Intel® Cluster Studio XE 2012
for Distributed Performance

Boost Performance. Code Reliably. Scale Forward

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Intel® Cluster Studio XE
Scale Forward, Scale Faster – for HPC Clusters

Relentless Pursuit of Compute Capacity

MPI Cluster

with

Multicore Today
Many-core Tomorrow

2x Moore’s Law

Relentless Pursuit of Compute Capacity

Software Development Solutions Must Scale

Scale Performance

MPI Latency
Analysis Tools
Parallel Models
Performance Libraries
Compilers

Scale Forward

MPI Scalability
Parallel Models
Multicore ➔ Many-core

Efficiency

MPI Correctness
Memory & Thread Correctness
Parallel Models

• Industry Leading Commercial MPI Latency & Scalability
• Industry Leading Compiler Performance
• Industry Leading Threading & Performance Analysis Tools Integrated for MPI Analysis
• Powerful Parallel Programming Models
Intel® Cluster Studio XE
Scale Forward, Scale Faster – for HPC Clusters

• Scale Performance – Perform on More Nodes
  – MPI Latency - Intel® MPI Library - Up to 6.5X as fast as alternative MPI libraries
  – Compiler Performance – Industry leading Intel® C/C++ & Fortran compilers

• Scale Forward – multicore now, many-core ready
  – Intel® MPI Library scales beyond 90k processes
  – Parallel Programming Models – Commercially supported Intel® versions of open source Threading Building Blocks 4.0 and Intel® Cilk™ Plus 1.1, MPI, OpenMP 3.1, Coarray Fortran
  – Focused to preserve programming investments for multicore on future many-core machines

• Scale Efficiently – Tune & Debug on More Nodes
  – Thread & Memory Correctness Checking – Intel® Inspector XE now MPI enabled across many nodes
  – Rapid Node Level Performance Profiling – Intel VTune Amplifier XE can identify hotspots faster and on thousands of nodes
Intel® MPI Library Overview

• Optimized MPI application performance
  – Application-specific tuning
  – Automatic tuning
• Lower latency and multi-vendor interoperability
  – Industry leading latency
  – Performance optimized support for the latest OFED capabilities through DAPL 2.0
• Faster MPI communication
  – Optimized collectives
• Simplify and accelerate clusters
  – “Intel® Cluster Ready”
• More robust MPI applications
  – Seamless interoperability with Intel® Trace Analyzer and Collector
**Intel® MPI Library 4.0 Update 3**

**What's New**

- Increased MPI application performance and scalability
  - New Intel® MPI Library architecture provides industry-leading performance and sustainable scalability beyond 90K cores
    - Dynamic connection mode for shared memory
    - TCP improvements
    - Dynamic queue pair (QP) creation and extensible reliable connection (XRC) mode for the ofa fabric
    - Scalable hybrid UD/RDMA mode for the dapl fabric
  - A new default Hydra process manager
    - Tight integration with SLURM*
  - Optimizations to all levels of cluster fabrics: from shared memory to Ethernet and RDMA-based fabrics
    - Shared memory optimizations for Intel® SSE4.2 and Intel® AES-NI platforms
    - Accelerated RDMA memory registration cache
    - RDMA over converged ethernet (RoCE) support for the dapl fabric
- Tune MPI code for best performance
  - Substantially accelerated and enhanced mpitune utility

Intel® MPI Library 4.0 Update 3 contains leading edge technology to further improve performance, scalability and usability
MPI Latency: 768 Processes / 64 Nodes on Intel processor running Linux* 64

Intel® MPI Library vs. alternative MPI libraries

Industry Leading Performance with Intel® MPI Library 4.0
Relative (Geomean) MPI Latency Benchmarks on Linux* 64 (Higher is Better)
768 processes on 64 nodes (InfiniBand + shared memory)

Up to 6.5X as fast as on 64 nodes than alternative Linux MPI libraries

Configuration Info - SW Versions: C/C++ version 12.1 update 6, Intel® MPI Library 4.0 Update 3, MVAPICH2 1.6, Open MPI 1.5.4, Intel® MPI Benchmarks 3.2.3; Hardware: Intel® Xeon® CPU X5670 at 2.93GHz, 2x2.93GHz, RAM 24GB, Interconnect: InfiniBand, Connectx adapters; O/S: Operating System: RHEL Server 6.1; Notes: 768 Processes on 64 nodes (InfiniBand + shared memory). All listed MPI libraries were built with the Intel® C++ Compiler 12.0.1 for Linux*. Benchmark Source: Intel Corp.

