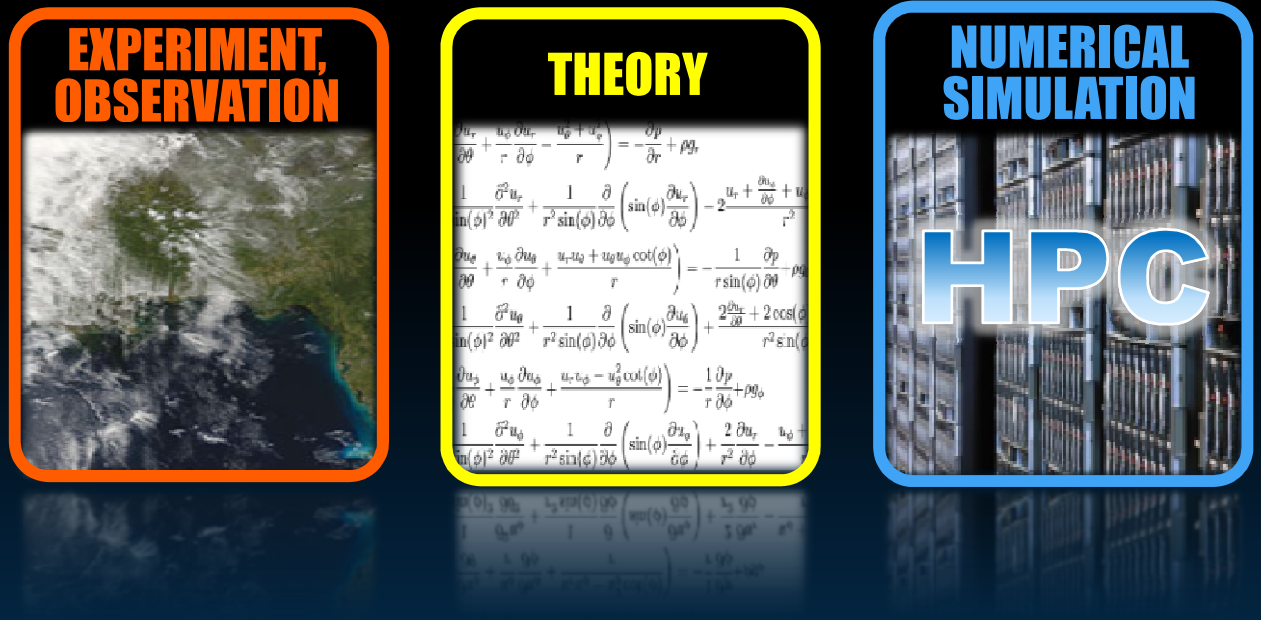

Intel in HPC -
Intel Software Development Tools
eXtreme XQCD
Bern
Aug 5th, 2013
Edmund Preiss
Manager Business Development, EMEA

Topics Covered Today

- Intel's offerings to HPC
- Update on Intel Architecture Roadmap
- Overview on Intel Development Tools for (hybrid) HPC and SMP Systems
- Intel Development Support for Intel Xeon Processors and Intel Xeon Phi Coprocessor
  - Considerations of Porting existing X86 Applications
  - Programming Models
  - How to start with MIC Architecture
- More Details and Benefits of Intel Development Tools

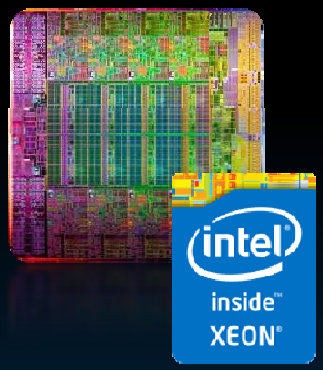
Intel in HPC

The Three Pillars of Modern Science, Research & Engineering

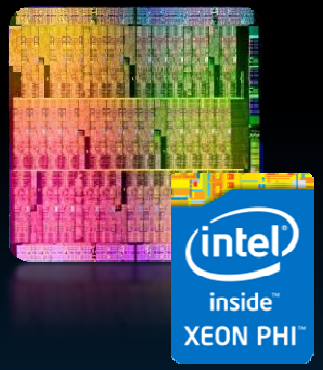


Intel's Assets for HPC

Processors
Intel® Xeon® Processor

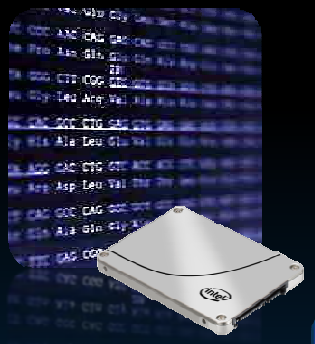


Co-Processor
Intel® Many Integrated Core



Network & Fabrics

Storage



Software & Services

*Other brands and names are the property of their respective owners

Efficiency at Scale in Supercomputing

Top500* (1997 – 2012)

