Intel® Centrino® Duo Mobile Technology Performance Brief

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Executive Summary:

Intel® Centrino® Duo Mobile Technology

On July 29th 2006, Intel® Corporation introduced the revolutionary Intel® Core™ 2 Duo processor as an upgrade to existing Intel® Centrino® Duo mobile technology platforms. The Intel® Centrino® Duo Mobile Technology platforms were introduced in January 2006, enabling a whole new generation of thin and light notebook PCs that are designed to enable outstanding performance and improved battery life over previous generation Intel® Centrino® Mobile Technology platforms.

The addition of the Core™ 2 Duo processor to Intel® Centrino® Duo Mobile Technology laptops take these platforms to an even higher level of outstanding performance. Intel® Centrino® Duo platforms feature the following three components working together:

- Intel® Core™ 2 Duo Processor
- Mobile Intel® 945 Express Chipset Family
- Intel® PRO/Wireless 3945ABG Network Connection

The Intel® Core™ 2 Duo processor is Intel's second-generation mobile dual-core processor designed to deliver breakthrough performance with great power savings for improved battery life. With the new Intel Core™ 2 Duo processor with 4 MB cache, you'll experience more performance when doing processor-intensive tasks like multitasking compared to previous-generation laptops with the Intel® Core™ Duo processors. and even greater performance increases when doing processor-intensive tasks like multitasking compared to previous generation Intel® Centrino® based laptops. It delivers this outstanding performance boost while maintaining the same great power savings of Intel® Centrino® Duo mobile technology platforms with the Intel® Core™ Duo processor.

The Mobile Intel® 945 Express Chipset Family is the next generation Intel Hub Architecture for the notebook PCs using Intel® Centrino® Duo Mobile Technology. The Mobile Intel® 945 chipset family offers higher performance for flexible and scalable platforms based on integrated graphics (945GM/GMS) or discrete graphics (945PM).

The Mobile Intel® 945GM chipset with Intel® Graphics Media Accelerator (GMA) 950 delivers exceptional improvements in graphics performance over the previous generation chipset, the Intel® 915GM. The Mobile Intel® 945 Express chipset family also supports dual channel DDR2 memory @ 667MHz, which enables system performance gains on applications that benefit from increased memory bandwidth. Graphics intensive applications, gaming applications, and scientific / technical computing applications all benefit from the improvement in peak memory bandwidth. The Mobile Intel® 945 Express Chipset Family also includes support for native HW acceleration for multi-streaming MPEG-2 (SD & HD) video encode/decode that enables simultaneous playback and record and picture in picture and adaptive de-interlacing enables enhanced visual quality of interlaced content on progressive displays. Features such as Intel® Display Power Saving Technology 2.0 and Intel® Dual Frequency Graphics Technology deliver improved power savings.

The Intel® PRO/Wireless 3945ABG Network Connection is advancing WLAN performance of standard Wi-Fi networks, and supports enhanced features that make applications more aware, connected, and responsive, delivering a better on-the-go end-user experience. Available in a smaller PCIe mini-card form factor, the Intel PRO/Wireless 3945ABG Network Connection helps enable lighter and thinner notebooks. With the available Intel® PROSet/Wireless software version 10, enterprise users can take advantage of new IT administration tool capabilities and an API built around 802.11e QoS for VoIP.

This performance brief highlights the features and technologies that make the Intel® Centrino® Duo Mobile Technology-based laptops an outstanding mobile platform. It also shows how Intel® Centrino® Duo Mobile Technology currently performs on each of the respective benchmarks. When new benchmarks are introduced, this performance brief will be updated as appropriate.

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1. Introduction

The Intel® Core™ 2 Duo Processor delivers low power and efficient breakthrough mobile performance and responsiveness for demanding business users and consumers alike to concurrently execute multiple threads and run multiple intense applications simultaneously. It includes several innovative features such as a power-optimized 667MHz system bus, 4 MB level-2 shared Intel® Advanced Smart Cache, enhanced power management and power saving features such as Intel® Dynamic Power Coordination, Enhanced Intel® Deeper Sleep with Dynamic Cache Sizing and Enhanced Intel® SpeedStep® Technology. The Intel® Core™ 2 Duo processor also features an enhanced data cache pre-fetch logic, deeper write output buffers and Intel® Advanced Digital Media Boost, a micro-architectural performance enhancement for multimedia and floating point applications. Furthermore, the Intel® Core™ 2 Duo Processor provides support for Intel® Virtualization Technology - a set of hardware enhancements to Intel server and client systems which, combined with the appropriate software, enables enhanced virtualization robustness and performance for both enterprise and consumer uses.

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Notebook PC performance does not depend on the microprocessor alone. Hardware and software system components—such as the operating system, the graphics and I/O subsystems, application software, and memory—may significantly affect performance results. For this reason, this Performance Brief illustrates Intel® Centrino® Duo Mobile Technology performance on a consistent notebook PC configuration. Details of the notebook PC configuration used for the performance scores throughout this brief can be found in Appendix A.

