SOLUTION BRIEF

Intel® Builders
High Performance Computing
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Intel® Select Solutions for Professional Visualization

Quickly assemble a solution that delivers the highest-quality visualizations possible in the big data age, with both excellent performance and lower costs.

Visualizations serve the crucial role of making complex data intelligible to the human eye, and for this reason, they are needed in industries as diverse as architecture, scientific research, entertainment, and engineering. But as data sizes in these industries increase exponentially, the limitations of today's graphics-processing hardware make visualizing the large datasets a growing challenge. This challenge is especially pronounced because excellent image fidelity in visualizations is essential. Visualizing a scientifically accurate model fosters insight about the problem being investigated, but a model that compromises resolution or fidelity potentially sows misunderstanding, hindering the analysis and discovery process.

On top of these already processing-intensive demands for image fidelity, scientists and researchers are increasingly demanding interactivity in their visualization environments. Interactive visual computing enables users to dynamically modify parameters during computation and manipulate the visual representation of data in real time, driving even more scientific discoveries. The high processing requirements for interactivity, however, can significantly slow down a visualization system, especially with larger datasets.

The technical solutions available for rendering visualizations and interactivity have, until recently, failed to strike an adequate balance among performance, visual fidelity, and cost. Rasterization techniques on graphics-specific hardware, for example, sometimes allow for speedier rendering of smaller-sized 3D models, but at the expense of higher fidelity. As another example, ray tracing techniques offer the highest fidelity for visualizations; however, the performance of ray tracing algorithms on graphics hardware has been an impediment. The inherent raster-focused architecture of graphics processing units (GPUs), along with their limited memory and input/output (I/O), fail to deliver adequate performance for ray tracing algorithms.

Although not as broadly known, the facts are that the highly flexible processing capability and directly accessible memory of Intel® parallel processors provide an excellent platform for high, interactive performance for both raster-based (OpenGL*) and ray-tracing-based visualizations. Intel parallel processors can render large-scale datasets, whereas GPUs are limited by their memory constraints.

Software-Defined Visualization

At the foundation of the Intel® Select Solutions for Professional Visualization are Intel's software-defined visualization libraries. These libraries offer CPU-based software that delivers a flexible, high-performance, scalable, cost-effective, and power-efficient solution for visualizations, including large 3D data (more than 1 terabyte) visualizations that are not achievable with GPU-based solutions. Running these software libraries on CPU-based hardware avoids the need for a discrete GPU, which allows scientists, engineers, and digital artists to use one holistic platform for both simulations and visualizations. Another advantage of a CPU-based solution is that it can scale as needed across the nodes in a cluster or inside a computational cloud to meet the performance or memory size required. Unlike with GPU-based visualization solutions, CPU-based solutions can scale without needing to rely on tricks or techniques to "fit" the data into a constrained memory for analysis. Finally, software-defined visualization running on Intel CPUs provides the performance needed to help speed up interactivity during visualizations.

Intel's software-defined visualization libraries offer a set of optimized, open-source capabilities that enable high-performance, high-fidelity visualization applications to run on Intel platforms. The libraries scale in a parallel processing environment, such as a high-performance computing (HPC) cluster or a cloud infrastructure. The libraries include:

- **Embree*:** A CPU-optimized ray tracing kernel library
- **OSPRay*:** A rendering engine for clusters based on Embree
- **OpenSWR*:** A high-performance Mesa* OpenGL CPU rasterization library

Intel Select Solutions for Professional Visualization

Intel Select Solutions for Professional Visualization provide a fast path for purchasing and deploying a cluster to enable visualization workloads without the cost, limitations, and system challenges of GPU-based solutions. Intel Select Solutions for Professional Visualization consist of a pre-validated selection of software and hardware components designed to meet the demands of HPC and enterprise applications that include visualization workflows. These systems also provide the capabilities and agility needed to eliminate the need for multiple single-purpose systems. In addition, the performance of key system characteristics are verified for Intel Select Solutions for Professional Visualization at both the node and cluster level.

Hardware Selected for Professional Visualization

Intel Select Solutions for Professional Visualization are verified solutions that combine Intel® Xeon® Scalable processors with the Intel® Scalable System Framework (Intel® SSF) and other Intel technologies, helping to eliminate the need to perform lengthy research to determine the right hardware for maximizing both simulation and visualization capabilities. The solutions deliver optimized performance for professional visualization applications registered with Intel SSF. The technical supportability of the software environment is also improved through the inclusion of Intel® Cluster Checker, a tool that provides expert systems advice for administrators to help keep a cluster functioning well.

