

# **Multi-Drive and RAID Configurations in Notebook Computers and Mobile Workstations Boost Performance and Information Protection**

## ***Summary***

Redundant array of independent disks, generally known as RAID, has been in use for many years to increase hard disk drive performance and protect against the failure of hard drives. RAID is a special, widely used instance of multi-drive systems that can deliver data at great speed and maintain the integrity of data and applications. As mobile computers evolve from basic notebook computers into high-performance mobile workstations for demanding business and home use applications, multi-drive systems offer compelling advantages in terms of performance and data protection. Seagate Technology® and Intel® Corporation are firmly committed to supporting mobile environments; they offer complementary technologies that allow RAID and other multi-drive configurations to deliver optimal performance and strong data protection for notebook computers and mobile workstations. This paper explains some dual-drive, RAID configurations and their advantages, and discusses related innovations of Seagate and Intel.

## **Hard Drive Redundancy as Data Protection and Performance Strategy**

For many years, corporate systems administrators have been using multi-drive configurations, including redundant arrays of independent disks (RAID), to protect critical data and applications. The main concept behind RAID is redundancy. All RAID configurations involve multiple hard drives that back each other up in a variety of ways.

RAID systems have followed the migration of large stores of data and complex applications from servers to mobile devices. First implemented many years ago in enterprise servers and high-end storage systems, RAID systems today are common in small business servers and, increasingly so, in desktop computers. Recently, more and more notebook computers use RAID systems. Several factors drive this development:

- More people than ever before work at more than one location or are always mobile, and the drives in their notebook computers store a significant amount of valuable information.
- Loss of information can have severe, negative consequences for a company's ability to do business and compete successfully.
- The performance capabilities and reliability of notebook computers are at an unprecedented high level, and people use notebooks more and more in challenging or data-intensive scenarios, such as high-end gaming or complex engineering applications. In almost any line of business, reliability is more important than ever. For example, notebooks today play a critical role in financial management companies and the finance departments of corporations, which were initially slow to embrace mobility. Factors such as regulatory regulation and competitive reasons compel companies to maintain and safeguard financial information as securely as possible.

Two of the conventional RAID configurations require a minimum of only two hard drives and, therefore, can be implemented within the confines of a notebook computer: RAID 1 and RAID 0.

RAID 1 introduces full redundancy with mirrored drives. Simultaneously, the system writes data to both drives in a pair. If one of the drives fails, the other one continues to work without any system interruption. This system and data level fault tolerance requires a doubling of the amount of hard drives needed; RAID 1 provides a full, current backup copy of all data but has additional "disk overhead" over a single hard drive system.

RAID 0 is also known as a "striped disk array without fault tolerance." A RAID 0 configuration breaks data into blocks, and the system then writes or "stripes" these blocks to separate disk drives. By spreading I/O load evenly across multiple drives and drive controllers, RAID 0 can improve I/O performance.

However, RAID 0 is not fault-tolerant. If one drive in a RAID 0 configuration fails, the other drives cannot compensate for the failure—all data in an array is lost. Because RAID 0 does not boost the integrity of data and applications, some technologists may not consider it a "real" RAID configuration.

RAID 0 and RAID 1 show value in different application and usage scenarios, depending on whether performance or data integrity is most important to the person using the notebook computer. For systems builders, multi-drive and RAID systems in notebooks serve to strengthen competitive product differentiation and help to widen gross margins. At the same time, they effectively address customer concerns and can improve customer satisfaction.

## **Advantages of RAID 0 and RAID 1**

Both Seagate Technology®, the world's largest maker of hard disk drives, and Intel® Corporation, the world leader in silicon innovation, extensively support notebook users with advanced products and technologies. The two companies encourage the use of RAID 0 and RAID 1 to improve the performance and data protection of notebook computers. They also agree that both RAID 0 and RAID 1 can be of advantage in homes and offices where software applications and digital storage play an important role. Depending on the need for either improved performance or increased data protection, RAID 0 or RAID 1 become preferable.

