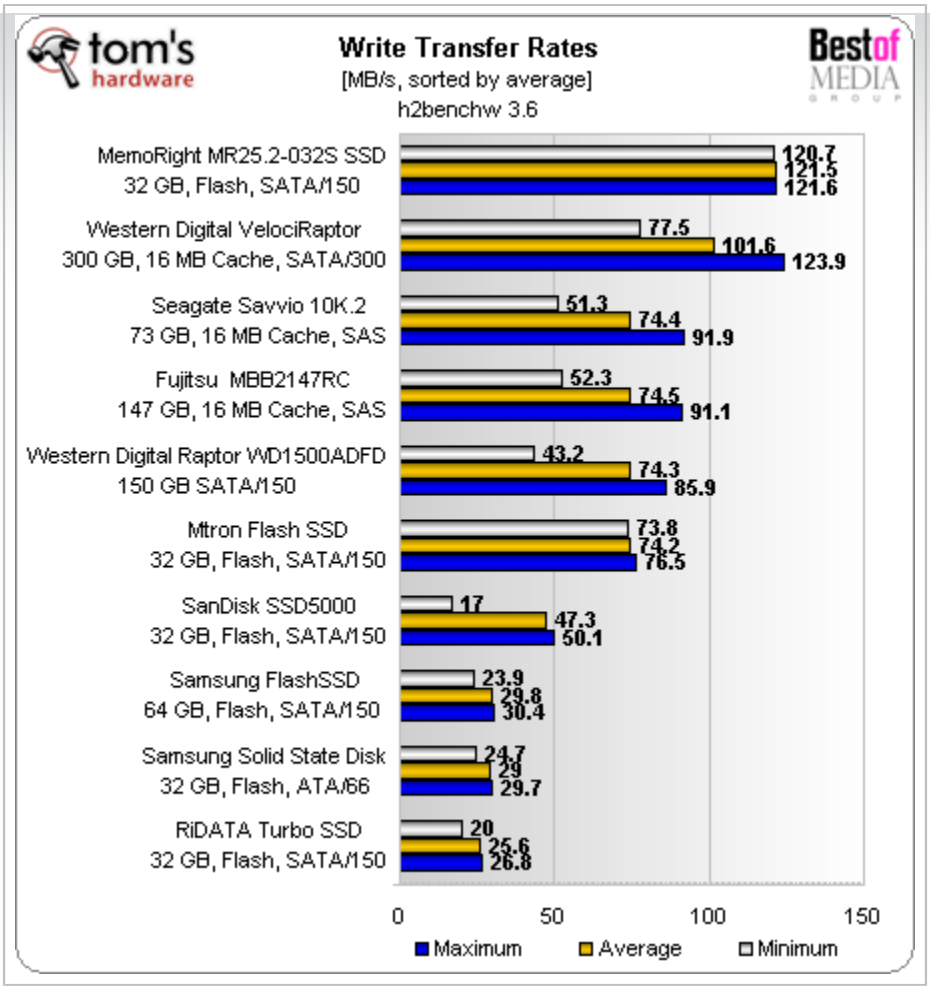
Interface performance reflects the maximum throughput for the Serial ATA interface. The Memoright's SATA interface supports 150MB/s operation and is limited to 126 MB/s, which equals the highest transfer rate to or from the flash memory chips. Other hard drives reach better interface throughput because they come with an additional cache memory (DRAM), which is even faster than Flash.

Read Transfer Performance



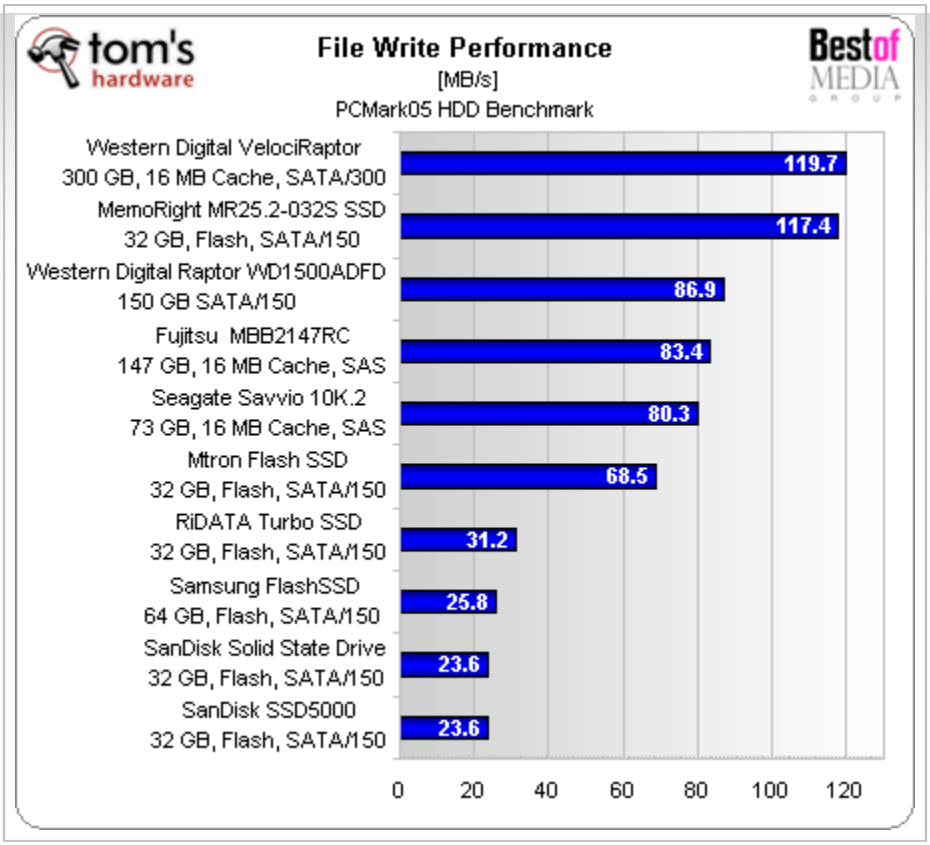
The throughput of 115 MB/s is a new record. It is especially interesting to see that it only drops to a minimum of 112 MB/s, while all mechanical hard drives deliver slower data transfer once you move from the faster outer sectors to the inner sectors of the rotating platters. A Western Digital VelociRaptor provides slightly better maximum transfer rates, but its minimum transfer speed drops to only 65 MB/s. While this is still a great result, it cannot compare to the flash SSDs.

