



THE SOLARIS™ OPERATING SYSTEM AND THE NEW INTEL® CORE™ MICROARCHITECTURE

White Paper
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Intended Audience

This white paper offers a high-level overview of key features of the new Intel® Core™ Microarchitecture (formerly code-named Nehalem), and the advantages of running the Solaris™ Operating System (OS) in these environments. This white paper is intended mainly for business decision makers, developers and IT professionals—people who make systems, architecture, platforms, and IT decisions in small, medium and large companies.

Executive Summary

The decision to invest in an IT development and deployment platform is complex, and requires assessing current needs as well as accurately predicting future technology and business trends. IT professionals want to ensure that their development and deployment platforms take full advantage of all that can be offered, including end-to-end performance, runtime flexibility, rock-solid reliability, and minimizing power requirements. Innovative server designs can deliver on these requirements, but maximizing value and utility demands unprecedented collaboration between processor architecture and operating environment groups.

Intel and Sun Microsystems have been working together to create a clear choice. Engineering teams from the two companies are collaborating on optimizing how the Solaris ecosystem and the new Intel Core Microarchitecture (formerly code-named Nehalem) for the Intel® Xeon® processor work together, with compelling results, including:

- Increased performance as the Solaris OS leverages Intel® multi-core processor capabilities and turbo mode.
- Optimized power efficiency and utilization by enabling Solaris to take advantage of the new Intel Core Microarchitecture performance-enhanced dynamic power management capabilities.
- Improved reliability by incorporating new Intel Core Microarchitecture features into the Solaris Fault Management Architecture (FMA).
- Cost-effective virtualization by enhancing the Solaris OS to take advantage of the latest Intel® Virtualization Technology features.

Sun and Intel, as part of a broad strategic alliance, have been working together — from design and architecture through implementation — to ensure that the Solaris OS is optimized to unleash the power and capabilities of current and future Intel Xeon processors at the time of launch. Within the first year of the strategic alliance,

Sun and Intel have made significant advances¹ to optimize the Solaris OS for Intel Xeon processor-based systems. Now, Sun and Intel are working closely to unleash new capabilities that are part of the new Intel Core Microarchitecture.

The Solaris ecosystem, including the Solaris OS, Sun Studio development tools, and the OpenSolaris™ community, will offer a compelling value for developers and users who embrace the breakthrough capabilities of the new Intel Core Microarchitecture. The result will deliver a robust choice for both the leading edge and the established enterprise datacenter applications.



New Intel Core Microarchitecture for Intel Xeon Processor

The new Intel Core Microarchitecture is the next step in Intel's continuing success in leading the industry in processor performance and energy efficiency. Building on the successful transition of the Core Microarchitecture to 45nm manufacturing process technology in 2007, the new Intel Core Microarchitecture represents a significant leap in performance and energy efficiency over the current 45nm processor, similar to the leap made by Intel Core microarchitecture from the two generations of 65nm Intel® processors. The new Intel Core Microarchitecture continues Intel's philosophy of focusing on improvements in how the processor uses available clock cycles and power, rather than just increasing clock speeds which raises energy requirements. In nearly every way, the new Intel Core Microarchitecture delivers more capability—performance, scalability, reliability, and virtualization—with the same or reduced power envelope compared to current-generation Intel® Xeon® processors.

The scalable and modular processor architecture enables Intel to easily provide versions that are optimized for mobile, desktop, and data center markets. Intel will deliver versions differing in the number of cores, cache sizes, interconnect capabilities, and memory controller capabilities, as well as the optional use of an integrated graphics controller. This allows Intel to deliver a wide range of price, performance, and energy efficient implementations for servers, workstations, desktops, and laptops, all using a common microarchitecture to ensure application compatibility. When combined with the Solaris OS, it dynamically manages cores, threads, cache, interfaces, and power to deliver outstanding energy efficiency, performance, and scalability on demand.

1. blogs.sun.com/ontherecord/entry/sun_and_intel_celebrate_one



Solaris™ Leadership

The Solaris ecosystem consists of the Solaris and open source OpenSolaris OS releases, as well as the Sun Studio development tools. The free and open Solaris OS is a proven, industry leading operating system with features designed to save time and money in business-critical operations. The Solaris OS provides stability, virtualization, massive scalability, high performance, and guaranteed forward binary compatibility. Intel is embracing Solaris as a mainstream OS and the enterprise class, mission critical UNIX® OS for Intel Xeon processor-based servers.²

The OpenSolaris community is where the next generation of Solaris is being built, and where the latest innovations from Sun and Intel can be found. The OpenSolaris OS release offers cutting-edge features contributed by a global development community, which provides accelerated time to market and support for the latest technologies and innovation in an environment familiar to GNU/Linux and UNIX developers and administrators. Future releases of the Solaris OS will be based on OpenSolaris OS releases; Solaris OS releases feature an extended support life cycle as needed in today's demanding datacenters.³