### **RAID 0: Garner a Substantial Performance Increase**

With RAID 0 systems in notebook computers running demanding applications, testing at Intel and Seagate verified performance boosts of 40 percent or more compared to single-drive systems—a clearly noticeable improvement for users. The system's drive controller can send double the amount of data to be written to the drives simultaneously, whereas it would need to queue the write commands if only a single drive were present. Therefore, applications that require intensive writes to the disks can benefit from RAID 0. Such applications include multimedia work—video editing, image editing and pre-press processes—as well as high-end gaming. RAID 0 accelerates the loading of game levels and the editing and writing of changes to digital videos and images.

Other write-intensive applications, such as computer-aided design, engineering programs and mapping programs (especially if they involve frequent updates to large map files) also stand to benefit from performance improvements facilitated by RAID 0. However, users should bear in mind that RAID 0 does not offer system and data

fault tolerance to protect the notebook computer and its data and applications against the failure of a hard disk drive. For that reason, home or office users might want to look for a performance boost from RAID 0 only for those applications and data that they can restore with relative ease, should a hard drive fail.

### **RAID 1: Protect Data and Applications**

When it's not possible for users to retrieve, re-create or re-install digital films, videos, documents, and other files, RAID 1 is a solution that provides continuous availability of all that critical content and the applications used to create and manage it. Both drives in a RAID 1 configuration are perfect copies of each other, so a breakdown of one drive does not result in a system failure with potentially catastrophic loss of files and information.

Any critical application or file can benefit from availability made possible by RAID 1: financial applications and data, competitive information, tax documents, intellectual property, digital videos and images that can never be re-created once the moment has passed. RAID 1 systems in notebook computers provide an additional buffer to the shocks and other challenges a mobile device can experience.

When Serial ATA (SATA) drives are present in a RAID 1 configuration, hot-swapping a failed drive without interrupting business processes is an easy step to take. Original equipment manufacturers (OEMs) and systems builders can minimize the amount of field returns and save freight expenses by shipping replacement drives directly to their more technically savvy customers, who then can replace the failed drive with a new one. Customers can enjoy minimal disruption and do not need to ship and wait for the return of their notebook computer to and from the technology vendor.

### **From Notebook Computers to Mobile Workstations**

The increased protection of data and applications brought about by RAID 1 is the primary benefit in implementing RAID 1 storage, but RAID 1 can also help performance. Read performance can increase by approximately 20 percent, because the controller can split up the read workload between the two drives and read from both of them. Write performance under RAID 1 tends to be unchanged compared to the write performance with just a single hard drive present.

In recent years, notebook computers have become the computers of choice in many businesses and homes. Notebooks that can run extremely fast, offer excellent screens, and provide ample storage for data and applications are becoming the mobile workstations that can replace traditional desktop systems. Form factor rather than mobility may be one of the more important features of mobile workstations, which are more likely to remain in the same location for most of the time. However, speed, storage capacity and reliability are critical. RAID 0 and RAID 1 configurations can be of great value in the mobile workstations that support high-tech manufacturing and engineering, video processing, multimedia production and other demanding environments.

### **Two Industry Leaders Deliver the Value of RAID Arrays in Mobile Scenarios**

Seagate and Intel deliver the technological innovation and products that allow system builders and OEMs, as well as their end-user home and business customers, to benefit from notebook computers and mobile workstations with RAID 0 and RAID

1 drive configurations. Seagate provides the hard drives, while Intel provides the controllers, processors, chipsets and software solutions.

### **Seagate Momentus: Most Flexible and Reliable Storage Technology for Notebook Computers and Mobile Workstations**

The Seagate® Momentus™ series is designed for use in notebook computers, mobile workstations, tablet PCs, external storage and smaller servers. All Momentus products are RAID-ready, 2.5-inch hard disk drives. Seagate engineered the Momentus drives to feature high shock tolerance in mobile environments and consume minimal power, which increases the length of a battery charge<sup>1</sup>. All Momentus drives are available with a SATA interface, which means they deliver consistent, high-level performance with lower power consumption resulting from SATA features such as native command queuing (NCQ) and Link Power Management (LPM). It also means that disk drives can be integrated into systems easily with small connectors and narrow, flexible cables. In addition, perpendicular recording increases the drives' areal density, making it possible to pack substantially more data into the same space.

