WHITE PAPER

3rd Generation Intel® Core Processors
Digital Signage with Intel® Audience Impression Metrics Suite (Intel® AIM Suite)

Improved Graphics Performance Changes the Cost Equation in Digital Signage

3rd Generation Intel® Core™ processors deliver graphics performance on par with $350[1] GPUs

Intel® processors with integrated graphics are now a practical substitute for many discrete GPUs in media players, saving hundreds of dollars and hundreds of watts.

The quality and flexibility of digital signage is a function of the graphics processing capability of the media players that drive the displays. To deliver a high level of graphics performance, media players tend to incorporate discrete graphics processing units (GPUs), although some players use the graphics engine on the CPU platform. But more vendors are expected to turn to integrated graphics as performance increases, and it becomes better aligned to CPU performance.

It's expected that CPU performance will increase year after year. And indeed, this has been the case for Intel® architecture processors that are typically refreshed annually. This time around, Intel has also boosted graphics performance by up to 60 percent in the move from 2nd Generation to 3rd Generation Intel® Core™ processors. This remarkable step up in graphics speed has changed the cost equation for media players. For a large portion of the media player market, developers can eliminate GPUs, saving on the order of $350 (USD) and reducing power consumption by a couple hundred watts[2] without sacrificing performance. Media player vendors who are using the on-board graphics on 2nd Generation Intel Core processors (codenamed Sandy Bridge) will benefit significantly from migrating to these latest Intel® processors.

Shrinking Die Size

3rd Generation Intel Core processors (codenamed Ivy Bridge) are manufactured with a new 22 nm silicon process, which enables a better than 50 percent area shrink over the prior 32 nm technology. The new processors also have a completely redesigned GPU core that is integrated on-chip. The number of execution units increased, an L3 cache was added and many other additions were made. The graphics performance improvement was the result of both architectural enhancements and smaller silicon geometries.

Testing Graphics Performance

Intel contracted an independent software services company to use a digital signage application to compare the graphics performance of 2nd and 3rd Generation Intel Core processors against the NVIDIA* GeForce* GTX 570 GPU. The company performed benchmark testing based on a video analytics application, called Intel® Audience Impression Metrics Suite (Intel® AIM Suite), which stresses many aspects of a GPU.[3] The application was written in the OpenCL* language, allowing the engineers to decide how the algorithms should be distributed between the CPU and the GPU (NVIDIA* or Intel) to make the best use of both. More implementation details are provided in the following.

Figure 1. Example of Customer Demographic Information Gathered with Anonymous Video Analytics

- **Intel AIM Suite**, an Anonymous Viewer Analytics (AVA) product, is designed to bring personalized content to consumers, and provide retailers and advertisers with measurable results through digital signs. The software anonymously monitors viewer metrics, such as gender, age bracket and length of attention (Figure 1), and analyzes the data in real time. It does all of this while respecting the personal privacy of viewers, as outlined in the 7 foundational principles of Privacy by Design.[4]

  With Intel AIM Suite, retailers and advertisers can instantly tailor the featured content of digital signs to align with viewer demographics, providing consumers with more relevant, customized advertising while enabling advertisers to gather more accurate data for better tracking.

  Software flow: The first step is to retrieve each frame from video. The retrieved frame is converted to grayscale. Gaussian down sampling and Gaussian create a smoothing effect. The frame is sub-sampled to ensure performance. Motion in the frame is analyzed using the previous input image. New faces are detected using the Haar Classifier, and previously detected faces are tracked by using a search window on the predicted space and matching the histogram.

  ### GPU workload characteristics

  a) High data parallelism

  b) Low input data reutilization

  c) Algorithms with big data streams

  d) High arithmetic complexity per stream element

- **OpenCL** (Open Computing Language*) is the first open, royalty-free standard for general-purpose parallel programming of heterogeneous systems. OpenCL provides a uniform programming environment for software developers to write efficient, portable code for client computer systems, high-performance computing servers, and handheld devices using a diverse mix of multi-core CPUs and other parallel processors.

Comparing Graphics Performance: Two Generations of Intel® Core™ Processors

The graphics performance improvement of 3rd Generation Intel Core processors was measured in a match up with the previous generation Intel processors. The benchmark tests measured the average time per frame required to perform audience measurement on three video streams using the Intel AIM suite software that performs video analytics:

Video Streams

1. Highest compute: 1280 x 1024 video with high motion near the camera
2. Middle compute: 640 x 480 video with medium motion near the camera
3. Lowest compute: 640 x 480 video of assorted road crossings from 7-20 feet - light motion

Results

The 3rd Generation Intel Core processor outperformed its predecessor by between 47 and 60 percent for the three video stream scenarios, as depicted in Figure 2.[3] This corresponds to a processing speedup in the range of 1.9 to 2.5 times. The computing platform configuration details are provided in Appendix A.

