Solution Brief
Industrial Control Devices

Microsoft Windows® Embedded CE 6.0 Intel® Atom™ Processor

A Simple Path to True Real-Time Performance

Standards-based devices shorten development time and lower cost

The question for many device development managers is whether to stay with time-tested, proprietary software and hardware components or transition to less costly off-the-shelf components. Leveraging homegrown real-time operating systems, FPGAs and ASICS, OEMs seek to differentiate with respect to time-critical performance and reliability. But this specialty component approach comes at a price. Unique components may create hardware and software compatibility issues; increase the cost of maintaining aging proprietary systems; and introduce new security holes.

Device manufacturers, supporting industrial, instrumentation and control systems, can achieve bounded, deterministic response times without developing custom operating systems and hardware components. Eliminating expensive component development, a device based on the Microsoft Windows® Embedded CE operating system and the very low power Intel® Atom™ processor delivers cost-effective, real-time performance. This platform is standards-based, has long life cycle support and runs industry-leading security software, which minimizes compatibility, supply and security issues. With Windows Embedded CE, developers don't have to share their operating system modifications because there's no general public license (GPL) concern associated with open source software. Plus, Microsoft offers IP protection to device manufacturers who use Windows Embedded CE.

True Real-Time Performance

It's not enough to reach the correct result; industrial control devices must also produce results within a well-defined time window. Automation applications, like high speed I/O, robotics and machinery controls, have some of the most demanding timing constraints and require a deterministic software response. Such performance starts with a hard real-time embedded operating system that is architected differently than operating systems running on desktops and laptops.

Delivering predictable performance, Windows Embedded CE 6.0 is designed specifically for embedded developers who need to bring new devices to market in minimum time and at the lowest possible cost. This fully integrated development environment (IDE) is based on a 32-bit native hard real-time operating system that enables a finite response though a performance optimized kernel. This preemptive and multi-threaded kernel runs a large number of applications simultaneously (e.g., 32,000 processes), which is key to increasing functionality. Its flexible file system supports large storage media, large file sizes and removable media encryption.

Combining a small footprint operating system and powerful embedded development tools, Windows Embedded CE 6.0 interoperates with industry standards and existing Microsoft desktop and server technologies to establish a solid foundation for full-featured devices. Developers have access to parts of the Windows Embedded CE 6.0 source code, which helps them debug, test and make changes to an operating system image. The operating system software can be modified to create differentiated features, like running a PLC more efficiently in kernel space, without sacrificing control over intellectual property. Windows Embedded CE 6.0 offers additional features, listed in Table 1, that help device manufacturers shorten development time and lower costs compared to writing custom real-time operating systems (RTOS) themselves.

Performance Benchmarks

Real-time is often characterized by interrupt response, the delay between a hardware interrupt and the start of the actual processing of the interrupt. This is a key benchmark since it measures the device's response to outside events.

Windows Embedded CE 6.0 interrupt handling is a multistage process, as shown in Figure 1. First an interrupt event initiates an interrupt request (IRQ), which triggers an interrupt service routine (ISR) run in kernel mode. Then the kernel invokes a kernel or user mode function, called an interrupt service thread (IST), that provides processing when any substantial work must be done.

The overall interrupt handling latency is shown in Table 2, the sum of the two processing steps just described. The table shows the time required to switch from the interrupt line being asserted until the interrupt service routine is entered, including hardware delay. For a sample of 4999 events, the maximum latency was 30.1 microseconds[1], which is significantly below the 100 microseconds often considered a tolerable response time for embedded real-time systems.

Feature	Benefit
Hard real-time OS	▪ Delivers real-time performance, such as less than 32 microsecond interrupt or thread switching response on a 200 MHz CPU.
Unified kernel architecture	▪ Improves system performance ▪ Increases security and robustness
Support for concurrent processes with dedicated virtual memory	▪ Enables devices with a rich set of features and functions ▪ Simplifies device upgrade as end-user requirements change over time
IP indemnification	▪ Reduces litigation risk for device makers
Shared source program	▪ Permits developers to use shared source code to document, debug, test and modify the OS image to create differentiated features
Comprehensive set of drivers	▪ Supports kernel mode drivers (performance) and user mode drivers (robustness)
Exceptional tools	▪ Helps accelerate time-to-market and manage development costs
Integrated board support	▪ Reduces development time

Table 1. Benefits of Windows® Embedded CE 6.0

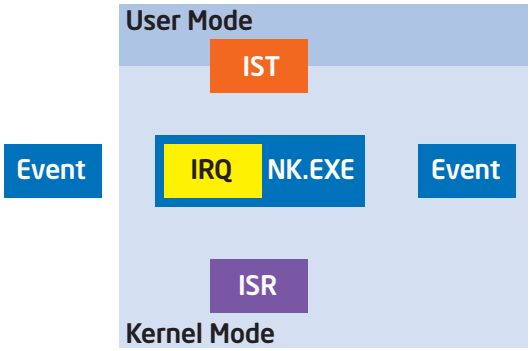

Figure 1. Interrupt Handling in Microsoft* Windows* Embedded CE 6.0

Test	Sample Quantity	Average	Maximum	Minimum
Latency IRQ to ISR	4999	6.3 µs	10.2 µs	5.0 µs
Latency ISR to IST	4999	6.3 µs	19.9 µs	5.7 µs
Sum of Latencies		12.6 µs	30.1 µs	10.7 µs

Table 2. Interrupt Handling Latency[i]

Another key real-time performance metric is thread switching latency, which is the time the operating system needs to switch the CPU to another thread. This comes into play when developers follow the best practice of separating human-machine interface (HMI) code from the application control software; as a result, the CPU switches frequently between HMI and control functions. Table 3 shows the switching time [16.0 - 31.8 maximum][i] between threads when there are 2, 10 and 128 active threads of the same priority level.

