



Performance Benchmarks for Intel® Integrated Performance Primitives

on Intel® Pentium® and Intel® Itanium® Processors

Executive Summary

The Intel® Integrated Performance Primitives (Intel® IPP) is a cross-architecture software library that provides a range of library functions for multimedia, audio codecs, video codecs (for example, H.263 and MPEG-4), image coding (for example, JPEG), image processing, signal processing, speech compression (for example, G.723, GSM AMR), cryptography, and computer vision, as well as math support routines for such processing capabilities. Intel IPP is optimized for the broad range of Intel microprocessors, including:

- Intel® Pentium® 4 processor
- Intel® Pentium® M processor component of Intel® Centrino™ mobile technology
- Intel® Itanium® 2 processor
- Intel® Xeon™ processor
- Intel® PCA application processors based on the Intel® XScale™ microarchitecture

With a single API across the range of architectures, independent software vendors can achieve platform compatibility and reduced development costs. Intel IPP

also provides an extensive list of encoder-decoder samples to speed your application, component, and codec development.

This paper presents a performance summary for a range of functionality enabled by Intel IPP. This performance illustration has been provided utilizing the Intel IPP performance test suite¹ and a subset of the encoder-decoder samples.²

Performance Overview

Figure 1 shows the average performance gain for eight of the Intel IPP application domains. These results are derived from test suite data available with Intel IPP, a suite of data providing over 61,000 test vectors.¹ The test vectors include several problem sizes and data types for each function in the Intel IPP library. The tests were run on a PC with a Pentium 4 processor running at 2.8 GHz, with 256 KB of L2 cache and 512 MB of memory using Microsoft Windows* XP.

The gray columns in the graph indicate the performance gain obtained from the IPP code optimized for the Pentium III processor as compared

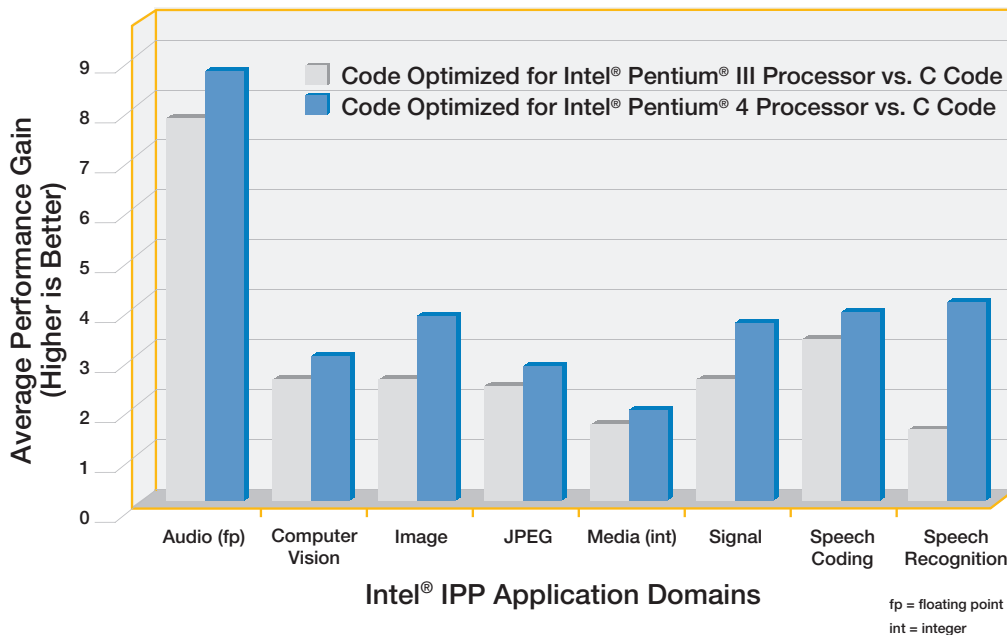


Figure 1. Average Intel® IPP Performance Gain over Compiled C Code³

to the compiled C version. The blue columns indicate the performance gain obtained from the IPP code optimized for the Pentium 4 processor as compared to the compiled C version. These results show the substantial performance gain obtained by using Intel IPP, and the average performance gain obtained by using the run-time dispatching mechanism in Intel IPP to select the correct processor version for the host processor. With pre-built library functions optimized for the various Intel microprocessors, developers are saved from hand coding processor-specific optimization work.