Write Transfer Performance

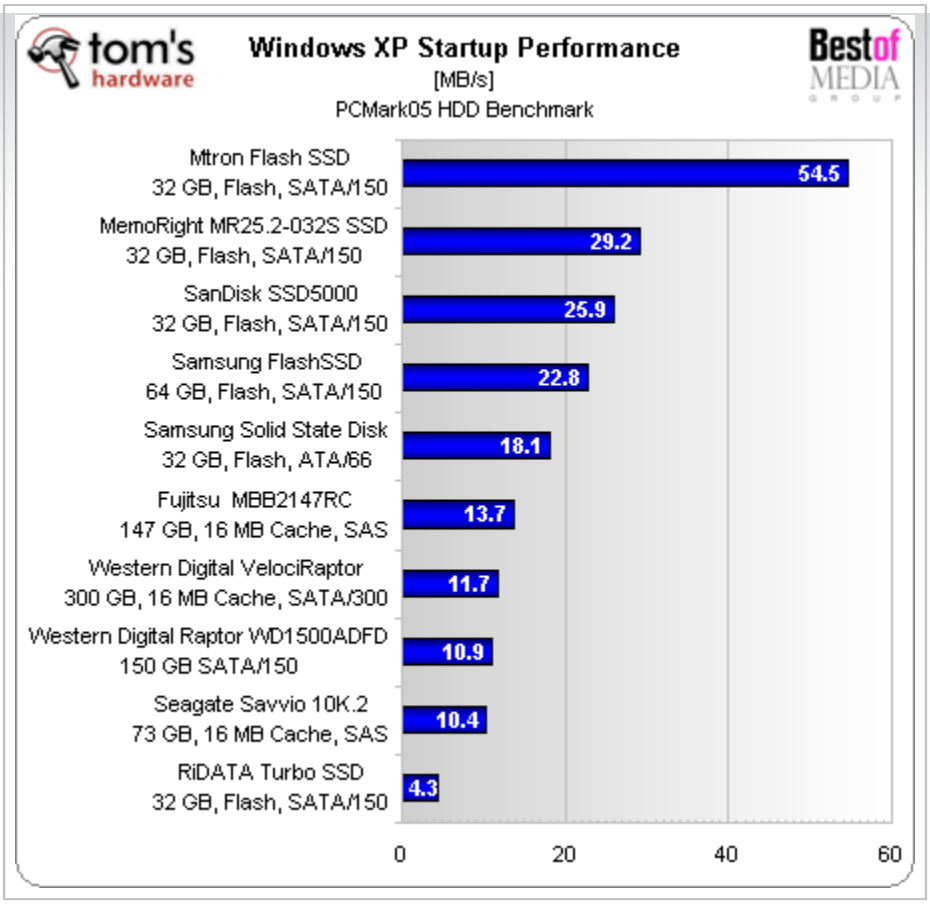


A write speed of 120 MB/s is a result that might have been stimulated by the Adaptec controller's cache memory. However, the data transfer diagram clearly shows that this drive maintains this high throughput.