2. The Intel® Core™ 2 Duo Processor

Intel® Centrino® Duo mobile technology platforms now feature the revolutionary new Intel® Core™ 2 Duo processor with the existing Mobile Intel® 945 Express Chipset Family and Intel® PRO/Wireless 3945ABG Network Connection wireless components.

The Intel® Core™ 2 Duo processor is Intel's second-generation mobile dual-core processor designed to deliver breakthrough performance with great power savings for improved battery life. Key performance and power management features are detailed below:

Optimized Performance Technologies

Dual-Core Technology

Two mobile-optimized execution cores in a single processor designed to increase performance and power savings.

Intel® Wide Dynamic Execution

Intel Wide Dynamic Execution improves performance and efficiency as each core can complete up to four full instructions simultaneously using an efficient 14-stage pipeline.

Intel® Advanced Smart Cache

With up to 4 MB L2 shared cache compared to 2MB L2 on the Intel® Core™ Duo processor, the Intel® Core™ 2 Duo processor offers even more efficient data sharing, providing enhanced performance, responsiveness and power savings.

Intel® Advanced Digital Media Boost

Intel Advanced Digital Media Boost delivers enhanced performance for a broad range of applications including video, speech and image, photo processing, encryption, financial, engineering and scientific. It provides two times the streaming media compute throughput compared to the Intel Core Duo processor.

Intel® Smart Memory Access

Intel Smart Memory Access improves system performance by optimizing available bandwidth in the system bus and memory subsystems; it reduces memory latencies to provide data to the processor when and where it's needed.

Intel® 64

An enabling technology that can take advantage of 64-bit operating systems (like Microsoft Vista*) and applications as they become available.

Power-Optimized 667 MHz Front Side Bus

Provides increased data bus bandwidth, vs. prior generations, for faster data transfer to help meet the requirements of demanding applications.

Intelligent Power Capability

Mobile Unique Features:

Intel® Dynamic Power Coordination

Coordinates Enhanced Intel® SpeedStep® technology and idle power-management state (C-states) transitions independently per core to help save power.

Enhanced Intel® Deeper Sleep with Dynamic Cache Sizing

Saves power by flushing cache data to system memory during periods of inactivity to lower CPU voltage.

Other Features:

Advanced Power Gating

Allows parts of the CPU core to be shut down even during periods of high-performance execution to optimize performance per watt.

Split Bus Array

Many buses and arrays are split so data required in some modes of operation can be put in a low-power state when not needed for power savings.

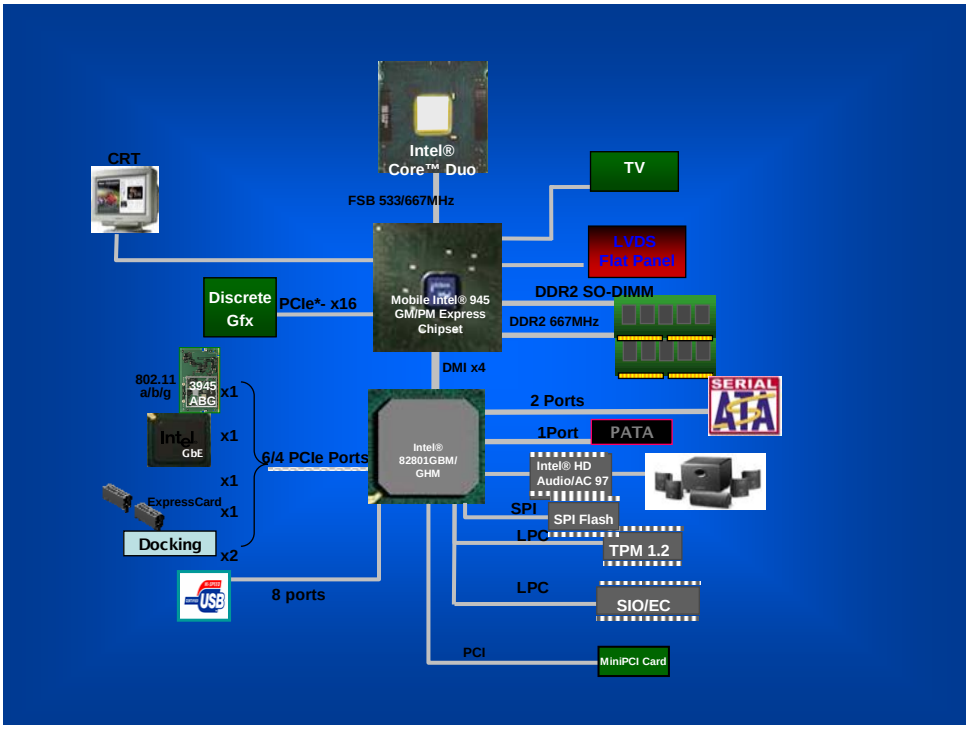
Dynamic Cache Sizing

Dynamic Cache Sizing enables the Intel Advanced Smart Cache to dynamically flush data to system memory based on demand for power savings.