The results illustrated in Figure 1 are averages. Performance gains for individual functions and different problem sizes will vary. The number of test vectors for the different domain areas varies as: Audio - 157, Computer Vision - 948, Media - 450, JPEG - 600, Signal Processing - 20,500, Image Processing - 16,750, Speech Coding - 330, Speech Recognition - 21,850. The data used for this graph is available as part of the test suite data available with Intel IPP. Test applications are provided for both the Windows and Linux* operating systems.

JPEG Still Image Encode/Decode Performance

JPEG (Joint Photographic Experts Group) is a lossy compression method standardized by the International Standards Organization in August 1990. JPEG encoding and decoding is commonly used in commercial applications for handling still images. Such encode-decode capability can be enhanced for improved performance using Intel IPP. The graphs in Figures 2 and 3 show the performance gains achieved by utilizing the optimized Intel IPP functionality for a variety of JPEG encoder and decoder implementations, using samples available with Intel IPP.⁴

JPEG Encode

Figure 2 shows JPEG encoding performance for a variety of image frame sizes over a range of nearly three orders of magnitude.

Interestingly, performance varies almost linearly with the size of the image. Web, e-mail, and handheld sizes are represented by 160x120 and 320x240 image tests.⁵ High-resolution scanner images are represented by 1024x768 and 4096 (4K) x 4K image tests.⁵



Figure 2. JPEG Encode Performance Results³

The *IJG Encoder Reference* curve (blue line) shows the performance of the C-implemented reference code compiled with Pentium 4 processor optimizations using the Intel® C and C++ compilers.⁶

The *IJG Encoder with Intel IPP* curve (light green line) shows the performance of the IJG implementation with Intel IPP functions substituted for similar components in the reference implementation. You can see that over a variety of image sizes, by using Intel IPP, the encode time is reduced.

The light pink and hot pink lines show the performance of two other JPEG samples available with Intel IPP.

The *JPEG Encoder sample with Intel IPP* (light pink line) shows the performance of the JPEG sample built with Intel IPP functions. Startup overhead reduces the performance for small images versus for larger images.

The *JPEG Viewer sample encoder* (hot pink line) shows the best performance. The performance gain of the JPEG Viewer sample encoder over the IJG reference encoder is greater than three times faster as seen over all of these image sizes.

These measurements were made using a PC with a Pentium 4 processor at 3.06 GHz, with 512 KB of L2 cache and 512 MB of memory running the Windows XP operating system. A logarithmic scale was used for ease of representation.

JPEG Decode

Figure 3 shows JPEG decode performance for a variety of image frame sizes over a range of nearly three orders of magnitude.

As with JPEG encode, performance varies almost linearly with the size of the image. Web, e-mail, and handheld sizes are represented by 160x120 and 320x240 image tests.⁵ High-resolution scanner images are represented by 1024x768 and 4096 (4K) x 4K image tests.⁵

The *IJG Decoder Reference* curve (light pink line) shows the performance of the C-implemented reference code compiled with Pentium 4 processor optimizations using the Intel C and C++ compilers.⁶

The *IJG Decoder with Intel IPP* curve (light green line) shows the performance of the IJG implementation with IPP functions substituted for similar components in



Figure 3. JPEG Decode Performance Results³

the reference implementation. You can see that over a variety of image sizes, by using Intel IPP, the decode time is reduced.

The blue and hot pink lines show the performance of two other JPEG samples available with Intel IPP.

The *JPEG Decoder with Intel IPP* curve (blue line) shows the performance of the JPEG sample built with Intel IPP functions. Startup overhead reduces the performance for small images versus for larger images.

The *JPEG Viewer sample decoder* (hot pink line) shows the best performance. The performance improvement for the JPEG Viewer decoder over the IJG reference is greater than 1.5 times faster as seen over all of these image sizes.

These measurements were made using a PC with a Pentium 4 processor at 3.06 GHz, with 512 KB of L2 cache, 512 MB of memory running the Windows XP operating system. A logarithmic scale was used for ease of representation.

About These Samples

The IJG encoder-decoder sample provided with Intel IPP is an example of implementing the IJG JPEG library using embedded Intel IPP primitives. The Independent JPEG Group (IJG, see <http://www.iijg.org>) library is well known among multiple JPEG libraries and codecs that have been created since the first JPEG standard was published. Created as an example of the JPEG standard implementation, the IJG library has established a positive reputation because of its portable, effective, stable, and reliable code, as well as due to providing access to the JPEG low-level data.