Intel® Select Solutions for Professional Visualization:

- Are performance-optimized for highly scalable simulation and visualization applications
- Include open source libraries developed by Intel that are available for adoption by third-party applications
- Achieve the highest level of photorealism through superior ray tracing libraries
- Are optimized for parallel-processing architectures in Intel® CPUs for increased performance
- Consist of open source technology, delivering vivid visualizations of complex, enormous datasets
- Produce high-fidelity images that help gain deeper, faster insights in science and industry

Verified Performance through Benchmark Testing

All Intel Select Solutions are verified to meet a specified minimum level of workload-optimized performance capability. Intel Select Solutions for Professional Visualization define performance watermarks that demonstrate optimized capabilities for HPC and visualization applications. Verified solutions meet or exceed design and testing standards, including two visualization-focused benchmarks, two well-known compute application benchmarks, plus three well-known industry computing micro-benchmarks that support a range of important system aspects and indicate potential scale-up and scale-out performance.

Visualization Benchmarks

To model and tune for visualization performance, an OSPRay ray tracing performance benchmark was used that measures and tests a system's capability for single node and multi-node scalability for ray tracing rendering. This solution is also tested and optimized for a broader range of visualization workloads with a set of ParaView* benchmarks focused on OpenSWR, OSPRay, and Embree performance as integrated into the popular ParaView application from Kitware, Inc.

HPC Benchmarks

To ensure fast turnaround from computation to visual results, including the rapidly emerging workflow of "in situ" visualization (in which compute and visualization run in tandem to provide instantaneous turnaround for visual results), Intel Select Solutions for Professional Visualization are also optimized for compute-intensive workloads. Two popular HPC benchmarks are used to represent and model a variety of common compute applications and to verify

high performance. The High Performance LINPACK* (HPL*) benchmark solves a dense linear system in double precision arithmetic calculation on distributed memory. The High Performance Conjugate Gradients* (HPCG*) benchmark models data-access patterns of real-world applications such as sparse-matrix calculations, testing memory subsystems, and internal interconnect. HPL and HPCG benchmarks also provide the ability to look at both individual node performance and the combined performance of the entire system.

System Benchmarks

Finally, Intel uses three additional micro-benchmarks to measure performance of key characteristics of the system necessary for robust compute to best pair with visualization. These benchmarks measure compute power, memory bandwidth, and interconnect fabric performance. DGEMM* is a double precision general matrix multiplication workload that measures computing capability of processor and memory. STREAM* measures the sustainable memory bandwidth and corresponding computation rate for simple vector kernels. IMB PingPong* measures the speed and latency of passing a single message from peer to peer across the interconnect fabric.

Base and Plus Configurations

Intel Select Solutions for Professional Visualization include two configurations. The "Base" configuration specifies the minimum required performance capability for an Intel Select Solution for Professional Visualization. The "Plus" configuration provides one example of how system builders, system integrators, and solution and service providers can further optimize to achieve higher performance and capabilities.

Configurations for Intel Select Solutions for Professional Visualization

Table 1 shows the two hardware configurations of Intel Select Solutions for Professional Visualization. To refer to a solution as an Intel Select Solution, a server vendor or data center solution provider must meet or exceed the defined minimum configuration ingredients and reference minimum benchmark-performance thresholds listed.

Intel Select Solutions for Professional Visualization include separate specifications for the master/head node and compute nodes. The Base configuration consists of a four-node cluster (one dedicated master/head node and three compute nodes). The Plus configuration demonstrates scalability through an eight-node cluster (one dedicated master/head node and seven compute nodes).

