## OVERVIEW

Marvell® is the market leader for Serial Advanced Technology Attachment (SATA) embedded controller products and the first to market with an end-to-end 6Gb/s SATA solution stack – from 6Gb/s SATA host controllers to 6Gb/s target hard disk drive (HDD) and solid state drive (SSD) controllers. Marvell works closely with industry leaders in such markets as PC motherboards, home network attached storage (NAS), set-top boxes, SSD/HDD drives and consumer SATA host bus adapters (HBAs). Marvell's revolutionary HyperDuo technology will help enable pervasive, mass-market SSD adoption.

Marvell HyperDuo offers a breakthrough embedded technology for new-generation PCIe to SATA 6Gb/s controllers, including the Marvell 88SE9130, 88SE9220 and 88SE9230 series. Based on years of research and patent-pending software and hardware, HyperDuo enables 80 percent of the performance of a SSD at one-third the cost. Configured with one hard drive and one SSD, HyperDuo uses intelligent algorithms to automatically migrate hot data to the SSD, while enabling all data to be safely stored on a larger capacity SATA HDD. With the introduction of the 88SE9230 controller, HyperDuo has been enhanced to support multiple SSDs to scale both SSD performance and capacity.

THE PROBLEM TODAY

The storage market landscape is rapidly changing. Previous generation 3Gb/s SATA technology is quickly giving way to 6Gb/s SATA. By 2010, several disk drive vendors such as Western Digital® and Seagate® have launched 6Gb/s SATA HDDs, while memory vendors such as Micron® have launched 6Gb/s SATA SSDs. In the consumer desktop market, SATA motherboard leaders such as ASUS® and Gigabyte® have launched 6Gb/s SATA motherboards as well.

But a fundamental challenge exists. While 6Gb/s SATA storage technologies are rapidly becoming available, SSD technology is still relatively expensive for consumers. Storing all consumer data on SSDs is impractical due to cost. Using a hybrid approach of manually combining an HDD and SSD (for example as a boot device) doesn't offer a true solution for achieving consistent application acceleration for performance-sensitive applications such as gaming, video and rich media or I/O intensive programs.

HDD	SDD
Cheap but slow	Fast but expensive
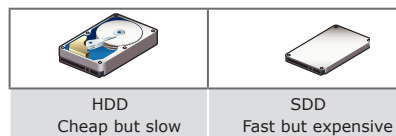
THE SOLUTION: MARVELL HYPERDUO TECHNOLOGY

Marvell HyperDuo technology is the answer. By embedding automated tiering technology into the chipset that goes into the world's leading motherboards, NAS, set-top boxes and desktop HBAs, Marvell's HyperDuo enables immediate performance value from day one. User applications such as Microsoft® Office and Media Player, Adobe® Creative Suites, Apple® iTunes, Internet browsers and "hot" accessed OS-related files will automatically be pinned to the SSD for improved system performance. No need for consumers to do any manual copying that is often error-prone and requires tedious monitoring. And no additional costs or complexity are incurred from buying add-on software. Best of all, because Marvell is the market leader in 6Gb/s SATA technology from host-to-target, consumers can rest assured that HyperDuo embedded technology works flawlessly with the world's leading 6Gb/s HDDs and SSDs.

	HDD	SDD	HyperDuo
• Capacity	High	Low	High
• Performance	Slow	High	High
• Cost	Low	High	Lower

Fig 1. Marvell HyperDuo avoids compromise, delivering low cost, high storage capacity and blazing performance.

HyperDuo enables two modes: Safe Mode and Capacity Mode. Safe Mode provides optimal data protection by mirroring data from the SSD to the hard disk for maximum resiliency. Capacity Mode augments SSD and HDD capacity for the most cost-effective configuration. Both modes automatically identify LBA ranges across both the SSD and HDD so that the user experience is exactly the same. By allowing consumers to view the same single drive volume (e.g. Data (D:) as they do today, HyperDuo requires no behavioral changes by consumers, which maximizes simplicity and eliminates user error.