3. Mobile Intel® 945 Express Chipset Family Feature Highlights

The Mobile Intel® 945 Express Chipset Family is the next generation Intel Hub Architecture for the notebook PCs using Intel® Centrino® Duo Mobile Technology.

The Mobile Intel® 945 chipset family offers higher performance for flexible and scalable platforms based on integrated graphics (945GM/GMS) or discrete graphics (945PM). The Mobile Intel® 945GM chipset with Intel Graphics Media Accelerator 950 delivers exceptional improvements in graphics performance over the previous generation chipset, the Intel® 915GM. The Mobile Intel® 945 Express chipset family also supports dual channel DDR2 memory @ 667MHz, which enables system performance gains on applications that benefit from increased memory bandwidth. Graphics intensive applications, gaming applications, and scientific / technical computing applications all benefit from the improvement in peak memory bandwidth.



In addition to advanced application support, the Mobile Intel® 945GM chipset was designed with the following features to enhance the end-user experience:

- 667 MHz system bus delivers a high bandwidth connection between the Intel® Core™ 2 Duo processor and system memory.

- Native HW acceleration for multi-streaming MPEG-2 (SD & HD) video encode/decode that enables simultaneous playback and record and picture in picture.
- Adaptive de-interlacing enables enhanced visual quality of interlaced content on progressive displays.
- Intel® Dual Frequency Graphics Technology support that allows the chipset to dynamically switch render clock frequency to match graphics workloads delivering enhanced power savings.
- 4GB maximum memory support
- Support for Dual Channel DDR2 400/533/667-MHz Memory Technology with peak bandwidth up to 8.5GB/s, a 60% improvement in peak bandwidth over DDR533
- PCI Express Bus Architecture delivers a 4x increase in discrete graphics bandwidth and a 2x increase in I/O bandwidth
- Intel® High Definition Audio with increased bandwidth that enables 32-bit output and 192-kHz multi-channel audio. Multi-streaming capabilities enable support for separate audio channels with independent audio streams to different devices.
- Integrated high speed USB 2.0 enables up to 15x faster data transfer rate of USB 1.1 and backward compatibility to support for USB 1.1 devices. The Mobile Intel® 945 Express chipset family provides support for 8 USB 2.0 peripherals.
- Direct Media Interface (DMI) with up to 2-GB/sec concurrent bandwidth. DMI provides up to 4x faster I/O bandwidth compared to previous Intel proprietary Hub link I/O interface.
- Integrated low voltage differential signal (LVDS) interface that enables the notebook display panel to connect directly to the chipset and eliminates the need for a video controller hub component. The result is higher integration for savings in mother board space and reduced bill of materials cost for OEMs.
- Dual Independent Display allows viewing two independent video sources when an external monitor or panel is connected to the notebook.
- Intel® Stable Image Technology is a capability built into the chipset and enabled in the BIOS. This silicon technology provides greater IT software image stability by enabling simple chipset hardware changes without triggering the "new hardware found" message—eliminating automatic and unnecessary re-qualification.
- Serial ATA is a storage interface technology that provides up to 150-MB/Sec transfer rate for disk traffic and provides aggressive link power management functionality.
- Intel® Display Power Saving Technology 2.0 (Intel® DPST 2) reduces display backlight power by up to 400-mW with minimal visual impact to the end user (depending on Intel DPST settings and system use).
- DDR2 Memory self-refresh provides chipset and DIMM power savings by putting memory into a reduced power state when display is still active on DDR2 based platforms.
- Integrated TV Out functionality provides the ability to use a TV as an output device for movie playback, digital images, and gaming.
- DirectX* 9 integrated graphics solution for high definition playback and 3D games.

- Support for wide aspect ratio display modes.

4. Intel® PRO/Wireless 3945ABG Network Connection Product Feature Highlights

The Intel PRO/Wireless 3945ABG Network Connection is advancing WLAN performance of standard Wi-Fi networks, and supports enhanced features that make applications more aware, connected, and responsive, delivering a better on-the-go end-user experience. Available in a smaller PCIe mini-card form factor, the Intel PRO/Wireless 3945ABG Network Connection helps enable lighter and thinner notebooks. With the available Intel® PROSet/Wireless software version 10, enterprise users can take advantage of new IT administration tool capabilities and an API built around 802.11e QoS for VoIP.

Advancing WLAN performance and Network Robustness

- Improved performance in noisy environments
- Business Class Wireless Suite, consisting of Optimal AP Selection Technology and Enhanced VoIP Quality Technology
- New API built to take advantage of 802.11e QoS for VoIP

Enhanced Manageability

- Updated IT Administrator Tool providing centralized deployment and control for IT Administrators
- Install package creator to create and distribute profiles, user settings and software updates
- Wake on WLAN

Superior Security

- Cisco Compatible Extensions v4
- Continued support for 802.11i
- Enhanced GUI making it simpler to connect to secure networks.