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MPI Latency: 96 Processes / 8 Nodes on Intel processor running Windows * 64
Intel® MPI Library vs. alternative MPI libraries

![Graph showing performance comparison between Intel® MPI Library 4.0 and alternative MPI libraries.](image)

**Industry Leading Performance with Intel® MPI Library 4.0**
Relative (Geomean) MPI Latency Benchmarks on Windows* 64 (Higher is Better)
96 processes on 8 nodes (InfiniBand + shared memory)

- Up to 2.7X as fast as on 64 nodes than alternative Windows MPI libraries

- **Configuration Info:** SW Versions: Intel® C/C++ version 12.1 update 6, Intel® MPI Library 4.0 Update 3, MS MPI 3.2, Intel® MPI Benchmarks 3.2.3; Hardware: Intel® Xeon® CPU X5670 @ 2.93GHz, 2x2.93GHz, RAM 24GB; Interconnect: InfiniBand, ConnectX adapters; OS: Operating System: Windows Server 2008 R2 X64 HPC Edition; Notes: 96 Processes on 8 nodes (InfiniBand + shared memory). All listed MPI libraries were built with the Intel® C++ Compiler 12.0 U3 for Windows*. Benchmark Source: Intel Corp.

- Performance tests and ratings are measured using specific computer systems and/or components and reflect the 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 the performance of Intel products, refer to [www.intel.com/performanceresources/benchmark_limitations.htm](http://www.intel.com/performanceresources/benchmark_limitations.htm). * Other brands and names are the property of their respective owners.

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Scale Performance
Tune Hybrid Cluster MPI and Thread Performance

Intel® Trace Analyzer and Collector

Tune cross-node MPI
• Visualize MPI behavior
• Evaluate MPI load balancing
• Find communication hotspots

Intel® VTune™ Amplifier XE

Tune single node threading
• Visualize thread behavior
• Evaluate thread load balancing
• Find thread sync. bottlenecks
Intel® Trace Analyzer and Collector Overview

- Intel® Trace Analyzer and Collector helps the developer:
  - Visualize and understand parallel application behavior
  - Evaluate profiling statistics and load balancing
  - Identify communication hotspots

- Features
  - Event-based approach
  - Low overhead
  - Excellent scalability
  - Comparison of multiple profiles
  - Powerful aggregation and filtering functions
  - Fail-safe MPI tracing
  - Provides API to instrument user code
  - MPI correctness checking
  - Idealizer
Intel® Trace Analyzer and Collector

Compare the event timelines of two communication profiles

Blue = computation
Red = communication

Chart showing how the MPI processes interact
Intel® VTune™ Amplifier XE
Tune Applications for Scalable Multicore Performance

• **Fast, Accurate Performance Profiles**
  - Hotspot (Statistical call tree)
  - Hardware-Event Based Sampling

• **Thread Profiling**
  - Visualize thread interactions on timeline
  - Balance workloads

• **Easy set-up**
  - Pre-defined performance profiles
  - Use a normal production build

• **Compatible**
  - Microsoft, GCC, Intel compilers
  - C/C++, Fortran, Assembly, .NET
  - Latest Intel® processors and compatible processors

• **Find Answers Fast**
  - Filter extraneous data
  - View results on the source / assembly
  - Event multiplexing

• **Windows or Linux**
  - Visual Studio Integration (Windows)
  - Standalone user i/f and command line
  - 32 and 64-bit

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1 IA32 and Intel® 64 architectures. Many features work with compatible processors. Event based sampling requires a genuine Intel® Processor.
Tune MPI Apps Single Node Threading
Intel® VTune™ Amplifier XE Performance Profiler

• Launch Intel® VTune™ Amplifier XE
  – Use mpirun or mpiexec
  – List your app as a parameter