PCMark05 Application Performance

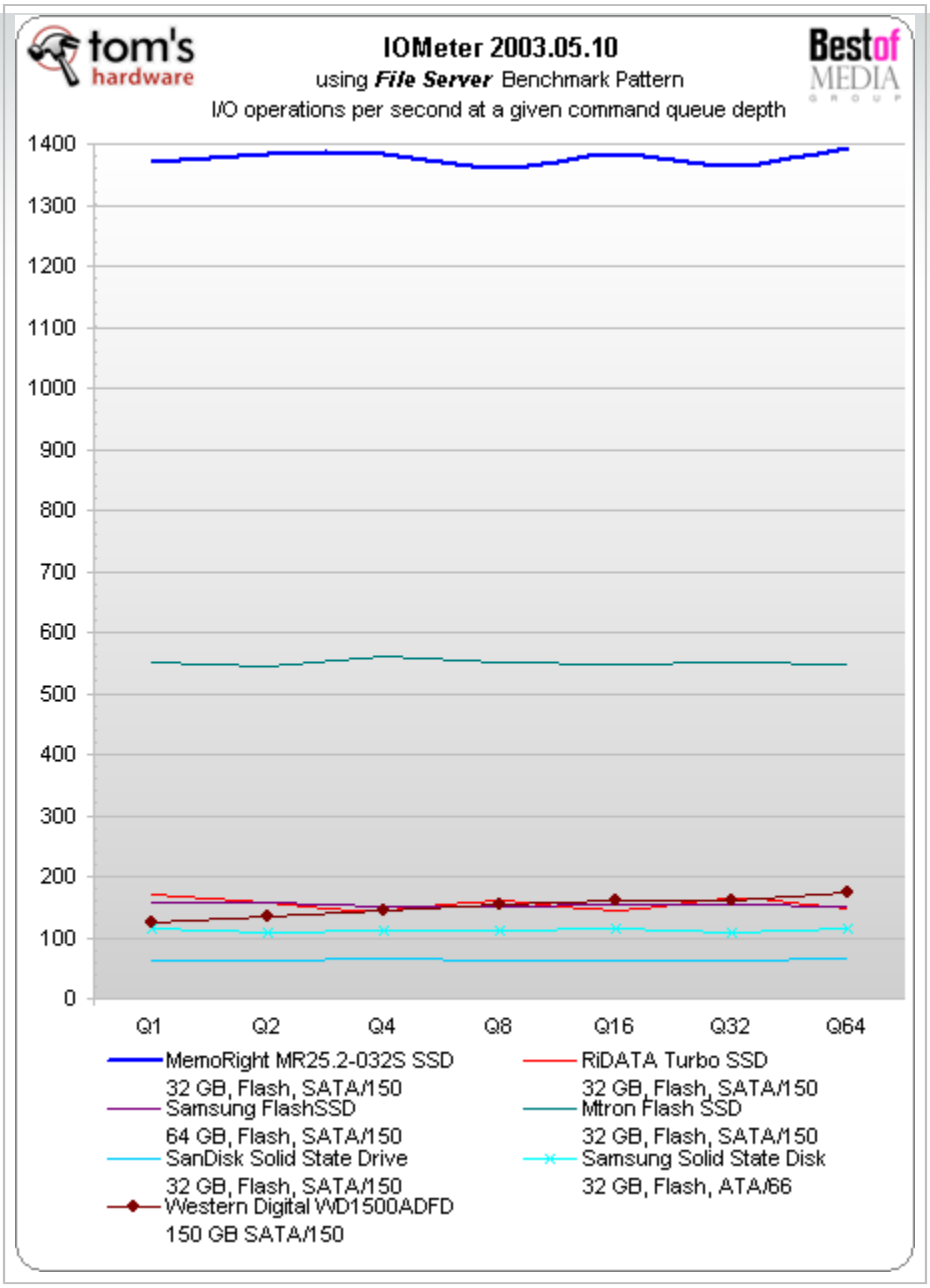


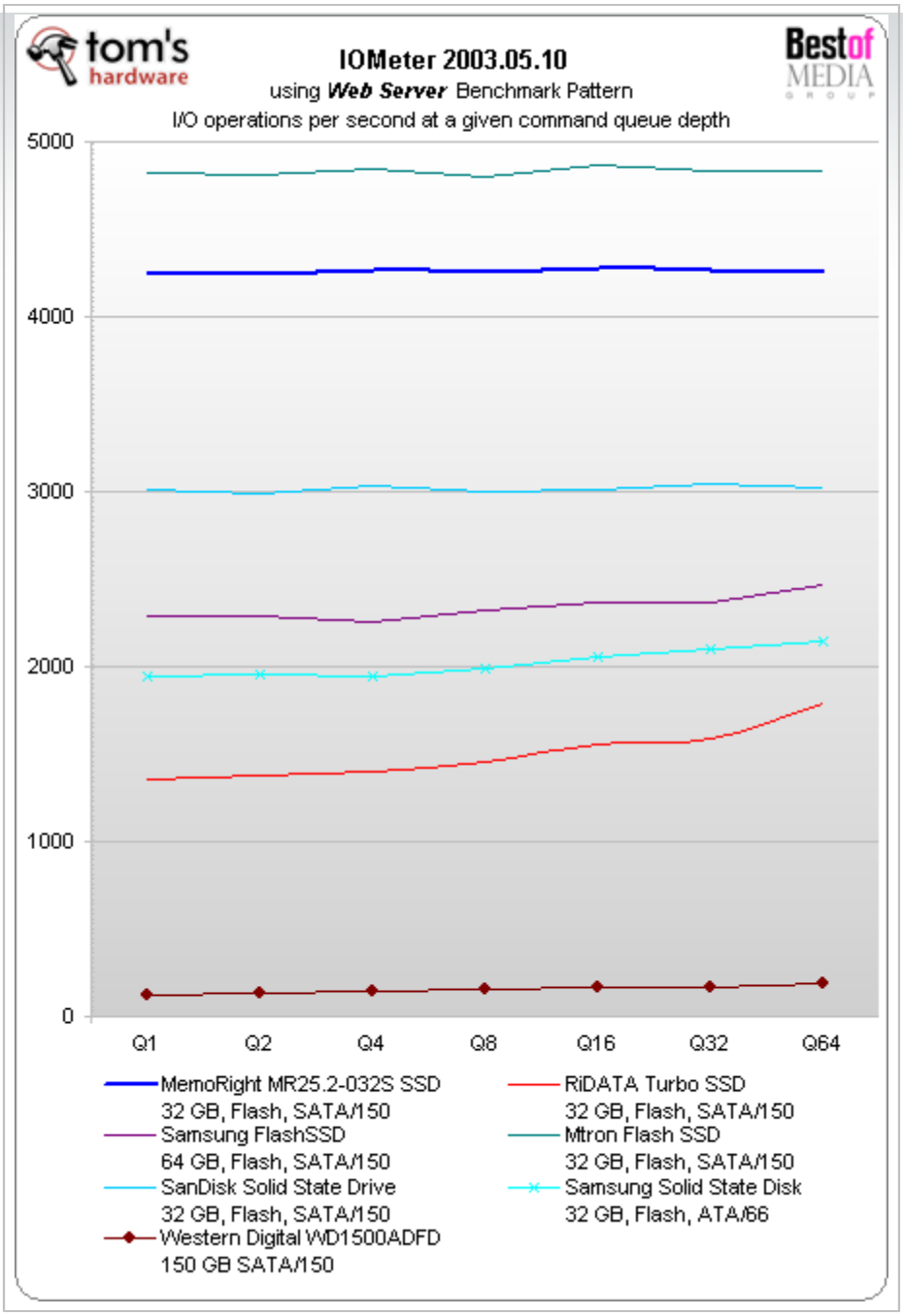
File write performance competes with the throughput of the WD VelociRaptor, which is excellent for a flash-based hard drive. However, the Memoright drive is also 10x more expensive than the VelociRaptor.