In addition to the core benefits of Intel® Centrino® Duo Mobile Technology, additional highlights of the Intel® PRO/Wireless 3945ABG Network Connection include:

- Intel Next Generation Silicon Radio and Mac
- Compact packaging with PCIe mini-card single sided PCB (~1/2 size of mPCI)

- New Value Added Features and Functionality
    - VoIP support
    - Intelligent Networking
    - Wake on Wireless LAN (WoWLAN)
    - Improved interference immunity
    - More flexible power management
    - Improved Tx/Rx performance
- Key Standards
    - 802.11a/b/g
    - 802.11e EDCA w/ Admission Control (for QoS)
    - 802.11i (security)
- Security
    - WEP (64 & 128 bit)
    - WPA, WPA2 / 802.11i
    - EAP-FAST
- Certifications
    - Wi-Fi, WHQL, WMM, WPA2
    - Cisco Compatible Extensions
- Available Intel® PROSet/Wireless software version 10 enables a superior mobile experience with:
    - Enhanced, even simpler User Interface
    - Added IT Administration Tool capabilities
    - Install package creator
    - Central control over driver & app settings
    - Single Sign On for networks
    - Enhanced VoIP usage model
    - New VoIP API for QoS
    - VoIP profiles and statistic reporting

- Wide band codec support
- Additional profile mgmt capabilities
- OS: Windows XP, Windows 2000, Linux (driver only)

5. Performance Summary

Productivity Performance: SYSmark* 2004 SE

SYSmark* 2004 SE is BAPCo*'s mainstream office productivity and Internet content creation benchmark tool used to characterize the performance of the business client. It features user-driven workloads and usage models developed by application experts as well as reflects current and emerging computing trends and the recommended benchmark for measuring productivity performance. http://bapco.com/

Figure 1. Intel® Centrino® Duo mobile technology Performance on SYSmark* 2004 SE

Consumer Performance: PCMark*05

PCMark*05 test from FutureMark* is a tool for measuring PC performance for home usage. PCMark measures system level performance as well as individual PC component. http://futuremark.com/products/pcmark05/

