I can see the future now.
and it has no moving parts.
Bartosz Kijanka,
VP of Engineering,
Gas Powered Games

Get Into the Game Faster

Processor advances, such as the recently released Intel® Core™ i7 processor Extreme Edition, have reset expectations for mobile gaming, desktop gaming, and digital content creation. Intel SSD technology offers a natural complement to the latest processor improvements, boosting storage solution performance to a level more appropriate to the latest processor advances. The trick to achieving outstanding performance: eliminate all moving parts and redefine storage paradigms.

The physical act of rotating platters and aligning a magnetic read head with a track and sector, as is done with conventional hard disk drives (HDDs), creates lag time and reduces the device’s lifetime, since moving parts inevitably wear out over time. By relying entirely on NAND flash technology, SSDs avoid the key negative aspects of conventional HDDs, increasing reliability and operational life in the process. Because no physical movement is required to access the wholly electronic storage areas of the SSD, access to data is substantially faster.

Another consideration is power consumption. “It takes a lot of power to keep conventional hard disk drives spinning,” Alan Frost, Marketing Programs Manager of Intel’s Solid-State Drive Group said, “and then to move the arm back and forth across the surface to find the information that you need. A solid-state drive has no moving parts. It uses less power. It is significantly faster. In a laptop configuration, you get better battery life. The visual computing hook—especially for game developers, but this could also be for artists, for digital content people, for video editing, or whatever—is that the system responds significantly faster. If you have a large amount of code to compile, your compile times go down.”

Developers doing rendering work, using art programs or lighting tools, typically get a lot of coffee breaks waiting for scenes to render or animations to complete. SSDs shave minutes off the wait time, delivering significantly better performance and much faster rendering times when large-volume data accesses are required.

“Everyone across the game-development tool chain is constantly looking for ways to improve their productivity,” Frost said. “Intel SSDs are the perfect complement to balancing the performance of Core i7 and Xeon 5500 systems for developers, artists, and testers. And, as every aspect of computing continues to skew toward mobility, Intel SSDs deliver better battery life and the reliability needed for performance on the go.”

Gauging Reactions

A seed program to put select SSD units in the hands of game developers and digital content creators has yielded early feedback for the technology. Design parameters for the SSDs favor either desktop and laptop uses, or enterprise configurations. It’s important to select an SSD model targeting the correct end use. At the recent NAB trade show, Michael Katz, who handles visual computing developer relations at Intel, noted the keen
interest in ramping up the use of SSDs as replacements to hard drives. "We have two classes of drives. The first is a mainstream drive, which is the X18-M and the X25-M. The ‘18’ means it is a 1.8-inch size for a laptop. The ‘25’ is a 2.5-inch drive, which fits in notebook or desktop computers. And then we have the enterprise drives, including the X25-E, which use a different flash memory cell technology to achieve faster performance."

Katz noted that the Intel SSD units are fully plug-compatible with the standard spinning hard drive. “You can take out your hard drive and put in an SSD,” he said. “The SSD uses the same interface—the SATA 2 interface—that a standard hard drive uses, so it is 100 percent compatible. The operating system doesn’t know it is an SSD. It just uses it as a hard drive. When a drive is used in a server, there are higher requirements for read-and-write cycles, which typically are better handled by the X25-E SSD. The requirements for a server deployment are different from those of an everyday workstation.”

The first reaction to the performance of Intel SSDs is typically enthusiastic. The seed program to solicit impressions from some leading game development companies yielded a number of positive comments. Tim Sweeney, CEO and founder of Epic Games said, “I experienced one of the first-generation SSDs from another vendor, and its nearly quarter-second random-access write performance left me quite jaded about SSD technology. So, when the first Intel SSD arrived, I plugged it into my laptop and was immediately astonished at the performance. The machine booted more than three times faster, and in the course of running applications, I never experienced an I/O-related delay. Between the performance and the spooky lack of hard drive chattering, it was really a game-changing experience.”

Is the Intel SSD a good fit for the game-development environment? "Game development is enormously taxing on a PC’s I/O resources because we work with enormous quantities of data—game content, compiled code, and so on,” Sweeney said. “The use of these resources is largely random-access, with frequent writes, which is the worst case for ‘Rusty Spinning Media’ technology like hard drives. Intel’s new SSDs provide an enormous boost for overall I/O performance, and for random-access writes in particular. When compiling thousands of source code files or loading game content spanning hundreds of megabytes, the opportunity for increased performance is dramatic.”

Bartosz Kijanka, VP of Engineering at Gas Powered Games, summed up his impressions after testing: “Very, very nice. I think we’d need a beefy RAIDed SCSI 320 drive array to match this kind of performance—at many times the cost. I can see the future now—and it has no moving parts.”