New technologies implemented in the last generation of microprocessors with Streaming SIMD instructions provide a good opportunity for the application programmers to increase performance of the JPEG codecs. To take full advantage of the new architecture and thus achieve a performance gain, developers find

it more effective to use embedded Intel IPP functions rather than to write programs straight in assembler for the new instruction set.

The JPEG sample provided with Intel IPP provides high-performance JPEG encoding and decoding of full color and grayscale still images. This sample provides an easy-to-use programming interface without sacrificing low-level JPEG control for advanced developers. The sample includes functionality that is typically necessary when working with JPEG images, and includes pre-processing and post-processing options like sampling and color space conversions. The JPEG sample also supports JFIF file format as well as streams extracted from JPEG-TIFF and FlashPix* file formats.

The JPEG Viewer sample available with Intel IPP is an example of implementing an application to open, view, and create JPEG files including the encoding and decoding process of a JPEG codec.

MPEG Video Encode and Decode Performance

The Moving Picture Experts Group (MPEG), a working group of ISO/IEC, provides definition standards for the coded representation of digital audio and video. MPEG-2 is a standard for Video CD, MP3, and HDTV. MPEG-4 is a standard for multimedia for the fixed and mobile web. Intel IPP can be used to implement high-performance solutions for MPEG encoders and decoders.

MPEG-2 Encoding and Decoding

Figure 4 shows the performance gains provided by utilizing the optimized Intel IPP functionality for MPEG-2 decode and encode performance for a variety of frame sizes and frame rates.

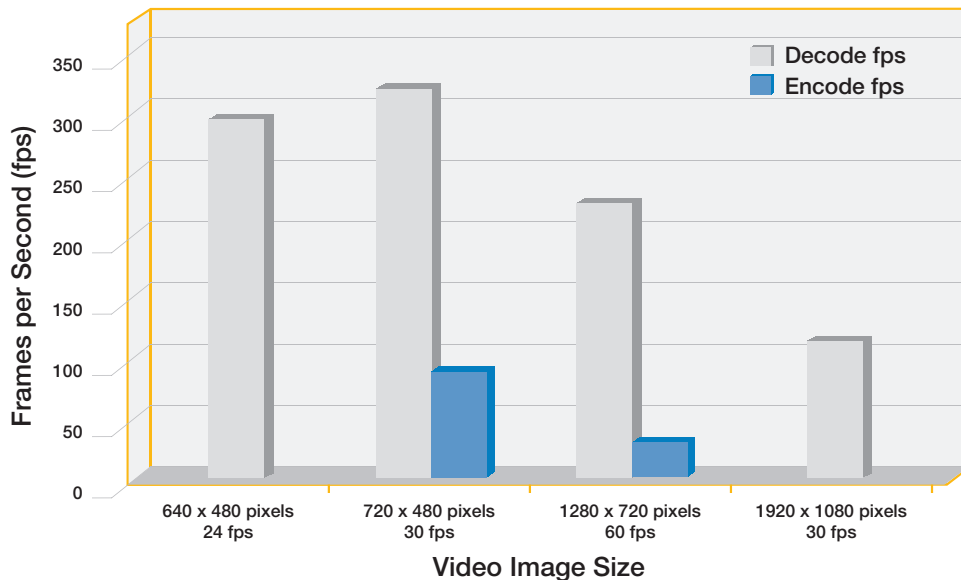


Figure 4. MPEG-2 Decode and Encode Performance Results³

Multiple video image sizes and frame rates, expressed in frames per second (fps), have been used to illustrate various video clip uses, such as 640x480x24fps video clips² common with DVD movies, 720x480x30fps for DVD standard video,^{7,8} 1280x720x60fps for HDTV progressive mode^{9,10} (often used in sports videos) and 1920x1080x30fps for HDTV interlaced clips.¹¹

The gray bars show the decode frame rate (frames per second) and the blue bars show the encode performance. Each shows that using Intel IPP functions provides a decode (or encode) rate much faster than the rate of the clip for all examples sited. This means that the processor has the bandwidth to not only decode the clip at the appropriate visual player frame rate, but can also process other critical tasks for the applications running on the platform at that time. These tests were run using a variety of test clips⁷⁻¹¹ with the MPEG-2 encoder-decoder samples⁴ available with Intel IPP and run on a PC with a Pentium 4 processor at 3.06 GHz, with 512 KB of L2 cache and 512 MB of memory running the Windows XP operating system.

