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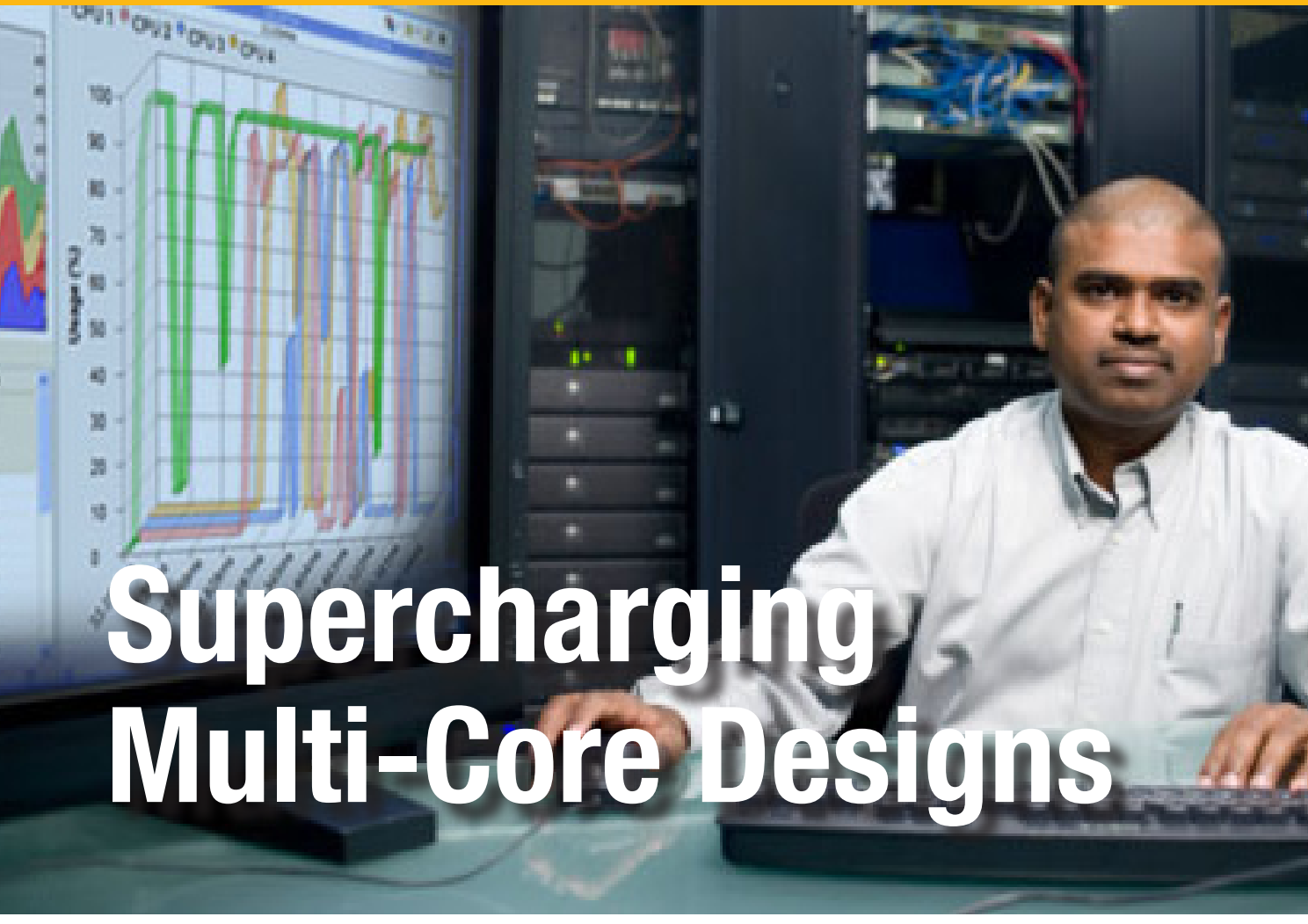
The INTEL STRATEGY for Processor Design Series



Supercharging Multi-Core Designs

Multi-core processor-based designs and visual development tools are boosting performance and system flexibility, transforming the way embedded systems are optimized and deployed, while enabling cost-saving opportunities. At the same time, parallel computing architecture is creating new challenges and opportunities, which can be addressed with today's tools.

"Multi-core is a disruptive technology — and I mean that in a good way — because it's only when you have disruption of the status quo that new innovations can affect technology with revolutionary advances," says David A. Bader, executive director of high-performance computing at Georgia Tech. Software developers who optimize their code for this groundbreaking technology can deliver new levels of functionality more cost-effectively. However, to achieve this optimization they'll need to tap into a new set of resources. "Making the most of multi-core systems will require new tools, new algorithms and new ways of looking at programming," says Bader. Advanced visual software tools are helping developers balance workload among all cores and consolidate more features and horsepower within a smaller form factor.

Supercharging Multi-Core Designs

Doing More with Multi-Core

OEMs are using Intel® multi-core processors to create next-generation products that achieve new levels of functionality, availability and upgradability. They can design one board that supports multiple SKUs with either dual- or quad-core processors and one or two processors to a board.