Driven by Moore's Law
and Architecture Innovation

1500X
More Performance

100X
Reduction $/FLOP

4X
Power Increase

Source: Intel Analysis / Top500

#1 TOP500 June 2013

48000x

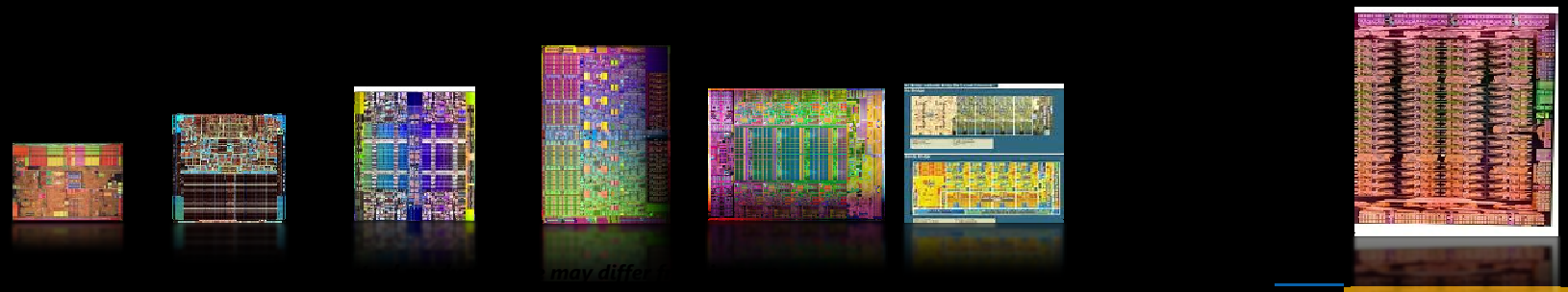
32000x

'Milky Way-2' in Guangzhou, China

54.9 PFLOPS – 33.8 PFLOPS HPL

Intel Road Map and Architectures

Intel Architecture Multicore and Manycore
More cores. Wider vectors. Co-Processors.



	Intel® Xeon® processor 64-bit	Intel Xeon processor 5100 series	Intel Xeon processor 5500 series	Intel Xeon processor 5600 series	Intel Xeon processor E5 Product Family	Intel Xeon processor code name Ivy Bridge	Intel Xeon processor code name Haswell	Intel® Xeon Phi™ Coprocessor
Core(s)	1	2	4	6	8	12	TBD	61
Threads	2	2	8	12	16	24		244

Intel® Xeon Phi™ Coprocessor extends established CPU architecture and programming concepts to highly parallel applications

*Other brands and names are the property of their respective owners

Next Intel® Xeon Phi™Processor:
Knights Landing

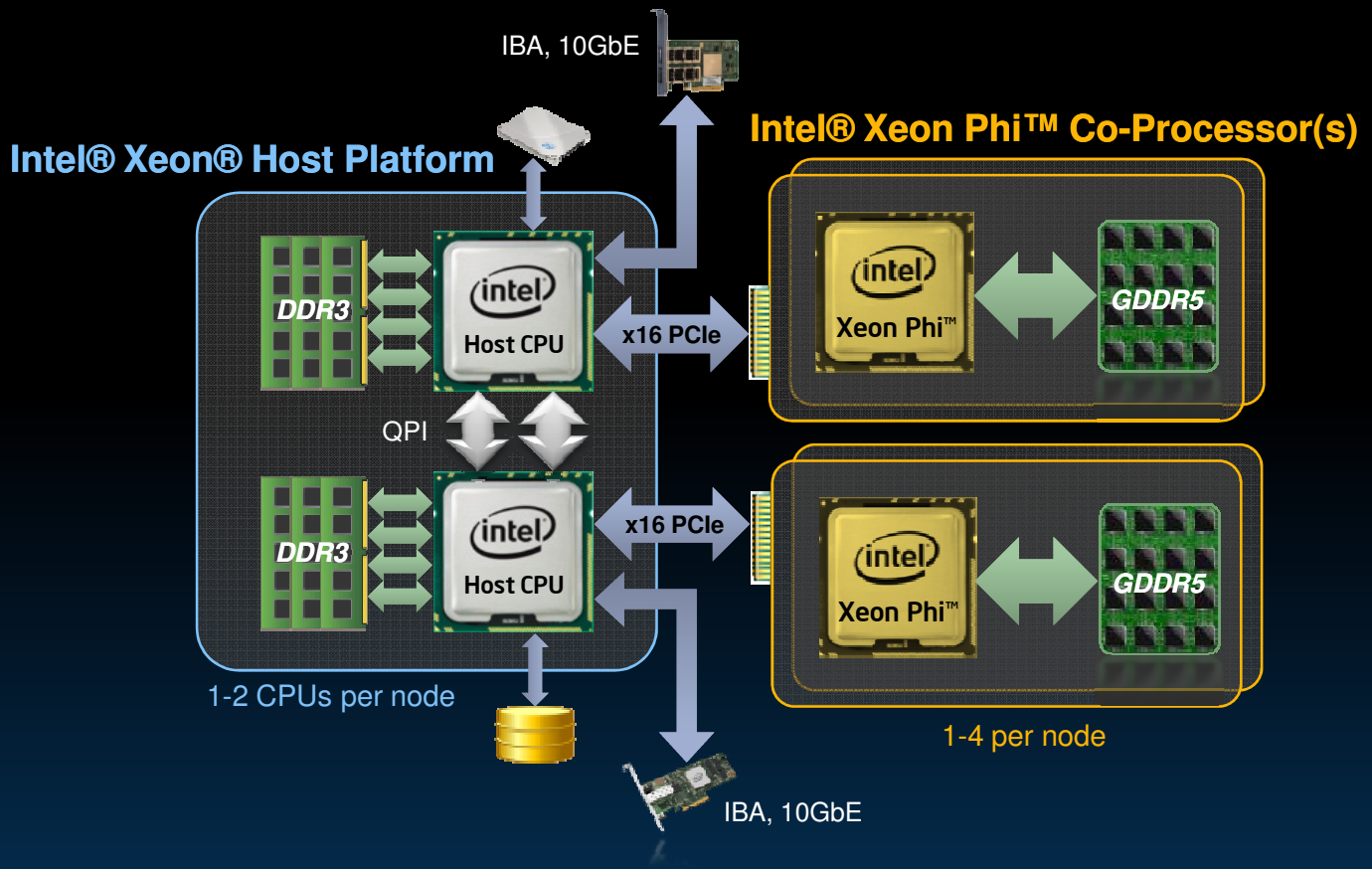
Designed using Intel's cutting-edge
14nm process