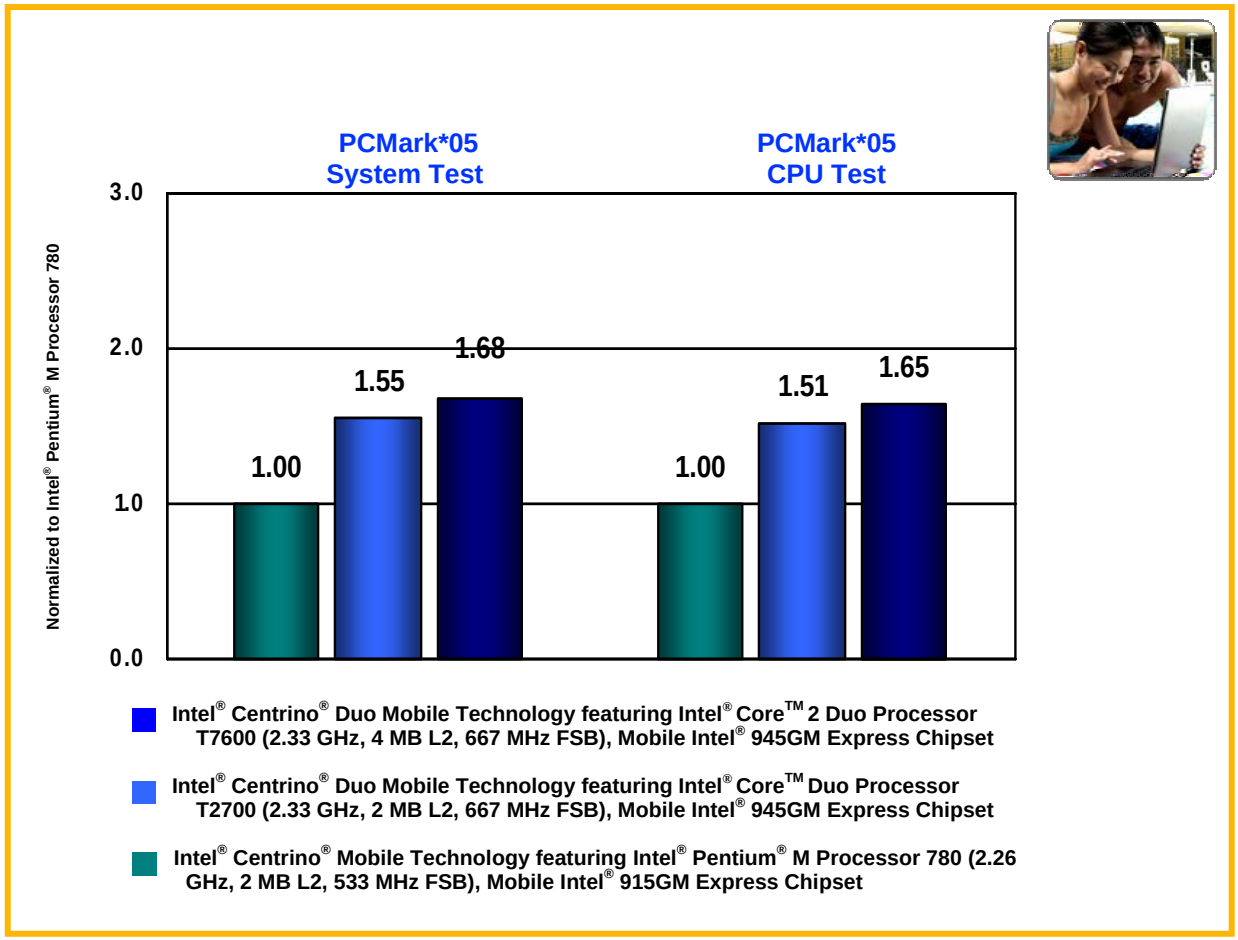


Figure 2. Intel® Centrino® Duo mobile technology performance on PCMark*05 System and CPU Test

3D Experience: 3DMark*05

3DMark* 2005 from FutureMark* is a benchmarking tool that combines DirectX* 9.0 support with unique tests and graphics. The CPU test measures the contribution of the processor on 3D graphical performance while the Game Test measures game simulation performance. http://futuremark.com/products/3dmark05/