• Results organized by MPI rank

• Review results
  – Graphical user interface
  – Command line report

Tune for Scalable Multicore Performance
Scale Efficiently
Intel® Cluster Studio XE correctness tools find errors early in the design cycle

Where are the application’s…

**Memory Errors**
- Invalid Accesses
- Memory Leaks
- Uninitialized Memory Accesses

**Threading Errors**
- Races
- Deadlocks
- Cross Stack References

**Security Errors**
- Buffer overflows and underflows
- Incorrect pointer usage
- Over 250 error types...

- MPI aware, cluster friendly
- Both dynamic and static analysis
- Multiple tools – common GUI
- Windows* & Linux*

"Having such a tool this early in the development stage frees the validation from trivial bug reports and gives our engineers the opportunity to code more efficiently from the very beginning of the product cycle."

Jean Kypreos
Advanced Video Processing Team Manager
Envivio

Developer friendly tools help you find errors earlier
Intel® Inspector XE
Find Memory, Threading and Security Errors

- Memory, Threading and Security Errors in one tool
- Locates difficult to find Race conditions
- Developer oriented workflow
  - Dynamic analysis: no rebuild
    Uses regular debug build
  - Static analysis: no central server – like a normal build
- New for 2011 SP1:
  - Auto static analysis setup in Visual Studio*
  - Dynamic analysis is faster with fewer false positives
Intel® Cluster Studio XE Correctness Tools
Analyze MPI Apps For Memory, Threading and Security Errors

Dynamic Analysis
• Launch Intel® Inspector XE
  – Use mpirun or mpiexec
  – List your app as a parameter
• Results organized by MPI rank
• Review results
  – Graphical user interface
  – Command line report

Static Analysis
• Source analyzed for errors (similar to a build)
• Review results
  – Graphical user interface
  – Command line report

Find errors earlier when they are less expensive to fix.
Intel® MPI Benchmarks 3.2.3
Overview and What's New

Standard benchmarks with OSI-compatible CPL license
• Enables testing of interconnects, systems, and MPI implementations
• Comprehensive set of MPI kernels that provide performance measurements for:
  – Point-to-point message-passing
  – Global data movement and computation routines
  – One-sided communications
  – File I/O

Enhancements:
• Added command-line option "-msglog" to control the maximum allocated message length
• Microsoft* Visual Studio* 10 project folder support

The Intel® MPI Benchmarks provide a simple and easy way to measure MPI performance on your cluster
“Intel Trace Analyzer and Collector for Linux helped to drastically improve the performance of RIKEN’s molecular dynamics cluster software. We were able to shorten MPI communication time by half by finding and removing bottlenecks with non-blocking communication patterns. Since Intel Trace Analyzer and Collector can embed instrumentation into the program, we can tell the execution time of each function and its load balance, which enabled us to very easily understand where to optimize. Intel’s MPI library and Cluster tools provide us the best cluster development environment.”

Dr. Takahiro Koishi, Computational Astrophysics Laboratory, RIDEN, Japan.

“Using Intel VTune Amplifier XE makes my work easier and speeds up the development process…it has helped us achieve performance gains from 20% to 360%”

Sergey Zaritchny – Open Cascade SAS

“We’re delighted by the efforts of the Intel cluster tools team in helping us scale our applications to 10s of cores with Intel MPI Library 4.0, and raising the performance bar in providing us with the most scalable commercial MPI library for Intel architecture based processors.”

Dr. Daniel Gruner, Chief Technical Officer - Software, University of Toronto

“Iron Inspector XE 2011 is a must-use to craft reliable code in C++. It helped me to quickly localize threading and memory problems in my code, making it easier to fix even the most difficult ones”

Jorge Martinis - Research & Development Engineer, BR&E Inc.
## Pricing and Availability

<table>
<thead>
<tr>
<th>Includes</th>
<th>C/C++ compiler</th>
<th>Fortran* compiler</th>
<th>Intel® Inspector XE</th>
<th>Intel® VTune™ Amplifier XE</th>
<th>For Linux*</th>
<th>For Windows*</th>
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Additional configurations including, floating and academic, are available at

[www.intel.com/software/products](http://www.intel.com/software/products)