Not bound by "offloading" bottlenecks
Standalone CPU
or PCIe Coprocessor

Leadership compute & memory bandwidth
Integrated
On-Package Memory

All products, computer systems, dates and figures specified are preliminary based on current expectations, and are subject to change without notice.

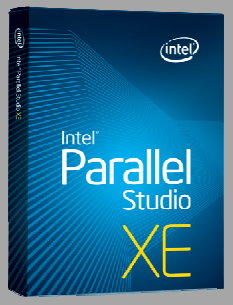
Typical Platform with Intel® Xeon Phi Coprocessor

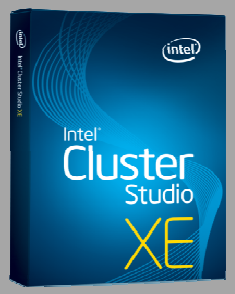


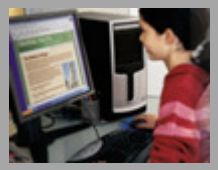
For illustration only.

Intro to Intel Software Dev Tools & Usefulness for Intel Xeon and Intel Xeon Phi

Intel Development Tools for Diverse Needs







Shared Memory

MPI HPC-Cluster

*Other brands and names are the property of their respective owners

More Cores. Wider Vectors. Performance Delivered.

Intel® Parallel Studio XE 2013 and Intel® Cluster Studio XE 2013

More Cores

Multicore (8+)

Many-Core (60)

Wider SIMD/Vector

Scaling Performance Efficiently

Serial

Task & Data Parallel

Distributed

Industry Leading Software Tools

High-Performance from advanced compilers

Comprehensive libraries

Parallel programming models

Insightful analysis tools

What are the Intel Development Components for ?

Phase	Product	Feature	Benefit
Build	Intel® Advisor XE	Threading design assistant (Studio products only)	• Simplifies, demystifies, and speeds parallel application design
	Intel® Composer XE	• C/C++ and Fortran compilers • Intel® Threading Building Blocks • Intel® Cilk™ Plus • Intel® Integrated Performance Primitives • Intel® Math Kernel Library	• Enabling solution to achieve the application performance and scalability benefits of multicore and forward scale to many-core
	Intel® MPI Library†	High Performance Message Passing (MPI) Library	• Enabling High Performance Scalability, Interconnect Independence, Runtime Fabric Selection, and Application Tuning Capability
Verify & Tune	Intel® VTune™ Amplifier XE	Performance Profiler for optimizing application performance and scalability	• Remove guesswork, saves time, makes it easier to find performance and scalability bottlenecks
	Intel® Inspector XE	Memory & threading dynamic analysis for code quality Static Analysis for code quality	• Increased productivity, code quality, and lowers cost, finds memory, threading , and security defects before they happen
	Intel® Trace Analyzer & Collector†	MPI Performance Profiler for understanding application correctness & behavior	• Analyze performance of MPI programs and visualize parallel application behavior and communications patterns to identify hotspots

