What are the differences between Intel® Core™ i3, i5 and i7 processors?

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Why the latest version of Advantech's leading medical panel PC features a 4th generation Intel® Core™ i7 processor.

In designing our latest point-of-care (POC) terminal – the 24" wide-screen POC-W242 – Advantech wanted to create a high performance all-in-one unit. The POC needed to aptly handle image-intensive medical applications such as radiology and endoscope applications in operating arenas, as well as a wide range of applications at bedside, nursing stations, or other point-of-care locations within the hospital or clinic. An important element in ensuring this performance was the selection of 4th generation Intel® Core™ i7 processors.

In this whitepaper, we look at the advantages for healthcare devices of 4th generation Intel® Core™ i7 processors over other members of the 4th generation Intel® Core™ processor family and 3rd generation Intel® Core™ processors. We consider compute and graphics performance, as well as security, manageability, connectivity, and other factors.

Intel's Tick-Tock Model

To appreciate the advantages of one generation of Intel® processor over another, it's important to look at the "tick-tock" model Intel uses for advancing its microprocessors. This model provides a continuous cycle (alternating between "ticks" and "tocks") of improvements and new capabilities based on regular innovations in manufacturing process technology and processor microarchitecture.

With every "tick" cycle, Intel advances its manufacturing process technology and delivers the expected benefits of Moore's Law. These advances increase transistor density, enabling new capabilities, higher performance levels, and greater energy efficiency—all within a smaller, more capable version of the previous "tock" microarchitecture.

In alternating "tock" cycles, Intel uses the previous "tick" cycle's manufacturing process technologies to introduce the next big innovation in processor microarchitecture. These advancements seek to further improve energy efficiency and performance, as well as functionality and density of features such as hardware-supported video transcoding, encryption/decryption, and other integrated capabilities.

4th Generation Intel® Core™ Processors

The last advance in manufacturing process technology, or tick, produced the 3rd generation Intel® Core™ processor (codenamed "Ivy Bridge") and the mobile Intel® HM76/QM77 Express Chipsets. Based on Intel's industry-leading 22nm process technology, these platforms delivered performance and graphics improvements, plus remote manageability and security, and power-saving functions ideal for medical applications. Embedded versions operate at maximum thermal design power (TDP) levels as low as 17 W.

Intel followed this tick with a significant advance in processor microarchitecture, or tock: the 4th generation Intel® Core™ processor product family (codenamed "Haswell"). Building on the innovations of the previous generation, the 4th generation Intel Core processor family delivers superior CPU, graphics and media performance, enhanced security features, improved power management features, and a maximum TDP as low as 15 W.

Advantech, a Premier member of the Intel® Internet of Things Alliance, uses 4th generation Intel Core processors designed specifically for the *embedded* market. These energy-efficient processors enable small form factor, fanless designs. Like other Intel embedded processors, 4th generation Intel Core processors feature long lifecycle support. Intel's 7-year extended lifecycle support for processors and chipsets ensures a long-period of availability for healthcare organizations using devices based on them.

Key Advantages of 4th Generation Intel® Core™ Processors for Medical Imaging

To help drive healthcare innovation and improved patient outcomes, the 4th generation Intel Core processor family delivers up to 2X faster image processing performance, rich 2D/3D graphics, and robust security. Targeted applications include medical imaging, ultrasound, patient monitoring, patient bedside terminals, fitness consoles, and many other medical devices.

Offering from two to four cores with up to 15 percent faster performance than previous generations, 4th generation Intel Core processors improve medical imaging performance through Intel® Advanced Vector Extensions 2.0 (Intel® AVX 2.0). This upgraded vector-processing technology introduces a fused multiply-add (FMA3) that effectively doubles the peak floating point throughput in comparison to the previous generation. Multiply-add workloads are a critical component of image processing, so this upgrade significantly speeds up medical imaging applications.