Table 1. The Base and Plus configurations for Intel® Select Solutions for Professional Visualization

INGREDIENT	INTEL® SELECT SOLUTIONS FOR PROFESSIONAL VISUALIZATION **BASE CONFIGURATION**	INTEL SELECT SOLUTIONS FOR PROFESSIONAL VISUALIZATON **PLUS CONFIGURATION**
Common Hardware Components		
Message Fabric Switch	Intel® Omni-Path Switch	Intel Omni-Path Switch
Management Network	1 gigabit Ethernet (GbE)	1 GbE
Master/Head Node		
Minimum Number	1	1
CPU	2 x Intel® Xeon® Gold 6148 processor at 2.40 GHz, 20 cores/40 threads, or a higher number Intel Xeon Scalable processor	2 x Intel Xeon Platinum 8180 processor at 2.50 GHz, 28 cores/56 threads
Memory	192 GB or higher with 2 GB/core or higher, 1 DPC 2,666 MHz (that is, all memory channels must be populated)	192 GB or higher with 2 GB/core or higher, 1 DPC 2,666 MHz (that is, all memory channels must be populated)
Boot Drive	Intel® Solid State Drive (SSD) DC S3520 Series or better or Intel SSD DC P3520 Series or better	Intel SSD DC S3520 Series or better or Intel SSD DC P3520 Series or better
Data Drives	4 x 4 TB Intel SSD DC P4500 Series or better/larger	4 x 4 TB Intel SSD DC P4500 Series or better/larger
RAID Controller (for Data Drives Only)	Intel® RAID Adapter RSP3TD160F or better	Intel RAID Adapter RSP3TD160F or better
Display Card**	Display card capable of driving 6 displays with a resolution of at least 4096 x 2160 pixels**	Display card capable of driving 6 displays with a resolution of at least 4096 x 2160 pixels**
Message Fabric	100 Gb Intel® Omni-Path Host Fabric Interface (HFI) Adapter 100 Series	100 Gb Intel Omni-Path HFI Adapter 100 Series
Software		
Software-Defined Visualization Software Stack	Version 2018.1 or later	Version 2018.1 or later
Cluster Software Stack**	OpenHPC*1.3.4 or later**	OpenHPC 1.3.4 or later**

Fabric Software	Intel® Omni-Path Fabric Software version 10.7.0.0.145 or later	Intel Omni-Path Fabric Software version 10.7.0.0.145 or later
Compute Nodes		
Minimum Number	3	7
CPU	2 x Intel Xeon Gold 6148 processor at 2.40 GHz, 20 cores/40 threads, or a higher number Intel Xeon Scalable processor	2 x Intel Xeon Platinum 8180 processor at 2.50 GHz, 28 cores/56 threads
Memory	192 GB or higher with 2 GB/core or higher, 1 DPC 2,666 MHz (that is, all memory channels must be populated)	192 GB or higher with 2 GB/core or higher, 1 DPC 2,666 MHz (that is, all memory channels must be populated)
Boot Drive	Intel SSD DC S3520 Series or better or Intel SSD DC P3520 Series or better	Intel SSD DC S3520 Series or better or Intel SSD DC P3520 Series or better
Message Fabric	100 Gb Intel Omni-Path HFI Adapter 100 Series	100 Gb Intel Omni-Path HFI Adapter 100 Series
Firmware and Software Optimizations		
Enabled Technologies	The following technologies or settings are required to be enabled: Trusted Platform Module (TPM) 1.2, Intel® Trusted Execution Technology (Intel® TXT), Intel® Hyper-Threading Technology (Intel® HT Technology), Intel® Turbo Boost Technology, Xtended Prediction Table* (XPT*) prefetch, performance power-management settings The following technology is recommended for enabling: Intel® Volume Management Device (Intel® VMD)**	The following technologies are required to be enabled: TPM 1.2, Intel TXT, Intel HT Technology, Intel Turbo Boost Technology, XPT prefetch, performance power-management settings The following technology is recommended for enabling: Intel VMD**
Minimum Performance Standards	Verified to meet or exceed the following minimum performance capabilities: • OSPRay*: less than 13,520 ms across all 4 nodes • ParaView* Volume Rendering: OSPRay less than 3.75 sec across all 4 nodes • ParaView Contour Geometry: OSPRay less than 16.6 sec, OSPRep* less than 4 sec, and SWR less than 1.55 sec across all 4 nodes • HPL*: more than 8,050 gigaflops across all 4 nodes • HPCG*: more than 135 gigaflops across all 4 nodes and 34 gigaflops on each node • DGEMM*: more than 2,048 gigaflops on each node • STREAM*: more than 166,000 MB/s on each node • IMB PingPong*: more than 11,300 MB/s bandwidth with a maximum of 1.8 µs latency	Verified to meet or exceed the following minimum performance capabilities: • OSPRay: less than 4,500 ms across all 4 nodes • ParaView Volume Rendering: OSPRay less than 1.35 sec across all 4 nodes • ParaView Contour Geometry: OSPRay less than 7.8 sec, • OSPRep less than 1.52 sec, and SWR less than 0.73 sec across all 4 nodes • HPL: more than 23,000 gigaflops across all 4 nodes • HPCG: more than 310 gigaflops across all 8 nodes and 39.4 gigaflops on each node • DGEMM: more than 3,050 gigaflops on each node • STREAM: more than 198,000 MB on each node • IMB PingPong: more than 11,500 MB/s bandwidth with a maximum of 1.7 µs latency
Business Value of Choosing a Plus Configuration Over a Base Configuration		3x faster ray tracing performance as measured by OSPRay ray tracing benchmark