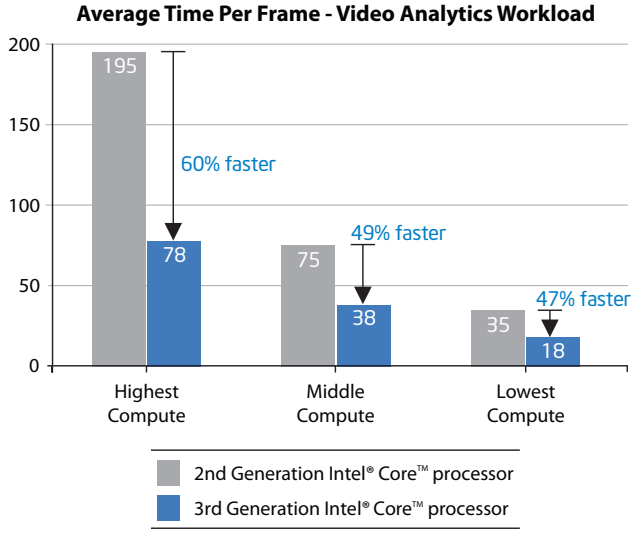

Figure 2. Graphics Performance Comparison between the GPUs on 2nd and 3rd Generation Intel® Core™ Processors

GPU Architecture Comparison: Intel and NVIDIA* GeForce*

A key objective in the design of a GPU is to exploit the intrinsic parallelism of graphics processing. The workload is broken up into work groups and sent to execution units (called streaming multiprocessors by NVIDIA) containing an ALU and fetch units. Performance is directly proportional to the number of execution units, whose throughput is a trade off between fast, single-thread performance and clock speed (i.e., power consumption).

GPUs also have shader cores that are hardware modules carefully tuned to optimize the performance of a small variety of tasks, such as transcoding and texture sampling. Modules such as these allow GPUs to support gather/scatter instructions from memory, something that is not efficiently implemented on CPUs. Gather/scatter operations are important to increase the execution of parallel applications operating on non-contiguous regions of memory in a SIMD (single instructing, multiple data) fashion.

The size of memory structures also greatly impacts GPU performance. Memory is partitioned various ways, including global, local, buffers and cache. Table 1 provides a comparison between two GPU architectures with respect to execution units, shader cores, memory and clock frequency.

Comparing Graphics Performance: On-processor versus the NVIDIA* GeForce* GTX 570 GPU

The NVIDIA GeForce GTX 570 GPU was evaluated using the same graphics performance benchmark tests described on page 2.

GPU Features	NVIDIA* GeForce* GTX 570	3rd Generation Intel® Core™ Processor
Execution Units	15[i]	16
Shader Cores	480[ii]	128
Global Memory	1,216 MB	2,104 MB
Local Memory	48 KB	64 KB
Constant Buffer	64 KB	64 KB
Cache Size	240 KB	2,048 KB
Clock Frequency	1,464 MHz	400 MHz

Notes:
[i] Streaming multiprocessor, each with 32 CUDA*
[ii] The same CUDA cores implemented in the execution units

Table 1. Comparison of GPU Features

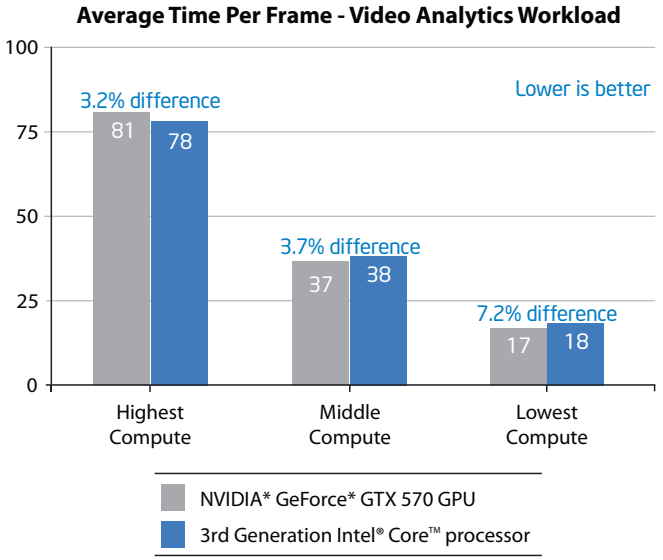

Figure 3. Graphics Performance Comparison between the NVIDIA* GeForce* GTX 570 GPU and the 3rd Generation Intel® Core™ Processor GPU

Results

The NVIDIA GeForce GTX 570 GPU and the 3rd Generation Intel Core processor GPU had similar performance when processing the three video streams labeled highest, middle and lowest compute. For the most compute intensive video, the 3rd Generation Intel Core processor GPU was 3.2 percent faster, and NVIDIA GeForce GTX 570 GPU was faster for the other videos, 3.7 and 7.2 percent respectively.[3] Overall, the graphics performance of the 3rd Generation Intel Core processor GPU is on par with NVIDIA GeForce GTX 570 GPU, as shown in Figure 3.