Safe Mode – Mirror SSD Data To HDD

HDD (Hot Files) | Cold Files ...

SSD (Hot Files)

Capacity Mode – Add SSD and HDD Capacities Together

SSD (Hot Files) | HDD (Cold Files)

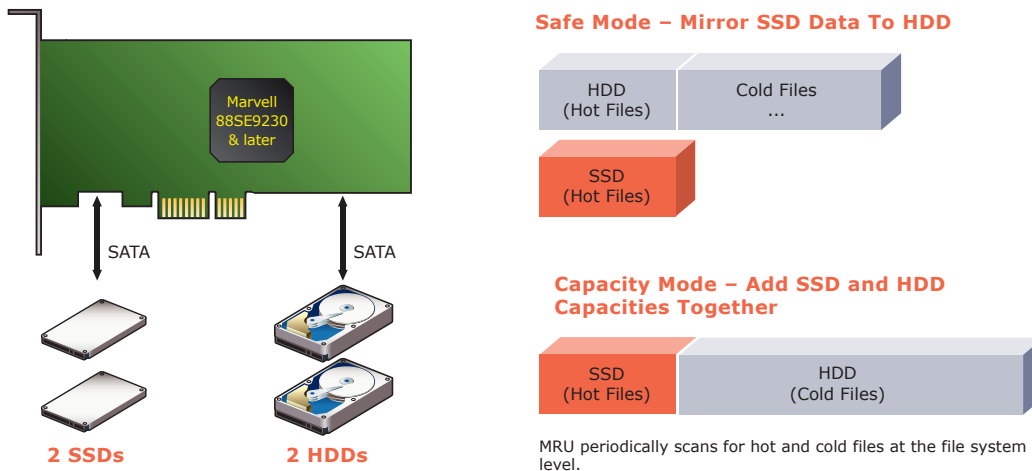MRU periodically scans for hot and cold files at the file system level.

2 SSDs   2 HDDs

Fig 2. Marvell HyperDuo can be configured in Safe or Capacity modes for maximum user flexibility.

HyperDuo also offers a graphical user interface (GUI) utility to enable fine-grained control of what files and directories are stored in the SSD. Power users can view file directories that the HyperDuo deems as hot data and decide whether to move it to the SSD or keep the data on the slower hard drive. For novice users, HyperDuo performs automatic background updates to periodically monitor hot file directories, with minimal CPU overhead.
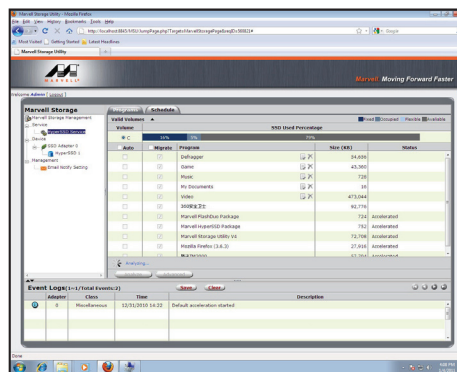

Fig 3. Powerful, highly intuitive graphical interface makes HyperDuo simple and manageable.

▶ FEATURE HIGHLIGHTS

- Price/Performance: 80% of SSD performance (PCMark) at 1/3 the cost
- RAID: 0/1 hardware RAID running on ARM-based CPU
- Modes: Safe Mode (Mirrored Protection), Capacity Mode (Cost-Optimized)
- GUI: Flexible, intuitive administration console for power users
- New! For 88SE9230 series (PCIe 2.0 x2, 4x 6Gb/s SATA ports)
  - Multiple SSD support (up to 3 SSDs + 1 HDD) for higher IOPS, throughput and capacity
  - HyperDuo with RAID 0/1 on HDDs for capacity and data protection (e.g. 2 SSDs + RAID 0/1 on dual HDDs)
  - On-the-fly AES 128/256-bit encryption for connected SATA SSD/HDD devices

Marvell HyperDuo for PCIe to SATA 6Gb/s Controllers

▶ PERFORMANCE BENCHMARKS

HyperDuo has undergone rigorous performance testing with various HDD and SSD capacities and vendor brands. Below are benchmark results based on industry-standard IOMeter, CrystalDiskMark and ATTO benchmark test measurements.