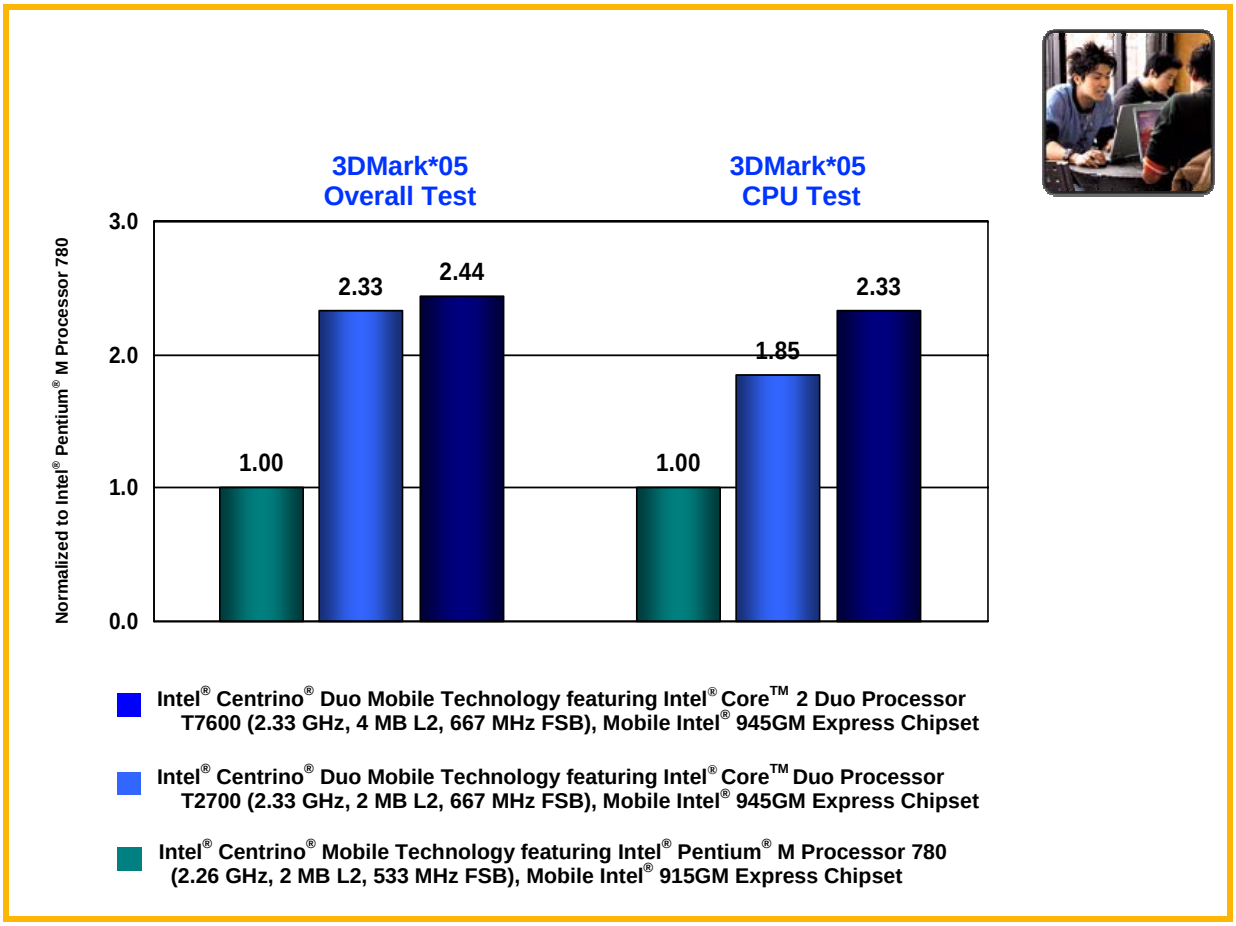


Figure 3. Intel® Centrino® Duo mobile technology performance on 3DMark*05 overall and CPU test

Productivity Power and Performance: MobileMark* 2005

MobileMark* 2005 is a benchmark used to evaluate notebook PC user experience by measuring both performance and battery life at the same time on the same workload. The productivity usage model provides computations representing today's business users using popular office productivity and content creation applications.
http://bapco.com/

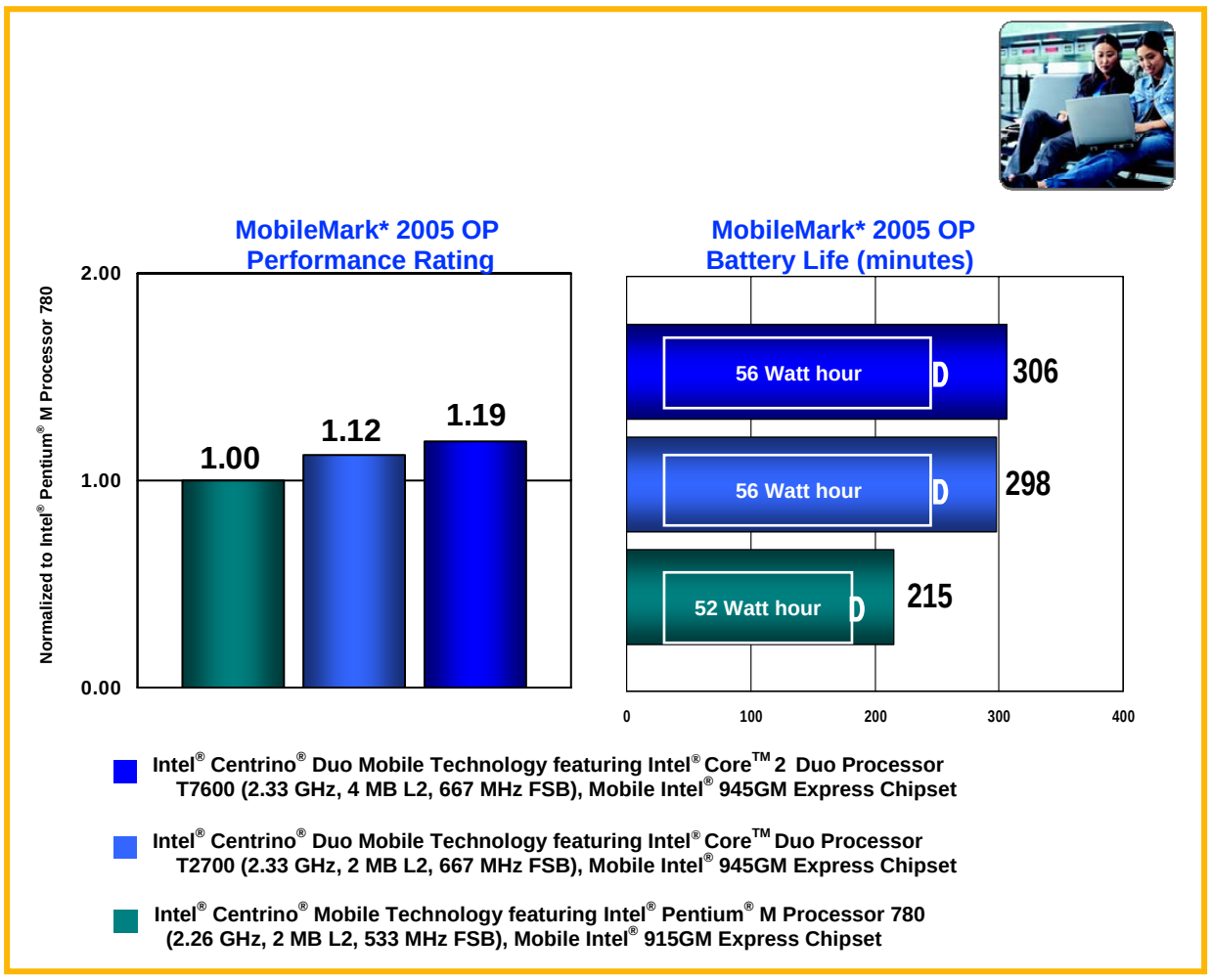


Figure 4. Intel® Centrino® Duo mobile technology performance on 3DMark*05 overall and CPU test