Intel AVX 2.0 doubles fixed-point performance as well by expanding most integer Intel AVX instructions from 128 bits to 256 bits. Adding 16 new "gather" support instructions, Intel AVX enables vector elements to be loaded from non-contiguous memory locations to simplify code vectorization and improve performance.

Graphics and Video Performance Gains

For 3D graphics, the 4th generation Intel Core processor family's upgraded graphics engine delivers up to a 60 percent improvement over previous generations, virtually eliminating the need for expensive, power-hungry discrete graphics cards. Enhanced high-resolution display capabilities support up to 4K resolution on three independent displays. A new collage mode can present multiple displays to the OS as one large unified screen for use in teaching hospitals.

Built-in video enhancements, including Intel® Clear Video HD technology and Intel® Quick Sync Video 2.0, deliver a 30 percent improvement in video playback and display capability over the 3rd generation Intel Core processors. These improvements provide smoother visual quality, increased ability to decode and transcode simultaneous video streams in real-time, and outstanding HD media playback for applications such as endoscopy.

Table 1 compares the processor and graphics performance of the ultra-low voltage Intel® processors used by Advantech in our products for the medical market. Note the performance gains of the 4th generation Intel Core processors over previous generations.

Table 1. Comparison of Ultra-Low Voltage Intel® Processors Used by Advantech

Generation	Product Name	Clock freq	Turbo speed	Max TDP	PassMark Performance Score	Graphic Processor	3D Mark06 Graphic Performance
4th Generation	Intel® Core™ i7-4650U	1.7Ghz	3.3Ghz	15W	4243	Intel® HD Graphics 5000	6124
4th Generation	Intel® Core™ i5-4300U	1.9Ghz	2.9Ghz	15W	3724	Intel® HD Graphics 4400	6024
N/A	Intel® Celeron® Processor 2980U	1.6Ghz	No	15W	na	Intel® HD Graphics	2345
3rd Generation	Intel® Core™ i7-3555LE	2.5Ghz	3.2Ghz	25W	4050	Intel® HD Graphics 4000	4613
2nd Generation	Intel® Core™ i7-2655LE	2.2Ghz	2.9Ghz	25W	2883	Intel® HD Graphics 3000	3817
2nd Generation	Intel® Core™ i7-2610UE	1.5Ghz	2.4Ghz	17W	2454	Intel® HD Graphics 3000	3817
2nd Generation	Intel® Core™ i3-2340UE	1.3Ghz	N/A	17W	1719	Intel® HD Graphics 3000	3817
N/A	Intel® Atom™ Processor D525	1.8Ghz	No	13W	699	Integrated	146

Sources: http://www.cpubenchmark.net/   http://nl.hardware.info/ and

Medical Security

Patient records in many countries require confidentiality by law and thus a high level of security when records are stored on a device or transmitted from device to device. This high level of security is best implemented through multiple layers of security. By selecting the right processor SKU paired with a Mobile Intel QM87 chipset and including Intel® vPro™ technology, companies like Advantech enable use of the multiple security layers. The resulting platform delivers intelligent security, supporting:

- Hardware-based device security
- Virtualization for improved security of virtualized environments
- Hardware acceleration of encryption/decryption operations

At the device level, OS Guard, an Intel vPro technology feature, detects and prevents malware from executing. Intel® Trusted Execution Technology (Intel® TXT), another Intel vPro technology feature, enhances this security capability by adding a versatile set of hardware extensions enabling measured launch and protected execution. Rather than relying on the detection of malware, Intel TXT builds trust into a known software environment and ensures that any software being executed in this known environment hasn't been compromised. This advanced security measure addresses many stealth attack mechanisms used today to gain access to or compromise information.

Intel TXT can also be combined with Intel® Virtualization Technology (Intel® VT), another Intel vPro technology feature, to create trusted, isolated environments for virtual machines (VMs). Intel VT allows operating systems and applications to run within their own space protected from all other software on the system. Working within this space, Intel TXT provides the measured launch and protected execution capabilities to protect against compromise and isolate the VM should malware attempt to launch.