The Solaris ecosystem, in conjunction with the new Intel Core Microarchitecture processors, will be a superior choice for both leading edge applications such as Web 2.0 and high performance computing, and all forms of enterprise computing. Organizations can leverage Solaris as the mission-critical enterprise class operating system on new Intel Core Microarchitecture processor systems from Sun, as well as other manufacturers—the Solaris OS is supported on over 1,000 systems, and OpenSolaris on over 2,500 systems.⁴

2. sun.com/aboutsun/pr/2007-01/sunflash.20070122.1.xml

3. sun.com/solaris/lifecycle.html

4. sun.com/bigadmin/hcl/

Combined Innovation: Solaris and New Intel Core Microarchitecture

With Intel and Sun collaborating on the Solaris OS for new Intel Core Microarchitecture processors, powerful innovations in computing are just around the corner. From the outset, the design goals of both the new Intel Core Microarchitecture and Solaris OS have been closely aligned to provide an environment that delivers advanced functionality for tomorrow's applications while running today's applications faster, more efficiently, and with improved manageability and availability.

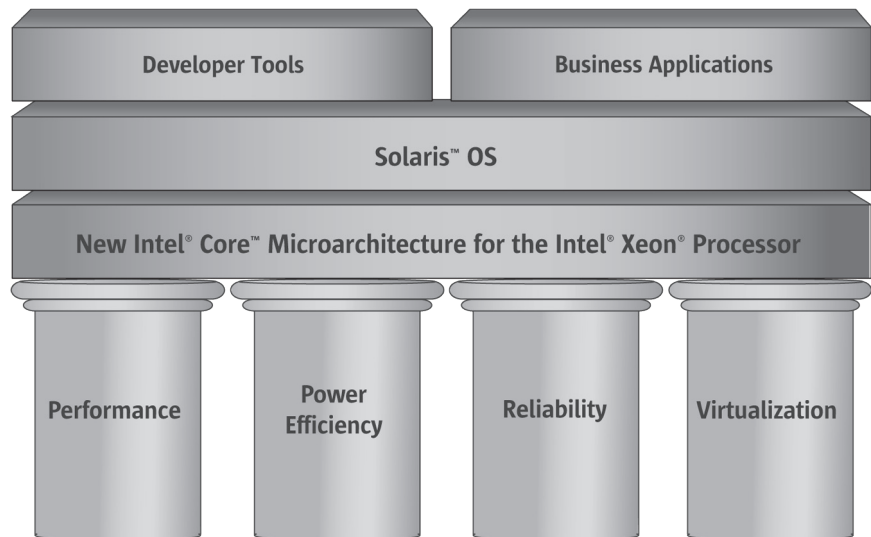


Figure 1: The Solaris ecosystem will be ready for systems built with the new Intel Core Microarchitecture.

The following sections describe several of the new features and capabilities of the new Intel Core Microarchitecture, and how the Solaris OS enables this next-generation functionality for developers, administrators, and end-users alike.

Performance

Building on a proven track record, Solaris will be ready to take advantage of the groundbreaking performance capabilities of the new Intel Core Microarchitecture. The new Intel Core Microarchitecture's most significant performance innovations come from optimizations of the individual cores and the overall multi-core microarchitecture, which increase both single-thread and multi-thread performance. As a result, the Solaris kernel and existing single- or multi-threaded applications will run faster, with no code changes or recompilation necessary.

There are significant areas where Solaris will provide an environment for maximum application performance by taking advantage of the new Intel Core Microarchitecture features.

- *Turbo mode* converts any available power headroom into higher frequencies. In those situations where the Solaris OS determines that maximum processing power is required, the new Intel Core Microarchitecture processor increases the frequency in the active core when conditions such as load, power consumption and temperature permit it. By utilizing thermal and power headroom as a performance boost, the Solaris OS and the new Intel Core Microarchitecture can deliver more work for less overall heat and power consumption.

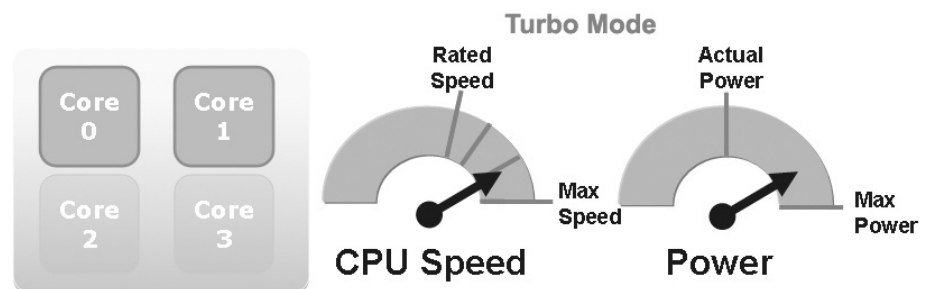


Figure 2: CPUs typically operate at a fixed maximum frequency regardless of the workload; however, most applications allow the CPU to operate below maximum power. Headroom may also be available if some cores are in idle mode, as pictured. Turbo mode speeds up the CPU to utilize available power headroom, as needed.