Code Creation → **Performance** → **Correctness & Stability**

*Other brands and names are the property of their respective owners

Big Gains for Highly Parallel Applications

Highly parallel and vectorized applications will run even faster on **Intel® Xeon Phi™ Coprocessors**

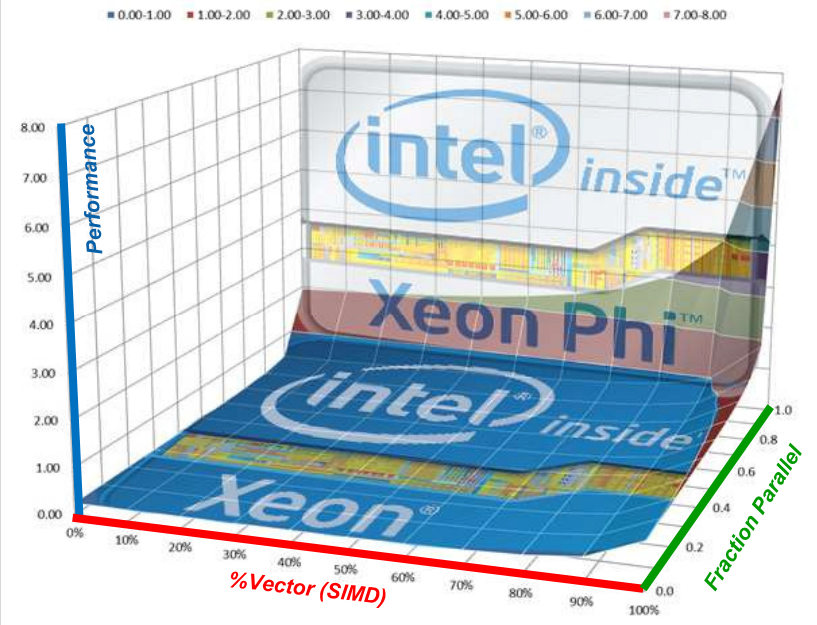
Most applications will still run best on multicore **Intel® Xeon® processors**

Optimizing code often delivers significant performance gains

RUNNING EXISTING SERIAL SOFTWARE

RUNNING OPTIMIZED SOFTWARE

Highly Parallel Applications

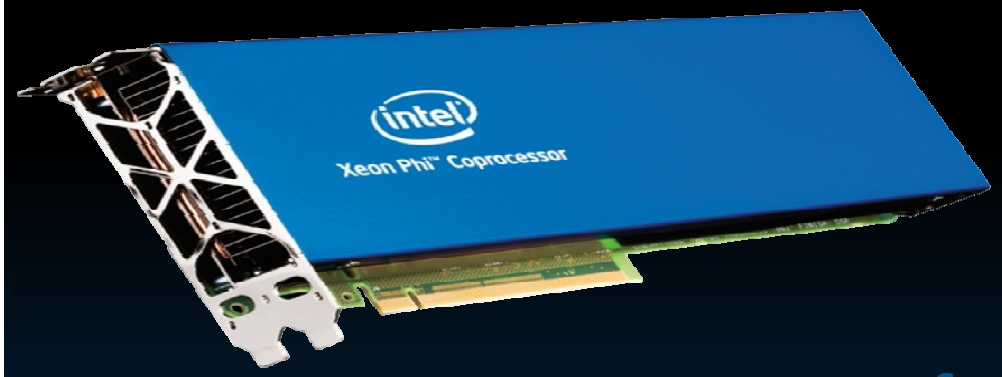


Theoretical acceleration of a highly parallel processor over a Intel® Xeon® parallel processor (<1: Intel® Xeon® faster) – For illustration only

Efficient vectorization, threading, and parallel execution drives higher performance for suitable applications

DEMONSTRATED PERFORMANCE BENEFITS

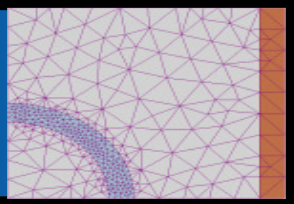
Intel® Xeon Phi™ Coprocessor



Finite Element Analysis

Sandia National Labs MiniFE[1]

UP TO **2x**



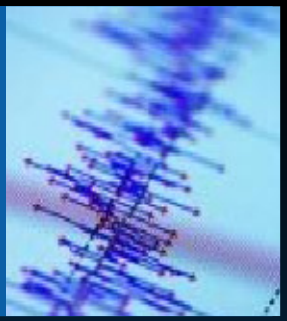
Seismic

Acceleware 8th Order Isotropic Variable Velocity[2]

UP TO **2.23x**

China Oil & Gas Geoeast Pre-stack Time Migration[3]