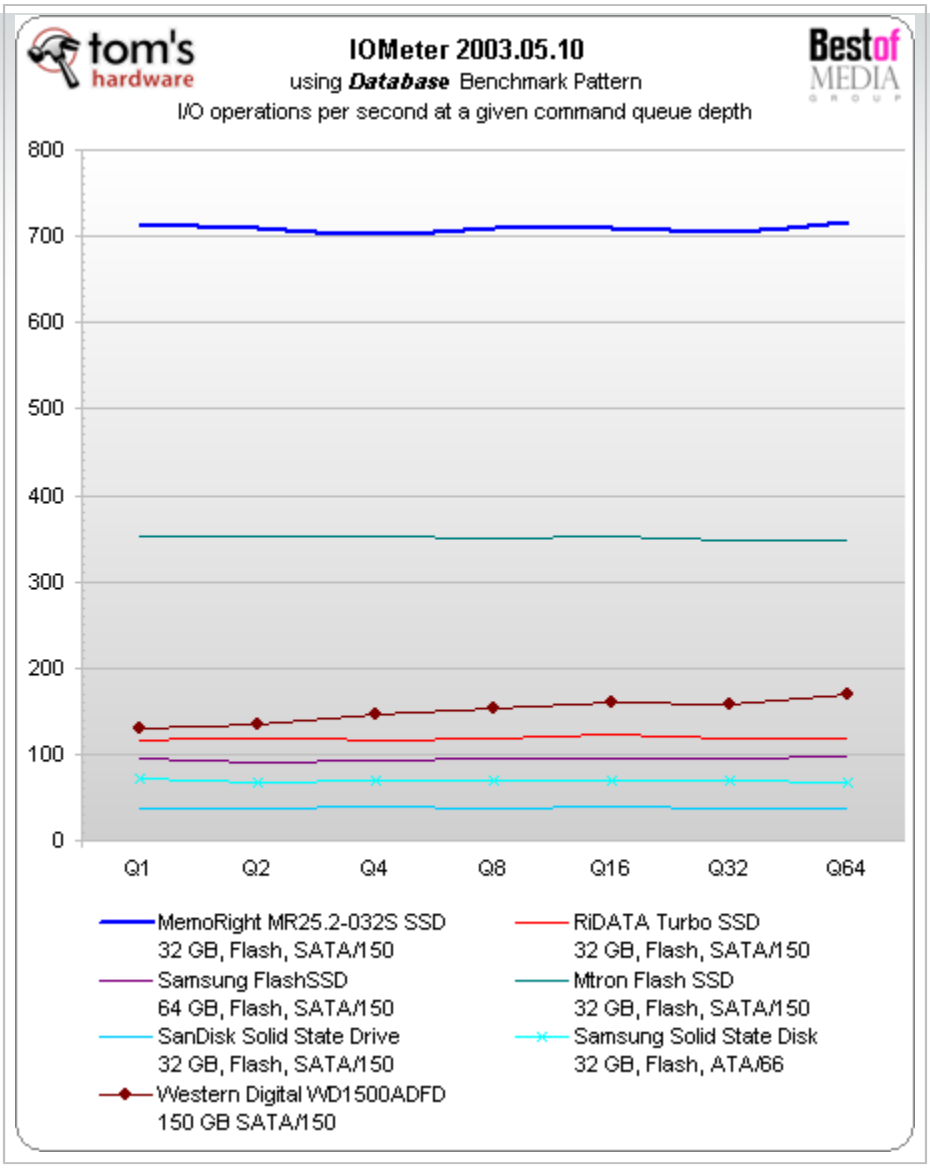


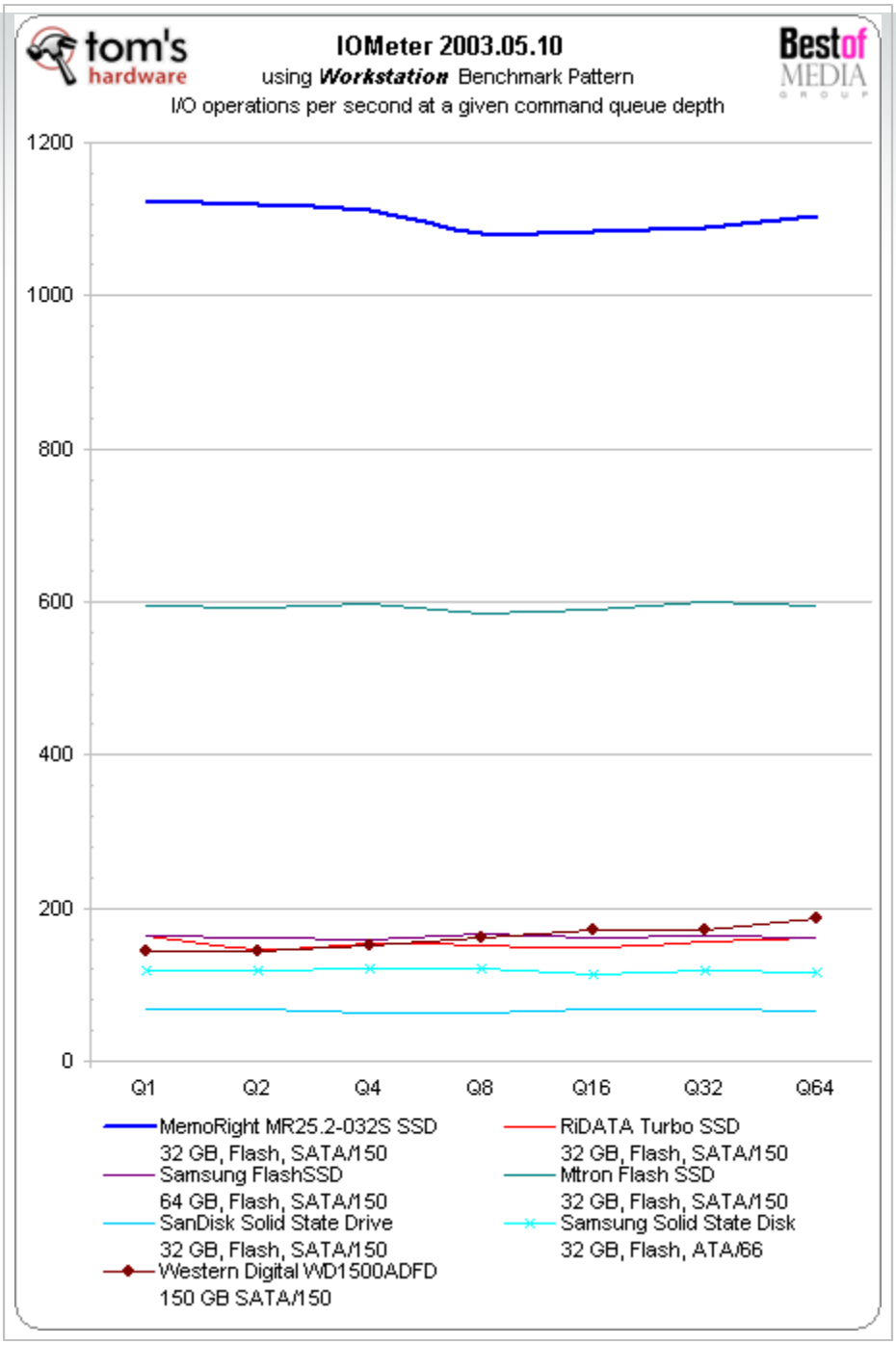
Obviously, Mtron's Flash SSD still is quicker when it comes to starting Windows XP. Yet, Memoright is the second fastest and more than twice as fast as any other mechanical hard drive.

I/O Performance


tom's hardware
IOMeter 2003.05.10
using File Server Benchmark Pattern
I/O operations per second at a given command queue depth
Bestof MEDIA GROUP
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Q1
Q2
Q4
Q8
Q16
Q32
Q64
MemoRight MR25.2-032S SSD
32 GB, Flash, SATA/150
RiDATA Turbo SSD
32 GB, Flash, SATA/150
Samsung FlashSSD
64 GB, Flash, SATA/150
Mtron Flash SSD
32 GB, Flash, SATA/150
SanDisk Solid State Drive
32 GB, Flash, SATA/150
Samsung Solid State Disk
32 GB, Flash, ATA/66
Western Digital WD1500ADFD
150 GB SATA/150

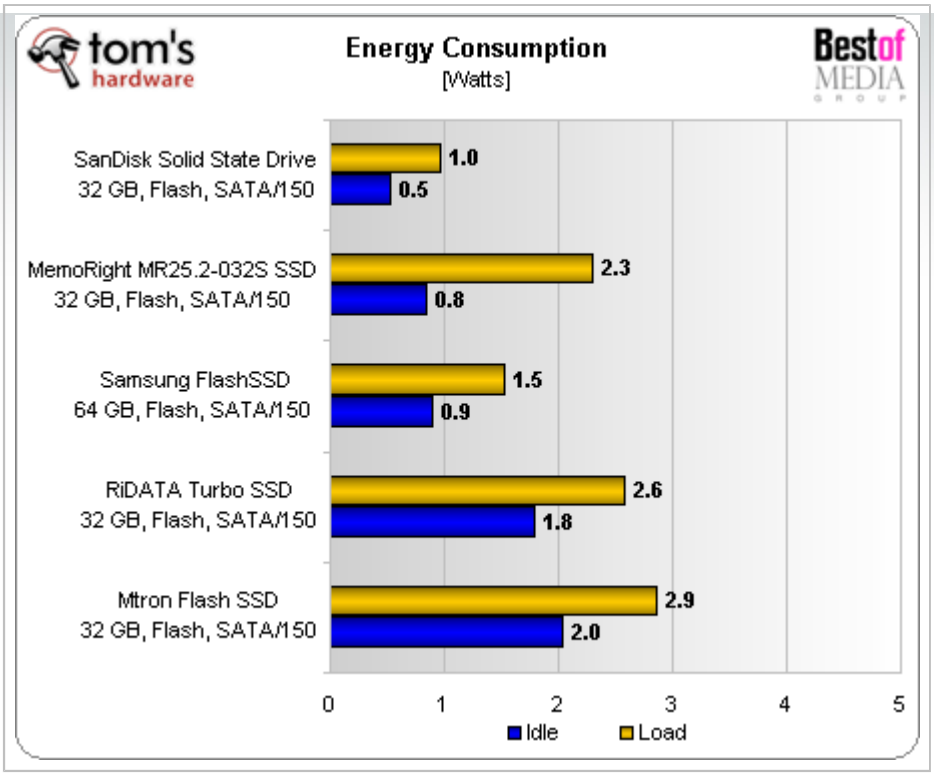

tom's hardware
IOMeter 2003.05.10
using Web Server Benchmark Pattern
I/O operations per second at a given command queue depth
Bestof MEDIA GROUP
5000
4000
3000
2000
1000
0
Q1
Q2
Q4
Q8
Q16
Q32
Q64
MemoRight MR25.2-032S SSD
32 GB, Flash, SATA/150
RiDATA Turbo SSD
32 GB, Flash, SATA/150
Samsung FlashSSD
64 GB, Flash, SATA/150
Mtron Flash SSD
32 GB, Flash, SATA/150
SanDisk Solid State Drive
32 GB, Flash, SATA/150
Samsung Solid State Disk
32 GB, Flash, ATA/66
Western Digital WD1500ADFD
150 GB SATA/150


tom's hardware
IOMeter 2003.05.10
using Database Benchmark Pattern
I/O operations per second at a given command queue depth
Bestof MEDIA GROUP
800
700
600
500
400
300
200
100
0
Q1
Q2
Q4
Q8
Q16
Q32
Q64
MemoRight MR25.2-032S SSD
32 GB, Flash, SATA/150
RiDATA Turbo SSD
32 GB, Flash, SATA/150
Samsung FlashSSD
64 GB, Flash, SATA/150
Mtron Flash SSD
32 GB, Flash, SATA/150
SanDisk Solid State Drive
32 GB, Flash, SATA/150
Samsung Solid State Disk
32 GB, Flash, ATA/66
Western Digital WD1500ADFD
150 GB SATA/150



With the exception of the Webserver I/O benchmark — where only very small blocks are requested and write operations are not required — Memoright dominates the I/O benchmark section as well. It is faster than a WD1500 Raptor by a magnitude ranging between four and 20.