For protection of data at rest and in transmission, authorities recommend encryption. To ensure this protection does not come at the cost of performance, upgrades to Intel® AES New Instructions (Intel® AES-NI) in 4th generation Intel Core processors allow security algorithms to benefit from hardware acceleration. These algorithms speed up data encryption and decryption, preserving valuable CPU performance for medical applications

Manageability

Through the inclusion of Intel® Active Management Technology (Intel® AMT), Intel vPro technology also plays an important role in manageability – an important advantage for healthcare organizations looking for ways to reduce operating costs. Intel AMT enables remote updates and repairs, even if a device is powered off. This ability to perform "out of band" management ensures that vital medical equipment can be easily monitored, maintained, and repaired remotely. Healthcare organizations can

use powerful security management products like Intel McAfee ePO Deep Command as the console to remotely access devices equipped with Intel AMT to remediate compromised systems, enable energy-saving initiatives, wake systems, and apply proactive security. Intel AMT also works with many popular IT management consoles.

Faster, More Flexible Connectivity

Fast data exchange is critical for communications between medical devices and peripherals. The 4th generation Intel Core processors support faster data exchange through integrated next-generation I/O technologies such as PCI Express* Gen 2.0, SATA 6.0 Gbps, and USB 3.0 with Intel® Flex I/O. This last feature enables users to assign four to six SATA 6.0 Gbps ports, six to eight PCI Express* Gen 2.0 ports and four to six USB 3.0 ports, based on configuration needs.

Differences within the Low-Power 4th Generation Embedded Intel® Core™ Processor Family

For its high performance, low power, fanless POC-W242 systems, Advantech recommends the Intel® Core™ i7-4650U. (The Intel® Core™ i5-4300U is also available for this device). The table below shows the key differences between the three dual-core, ultra low-voltage, 4th generation embedded Intel Core processors. Note: all feature a maximum TDP of 15 W that enables quiet, fanless operation.

Table 2. Comparison of 4th Generation Intel® Core™ Processors

	Intel® Core™ i3-4010U Processor (3M Cache, 1.70 GHz)	Intel® Core™ i5-4300U Processor (3M Cache, up to 2.90 GHz)	Intel® Core™ i7-4650U Processor (4M Cache, up to 3.30 GHz)
Performance Profile	Smart multitasking for basic computing	Performance with a boost	Maximized performance for medical imaging and graphics
Processor Graphics	Intel® HD Graphics 4400	Intel® HD Graphics 4400	Intel® HD Graphics 5000
Intel® Turbo Boost Technology	No	2.0	2.0
Intel® vPro™ Technology	No	Yes	Yes
Intel® Trusted Execution Technology	No	Yes	Yes

Particularly noteworthy, the inclusion of Intel HD Graphics 5000 in the Intel Core i7-4650U provides a definite graphics performance edge. Intel HD Graphics 5000 includes 40 execution units compared to the 20 execution units in Intel HD Graphics 4400. This advantage in number of execution units

significantly increases performance on graphics-intensive, compute-limited workloads.

From a compute performance perspective, all three SKUs support Intel® Hyper-Threading Technology, an advanced technology that delivers two processing threads per physical core to allow highly threaded applications to can get more work done in parallel and complete tasks sooner. Parallel processing is particularly important for medical imaging.

An important difference between the processors is that the Intel Core i3-4010U processor does not support Intel® Turbo Boost Technology, but the other two processors do. Intel Turbo Boost Technology dynamically increases performance by allowing processor cores to run faster than the rated operating frequency if they're currently operating below power, current, and temperature specification limits. In other words, Intel Turbo Boost allows a processor to operate at a power level that is higher than its TDP configuration and manufacturer-specified power for short durations to maximize (give a boost to) computing or graphics performance.

Finally, while both the Intel Core i5 and i7 processor support Intel vPro technology, the Intel Core i3-4010U processor does not. As described earlier, Intel vPro technology is an important security and manageability feature for medical applications. Intel TXT, another important security feature, is also not available with the Intel Core i3-4010U processor.