Test	Sample Quantity	Average	Maximum	Minimum
Thread switch latency, 2 threads	16,319	8.0 µs	16.0 µs	6.9 µs
Thread switch latency, 10 threads	10,916	12.0 µs	23.5 µs	8.3 µs
Thread switch latency, 128 threads	10,875	15.7 µs	31.8 µs	11.0 µs

Table 3. Thread Switch Latency[i]

Equipment Manufacturer Requirements

In addition to real-time performance, platforms based on Intel and Microsoft technologies satisfy other equipment manufacturer expectations around supply, compatibility, security, form factor and price-performance. Embedded products from Intel and Microsoft have long life support (i.e., extended supply) and are backward compatible, which protect manufacturers' investment. Windows Embedded CE 6.0 makes it easy to add enhanced features, such as the latest security technologies, by supporting existing applications and drivers. Standards-based components, like the Intel Atom processor, benefit from the economies of scale, which enables cost-effective small form factor devices.

Highlights of the Intel® Atom™ processor

Based on a new microarchitecture, the Intel Atom processor was developed specifically for targeted performance and low power. The processor packs an astounding 47 million transistors on a single chip and runs all the necessary industrial control and HMI functions supported by industrial control devices. The Intel Atom processor and companion chipset, the Intel® System Controller Hub US15W, have the performance and I/O that allows designers to eliminate costly FPGA and ASICs, save development time and lower product cost.

- Architecture
  - 512 kilobytes (KB) of L2 cache memory speeds up software applications
  - Multiple threads boost system responsiveness in multi-tasking environments
  - Software compatible with previous 32-bit Intel® architecture
- Low power, small footprint
  - New 45nm silicon technology enables lower power processors (4 watts TDP at 1.6 GHz).
  - Power consumption is 20 percent less than typical desktop processors
  - Two-chip, small-footprint platform provides more than 80 percent reduction in total footprint over previous-generation three-chip Intel® platform
  - Processor sleep states reduce power consumption when devices are idle
- Interfaces
  - 8 USB 2.0 ports, IDE channel, PCI Express* and general purpose I/O
  - Integrated graphics
  - Low-voltage differential signaling (LVDS) and serial DVO (SDVO) display ports

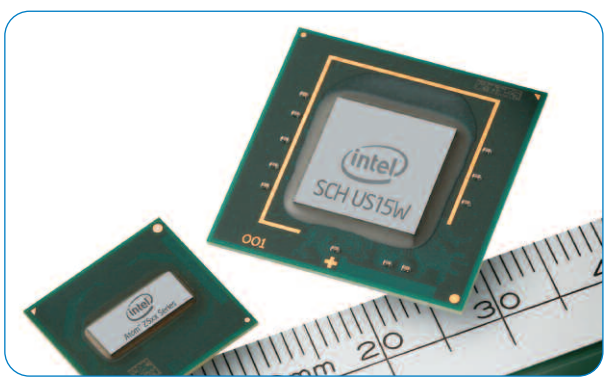

Figure 2. Intel® Atom™ Processor and the Intel® System Controller Hub US15W

Easy to get started

It's easy to test out a platform based on the Intel Atom processor and the Microsoft Windows Embedded CE 6.0 operating system using the following resources:

- ➢ Try out the Intel Atom processor using a customer reference board (CRB). Please contact local Intel field representative for additional information. For board details, please visit http://download.intel.com/design/intarch/manuals/320436.pdf.
- ➢ Download a free Windows Embedded CE 6.0 board support package (BSP) for Intel Atom processor-based CRBs from the following vendors: Bsquare*, Adeneo Embedded* or Wipro Technologies*.
- ➢ Start building and testing with the evaluation version of Windows Embedded CE 6.0 software free for 180 days. To download a trial version or order by mail, visit www.microsoft.com/windowsembedded/eval/trial.mspx.

Path to Real-Time Performance

The combination of Intel and Microsoft Windows Embedded platform technologies offers a customizable operating system and real-time performance suited for the next-generation industrial, instrumentation and control systems. Platforms based on the Intel Atom processor, Intel® Core™2 Duo processor and Intel® Xeon® processor cover all 'Industrial Pyramid' layers including HMI, operator panels, industrial PCs, automation and control systems and top floor servers. This scalability allows plants to use the same code base across different platforms with varying performance levels, because there's continuity among Windows Embedded CE 6.0, Windows® Vista® and Windows Server 2008. Control devices equipped with the Intel Atom processor and the Windows Embedded CE 6.0 operating system can offer the bounded, deterministic response required by time-critical embedded applications. Customer reference boards, free BSP packages and downloadable operating systems are already available for device development managers looking to jumpstart their next real-time design.

To learn more about embedded Intel® technologies, please visit:

- www.intel.com/embedded
- www.intel.com/go/industrial
- http://edc.intel.com

To learn more about Microsoft Windows Embedded, please visit:

www.windowsembedded.com

[i]Performance tests and ratings are measured using specific computer systems and/or components and reflect 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,
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