• **HBA Controller**	Marvell 88SE9230
• **SATA HDD**	WD® WD1002FAEX 1TB 6Gb/s HDD
• **SATA SSD**	OCZ® VERTEX 3 120GB 6Gb/s SSD
• **Windows Driver**	Inbox AHCI

Marvell 88SE9230 IOMeter Benchmark					
Test Mode [MB / Sec]	**1 HDD**	**HyperDuo (1 SSD + HDD)**	**1 SSD**	**HyperDuo (2 SSDs + 1 HDD)**	**2 SSDs**
• 4K Sequential Read	66	297	310	307	318
• 16K Sequential Read	129	422	438	635	582
• 64K Sequential Read	129	486	509	694	657
• 256K Sequential Read	129	505	523	672	664
• 1024K Sequential Read	129	507	524	682	658
• 4K Sequential Read	61	145	163	268	224
• 16K Sequential Read	115	142	164	272	271
• 64K Sequential Read	115	139	138	249	227
• 256K Sequential Read	116	153	129	268	276
• 1024K Sequential Read	117	150	129	269	267

Table 4. IOMeter benchmark comparing HDD only vs. SSD only vs. Marvell HyperDuo-powered 88SE9230 controller.

Marvell 88SE9230 CrystalDisk Benchmark					
Test Mode [MB / Sec]	**1 HDD**	**HyperDuo (1 SSD + HDD)**	**1 SSD**	**HyperDuo (2 SSDs + 1 HDD)**	**2 SSDs**
• Sequential Read (Block size=1024KB)	140	479	497	683	683
• Sequential Write (Block size=1024KB)	130	172	175	247	223
• 512K Random Read (Block Size=512KB)	51	439	443	613	616
• 512K Random Write (Block Size=512KB)	80	173	174	261	221
• 4K Random Read (Block Size=4KB)	1	29	30	29	28
• 4K Random Write (Block Size=4KB)	1	62	63	62	62
• 4K QD32 Random Read (Block Size=4KB, Qdepth=32 for NCQ&AHCI)	2	108	106	218	223
• 4K QD32 Random Write (Block Size=4KB, Qdepth=32 for NCQ&AHCI)	1	169	169	221	218

Table 5. CrystalDisk benchmark comparing HDD only vs. SSD only vs. Marvell HyperDuo-powered 88SE9230 controller.

Marvell 88SE9230 ATTO Benchmark					
Test Mode [MB / Sec]	1 HDD	HyperDuo (1 SSD + HDD)	1 SSD	HyperDuo (2 SSDs + 1 HDD)	2 SSDs
• 4K Write	62	182	179	178	178
• 8K Write	107	283	315	279	278
• 16K Write	129	383	393	396	376
• 32K Write	131	468	467	570	565
• 64K Write	132	493	496	720	711
• 128K Write	130	511	511	724	740
• 256K Write	131	517	511	726	731
• 512K Write	131	514	517	738	726
• 1024K Write	130	519	516	733	737
• 4K Read	63	114	128	116	117
• 8K Read	123	193	205	202	201
• 16K Read	134	332	352	338	340
• 32K Read	145	396	402	493	470
• 64K Read	147	442	444	672	591
• 128K Read	144	467	468	720	700
• 256K Read	148	516	518	756	749
• 512K Read	144	532	537	776	771
• 1024K Read	145	543	543	778	784

Table 6. ATTO benchmark comparing HDD only vs. SSD only vs. Marvell HyperDuo-powered 88SE9230 controller.