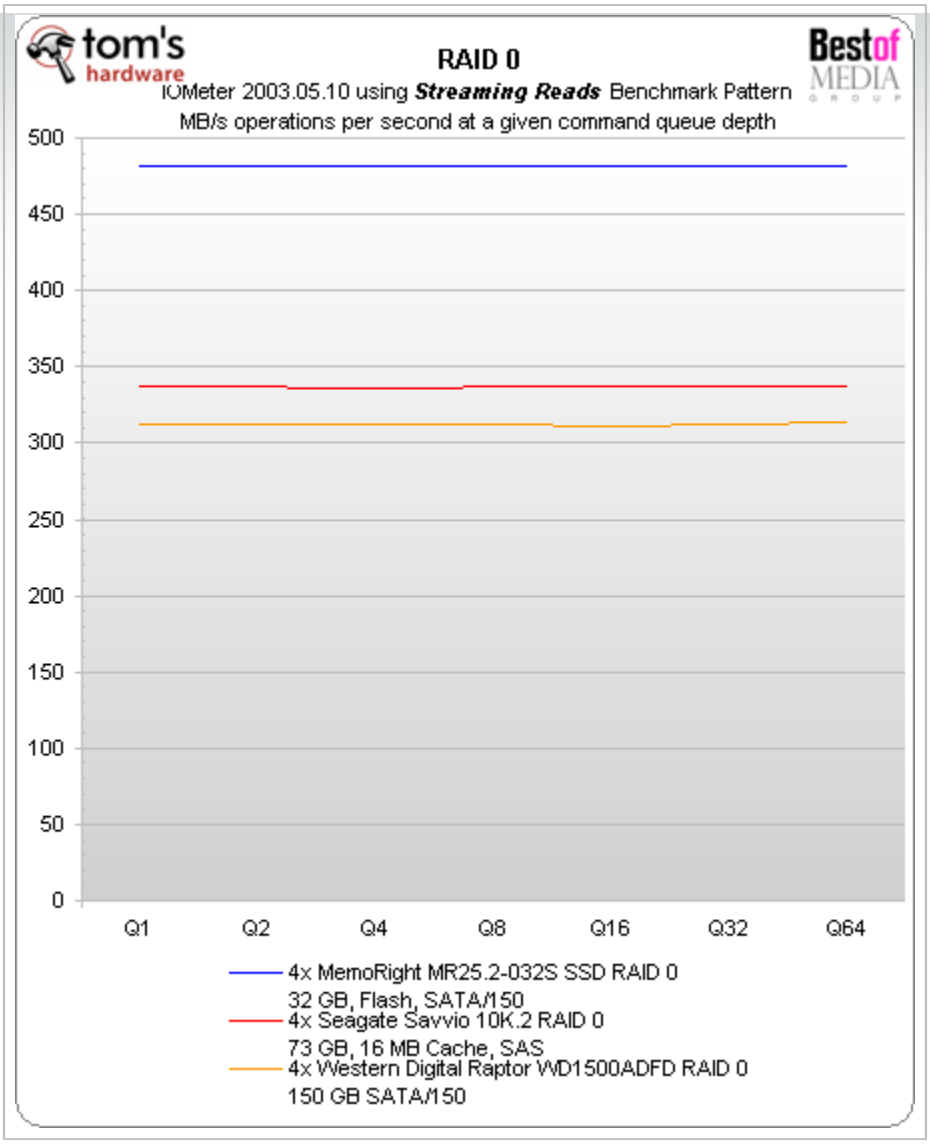
Power Consumption



Memoright isn't only faster than Mtron, it also required less power. A power consumption of 0.8 W instead of 2.0 W when idle is an excellent result, which is comparable to fast conventional 2.5" hard drives. The maximum power requirement is also lower at 2.3 W. Conventional hard drives require up to 4 W.

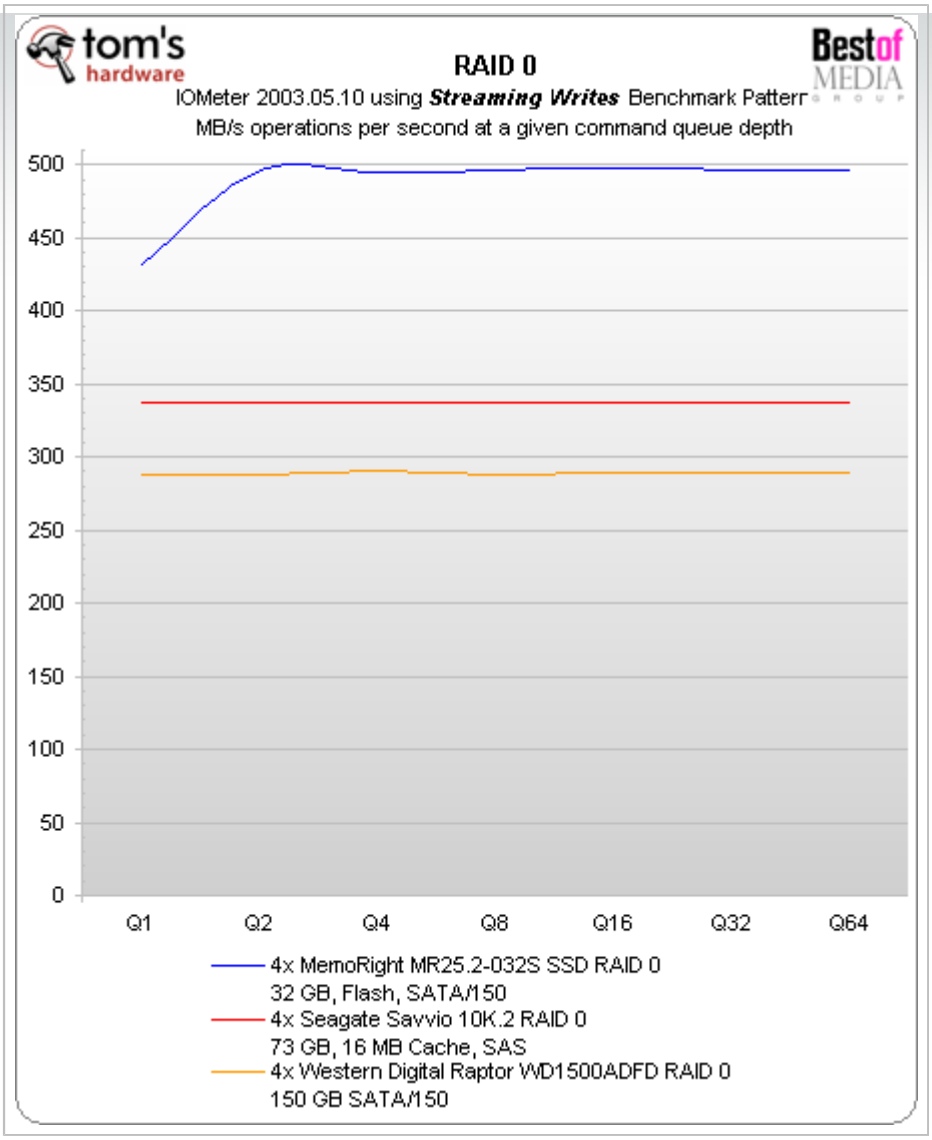
RAID 0 Benchmark Results: SSD vs. Conventional Drives