- The new Intel Core Microarchitecture will have *two hardware threads per core*, or up to eight threads per quad-core processor. Intel® Hyper-threading Technology provides two threads per core, enabling a more energy efficient means of increasing performance for multi-threaded workloads.

Solaris has an outstanding threading model for the commercial operating system market, outperforming the competition on customer applications as well as industry-standard benchmarks. With specific optimizations for the new Intel Core Microarchitecture, the Solaris OS enables new levels of performance as applications incorporate multi-threaded design, increasing throughput, responsiveness, efficiency, scalability, and overall performance.

- The Solaris OS will leverage the capabilities of the new *Intel® QuickPath Interconnect (Intel® QPI) architecture* with capabilities such as an optimized scheduler and memory placement optimization (MPO) capability that has proven performance benefits with non-uniform memory access (NUMA) architecture systems. The Intel QPI architecture delivers best-in-class performance, and unleashes the performance of next generation microarchitecture-based processors and future generations of Intel® multi-core processors.

Intel QPI connects processors and other components with a new high-speed point-to-point interconnect and includes a high-performance interconnect and integrated memory controller (IMC). The IMC has the significant advantage of being coupled with large high-performance caches. This relieves pressure on the memory subsystem and lowers overall latency, resulting in dramatically improved throughput.

- *Intel® Smart Cache* adds up to 8 MB of shared L3 (last-level) memory, improving speed and throughput in multi-threaded solutions. Solaris is being optimized to take advantage of this capability in the new Intel Core Microarchitecture.
- Innovative *extensions to the Intel® Streaming SIMD Extensions 4 (SSE4.2)*—and in particular its string and text processing instruction extensions—will enhance XML, string, and text processing, resulting in improved performance in areas such as Web 2.0 applications and virus scanning. There will be optimized routines in Solaris to take advantage of these new features.

The Solaris OS offers additional performance advantages that help improve overall throughput. For example, a turbocharged TCP/IP stack can leverage the high-performance I/O acceleration features available in the new Intel Core Microarchitecture. Sun development tools will be integrated to take advantage of specific features in the new Intel Core Microarchitecture, such as internal counters and a new instruction set. The Solaris OS also includes a highly integrated facility for troubleshooting and tuning applications in real time. Solaris Dynamic Tracing (DTrace) technology provides very detailed tracing and observability, making it possible to detect performance bottlenecks in remarkably short periods of time.

Power Efficiency

Intel weighed every architectural feature added to the new Intel Core Microarchitecture against a strict power/performance efficiency threshold. By measuring the benefit of the performance gain against the power cost, Intel was able to design the new Intel Core Microarchitecture to deliver greater power efficiency at any power envelope, resulting in performance-enhanced dynamic power management as part of a set of enhancements to Intel® Demand-Based Switching (DBS). Solaris and OpenSolaris will support DBS and other power saving features on the new Intel Core Microarchitecture. The Solaris OS running on servers powered by Intel Xeon processors already show improvements in power management and efficiency, reducing power

to processors, or idling them, when there is less demand. These systems can lower the voltage and frequency in steps without affecting overall throughput, and provide considerable energy savings at the same time. For the new Intel Core Microarchitecture, Sun and Intel are working to enhance power management capabilities in the Solaris OS, including:

- Adjusting processor power requirements in response to utilization, and enabling the system to go into the deepest power saving state possible when a processor is idle.
- Working to make the Solaris kernel “tickless,” which means it will not periodically wake up to process a clock tick, but rather stay idle until an event of interest occurs. This can save considerable energy.
- Creating tools for developers that show where applications may be waking the system up unnecessarily and preventing it from going into a power-saving sleep mode. To identify applications or programming systems which may be responsible for polling behavior, the Intel and Sun engineering teams have developed the PowerTOP application for Solaris. The PowerTOP application points the developer to areas which consume high power within the application.

In summary, Solaris will enable Intel Xeon processors based on the new Intel Core Microarchitecture to stay longer in idle states (C-states), have better granularity in power management states (P-states), and have better responsiveness to changes in demand. The end result is reducing unnecessary power costs.

