

# INTEL® PARALLEL STUDIO XE 2016 CLUSTER EDITION

For Distributed Performance

# Intel<sup>®</sup> Parallel Studio XE 2016 development suite -Empowering Faster Code Faster

### **Delivering HPC Development Solutions**

- Over 20 years
- Industry Collaboration on Standards
- Developed with Performance & Scaling with Intel hardware

### Meeting the Challenges

- Boosting Performance
- Increasing Scalability
- Increasing Productivity



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# How Intel<sup>®</sup> Parallel Studio XE 2016 helps make *Faster Code Faster* for HPC



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# Intel<sup>®</sup> MPI Library

### Value Proposition

What	Intel's High Performance MPI Library
Why	<ul> <li>Scale Performance – Tuned for Latest Intel Architectures</li> <li>Scale Forward – Multicore and Manycore Ready</li> <li>Scale Efficiently – Flexible Fabric Selection &amp; Compatibility</li> </ul>
How	<ul> <li>Standards Based – Built on Open Source MPICH Implementation</li> <li>Sustained Scalability – Tuning for Low Latencies, High Bandwidth &amp; Increased Processes</li> <li>Multi Fabric Support – Supports Popular High Performance Networking Fabrics</li> </ul>

# Intel<sup>®</sup> 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.x

### **Faster MPI communication**

Optimized collectives

### Sustainable scalability beyond 262K cores

 Native InfiniBand\* interface support allows for lower latencies, higher bandwidth, and reduced memory requirements

### More robust MPI applications

 Seamless interoperability with Intel<sup>®</sup> Trace Analyzer and Collector



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# Superior MPI performance on Linux\* 64

288 Processes, 8 nodes (InfiniBand + shared memory)

Superior Performance with Intel® MPI Library 5.1 288 Processes, 8 nodes (InfiniBand + shared memory), Linux\* 64 Relative (Geomean) MPI Latency Benchmarks (Higher is Better)



■ IntelMPI 5.1 ■ PlatformMPI 9.1.2 CE ■ MVAPICH2 2.1 ■ OpenMPI 1.8.5

Configuration Info:

Hardware: CPU: Dual Intel(R) Xeon(R) CPU E5-2699 v3 @ 2.30GHz; 64 GB RAM. Interconnect: Mellanox Technologies MT27600 [Connect-IB].

Software: RedHat\* RHEL 6.5; OFED 3.12-1; Intel® MPI Library 5.1; Intel® MPI Benchmarks 4.1 (built with Intel® C++ Compiler XE 15.0.3 for Linux\*);

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# Superior MPI performance on Linux\* 64

1792 Processes, 64 nodes (InfiniBand + shared memory)

#### Superior Performance with Intel® MPI Library 5.1

1792 Processes, 64 nodes (InfiniBand + shared memory), Linux\* 64 Relative (Geomean) MPI Latency Benchmarks (Higher is Better)



#### **Configuration Info:**

Hardware: CPU: Dual Intel(R) Xeon(R) CPU E5-2697 v3 @ 2.60GHz; 64 GB RAM. Interconnect: Mellanox Technologies MT27500 Family [ConnectX-3].

Software: RedHat\* RHEL 6.5; OFED 3.5-2; Intel® MPI Library 5.1 Intel® MPI Benchmarks 4.1 (Built with Intel® C++ Compiler XE 15.0.3 for Linux\*);

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# Superior MPI performance on Windows\* 64

96 Processes, 8 nodes (IP over InfiniBand + shared memory)

Superior Performance with Intel® MPI Library 5.1

96 Processes, 8 nodes (sock + shared memory), Linux\* 64 Relative (Geomean) MPI Latency Benchmarks (Higher is Better)



Configuration Info:

HOST Hardware : Intel<sup>®</sup> Xeon<sup>®</sup> CPU X5680 @ 3.33GHz, RAM 24GB; Interconnect: InfiniBand, Mellanox ConnectX VPI (MT26428) QDR;

Software: Microsoft Windows Server 2008 HPC Edition, OFED 3.2, Intel® C/C++ Compiler XE 15.0.3, Intel® MPI Benchmarks 4.1.