Price and Power Consumption

An important decision for media player developers is which GPU to deploy, typically a tradeoff between cost, performance and power consumption. There is a wide variety of GPUs on the market, with some high-end graphics cards for gamers costing in excess of $700. Media players are more likely to deploy a mid-range GPU, like the NVIDIA GeForce GTX 570 GPU, which is priced around $350[1] and was chosen for this analysis. With the greatly improved GPU on the 3rd generator Intel Core processor, many designs will no longer need a discrete GPU, which dramatically reduces cost and eliminates more than 200 watts, while providing comparable or higher performance.

Development Advantages of Intel Integrated Graphics

Digital signage comes in all shapes and sizes with varying pixel densities, number of zones and other rendering capabilities. Therefore, it's important for media player vendors to understand the requirements of the market segments they serve and deliver the right video quality at the right price. In this paper, the presented benchmark data suggests the integrated graphics in 3rd Generation Intel Core processors are suitable for systems with mid-range performance and higher. Once a vendor selects this course, it's worth noting the associated development advantages, including:

- **More compute power**
  - » Boost computing performance by migrating to 3rd Generation Intel Core processors
- **Lower design effort**
  - » Save time and effort by not having to design and integrate a GPU subsystem
- **Smaller system footprint**
  - » Eliminate the board space associated with a discrete GPU subsystem
- **Simpler thermal design**
  - » Reduce thermal solution complexity by eliminating hot-running discrete graphics
- **Industry standards tools**
  - » Use OpenCL* 1.1, DirectX* 11 and OpenGL* 3.1
- **Single tools chain**
  - » Simplify code development, integration and test
- **Regular CPU/GPU refreshes**
  - » Count on the Intel product roadmap to deliver more performance on a regular basis
- **Long life support**
  - » Protect development investments with embedded Intel® processors, which are supported for long life cycles of at least seven years.

Developers of media players can get started right away since systems with 3rd Generation Intel Core processors are readily available in all sorts of form factors. For more information on embedded hardware solution providers, please see **http://www.intel.com/design/network/ica**.

Author Biographies

Sanjay Addicam is a staff software engineer with a focus on video analytics, machine learning, and data mining algorithms. His primary interest is in developing a privacy-friendly targeted advertising framework around digital signs. He is also actively involved in optimizing machine learning and data mining algorithms using OpenCL, and has created new benchmarks for video analytic algorithms using OpenCV*. He is a contributing author to the book, "Break Away with Intel® Atom™ Processors", and has five patents in his name and numerous publications. He has been with Intel for the past 11 years and prior to that worked for Novell*. He has an M.S. from University of Maryland. His email is addicam.v.sanjay@intel.com

Shahzad Malik is a senior software architect in the Digital Signage Group at Intel. He was a co-founder of CognoVision Solutions, a video analytics software company that was acquired by Intel in 2010. Shahzad is the primary developer for the Intel AIM Suite service product. He has a PhD in computer science from the University of Toronto, with a specialization in computer vision and human-computer interaction. Shahzad's other research interests include computer graphics and augmented reality. He can be reached at shahzad.malik@intel.com

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For more information, see **www.intel.com/go/digitalsignage**

Appendix A: Platform Configuration

Platform	1	2	3
CPU	Intel® Core™ i7-990X Processor Extreme Edition	Intel® Core™ i7 Processor (2.2 GHz)	Intel® Core™ i7 Processor (2.2 GHz)
GPU	On-processor	On-processor	NVIDIA* GeForce* GTX 570
RAM	8 GB	8 GB	8 GB
Operating System	Microsoft* Windows* 7 64-bit	Microsoft Windows 7 64-bit	Microsoft Windows 7 64-bit

[1] Source for GPU launch price, Bjorn 3D and Maximum PC reviews: http://www.geforce.com/Hardware/GPUs/geforce-gtx-570/reviews.

[2] Source for power consumption: http://www.geforce.com/Hardware/GPUs/geforce-gtx-570/specifications.

[3] Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products.

[4] Sources: http://www.ipc.on.ca/images/Resources/7foundationalprinciples.pdf, http://www.privacybydesign.ca/

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