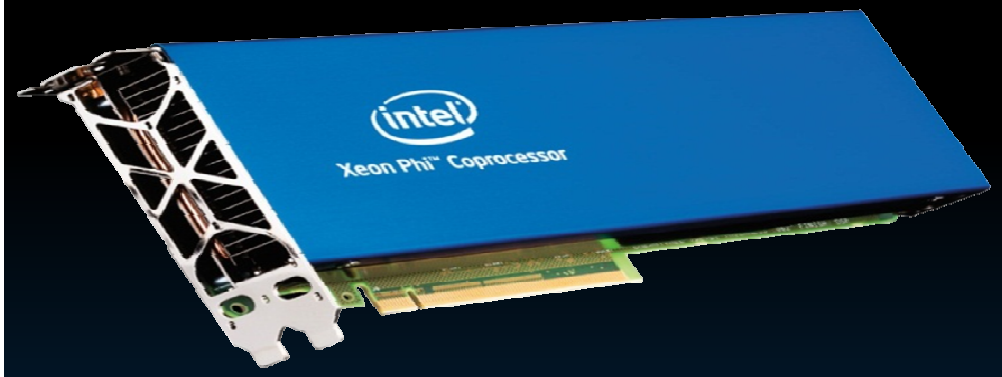
UP TO **3.54x**



1. 8 node cluster, each node with 2S Xeon* (comparison is cluster performance with and without 1 Xeon Phi* per node) (Hetero)
2. 2S Xeon* vs. 1 Xeon Phi* (preproduction HW/SW & Application running 100% on coprocessor (unless otherwise noted)
3. 2S Xeon* vs. 2S Xeon* + 2 Xeon Phi* (offload)

DEMONSTRATED PERFORMANCE BENEFITS

Intel® Xeon Phi™ Coprocessor



Embree Ray Tracing

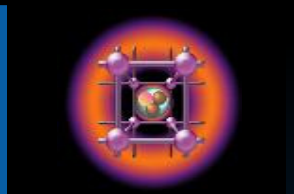
Intel Labs Ray Tracing[2]

SPEED-UP **2.11X**

Physics

Jefferson Lab Lattice QCD

UP TO **2.7X**



Finance

Black-Scholes SP[3]