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IntelMPI 5.1

MS-MPI v6

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### Superior MPI performance on Xeon Phi<sup>™</sup>

64 Processes, 8 nodes (InfiniBand + shared memory)

#### Superior Performance with Intel® MPI Library 5.1

64 Processes, 8 nodes (InfiniBand + shared memory), Linux\* 64 Relative (Geomean) MPI Latency Benchmarks (Higher is Better)



#### Configuration Info:

HOST Hardware : Intel® Xeon® CPU E5-2680 @ 2.70GHz, RAM 64GB; Interconnect: InfiniBand, Mellanox Technologies MT27500 Family [ConnectX-3];

MIC Hardware: Intel<sup>®</sup> Xeon Phi<sup>™</sup> coprocessor SE10/7120 series (rev 20) 1238095 kHz; 61 cores. RAM: 15872 MB per card.

Software: RHEL 6.5, OFED 3.12-1, MPSS Version: 3.5, Intel® C/C++ Compiler XE 15.0.3, Intel® MPI Benchmarks 4.1.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. \* Other brands and names are the property of their respective owners. Benchmark Source: Intel Corporation.

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# Intel<sup>®</sup> MPI Library 5.1 *What's New*

# MPI Library

### Ease of use

 Brand new Troubleshooting section for quicker issue resolution

### Performance & Scaling

- Support for OpenFabrics\* Interface (OFI\*) v1.0
- Additional features for faster automatic tuning

### Application performance at scale (Dual Xeon™ E5-2697 v3 @ 2.60GHz, -ppn 24)



Based on the following set of tests: SpecMPI-2.0/104.milc, SpecMPI-2.0/127.wrf2 (Built with Intel® C++ Compiler XE 15.0.3.187 for Linux\*); Hardware: CPU: Dual Intel® Xeon E5-2697V3@2.60Ghz; 64 GB RAM. Interconnect: Mellanox Technologies\* MT27500 Family [ConnectX\*-3] FDR. Software: RedHat\* RHEL 6.5; OFED 3.5-2-MIC-rc3; Intel® MPI Library 5.1, MVAPICH2-2.1. Environment: MV2 IBA. HCA=mix4\_0 (mvapich2 only).



# Performance Tuning Tools for Distributed Applications

### Intel® Trace Analyzer and Collector

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		P4
		P5
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### Tune cross-node MPI

- Visualize MPI behavior
- Evaluate MPI load balancing
- Find communication hotspots

### Intel<sup>®</sup> VTune<sup>™</sup> Amplifier XE



### Tune single node threading

- Visualize thread behavior
- Evaluate thread load balancing
- Find thread sync bottlenecks

#### **Optimization Notice**

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# Intel® Trace Analyzer and Collector

### **Value Proposition**

What	<ul> <li>Intel's High Performance MPI Communications Profiler &amp; Analyzer for Scalable HPC Development</li> </ul>
Why	<ul> <li>Scale Performance – Perform on More Nodes</li> <li>Scale Forward – Multicore and Manycore Ready</li> <li>Scale Efficiently – Tune &amp; Debug on More Nodes</li> </ul>
How	<ul> <li>Visualize - Understand parallel application behavior</li> <li>Evaluate - Profiling statistics and load balancing</li> <li>Analyze - Automated analysis of common MPI issues</li> <li>Identify - Communication hotspots</li> </ul>

# Intel<sup>®</sup> Trace Analyzer and Collector Overview



- Performance Assistance and Imbalance Tuning
- NEW in 9.1: MPI Performance Snapshot

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# Using the Intel<sup>®</sup> Trace Analyzer and Collector is ... Easy!