For another perspective from the development front, Michael Antonov, CTO of Scaleform Corporation, oversees the development and production of a vector graphics engine used in many award-winning game titles. As he describes it, "Scaleform GFx* is a solution used to display Adobe Flash*-based user interfaces, HUDs, and animated textures in games on all PC and console platforms. The major benefit of Scaleform GFx* is that it allows developers to rapidly create live, animated user interfaces by working in Flash Studio*.”

Antonov also had the opportunity to test drive an Intel SSD during the seed program. “My first impression of Intel’s SSD is that it is a high-performing drive solution that is available at very competitive prices. It performs well in many benchmarks. SSD greatly improves productivity when developing on the go. It beats any laptop drive in performance several times while using less power, which is a great thing. Fast disk performance is important for developers because of the extensive disk I/O that takes place during compilation, linking, and file searches. If these tasks are reduced, productivity improves. I wouldn’t want to have a laptop without an SSD and Intel’s SSD offers a good combination of capacity, performance, and cost.”
The growing role of SSDs in the game-development world and the potential for escalating productivity in the process has captured the imaginations of performance-bent coders and software companies engaged in data-intensive processes. The operative word is: **zoom**.

## Balancing Performance Across the Whole System

Straight-line processor performance has been the metric by which system performance has typically been measured, but this approach overlooks other aspects of system performance, such as the speed at which I/O operations with the storage system can be performed.

The speed at which those I/O operations can be accomplished makes a substantial difference in overall system behavior and responsiveness.

For example, virus-scanning software methodically searches through files on a drive to ferret out viruses and worms, causing a large impact on system performance. Many gamers routinely turn it off while playing games or installing patch updates for games. The fast access an SSD provides makes it possible to transparently perform virus-scanning operations without bogging down net system performance. Dedicated gamers can play and scan at the same
time. This kind of responsiveness, of course, translates well to a whole range of activities centered around drive access—such as cataloging photographs, installing applications, copying and exporting contacts or e-mail messages, and multitasking with Microsoft Office* applications.

The net result of relying on an SSD is marked improvement in overall system performance, as shown by the industry standard benchmark results depicted in Figure 1.

### Figure 1. Industry Standard Benchmark Performance Measurements

**Industry Standard Benchmarks**: SYSmark® 2007 Preview and PCMark* Vantage are two widely used industry benchmarks that measure the overall performance of computer systems.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Lenovo* T400* with Intel® Core™ processor T9600 with 200 GB HT 5722020K9SVA00 SATA Hard Disk Drive 7200 RPM, 8 MB cache</th>
<th>Lenovo* T400* with Intel® Core™ processor T9600 with 80 GB 1.8™ Intel® X18-M SATA Solid-State Drive</th>
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<tbody>
<tr>
<td>SYSmark 2007 Preview</td>
<td>1.11</td>
<td>1.59</td>
</tr>
<tr>
<td>PCMark Vantage - Overall</td>
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</tr>
<tr>
<td>PCMark Vantage - HDD</td>
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<td>7.71</td>
</tr>
</tbody>
</table>

![Graph showing performance improvements](Graph.png)

Intel® Solid-State Drive provides over 7x increase in disk performance

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As measured by PCMark* Vantage* HDD sub-test

Performance tests and ratings are measured using specific systems and/or components and reflect approximate performance of Intel products as measured by those tests. Any difference in system hardware, software, or configurations may affect actual performance. Buyers should consult other sources of information to evaluate performance of systems or components they are considering purchasing. For more information or performance tests and performance of Intel products, visit [www.intel.com/performance](http://www.intel.com/performance).

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Comparing Memory Cell Technologies

Specific differences in the design technologies of SSDs affect their suitability for desktop or server applications. Both single-level cell (SLC) and multi-level cell (MLC) SSDs use non-volatile solid-state NAND flash memory for storing data, but key differences affect the usage models:

Intel® X25-E Solid-State Drives

- **SLC SSDs:** With SLC technology, individual cells exist in one of two voltage states, basically storing a single bit per cell. This approach results in faster write operations and enhanced reliability. SLC SSDs have greater longevity with the capability of sustaining substantial numbers of write cycles.

  SLC SSD characteristics favor enterprise applications, in which speed and reliability are paramount. Typical applications include online transaction processing, database operations, data warehousing, enterprise resource planning, and business intelligence.

Intel® X25-M Solid-State Drives

- **MLC SSDs:** With MLC technology, four voltage states per cell can be handled, so each cell is capable of storing two bits. MLC SSDs store information at greater densities more cost effectively. Intel MLC SSDs have less longevity than their SLC counterparts, but will provide five years of useful life in client PC use. Because of their lower cost and higher capacity, MLC SSDs favor read-intensive enterprise applications, such as streaming video, and all client PC applications.