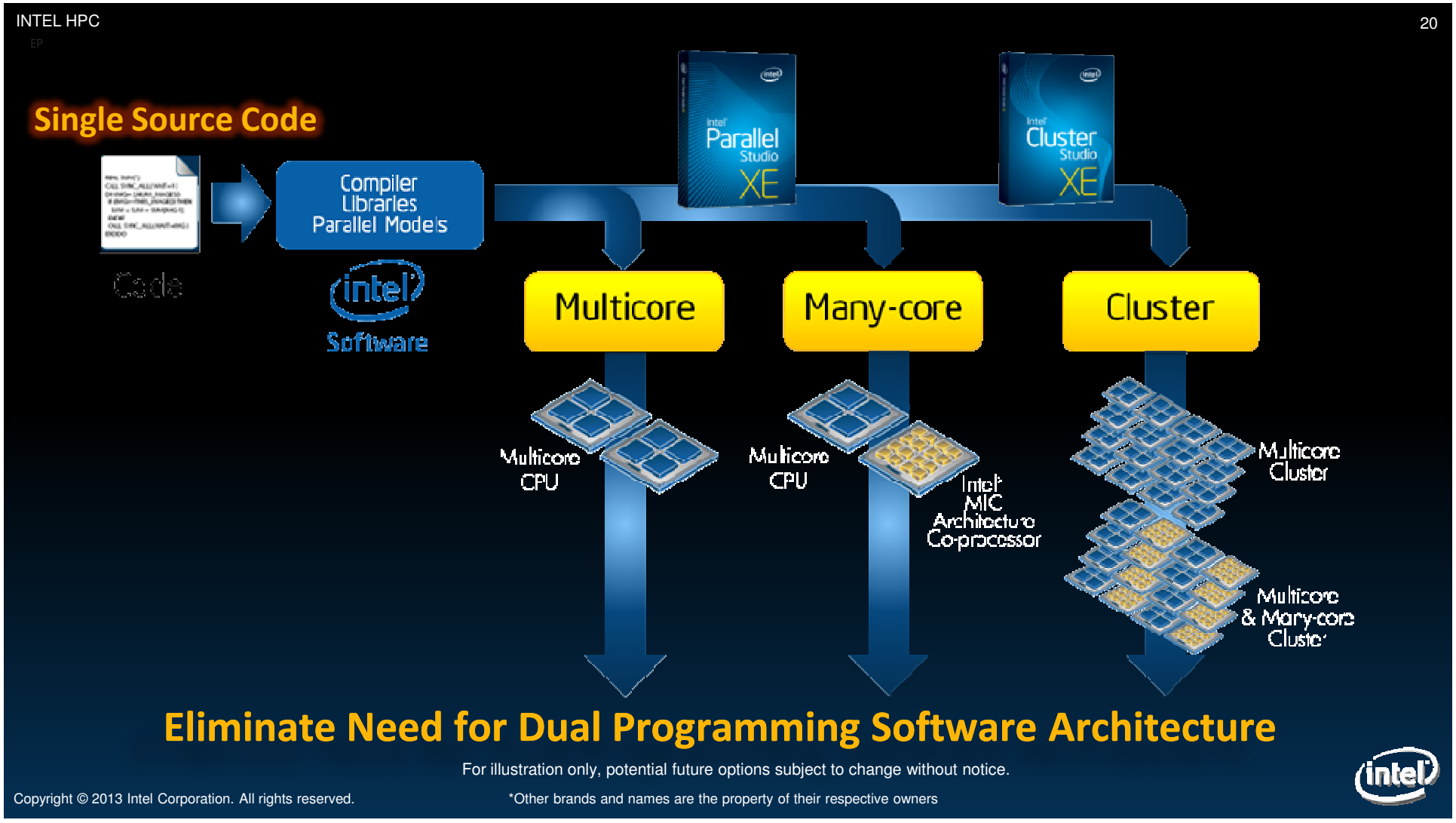
UP TO **7X**

Monte Carlo SP[3]

UP TO **10.75X**

Notes:

1. **2S Xeon* vs. 1 Xeon Phi* (preproduction HW/SW & Application running 100% on coprocessor unless otherwise noted)**
2. **Intel Measured Oct. 2012**
3. **Includes additional FLOPS from transcendental function unit**