As already mentioned, we also compared four of the Memoright Flash SSDs in a RAID 0 array. We used four Seagate Savvio 10K.2 drives as well as four Western Digital WD1500 Raptor drives. We regret that we did not yet have access to four VelociRaptor drives, which would have been an even better comparison, as four of them roughly equal the cost for one 32-GB Memoright MR25.2-032S.
Streaming Read Performance (RAID 0, 4 Drives)



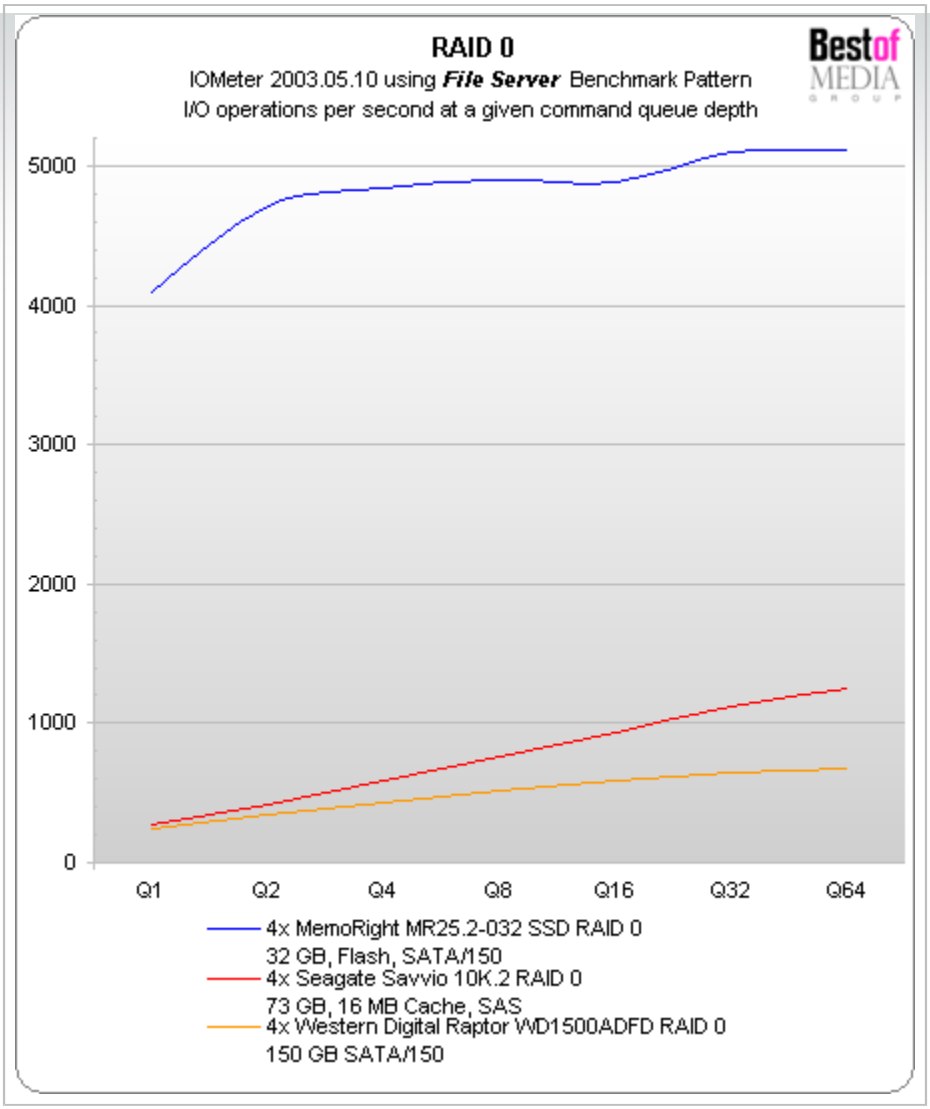
The Memoright Flash SSD RAID 0 array constantly writes 460 MB/s, while the conventional hard drives are limited to less than 350 MB/s. It’s obvious that the new VelociRaptors could come close to this excellent result, but they most likely won’t beat it.

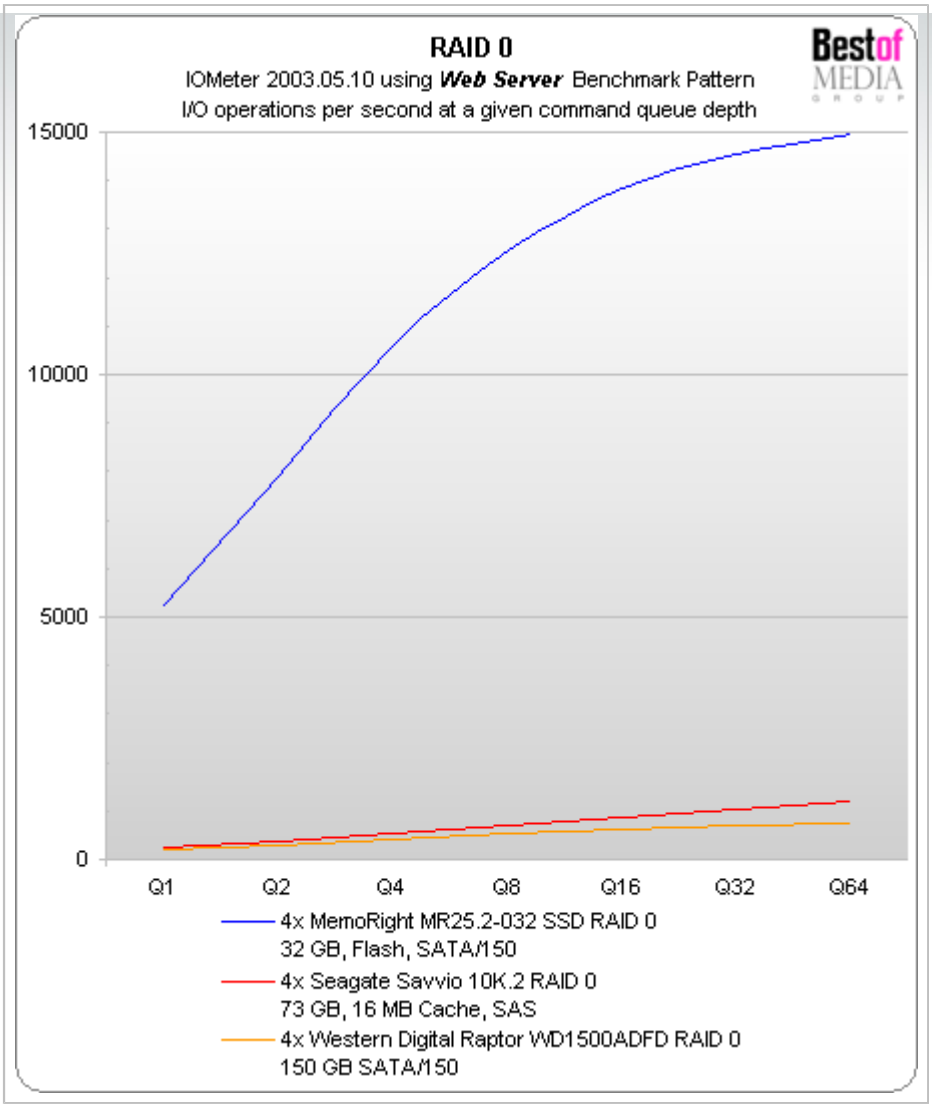
Streaming Write Performance (RAID 0, 4 Drives)