# Intel<sup>®</sup> Trace Analyzer and Collector





Chart showing how the MPI processes interact

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# Improving Load Balance: Real World Case



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# Improving Load Balance: Real World Case



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# Improving Load Balance: Real World Case



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# Ideal Interconnect Simulator (Idealizer)

# Helps to figure out application's imbalance simulating its behavior in the "ideal communication environment"

Actual trace

0 s 40 s 80 s 120 s	160 s 200 s 240 s 280 s 320 s 140 s 180 s 220 s 260 s 300 s	340 s 400 s 440 s 480 s
PCI Application Application Application	n_ <u>/#F151/#_IMATSJUUUT</u> 95/MITTIN/MITTIN/MApplication/MENTLATETIN/TELEVITENTELIN/TELEVITENT	I Application I IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
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Easy way to identify application bottlenecks



# **MPI Performance Assistance**

### Automatic Performance Assistant

- Detect common MPI performance issues
- Automated tips on potential solutions



Automatically detect performance issues and their impact on runtime

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# MPI Performance Snapshot High capacity MPI profiler



### **Lightweight** Low overhead profiling for 100K+ Ranks



### **Scalability** Performance variation at scale can be detected sooner



Identifying Key Metrics Shows PAPI counters and MPI/OpenMP imbalances

#### MPI Performance Snapshot Summary



	==== GENERAL	STATISTICS						
WallClock:	284.274 s	ec (All p	rocesses)					
MIN:	31.998 s	ec (rank	0)					
MAX:	35.534 s	ec (rank	7)					
	= HW COUNTER	S STATISTIC	s					
GFlops: 9.563	MPI: 11.2	8% NON M	PI: 88.72%					
		_	M	PT IMBALANCE	STATISTICS			
Floating-Point in	istructions:	45.77%		207 047	DIALIDITOD	72 12%	(711 m	
Vectorized DP in	istructions:	24.69%		207.047	sec	73,123	(ATT DI	COCES
Memory access in	istructions:	42.35%		23.044	sec	64,85%	(rank	6)
				30.113	sec	88,57%	(rank	1)
	== MEMORY USA	GE STATISTI	CS					
All processes:	256.740MB		1 mm 1	== OpenMP ST	ATISTICS ==:			
MIN:	30.608MB	(process	7)	228.631	sec	80,43%		56
MAX:	33.136MB	(process	1)	25.348	sec	71.33%		7
			MAX:	33.124	sec	97,42%		7
		OpenMP	Imbalance:	103.92	4 sec	36,56%	a (All	proc
			MIN:	11.52	2 sec	32,43%	(ran)	k 3)
			MAX:	15.05	7 sec	44,29%	(ran)	k 2)

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# **MPI Correctness Checking**

Highlights: Checks and pin-point hard to find run-time errors

- Unique feature to identify run-time errors
- Displays the correctness (parameter passing) of MPI communication for more robust and reliable MPI based HPC applications

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P2	ArMPL_Isend				MPI_Barrier				IPI_Barrier	MPI_Barrie			•			
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PE	ApMPI_Isend	lsend	Isend	lsend lsen	i Liser Liser	d Usen	lsend	Isend		MPI_Barrier	M M MPI_Finalize					
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	MPI	statist	ics													

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# Intel<sup>®</sup> MPI Benchmarks 4.1

### Standard benchmarks with OSIcompatible 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
  - Supports MPI-1.x, MPI-2.x, and MPI-3.x standards

### What's New:

Introduction of new benchmarks

Measure cumulative bandwidth and message rate values

### The Intel® MPI Benchmarks provide a simple and easy way to measure MPI performance on your cluster



# **Online Resources**

Intel<sup>®</sup> MPI Library product page

- www.intel.com/go/mpi
- Intel<sup>®</sup> Trace Analyzer and Collector product page
- www.intel.com/go/traceanalyzer

Intel<sup>®</sup> Clusters and HPC Technology forums

http://software.intel.com/en-us/forums/intel-clusters-and-hpc-technology 

Intel<sup>®</sup> Xeon Phi<sup>™</sup> Coprocessor Developer Community

http://software.intel.com/en-us/mic-developer 



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