**Recommended, not required

Technology Selections for Intel Select Solutions for Professional Visualization

In addition to the Intel® hardware-based foundation for Intel Select Solutions for Professional Visualization shown in Table 1, the following technologies provide further performance gains:

- **Intel® Advanced Vector Extensions 512 (Intel® AVX-512):** Boosts performance for the most demanding computational workloads, with up to double the number of floating point operations per second (FLOPS) per clock cycle, compared to previous-generation Intel processors.
- **Intel Cluster Checker:** Inspects more than 100 characteristics related to cluster health. Intel Cluster Checker examines the system at both the node and cluster level, checking that all components work together to deliver optimal performance. It assesses firmware, kernel, storage, and network settings and conducts high-level tests of node and network performance using the Intel® MPI Library benchmarks, STREAM, the HPL benchmark, the HPCG benchmark, and other benchmarks. Intel Cluster Checker can be extended with custom tests, and its functionality can be embedded into other software.
- **Intel® Cluster Runtimes:** Supplies key software runtime elements that are required on each cluster to ensure optimal performance paths for applications. Intel runtime performance libraries, including Intel® Math Kernel Library (Intel® MKL) and Intel MPI Library, deliver excellent performance optimized for clusters based on Intel architecture.
- **Converged parallel programming for Intel Xeon Scalable processors and Intel® Xeon Phi™ processors:** Enables the creation of a highly integrated portfolio of powerful technologies, software tools, and libraries. Intel Xeon Scalable processors offer an unparalleled flexible

Intel® Xeon® Scalable Processors

Intel Xeon Scalable processors:

- Offer high scalability for enterprise data centers
- Deliver performance gains for virtualized infrastructure compared to previous-generation processors
- Achieve exceptional resource utilization and agility
- Enable improved data and workload integrity and regulatory compliance for data center solutions

The family includes Intel Xeon Bronze processors, Intel Xeon Silver processors, Intel Xeon Gold processors, and Intel Xeon Platinum processors.

framework, based on a common programming model that supports code modernization initiatives across artificial intelligence (AI) frameworks.

- **OpenHPC*:** Provides a community-driven, open source software stack that includes a number of common ingredients required to deploy and manage Linux* HPC clusters. The package includes provisioning tools, resource management, I/O clients, development tools, and a variety of scientific libraries.

Inside Intel Select Solutions for Professional Visualization

Intel Select Solutions for Professional Visualization comprise several key hardware and software components. The Base and Plus configurations help ensure a right-sized solution across different environments and meet the needs of a wide range of use cases. Both configurations are tuned for optimal performance.

Compute

Intel Select Solutions for Professional Visualization require the Intel Xeon Gold 6148 processors or higher number Intel Xeon Scalable processors. Intel Xeon Gold 6148 processor dual-socket platforms offer 40 cores to deliver exceptional performance for compute- and data-intensive workloads. The Plus configuration showcases the Intel Xeon Platinum 8180 processors dual-socket platforms—with 56 cores—to meet the most challenging visualization and computation needs. Intel Xeon Scalable processors feature significant enhancements that can benefit visualization and compute applications, including improvements over the previous generation in I/O, memory, and fabric integration. In addition, the processors introduce Intel AVX-512, a new vector operations instructions set that accelerates performance for visualizations and other processor-intensive workloads.