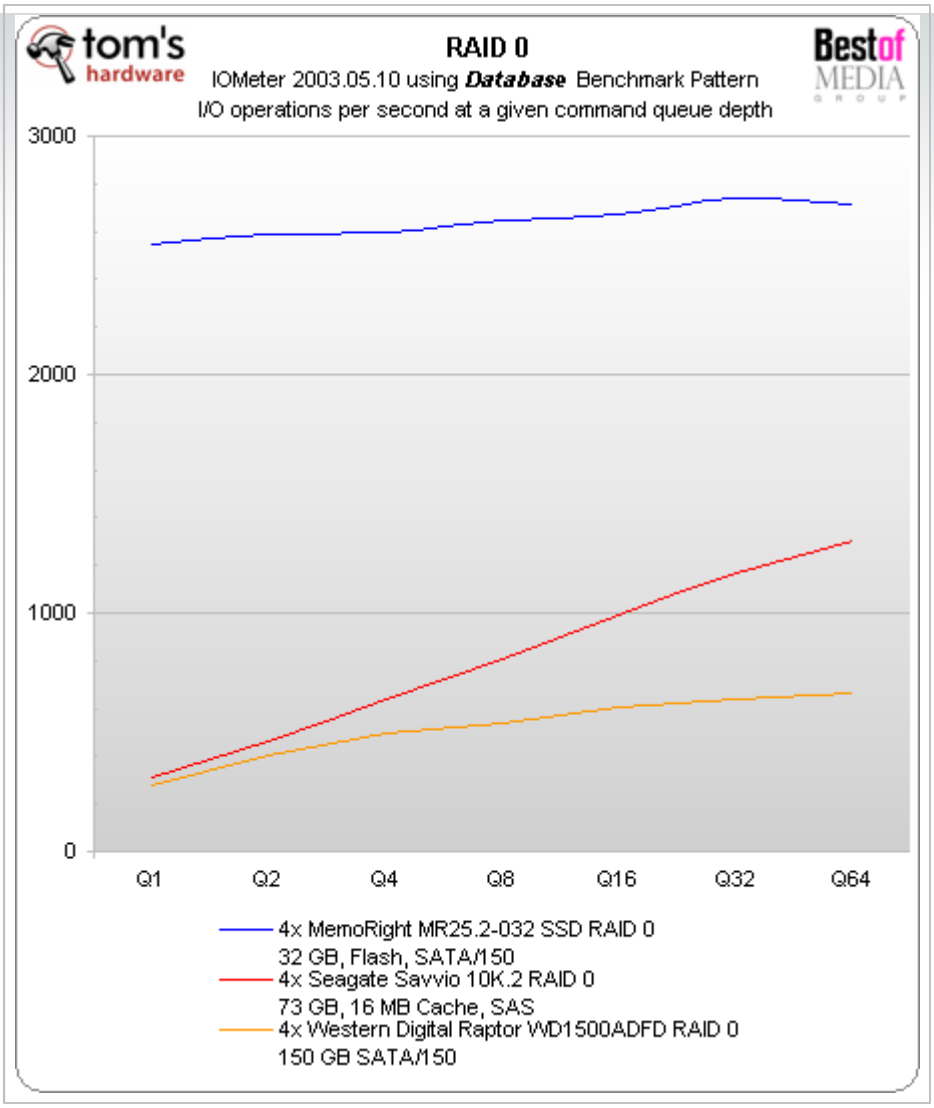


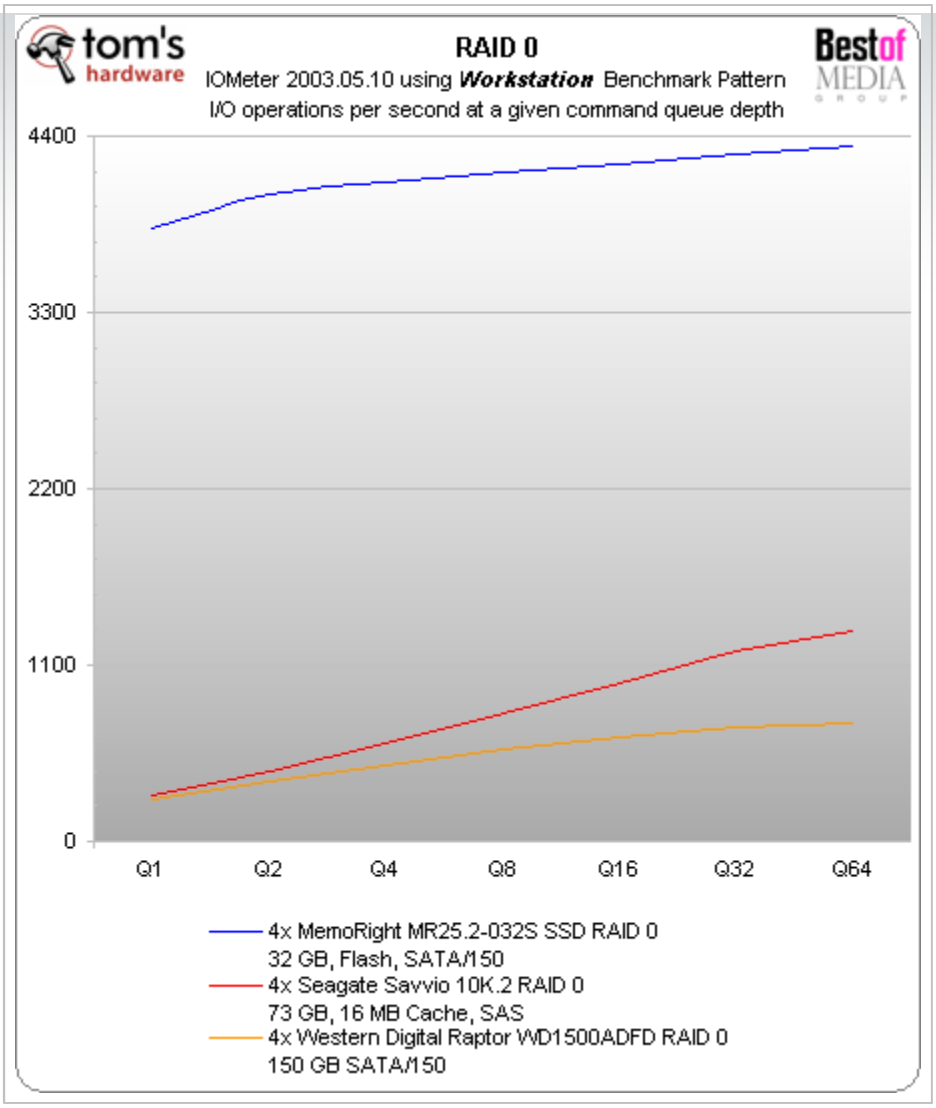
Streaming write performance is similar. It is important, though, to be aware that the controller cached most of the writing operations, hence the graph is somewhat inflated. The result of 430 MB/s at single commands (Q1) is realistic.