  These characteristics have a strong influence on the success or failure of a particular type of deployment. For example, using MLC SSDs for typical enterprise applications in which performance is important may lead to disappointing results. Similarly, the higher initial cost of SLC SSDs may make them unsuitable for mainstream desktop applications in which cost is a strong consideration.

Mobile Computing Perks

Power efficiency is particularly important in mobile computing. The advantages of SSDs—reduced power requirements, durability, and responsiveness—resonate well with mobile users who want all of these qualities in their selected storage system. With data loss a common concern for mobile users, the ability of the SSD to withstand shock and vibration far beyond the limits of a conventional HDD is a definite plus.

Testing conducted by Intel in the latter part of 2008 identified these key benefits of the SSD over conventional HDDs:

- Improved system performance—up to 50 percent improvement of system-level benchmarks
- Improved battery life (systems ran about 50 to 70 minutes longer between charges)
- Decreased support costs
- Quicker installation times for operating systems and applications
- No need for disk fragmentation software

For more details about the proof-of-concept study conducted by Intel, refer to the white paper *Improving the Mobile Experience with Solid-State Drives* at: [www.intel.com/go/ssd](http://www.intel.com/go/ssd).
Enterprise Advantages

Another proof-of-concept study conducted by Intel examined the ways in which SSDs contribute to the operational efficiency of the enterprise.

The test results and analysis went beyond the benchmarking of performance, power, and reliability and assessed the cost factors associated with using SSDs within the enterprise, which are currently more expensive than conventional HDDs. The study determined that when used to replace data HDDs in arrays, SSDs could deliver improved total cost of ownership, while also providing higher performance for many different I/O-intensive applications. In situations where the SSDs replaced operating system drives in servers, the study noted substantially faster performance for typical support tasks, such as builds and patches, as well as lower power consumption.

In conclusion, the study’s authors noted, “Obtaining the maximum benefit from SSDs requires a shift in how we think about disk performance. Current write caching assumptions may not apply, disk fragmentation is no longer an issue, and current RAID approaches—designed to improve performance with high-latency HDDs—may be less effective with SSDs.”

For more information about SSD enterprise applications, refer to the white paper Solid-State Drives in the Enterprise: A Proof of Concept and related white papers at: www.intel.com/go/ssd.

The Last Word

With an estimated life expectancy of 1.2 million hours mean time before failure, an operating shock capability of 1,000G for 0.5 ms, and a typical active power consumption of 150 mW, Intel SSD solutions deliver the goods for an expanding user community. For game development and digital content creation, these drives are the ideal performance match for the latest generation of Intel® Core™ processors—elevating storage performance to a level on par with multi-core processing performance capabilities.

“Intel SSDs are for everyone who needs performance,” Tim Sweeney said. “I can’t imagine installing a computer without an Intel SSD as the boot drive. Sure, if you need multi-terabyte storage to store your collection of... legally purchased... music and DVD movies, then you’d augment that with a traditional hard drive for mass storage of streaming media. But, for applications and data that you work with every day, Intel Solid-State Drives are the right technology.”

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Dates and plans are preliminary and subject to change without notice.

*Other names and brands may be claimed as the property of others.

PERFORMANCE GUIDE SYSTEM CONFIGURATIONS FOR INDUSTRY STANDARD BENCHMARKS

SOURCE: Intel® Corporation:

SYSTEM: LENOVO® T400
- Intel® Core™2 Duo processor T9600 (2.80 GHz, 6MB L2, 1066 MHz FSB),
- Platform: Mobile Intel® GM45 Express Chipset INF 8.7.0.1007,
- BIOS Lenovo® 7UET43WW 1.13 with default settings
- Memory: 2.0Gb (2x1GB) Dual Channel PC2-8500 Micron® B3SF1 2864HY-1G1D1 DDR3-1066-7-7-20
- Graphics: Integrated Mobile Intel® GM45, video driver 7.15.10.1502, 754 MB total video memory,
- Wireless Network Card: Intel® Wireless WiFi link 5300, driver Intel® V.12.0.0.75
- Display: 14” WSGA, Resolution 1440x900 (32bit), set to 73.5 nits for MobileMark® 2007 benchmark
- OS: Windows® Vista® Ultimate (Fresh install), 6.0 Build 6001 with SP1, NTFS file system, DirectX 10
- Power Management: Portable/Laptop for MobileMark® 2007 benchmark,
  Always On for other benchmarks
- Battery Capacity: 56.16 Whr
- HDD - 1: Hitachi* Travelstar* HTS722020K9SA00, SAT A 200 GB, 7200 RPM, 8 MB cache, Disk driver B56.3.1004
- HDD - 2: 1.8” Intel® X18-M SSDSA1MH080G1lE, SAT A-2 Solid State Disk, 80 GB, Disk driver B56.3.1004

*No moving parts: the promise of solid-state drives