Multi-core processors help reduce the total cost of ownership in many embedded applications. In point-of-sale (POS) applications, the trend is for a single computer board to control multiple airline check-in terminals, reducing the amount of hardware needed to implement a fleet of kiosks. Industrial control applications run real-time and human-interface software on separate CPU cores on one board instead of two. Military embedded computing, which has intensive multitasking requirements for high-speed data capture, analysis and storage, benefits from multi-core processors that can run these tasks in parallel.

Another equipment segment benefiting from multi-core technology is security, where systems can be upgraded from dual- to quad-core processors to accommodate more network traffic and preserve IT equipment investment. The performance gains from multi-core processing are changing the face of security appliances from single to multifunction systems. Instead of producing discrete boxes — firewall, intrusion detection, antispam, virtual private network (VPN) — OEMs are consolidating these functions into one appliance. This reduces the number of hardware components, like fans and power supplies, and brings down hardware costs.

In the past, security appliances that check incoming traffic were deployed on the network's perimeter. With BlackBerrys* and iPods* connecting to the network daily, additional opportunities exist for employees to breach corporate security, so IT departments are placing security appliances throughout the network to inspect incoming and outgoing traffic. Multi-core processors can address this additional workload and enable system upgrades that boost computing capability by adding processor cores and memory, relieving the corporation from having to purchase new equipment.

Reducing Development Cost

Many Intel dual-core and quad-core processors use the same socket for both processors, creating a smooth path for upgrading existing designs and ensuring investment protection. For example, OEMs can deploy a board with one Dual-Core Intel® Xeon® processor 5130 or increase its performance by a factor of four with two Quad-Core Intel® Xeon® processors 5345[1]. They can create more than a dozen equipment SKUs by utilizing other processor combinations.

OEMs developing multifunction security appliances often reuse legacy code, formerly written to run by itself on dedicated hardware. Instead of rewriting this code so that it runs in harmony with other applications, developers can isolate it by assigning it a dedicated core. Better yet, virtualization allows the code to run as if it had its own system.

Embedded equipment is regularly deployed in space-constrained environments, which place stringent restrictions on system power dissipation. According to Doug Davis, vice president and general manager of Intel's Embedded and Communications Group, quad-core processors offer a performance increase of up to 55 percent

Upgrade Path Protects Investment

Portwell NAR-7090 Communication Appliance Platform

American Portwell Technology develops world-leading communication appliance platforms that help manage and protect vital enterprise networks. These platforms run networking and security applications such as firewall/VPN and unified threat management (UTM). Customers such as security appliance OEMs look to Portwell to meet their increasing appetite for application and bandwidth performance by increasing computing power.

Portwell's NAR-7090 is one of the first appliance platforms deploying quad-core processors to meet the rising demand for higher performance. It supports both Quad-Core and Dual-Core Intel® Xeon® processors in dual-processing configurations (eight and four cores total). In designing the system, Portwell knew it could accommodate either processor with only a BIOS modification. "Intel's processor upgrade path allows us to amortize development costs over multiple SKUs, and it significantly speeds up our quad-core offerings," says Frank Shen, Portwell product marketing director.

To protect their investment, customers can later upgrade processors from dual-core to quad-core, and they have the flexibility to add up to 14 Gigabit Ethernet ports. Expansion slots support existing and future hardware peripheral requirements: three PCI-X and a PCI-Express*. Even with eight CPU cores, the NAR-7090 consumes 15 percent less power than its predecessor with just two cores. "The challenge is to raise the stakes while decreasing operating costs and integrating legacy infrastructure and emerging security applications," says Shen.

and a fourfold performance-per-watt increase when compared with the dual-core processors for embedded applications that Intel introduced last year[1].

Maximizing Performance with Visual Tools

CPUs like the Intel® Core™ 2 Duo and Quad-Core Intel Xeon processors allow systems to have two, four or eight cores, with any core able to work on any task. To make the most of these cores, software developers are parallelizing their code and splitting up their computing workload to keep all cores busy. Various multi-core tools, which typically use visualization technology, give developers insight into the dynamic use of the cores by the application. These tools provide a powerful picture of workload balance, contention and race conditions.

Visualization tools can also help developers determine whether software modifications are needed to preserve data integrity, like data locking and code synchronization. "In many cases, embedded and real-time code doesn't need much modification for SMP (symmetric multiprocessing); it's generally multithreaded. If good programming practices have been followed, porting your code can be fairly straightforward, particularly if you're using a mature SMP OS like QNX Neutrino* RTOS," says Bill Graham, development tools product line manager, QNX Software Systems.