The main models of the Seagate Momentus series include:

- **Momentus 5400.** The Momentus 5400 offers storage capacity of up to 160GB, spindle speed of 5400 RPM and resistance to nonoperating shock of up to 900 Gs. If you use the Momentus 5400.3 with 160 GB in a RAID 0 configuration, you can increase notebook storage capacity up to 360 GB.
- **Momentus 5400 with full disk encryption.** For customers who require strong data protection at the drive level, Seagate offers the Momentus 5400 with full disk encryption (FDE) as an optional feature. FDE protects all data on the drive by means of a password. Additional FDE capabilities include the ability to quickly erase or make unreadable all data on drives to be retired.
- **Momentus 5400 PSD.** As a hybrid drive, the Momentus 5400 PSD combines a nonvolatile (NV) cache with conventional memory in one enclosure, making it possible to retain data and applications in the cache. Notebook computers can boot and write to the cache, yielding fast response to user commands and highly reduced power usage. The Momentus 5400 PSD, with capacity of up to 160GB, spindle speed of 5400 RPM and 1.5Gb/s SATA throughput, is fully ready for the advanced storage management features of the new Microsoft Windows Vista operating system. Notebook and mobile workstation users need this type of hybrid drive to take full advantage of Windows Vista.
- **Momentus 7200.** With 7200 RPM, SATA throughput of 150 Gb/s and capacity of up to 100GB, the Momentus 7200 offers the strong performance users require for demanding applications running on mobile workstations and notebook PCs. The rugged, solid build of the Momentus 7200 can weather 250 Gs of operating and 900 Gs of nonoperating shock.

All products in the Seagate Momentus series are thoroughly tested and verified to work well with Intel's processors and chipsets.

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<sup>1</sup> Power consumption of Seagate hard drives tends to be highly economical, lagging behind the screen, video card and processor. Even with a two-drive RAID array present in a mobile workstation or notebook, the hard drives require less than 20 percent of the total power used by the machine.

## **Intel Matrix Storage Technology: RAID 0 and RAID 1 in the Same System, with Full SATA Support**

Intel's important innovation in the area of RAID is the introduction of a new type of RAID configuration that makes it unnecessary to choose between RAID 0 and RAID 1. Intel Matrix Storage Technology makes it possible to combine RAID 0 and RAID 1 in a two drive configuration. For example, on a mobile business workstation the operating system and intellectual property related to a patent could be subject to RAID 1 with increased data protection, while drawings and large-file product images could be under RAID 0, providing faster performance.

Users of notebook computers and mobile workstations will most likely only be interested in RAID 0 and RAID 1. However, Intel Matrix RAID can also incorporate and recombine RAID 5 and RAID 10, which require more than two sets of hard drives in order to function. Today, Intel Matrix RAID supports RAID 5 and RAID 10 on desktop platforms, and will provide the same capability to notebooks and mobile workstations in a future generation of Intel mobile platforms.

Intel Matrix Storage Technology combines a SATA RAID controller, chipset and other hardware components with Intel Matrix Storage Manager, a software tool that eases the management of RAID arrays and storage devices. In addition, Intel RAID Migration Technology gives users of mobile workstations an efficient way to migrate from a single drive to a RAID 0 or RAID 1 array without having to re-install the operating system. Users save the time required for re-installation of the operating system, do not need to address any of the errors that might occur during the system upgrade, and can continue to run processes on the machine while they convert to the RAID configuration.

Highly complementary to the Seagate Momentus drives, Intel Matrix Storage Technology fully supports important SATA features, including NCQ, the ability to switch out drives while the system is running (known as "native hot-plugging") and the SATA Advanced Host Controller Interface (AHCI). Intel takes the lead in the industry by being the first to support SATA both at the hardware and software levels.

## **Intel Centrino Duo Mobile Technology: Power and Performance for Mobile Environments**

Early in 2006, Intel announced a new hardware platform, until that time code-named "Napa": Intel Centrino® Duo Mobile Technology. It consists of the following:

- Intel Core™ Duo Processor
- Mobile Intel 945 Express Chipset Family
- Intel PRO/Wireless 3945/ABG Network Connection

Intel Centrino Duo Mobile Technology facilitates extensive mobile capabilities and outstanding performance to help businesses and sophisticated home users accomplish their goals in the digital world. Intel Centrino Duo Mobile Technology features a mobile dual-core design of the processor, resulting in fast performance, vastly extended battery life for mobile scenarios, and expanded connectivity options to give users a high level of flexibility in their communications.