Two Ways to Further Increase Performance
To further boost performance of its medical panel PC, Advantech offers configuration choices for the POC-W242. Purchasers can choose a faster speed memory (1600MHz versus 1333MHz) and install up to 16GB DDR3L SDRAM. In addition, purchasers have the choice of a tradition hard disk drive or the faster read/write speeds and reliability of a solid-state drive.

Broad Industry Support
An important element in processor selection is third-party support. Well-supported microprocessors backed by a healthy third-party ecosystem provide more options for applications and broader access to a skilled talent pool.

Intel's microprocessor family now spans four decades and dozens of generations, enabling the company to attract among the world's largest and richest support in software, development tools, and talent. This broad-based, global, and ever-expanding ecosystem make Intel's microprocessors uniquely effective in powering today's industrial and embedded devices

Advantech POC-W242 Point-of-Care Terminals
POC terminals serve as medical-grade panel computers for a variety of healthcare applications including medical imaging and the viewing of electronic patient records, use of medical software, and

barcode scanning.

The Advantech POC-W242 considered in this paper is a 24" medical-grade point-of-care terminal with the latest computing capabilities and wide-viewing angles in a slim profile. The system is fanless for quiet operation and energy efficiency. Its in-place switching (IPS) display enables users to view stunning images from any angle and offers a multi-touch option for a superior touchscreen experience. Even with its 24" display, the entire unit weighs less than 8 kg and has a narrow profile depth of only 7 cm.

The POC-W242 has an IP54-rated enclosure for bacteria control. The sealed LCD and enclosure prevent electronic emissions, resists spills, keeps out dust, and facilitates easy cleaning.

The POC-W242 offers rich connectivity. It supports four USB 3.0, and one VGA and one HDMI port. It's equipped with two mini PCIe and one PCIe x4 slots for extension cards.

Advantech in Healthcare

Advantech has been a leading provider of certified computing systems and services for the medical market for over a decade. We offer a wide range of medical products to fit all requirements, R&D teams dedicated to medical technology research and implementation, extensive customization capabilities and a global sales and service organization. Our success and reputation in the medical market is built on solid design, unmatched support, and vast manufacturing experience.

As a leader in clinical information systems, preoperative systems, electronic patient record systems, POC terminals, and diagnostic displays, Advantech is a supplier to the top ten global medical companies, leveraging our embedded systems and services expertise to provide superior healthcare technology.

Conclusion

The advantages for healthcare devices of 4th generation Intel® Core™ i7 processors over other members of the same Intel® Core™ processor product family and the previous generation provide POC terminals like the Advantech POC-W242 with extra processing and graphics performance to perform in image-intensive medical applications. In addition, the security, manageability and connectivity features, as well and the broad industry support and long lifecycle of these processors, make them a safe, reliable choice for a wide range of healthcare devices.

About Advantech

Advantech Co., Ltd. (TAIDEX:2395), a Premier member of the Intel® Internet of Things Solutions Alliance, is a leader in providing trusted, innovative products, services, and solutions. Advantech offers comprehensive system integration, hardware, software, customer-centric design services,

embedded systems, automation products, and global logistics support. We cooperate closely with our partners to help provide complete solutions for a wide array of applications across a diverse range of industries. Our mission is to enable an intelligent planet with Automation and Embedded Computing products and solutions that empower the development of smarter working and living. With Advantech, there is no limit to the applications and innovations our products make possible.

About the Intel[®] Internet of Things Solutions Alliance

From modular components to market-ready systems, Intel and the 250+ global member companies of the Intel[®] Internet of Things Solutions Alliance provide scalable, interoperable solutions that accelerate deployment of intelligent devices and end-to-end analytics. Close collaboration with Intel and each other enables Alliance members to innovate with the latest technologies, helping developers deliver first-in-market solutions. Find out more at intel.com/IoTSolutionsAlliance.

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