Reliability

The Solaris Operating System provides a proven architecture for building and deploying systems and services capable of Predictive Self Healing, which automatically diagnoses, isolates, and aids in recovery from hardware and application faults. Solaris Fault Manager is a key component of Predictive Self Healing.

Solaris Fault Manager receives data relating to hardware and software errors and automatically diagnoses the underlying problem. Once diagnosed, Solaris Fault Manager automatically responds by offlining faulty components. Sun and Intel are working together to extend these capabilities to systems based on the new Intel Core Microarchitecture, including chipsets and memory subsystems.

The new Intel QuickPath Interconnect provides tightly integrated reliability features to improve uptime and maintain high performance levels. For example, new cyclic redundancy check (CRC) capabilities ensure data quality and performance without the performance penalty of additional cycles. Sun and Intel are working together to leverage status information throughout the new Intel Core Microarchitecture to help the Solaris fault management system diagnose a hardware fault correctly. This verification ensures that users running the Solaris OS on Intel Xeon processor-based systems will get a correct diagnosis and recovery should a hardware fault occur.

One critical element to availability is reliable data subsystems. Solaris ZFS provides unparalleled data integrity, capacity, performance, and manageability. Solaris ZFS provides high-resiliency features such as metadata logging to guarantee data integrity and speed recovery in the event of system failure. ZFS dramatically simplifies file system administration to help increase protection against administrative error. Solaris ZFS was introduced in the Solaris 10 6/06 Update, and is the default file system in the current OpenSolaris OS release and all future Solaris releases.

Sun xVM

Virtualization

As strong proponents of open source software, Intel and Sun collaborate with the Xen community to enable the Xen hypervisor to take advantage of the latest Intel Virtualization Technology capabilities. The Sun xVM™ portfolio will offer comprehensive support⁵ for new Intel Core Microarchitecture virtualization capabilities.

The new Intel Core Microarchitecture includes next generation Intel® Virtualization Technology that delivers even more efficient virtual machine operation with optimizations that enable a higher level of performance and reliability. These new features will enable improved software performance, security, and reliability in virtualized environments. The new Intel Core Microarchitecture delivers faster virtualization performance by reducing transition latency into and out of virtual machine mode, as well as reducing the number of required transitions into and out of the virtual machine mode. In addition, the new Intel Core Microarchitecture will offer improved I/O virtualization as part of the core logic chipset, and improving I/O performance through direct assignment of a device to a virtual machine. Fast, reliable, comprehensive, hardware-assisted virtualization capabilities contribute to better power efficiency, improved reliability, and increased asset utilization.

The Sun xVM portfolio, part of a comprehensive line of virtualization products from Sun, is an enterprise-class software infrastructure offering for the virtualization and management of heterogeneous IT infrastructure. Sun xVM Server uses OpenSolaris OS technologies to take advantage of the new Intel Core Microarchitecture capabilities. This will build on existing functionality—the very first release of xVM Server makes use of the Intel Virtualization Technology available today, providing high-speed performance and secure isolation of virtual machines. For example, para-virtualized drivers will be available at launch, allowing non-Intel Virtualization Technology-aware operating systems—such as Windows XP, Windows 2003 and older Solaris releases—to run on top of the Intel Virtualization Technology-enabled chipsets.

xVM Server supports Solaris operating systems and other major operating systems. Sun xVM VirtualBox, part of the Sun xVM portfolio, is a hosted virtualization product that also takes advantage of Intel Virtualization Technology chipsets to improve the performance of Windows OS guest operating systems over systems without Intel Virtualization Technology.

5. developers.sun.com/events/techdays/presentations/locations-2008/joburg/java_devdeploy_track/td_jb_intel_alt.pdf

Conclusion

Intel Xeon processors and the Solaris OS are both widely recognized as the technologies of choice for enterprise and mission-critical applications. The collaboration of Sun and Intel, including the joint engineering work from both companies, has already resulted in state-of-the-art development and deployment platforms for environments based on Intel Xeon processors. The next step is focusing on delivering the Solaris OS optimized for Intel Xeon processors based on the new Intel Core Microarchitecture—maximizing performance, power efficiency, reliability, and virtualization. The result will be the ideal platform for current and future application development and deployment.

More Information

Intel

New Intel Core Microarchitecture white paper:

intel.com/technology/architecture-silicon/next-gen/whitepaper.pdf

Intel QuickPath Interconnect:

intel.com/pressroom/archive/reference/whitepaper_QuickPath.pdf

Intel and Sun Alliance:

intel.com/sunalliance/

Sun

Solaris OS:

sun.com/solaris/

OpenSolaris OS:

opensolaris.org, opensolaris.com

Sun and Intel Alliance:

sun.com/intel

PowerTOP:

opensolaris.org/os/project/tesla/work/powertop

Sun Partners:

partneradvantage.sun.com



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