Important for mobile workstation and notebook computer users looking for even better performance and data protection, Intel Centrino Duo Mobile Technology is the first platform for mobile applications that is fully enabled for RAID arrays—RAID 0, RAID 1 and Intel Matrix RAID.

## **Intel Facilitates RAID on the Run**

Space is always at a premium in notebook computers and mobile workstations. Seagate Momentus hard drives are small, but at least two of them are needed to build a RAID array. Some notebook designs would require removal of the optical drive to make room for the second hard drive.

Intel has developed an effective solution for this space challenge. A new RAID technology, Intel Rapid Recovery Technology, and first announced at the Intel Developer Forum in September 2006, obviates the requirement for more space. With Intel Rapid Recovery Technology, notebook owners can continue to enjoy small-size notebooks together with the much improved availability of data and applications made possible by RAID 1.

Intel Rapid Recover Technology supports a RAID 1 configuration with one crucial difference from traditional RAID 1 arrays with fixed hard drives: The second hard drive is enabled to be intermittently connected to the system by means of a swap bay or docking station. When that drive is connected, it synchronizes with the drive that is permanently installed in the system, producing a complete mirror. If the system drive should fail, the replacement is ready to take over.

## **Concerted Innovation to Continue**

OEMs and system builders serving the notebook computer and mobile workstation market segments likely can capitalize on a vast business opportunity. For end user customers, that system builder business opportunity translates into the promise of better notebooks and mobile workstations that allow them to boost their productivity and accomplish more effectively what they wish to achieve.

The market opportunity for notebooks with multi-drive systems, including RAID configurations and Intel Rapid Recovery Technology, is significant and likely to extend to an increasing share of the notebook market. The size of the notebook market itself, market research from Seagate and other observers shows, will amount to approximately 15 to 20 million units per year, for the next five years, for a total of roughly 100 million units—close to the size of the desktop market.

Seagate Technology and Intel will continue to work closely together to develop and introduce new technologies that benefit the home and business users of notebooks and mobile workstations. The two companies regularly exchange information about their nascent innovations to ensure optimal consistency, stability and interoperability for their platforms and storage devices.

## **Resources**

For notebook and mobile workstation users, systems builders and OEMs, both Seagate and Intel offer extensive information and resources online.

Seagate resources:

- Seagate Partner Program: [spp.seagate.com](http://spp.seagate.com)
- Seagate Momentus 7200 information online: [www.seagate.com/products/notebook/momentus.html](http://www.seagate.com/products/notebook/momentus.html)
- Seagate white paper on perpendicular recording: [www.seagate.com/docs/pdf/whitepaper/TP-549\\_PerpRecording\\_Feb-06.pdf](http://www.seagate.com/docs/pdf/whitepaper/TP-549_PerpRecording_Feb-06.pdf)
- Seagate white paper on Full Disc Encryption: [fde.seagatestorage.com](http://fde.seagatestorage.com)

- Contact Seagate: [www.seagate.com/contact/index.html](http://www.seagate.com/contact/index.html)

Intel resources:

- Intel channel partner programs:  
[http://www3.intel.com/cd/channel/reseller/asm-na/eng/membership/281133.htm?iid=HPasmonaeng\\_In\\_mbr](http://www3.intel.com/cd/channel/reseller/asm-na/eng/membership/281133.htm?iid=HPasmonaeng_In_mbr)
- Intel Matrix Storage Technology:  
[www.intel.com/design/chipsets/matrixstorage\\_sb.htm](http://www.intel.com/design/chipsets/matrixstorage_sb.htm)
- Intel Centrino Duo Mobile Technology: [www.intel.com/centrinoduo/?pin=Intel](http://www.intel.com/centrinoduo/?pin=Intel)
- Intel Hardware Design Resource Center:  
[developer.intel.com/sites/developer/index.htm?iid=CorporateV3+Header\\_2\\_Resource\\_HardwareDesign](http://developer.intel.com/sites/developer/index.htm?iid=CorporateV3+Header_2_Resource_HardwareDesign)
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