I/O Performance (RAID 0, 4 Drives)


RAID 0
IOMeter 2003.05.10 using File Server Benchmark Pattern
I/O operations per second at a given command queue depth
Bestof MEDIA GROUP
5000
4000
3000
2000
1000
0
Q1
Q2
Q4
Q8
Q16
Q32
Q64
4x MemoRight MR25.2-032 SSD RAID 0
32 GB, Flash, SATA/150
4x Seagate Savvio 10K.2 RAID 0
73 GB, 16 MB Cache, SAS
4x Western Digital Raptor WD1500ADFD RAID 0
150 GB SATA/150


RAID 0
IOMeter 2003.05.10 using Web Server Benchmark Pattern
I/O operations per second at a given command queue depth
Bestof MEDIA GROUP
15000
10000
5000
0
Q1
Q2
Q4
Q8
Q16
Q32
Q64
4x MemoRight MR25.2-032 SSD RAID 0
32 GB, Flash, SATA/150
4x Seagate Savvio 10K.2 RAID 0
73 GB, 16 MB Cache, SAS
4x Western Digital Raptor WD1500ADFD RAID 0
150 GB SATA/150


tom's hardware
RAID 0
IOMeter 2003.05.10 using Database Benchmark Pattern
I/O operations per second at a given command queue depth
Bestof MEDIA GROUP
3000
2000
1000
0
Q1
Q2
Q4
Q8
Q16
Q32
Q64
4x MemoRight MR25.2-032 SSD RAID 0
32 GB, Flash, SATA/150
4x Seagate Savvio 10K.2 RAID 0
73 GB, 16 MB Cache, SAS
4x Western Digital Raptor WD1500ADFD RAID 0
150 GB SATA/150



It doesn't matter which benchmark pattern you compare; Memoright beats the pants off the conventional hard drives. If you want to create really fast storage arrays and money is not an object, then take these Flash SSDs and a powerful RAID controller. Note that we only ran RAID 0, which doesn't provide redundancy and data protection.

Conclusion

The benchmark results for the Memoright flash SSDs (we used four 32-GB models MR25.2-032S) speak for themselves. A sequential throughput of 115 MB/s is a new record for flash-based drives, and Memoright even managed to sustain almost the same throughput for write operations as well. I/O performance is stellar and the drive's power consumption is lower than the power requirements of the direct competitor, the Mtron Flash SSD. The only benchmark sections where it cannot beat everything else is the PCMark05 Windows XP startup benchmark and the IOmeter Webserver benchmark. In every other test, Memoright slaps the other drive manufacturers in the face by providing bone-crushing storage performance. Server administrators should especially study the benchmark results carefully, as we're talking about many hundreds to thousands of I/O operations per second on an individual drive.
Memoright's Flash SSDs are also very RAID-friendly, as they worked properly with an Adaptec RAID 5805. We decided to use four Memoright flash SSDs to compare against four Seagate Savvio

10K.2 drives and four Western Digital Raptor WD1500 drives – all in RAID 0, so we could determine the absolute maximum performance. The result didn't come as a surprise, but it still was an eye opener: The Memoright drives are significantly superior providing multiple times better I/O performance and up to 50% more throughput for streaming applications.

Clearly, this Flash SSD is the best system hard drive you can possible use. But it has one major disadvantage, which is its price point. A capacity of 32 GB costs as much as $1,000 and the higher capacity versions, which would be very nice to have, are even more expensive. Although the 128-GB model provides the best cost per gigabyte ratio, all these drives are way too expensive. Most users would not even spend $1,000 on their entire PC. If you can live with the fact that these drives will probably cost half of today's cost or maybe only a third by the end of this year, then you can go for it, as you can be sure to get the very best hard drive available.

The transition from conventional HDDs to Flash SSDs has begun, as these results are convincing enough to make decision makers rethink their storage media strategies. If fast throughput rates are especially critical for a particular enterprise's datacenter, for example, then the high costs required to invest in high-performance SSDs can make sense. It's clear that 15,000 RPM hard drives will be among the first victims, as I'd rather go for a small-and-fast flash SSD plus a large storage drive instead of a single, medium capacity 15k SAS drive for a server.

But all of this will remain in the high-end or enterprise segment for the time being, as it won't be possible to replace all 500 million hard drives sold in 2007, or even only all server and system drive with flash-based hard drives for another very simple reason: According to Western Digital, all the flash production sites in the world aren't sufficient to produce enough memory to replace that of traditional hard drives. Hence, we will have to wait for further improvements in flash memory density and affordable 100+ GB flash drives to drop below $500 before they enter the mainstream.

Flash SSD Comparison Table

Manufacturer	MemoRight	Mtron	Ridata
Family	GT Series	Solid State Disk	Turbo Solid State Drive
Model Number	MR25.2-032S	MSD-SATA6025032NA	NSSD-S25-32-C02T
Capacity	32 GB	32 GB	32 GB
Rotational Speed (RPM)	Flash	Flash	Flash
Available Capacities	64, 128 GB	64, 128 GB	32 GB
Geometry	n/a	n/a	n/a
Interface	SATA/150	SATA/150	SATA/150
Form Factor	2.5"	2.5"	2.5"
Cache (MB)	-	-	-
NV Cache Size	-	-	-
NCQ	-	-	-
Weight	100g	114g	64g

Manufacturer	Samsung	Samsung	SanDisk
Family	FlashSSD	Solid State Flash Drive	Solid State Flash Drive
Model Number	MCBQE64GBMPP-		SATA 5000
Capacity	64 GB	32 GB	32 GB
Rotational Speed (RPM)	Flash	Flash	Flash
Available Capacities	16, 32 GB	-	-
Geometry	n/a	16 x 32 Gb	n/a
Interface	SATA/150	UltraATA/66	SATA/150
Form Factor	2.5"	2.5	2.5"
Cache (MB)	-	-	-
NV Cache Size	-	-	-
NCQ	-	-	-
Weight	77g	46 g	94 g