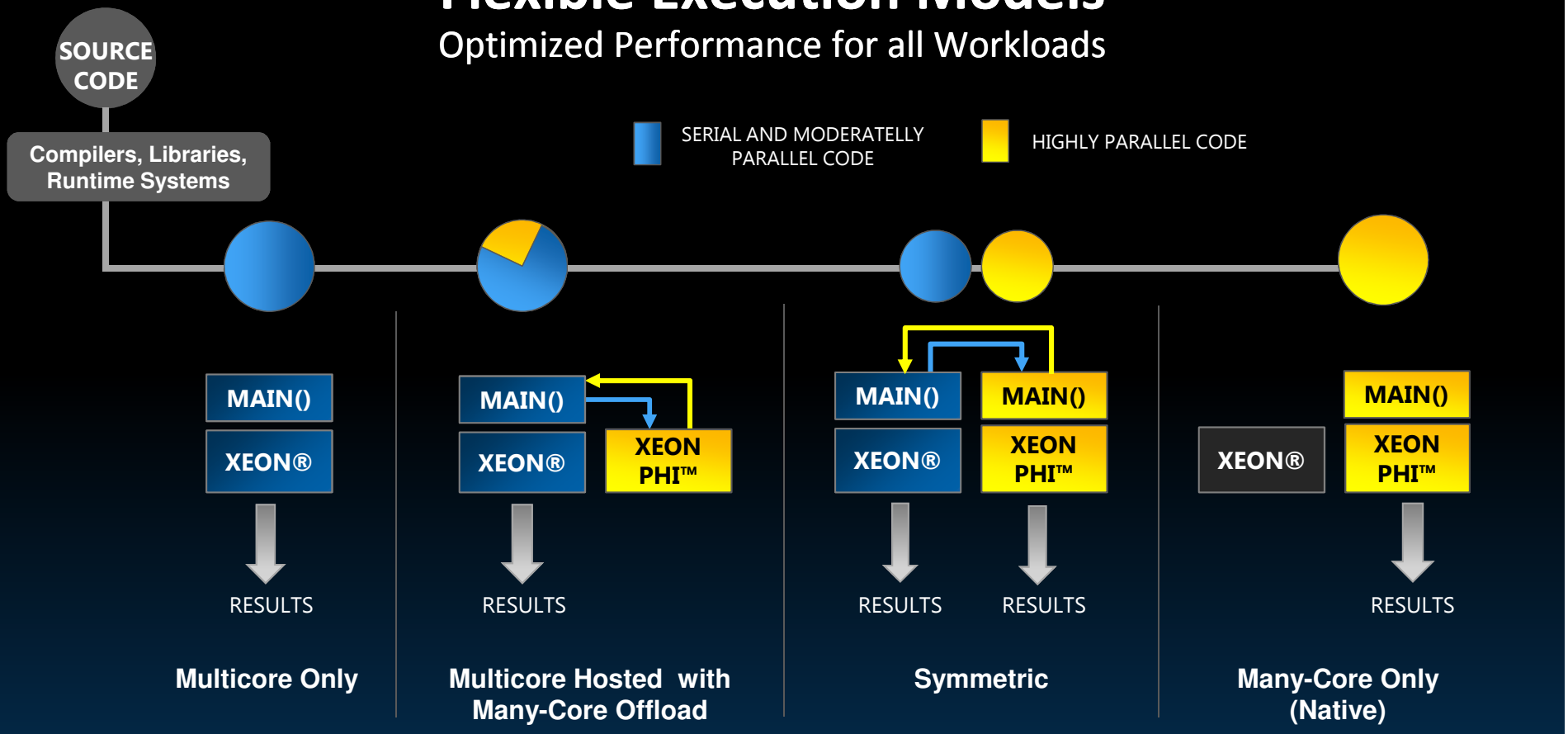


Eliminate Need for Dual Programming Software Architecture

For illustration only, potential future options subject to change without notice.

Flexible Execution Models

Optimized Performance for all Workloads



How to get Started with Xeon Phi

Get Started

www.intel.com/xeonphi

Download the programming guide to find out whether your workload can benefit from Intel® Xeon Phi™ coprocessors:

software.intel.com/mic-developer

Link to Best Practices (for Xeon Phi)

http://www.prace-ri.eu/IMG/pdf/Best-Practice-Guide-Intel-Xeon-Phi.pdf

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

Intel® Xeon Phi™ Coprocessor (codename Knights Corner)
http://software.intel.com/en-us/articles/intel-xeon-phi-coprocessor-codename-knights-corner

Intel® Xeon Phi™ Coprocessor Instruction Set Architecture Reference Manual
http://software.intel.com/en-us/articles/optimization-and-performance-tuning-for-intel-xeon-phi-coprocessors-part-2-understanding

An Overview of Programming for Intel® Xeon® processors and Intel® Xeon Phi™ coprocessors
http://software.intel.com/sites/default/files/article/330164/an-overview-of-programming-for-intel-xeon-processors-and-intel-xeon-phi-coprocessors_1.pdf

Intel® Manycore Platform Software Stack (MPSS)
http://software.intel.com/en-us/articles/intel-manycore-platform-software-stack-mpss

Intel® Xeon Phi™ Coprocessor Developer's Quick Start Guide
http://software.intel.com/en-us/articles/intel-xeon-phi-coprocessor-developers-quick-start-guide

Programming and Compiling for Intel® Many Integrated Core Architecture
http://software.intel.com/en-us/articles/programming-and-compiling-for-intel-many-integrated-core-architecture

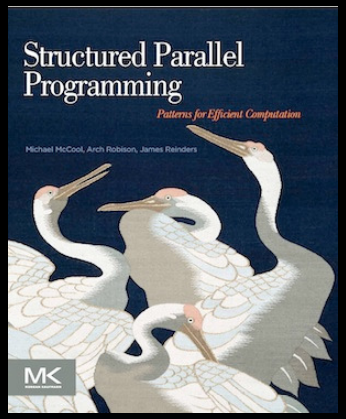
Intel® Xeon Phi™ Coprocessor System Software Developers Guide
http://software.intel.com/sites/default/files/article/334766/intel-xeon-phi-systemsoftwaredevelopersguide.pdf

Intel and Third Party Tools and Libraries available with support for Intel® Xeon Phi™ Coprocessor
http://software.intel.com/en-us/articles/intel-and-third-party-tools-and-libraries-available-with-support-for-intelr-xeon-phitm

Optimization and Performance Tuning for Intel® Xeon Phi™ Coprocessors - Part 1: Optimization Essentials
http://software.intel.com/en-us/articles/optimization-and-performance-tuning-for-intel-xeon-phi-coprocessors-part-1-optimization

Optimization and Performance Tuning for Intel® Xeon Phi™ Coprocessors, Part 2: Understanding and Using Hardware Events
http://software.intel.com/en-us/articles/optimization-and-performance-tuning-for-intel-xeon-phi-coprocessors-part-2-understanding

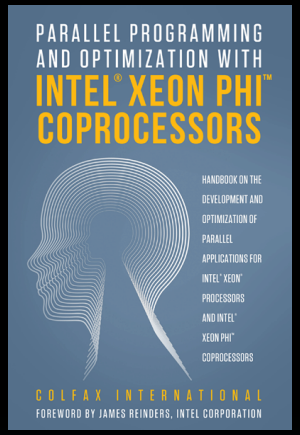
Books for Parallelisation and Xeon Phi Programming



Structured Parallel Programming
Michael McCool, Arch D. Robinson, and James Reinders,
ISBN 978-0-124-15993-8 (Morgan Kaufmann)

Intel Xeon Phi Coprocessor High Performance Programming
Jim Jeffers and James Reinders (Morgan Kaufmann)
Publication Date: March 1, 2013 | ISBN-10: 0124104142 | ISBN-13: 978-0124104143 | Edition: 1