Fabric

Intel® Omni-Path Architecture (Intel® OPA) provides 100 gigabits per second (Gbps) bandwidth and a low-latency, next-generation fabric for HPC clusters. The Intel OPA switch design can help deliver an increase in density compared to the switch design historically used for InfiniBand* networking, which reduces the number of required switches as solutions are scaled up. Intel OPA also helps reduce cabling-related cost, power consumption, space requirements, and ongoing system-maintenance requirements. These capabilities can help lower fabric costs.

Intel® Scalable System Framework (Intel® SSF)

The Intel SSF specification brings together Intel's latest compute, fabric, memory, storage, and software technologies for the next wave of high performance systems. Its standards-based programmability allows scientists, engineers, content creation, media professionals, and others to run diverse workloads on a broadly available, common infrastructure. Intel SSF enables organizations to achieve high performance with flexibility, scalability, balance, and portability.

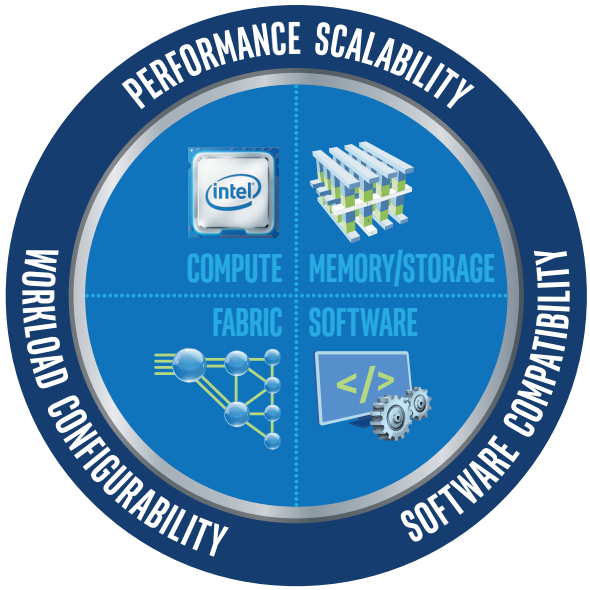


Figure 1. Intel® SSF delivers balanced systems through tighter integration of compute, fabric, memory, storage, and software

Meet the Compute and Visualization Challenges for Big Data with Intel Select Solutions for Professional Visualization

Intel Select Solutions for Professional Visualization draw upon the power of Intel Xeon Scalable processors, Intel® Omni-Path Fabric, and Intel's software-defined visualization libraries to help research organizations, engineering firms, digital content creators, and others gain a deeper understanding of data or deliver stunning photorealistic imagery. Intel Select Solutions for Professional Visualization make high-fidelity, photorealistic images possible, even as datasets become increasingly large and more complex.

Software-defined visualization applications run on CPU-based systems and avoid the need for a discrete GPU. Using CPU-based platforms enables organizations to avoid data transfer, the expense of GPU devices, or the expense of separate systems. In this way, Intel Select Solutions for Professional Visualization can help save time and money while helping users get results more quickly by solving computing and modeling problems simultaneously. These advantages can help lead to better, faster insights for solving the toughest problems.

Visit intel.com/selectsolutions to learn more, and ask your infrastructure vendor, system integrator, or solution provider for Intel Select Solutions.

What Are Intel® Select Solutions?

Intel Select Solutions are verified hardware and software stacks that are optimized for specific software workloads across compute, storage, and network. The solutions are developed from deep Intel experience with industry solution providers, in addition to extensive collaboration with the world's leading data center and service providers.

To qualify as an Intel Select Solution, solution providers must:

1. Follow the software and hardware stack requirements outlined by Intel
2. Replicate or exceed Intel's minimum benchmark-performance thresholds
3. Provide resources, services, or documentation to facilitate customer deployment

Solution providers can develop their own optimizations to add further value to their solutions.

Learn More

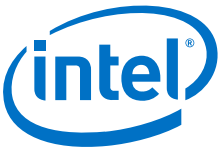
Intel Select Solutions: **intel.com/selectsolutions**

Software-Defined Visualization: **http://software.intel.com/sdvis**

Intel Xeon Scalable processors: **intel.com/xeonscalable**

Intel Scalable System Framework: **intel.com/ssf**

Intel Select Solutions are supported and can be ordered through the Intel® Builders Program: **http://builders.intel.com**. Follow us on Twitter: **#IntelBuilders**



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