Scientific Experience: SPEC* CPU2000

SPECint_rate_base2000 and SPECfp_rate_base2000 are capacity-based metrics used to measure throughput of a computer that is performing a number of tasks. This is achieved by running multiple copies of each benchmark simultaneously with the number of copies set to the number of logical hardware cores seen by the operating system. http://www.spec.org/

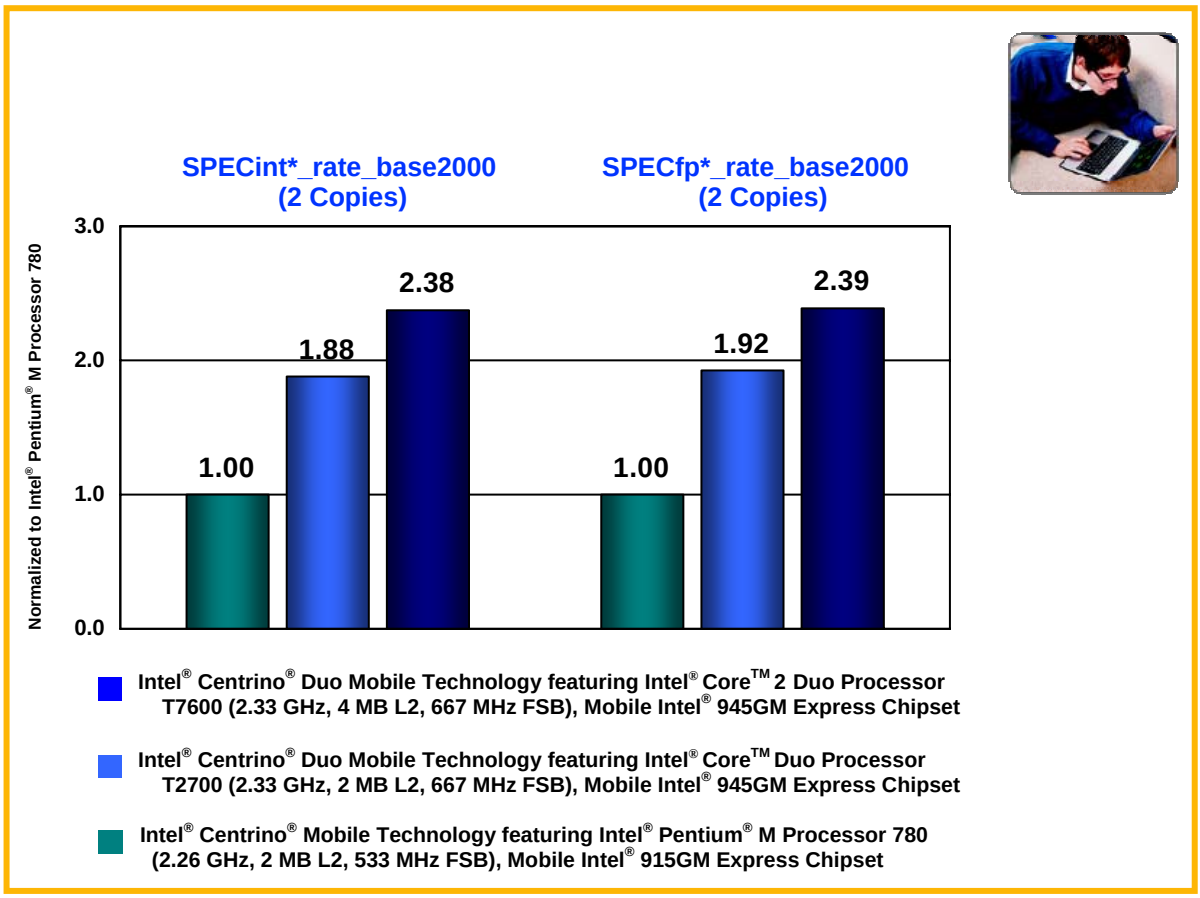


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Figure 5. Intel® Centrino® Duo mobile technology performance on SPEC* CPU2000 Rate - 2 copies

6. Summary of Benchmark Results

Table 1 summarizes the benchmark performance of Intel® Centrino® Duo Mobile Technology featuring the Intel® Core™ 2 Duo processor T7600 and Intel® Core™ Duo processor T2700, Intel® Centrino® Mobile Technology featuring Intel® Pentium® M processor 780.