	Capacity	Storage Cost*	Performance (CrystalDisk Seq Read)
• 1 SSD Only	1TB SSD	$2000+ (100% baseline)	497 (100% baseline)
• HyperDuo (2 SSD + 1 HDD)	2x 120GB + 1TB = 1.24TB	$490 (25%)	683 (137%)
• HyperDuo (1 SSD + 1 HDD)	120GB + 1TB = 1.12TB	$290 (15%)	479 (96%)
• 1 HDD Only	1TB HDD	$90 (5%)	140 (28%)

Table 7. Marvell HyperDuo achieves near-SSD performance at less than 1/3 the cost.
* Prices based on Google Products online search, Nov 2011.

CONCLUSION

Marvell HyperDuo will usher in a new era by enabling truly cost-effective SSD performance. Unlike custom add-on software that adds cost and complexity, HyperDuo technology is built into the Marvell system-on-a-chip with the Marvell 88SE9130, 88SE9220 and 88SE9230 series. As opposed to manual tuning, where consumers have to tediously keep on top of what data is hot or cold and where it's stored, HyperDuo is fully automated. Users see the same Windows environment (e.g. D: drive) that they experience today. Any desktop motherboard, home NAS, set-top device or SATA HBA with the Marvell HyperDuo-powered ASIC will offer this automated SSD acceleration technology "built-in" from day one. Because it is embedded, consumers automatically will get the benefits of SSD acceleration and automated tiering without any added complexity or risk.

Marvell HyperDuo for PCIe to SATA 6Gb/s Controllers

• Part Number	HyperDuo technology is embedded in new-generation Marvell PCIe to SATA 6Gb/s controllers, including the Marvell 88SE9130, 88SE9220, and 88SE9230 series controller
• Chip-Level Requirements	88SE9130, 88SE9220, 88SE9230 series controllers
• Platform Requirements	• Desktop motherboards • Home and Prosumer NAS (Network Attached Storage) • Consumer set-top boxes, DVRs and gaming consoles • Consumer PCIe HBAs (Host Bus Adapters)
• Storage Hardware	Any SATA-based HDD or SSD is supported. Marvell recommends 6Gb/s SATA HDDs and SSDs for maximum performance, but HyperDuo technology also will work with older 3Gb/s SATA HDDs and SSDs. The following is a sample list of supported storage hardware (not comprehensive): • Western Digital® • Micron® • Seagate® • Toshiba® • Hitachi® • Samsung® • OCZ®
• OS Support	• Microsoft® Windows® XP • Windows Vista • Windows 7 Note: Inbox drivers enable users to take advantage of OS commands like TRIM to extend the life of SSDs for maximum durability.
• RAID Support	• RAID 0 • RAID 1
• User Configurations	• Safe Mode: Automated mirroring from SSD to HDD for maximum protection • Capacity Mode: SSD capacity augments the hard drive to optimize cost efficiency
• Administration Console	Marvell provides a Graphical User Interface (GUI) via Marvell's storage administration console. This provides a simple, highly intuitive interface for power and flexibility: • Power users can view the file directories that HyperDuo recommends pinning to the SSDs and decide whether to select or deselect each item. Users can also set and configure the scheduled frequency of running HyperDuo. • For mainstream users, Marvell recommends enabling HyperDuo to automatically migrate hot files and directories from HDDs to SSDs.

THE MARVELL ADVANTAGE: Marvell chipsets come with complete reference designs which include board layout designs, software, manufacturing diagnostic tools, documentation, and other items to assist customers with product evaluation and production. Marvell's worldwide field application engineers collaborate closely with end customers to develop and deliver new leading-edge products for quick time-to-market. Marvell utilizes world-leading semiconductor foundry and packaging services to reliably deliver high-volume and low-cost total solutions.

ABOUT MARVELL: Marvell is a leader in storage, communications, and consumer silicon solutions. Marvell's diverse product portfolio includes switching, transceiver, communications controller, processor, wireless, power management, and storage solutions that power the entire communications infrastructure, including enterprise, metro, home, storage, and digital entertainment solutions. For more information, visit our Web site at www.marvell.com.

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