About These Samples

The MPEG encoder and decoder samples provided with Intel IPP illustrate methods for building a MPEG-2 based decoder and encoder functionality using Intel IPP. These samples may also be useful for implementations using Intel IPP in support of high definition video (for example, HD, HDTV, High-Definition Television).

Conclusion

The Intel Integrated Performance Primitives software library offers many benefits to optimize your code:

- No more hand-coding, processor-specific optimizations
- Get your optimized applications to market faster
- Enjoy the ease of portability of performance-based applications across Intel microprocessors

The built-in dispatcher saves you time by choosing the best optimizations and automatically dispatching run-time processor-to-processor-specific code.

Try It Today!

The performance, compatibility, and support provided by the full range of Intel software development products is something best experienced. Try the Intel Integrated Performance Primitives software library today by visiting <http://www.intel.com/software/products>

References and Downloads

For additional information regarding the Intel Integrated Performance Primitives software library product line: <http://www.intel.com/software/products/ipp/>

For information regarding the Intel C++ Compiler for Windows and Linux: <http://www.intel.com/software/products/compilers/>

For information regarding training for Intel software products: <http://www.intel.com/software/college>

For information regarding Intel® Premier Support: <http://premier.intel.com>

For JPEG standards information: <http://www.jpeg.org/>

For Frequently Asked Questions (FAQs) regarding JPEG:

- <http://www.faqs.org/faqs/jpeg-faq/part1/>
- <http://www.faqs.org/faqs/jpeg-faq/part2/>

For information regarding the Independent JPEG Group (IJG): <http://www.iijg.org/>

For MPEG standards information: <http://mpeg.telecomitalia.com/>

¹ Performance Test Suite utility and data available with Version 3.0 of Intel IPP.

² MPEG 640x480x24 Decoder Test clip: "Terminator 2 - Judgment Day*" DVD movie clip (mpg file) Chapter 60, Time codes 1 hour 53 minutes 58 seconds to 1 hour 56 minutes 00 seconds.

³ Performance tests and ratings are measured using specific computer systems and/or components and reflect the appropriate performance of Intel products as measured by those tests. Any difference in system 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, go to <http://www.intel.com/software/products>.

⁴ Intel IPP encoder-decoder samples available with Version 3.0 of Intel IPP.

⁵ JPEG test clips available on Intel® Premier Support, for registered customers: JPEGFiles.zip, <http://www.intel.com/software/products/support>.

⁶ IJG encode and decode reference source available through the Independent JPEG Group (IJG) at <http://www.iijg.org>

⁷ MPEG 720x480x30 Decoder Test clip: "A Bug's Life*" DVD movie clip (mpg file) Chapter 5, Time codes 0 hour 13 minutes 14 seconds to 0 hour 25 minutes 00 seconds.

⁸ MPEG 720x480x30 Encoder Test clip: "A Bug's Life" DVD movie clip (yuv file) Chapter 5, Time codes 0 hour 13 minutes 14 seconds to 0 hour 25 minutes 00 seconds.

⁹ MPEG 1280x720x60 Decoder Test clip: MPEG-2/ATSC stream. MPEG-2 /ATSC Syntax Bit Streams available from Sarnoff Corporation, http://www.sarnoff.com/products_services/video_vision/compliance_bitstreams/index.asp.

¹⁰ MPEG 1280x720x60 Encoder Test clip: MPEG-2/ATSC stream. MPEG-2 /ATSC Syntax Bit Streams available from Sarnoff Corporation, http://www.sarnoff.com/products_services/video_vision/compliance_bitstreams/index.asp.

¹¹ MPEG 1920x1080x30 Test clip: MPEG-2/ATSC stream. MPEG-2 /ATSC Syntax Bit Streams available from Sarnoff Corporation, http://www.sarnoff.com/products_services/video_vision/compliance_bitstreams/index.asp.



Intel Corporation
2200 Mission College Blvd.
Santa Clara, CA 95052-8119
USA

For product and purchase information visit:
www.intel.com/software/products

Intel, the Intel logo, Itanium, Pentium, Intel Xeon, Intel Centrino, and Intel XScale are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

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