Optimizing Workload Balance

The most fundamental benefit from using visual multi-core tools is "seeing" how the workload is distributed among the cores. Normally, developers want to balance the workload to maximize the computing performance of the system by ensuring that all cores share the workload equally. Unique situations may warrant keeping a core lightly loaded so that it responds faster to time-critical code, like interrupt servicing. Whether implementing

Figure 1. The QNX Momentics* System Profiler

balanced or unbalanced loading, developers can more easily distribute workload with a tool that clearly displays core usage and shows which threads are running on each core. The QNX

High-performance multi-core processors are providing opportunities to consolidate multiple applications into a single system. However, embedded applications often have real-time requirements that can't be jeopardized by other software competing for the same system resources, such as CPU cycles and memory. To provide greater security and reliability for critical code, QNX Software Systems supports Secure Partitioning for Multi-Core Processors, which guarantees system resources as specified by system designers.

Real-time applications can be put into secure partitions that receive a guaranteed minimum of CPU time and memory even when the system is heavily loaded. Unlike prior partitioning methods based on single-processor systems, QNX secure partitioning targets multi-core platforms and scales easily to support additional cores. This approach offers two immediate advantages: System resources are partitioned at a system level, not at a per-core level, and the design uses just one OS copy instead of proliferating OS copies to each core.

Partitioning can also protect mission-critical applications, such as aerospace, medical and military, which otherwise might be susceptible to denial-of-service attacks or faulty subsystems that overload the CPU or exhaust memory. Since partitions are guaranteed a minimum amount of system resources, they're insulated from untrusted applications or rogue attacks that could compromise the entire system.

Momentics* System Profiler displays the CPU usage of four cores executing an application over a 22-millisecond time interval (see the right side of Figure 1). This macro-level perspective helps pinpoint opportunities to balance the workload across the system. The left side of Figure 1 lists various threads and the time they spend running on each core.

Trapping the Right Data

To provide a deep system insight, tools can gather a massive amount of system information, including interrupts, kernel calls, scheduling events, thread states and more. "Developers want a rich picture of the behavior of the system ... critical informa-

tion may result anytime the operating system or application does something interesting. Visibility into when a task starts, stops or switches, or when a user-defined event, such as a loop counter, reaches a specified value, is invaluable," says Rob McCammon, director of advanced technology planning at Wind River Systems.

In Figure 2, the Wind River System Viewer displays multiple windows that allow the developer to zoom in on the behavior of multiple processes, threads and functions. The visualization of each thread or function includes graphical symbols representing the timing of a wide range of events, from semaphores to user-defined event flags. The top panel in each view represents the total runtime over which data was collected, while the lower panel shows a zoomed-in view centered on a specific point in time. The ability to move through time, to zoom in and zoom out, helps developers debug code faster.

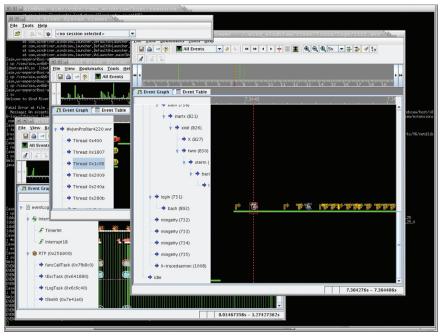


Figure 2. The Wind River System Viewer

Developing with Intel® Tools

In addition to the many companies supplying tools for Intel multi-core processors, Intel itself provides a number of tools to help reduce the complexity and time it takes to develop and debug code. The Intel tools include:

- Intel® Thread Checker 3.1 for Windows* and Linux*, which detects errors in the coding of parallelism so that developers can introduce threading more safely and quickly.
- Intel® Thread Profiler 3.1 for Windows, which shows how application threads behave and pinpoints parallel performance problems such as bottlenecks.
- Intel® Threading Building Blocks 1.1 for Windows, Linux and Mac* OS X, a C++ template library that simplifies introducing threads to an application.
- Intel® VTune™ Performance Analyzer 9.0, a graphical tool that locates performance bottlenecks and quickly drills down to source code.

"Our Intel® Core® 2 Duo processors have essential new profiling capabilities we're taking advantage of for the first time in our VTune Analyzer 9.0. Since many systems are now multi-core systems, developers have been asking us for these parallelism tools," says James Reinders, director of marketing for Intel's Developer Products Division.

Looking Ahead to VT-d

Virtualization technology is gaining traction in embedded designs as a way to consolidate and isolate software. Later this year, Intel® Virtualization Technology for Directed I/O (Intel® VT-d) will be available in an Intel® chipset and will make it easier to handle I/O traffic across multiple virtualized applications. Devices that handle a high volume of network traffic, like security appliances, will find it easier to manage multiple networking ports across different security applications.

Letting Intel® Communications Alliance Help

American Portwell Technology, Wind River and QNX Software Systems are members of the Intel® Communications Alliance, a community of communications and embedded developers and solution providers committed to the development of modular, standards-based solutions on Intel technologies. Wind River and QNX provide operating systems and tools for multi-core software developers.

More than 100 Alliance members provide software, hardware and tools solutions to help developers reduce their time to market and overall development costs. For more information, visit http://www.intel.com/go/ica/.

[1]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, visit http://www.intel.com/performance/resources/benchmark_limitations.htm.

For more information on embedded Intel multi-core processors, visit http://www.intel.com/go/embedded