Benchmarks	Intel® Centrino® Mobile Technology featuring Intel® Pentium® M processor 780	Intel® Centrino® Duo Mobile Technology featuring Intel® Core® Duo processor T2700	Intel® Centrino® Duo Mobile Technology featuring Intel® Core® 2 Duo processor T7600
SYSmark* 2004 SE – Overall Score	182	243	273
PCMark*05 – Overall Score	2350	3646	3957
PCMark*05 – CPU Test	3587	5399	5909
3DMark*05 – Overall Test	254	593	621
3DMark*05 – CPU Test	2259	4186	5261
MobileMark* 2005 – OP Battery Life (minutes)	215	298	306
MobileMark* 2005 – OP Performance Rating	253	283	300
SPECint*_rate_base2000 (2 Copies)	20.7	38.9	49.2
SPECfp*_rate_base2000 (2 Copies)	15.7	30.1	37.6

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For more information go to: http://www.spec.org/spec/trademarks.html

Table 1. Performance Data

Appendix A: Notebook PC Configuration

Table 2. Notebook PC Configuration Used for Performance Measurement

Intel® Mobile System	Intel® Centrino® Mobile Technology	Intel® Centrino® Duo Mobile Technology	Intel® Centrino® Duo Mobile Technology
Processor Name	Intel® Pentium® M Processor 780	Intel® Core™ Duo Processor T2700	Intel® Core™ 2 Duo Processor T7600
Processor Speed	2.26 GHz	2.33 GHz	2.33 GHz
Front Side Bus	533 MHz	667 MHz	667 MHz
Processor Secondary Cache	2MB Level 2 Cache	2MB Level 2 Cache	4MB Level 2 Cache
OEM Laptop	Lenovo* ThinkPad* T43 (Modified)	Lenovo* ThinkPad* T60 (Pre-production)	Lenovo* ThinkPad* T60 (Pre-production))
Chipset	Mobile Intel® 915GM Express Chipset	Mobile Intel® 945GM Express Chipset	Mobile Intel® 945GM Express Chipset
Wireless Network Card	Intel® 2915 ABG with driver 9.0.4.13	Intel® PRO/Wireless 3945ABG with driver 10.1.1.3	Intel® PRO/Wireless 3945ABG with driver 10.1.1.3
Platform BIOS	IBM* 70ET66WW with default settings	Lenovo* V.79ETB0WW with default settings	Lenovo* V.79ETB0WW with default settings
Memory Size	2x512 MB Samsung PC2-4200 DDR2-533 4-4-4-12	2x512 MB NANYA PC2-5300S DDR2-667 5-5-5-12	2x512 MB NANYA PC2-5300S DDR2-667 5-5-5-12
Chipset INF File	Intel® INF 6.1.0.1008	Intel® INF 7.1.1	Intel® INF 7.1.1
Hard Disk	Hitachi* TravelStar* (Lenovo* Part #13N6807) 60GB 7200RPM	Hitachi* HTS721010G9 SATA 100GB 7200RPM	Hitachi* HTS721010G9 SATA 100GB 7200RPM
DirectX* Version	DirectX* 9.0c	DirectX* 9.0c	DirectX* 9.0c
Video Controller	Intel® Graphics Media Accelerator (GMA) 900	Intel® Graphics Media Accelerator (GMA) 950	Intel® Graphics Media Accelerator (GMA) 950
Video Memory Size/Type	128MB Dynamic Video Memory Technology	128MB Dynamic Video Memory Technology	128MB Dynamic Video Memory Technology
Video Driver Revision	6.14.10.4466	6.14.10.4436	6.14.10.4436
Operating System	Microsoft* Windows* XP Professional, Build 2600, Service Pack 2 on NTFS	Microsoft* Windows* XP Professional, Build 2600, Service Pack 2 on NTFS	Microsoft* Windows* XP Professional, Build 2600, Service Pack 2 on NTFS
Graphics	1024x768 resolution, 32-bit color XGA	1024x768 resolution, 32-bit color XGA	1024x768 resolution, 32-bit color XGA

Network Card	Integrated Broadcom* NetXtreme* Gigabit Ethernet	Intel® PRO/1000 PL	Intel® PRO/1000 PL
Battery Capacity	52 WHr	56 WHr	56 WHr
Weight	5.25 lbs	5.00 lbs	5.00 lbs
Screen Size	14.1"	14.1"	14.1"
Screen Brightness	~65 nits	~78 nits	~78 nits
Power Management Mode for MobileMark* 2005	Portable Laptop	Portable Laptop	Portable Laptop
Power Management Mode for all other Benchmarks	Always On	Always On	Always On

For more information on Intel® Processor Numbers, go to www.intel.com/products/processor_number/index.htm.

Wireless connectivity and some features may require you to purchase additional software, services or external hardware. Availability of public wireless LAN access points limited and some hotspots may not support Linux-based Intel® Centrino® mobile technology systems. System performance measured by MobileMark* 2005. System performance, battery life, wireless performance and functionality will vary depending on your specific operating system, hardware and software configurations. See http://www.intel.com/products/centrino/more_info for more information.

Performance is measured on pre-production systems and BIOS. Final benchmarks based on the final production system and BIOS may vary from these results. Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, visit http://www.intel.com/performance/resources/limits.htm.