Books for Parallelisation and Xeon Phi Programming

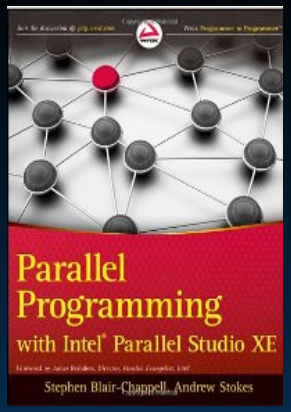


Parallel Programming and Optimization with Intel® Xeon Phi™ Coprocessors [517 Pages]

Handbook on the Development and Optimization of Parallel Applications for Intel® Xeon® Processors and Intel® Xeon Phi™ Coprocessors

ISBN 9780988523418

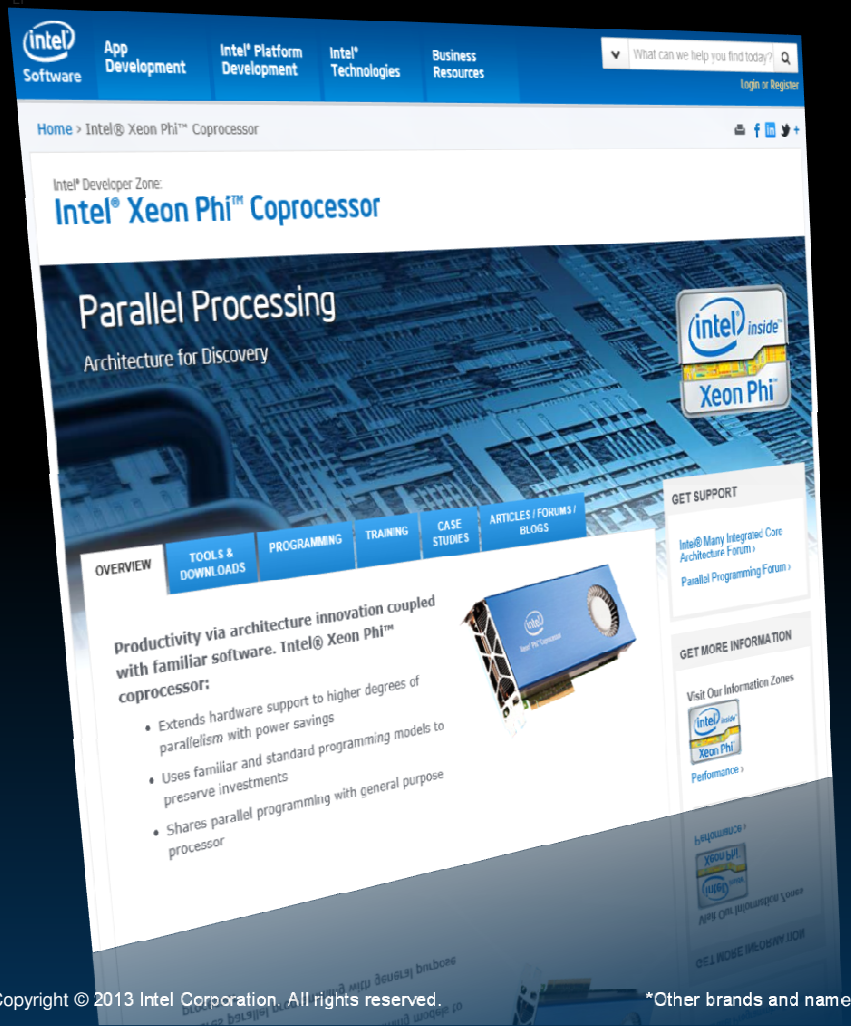
www.colfax-intl.com/xeonphi/book.html



Parallel Programming with Intel Parallel Studio XE

Handbook on the Development and Optimization of Parallel Applications for Intel X86 CPUs using Shared Memory Programming Models
(Textbook for Intel Parallel Studio XE)

2012, publisher: Worx



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

Highly recommended reading:

An Overview of Programming for Intel® Xeon® processors and Intel® Xeon Phi™ coprocessors

Submitted by James Reinders ... on Mon, 11/12/2012 - 12:59

Key Elements of Intel Tools Functionality

- Performance Optimisation
- Parallelisation
- Correctness of Applications

Fortran Compiler Comparison – Intel CPU (3rd party)

Fortran Execution Time Benchmarks - 64-bit Scientific Linux on Intel Core i5 2500k

	Absoft 11.1.3	G95 0.93	GFortran 4.7.2	Intel 13.0	Lahey 8.10b	PGI 12.9	Sun 8.6
AC	4.41	9.60	5.92	4.94	8.00	7.13	21.99
AERMOD	11.95	25.99	18.99	10.53	11.27	11.91	10.30
AIR	3.46	5.95	3.10	2.34	2.71	3.85	2.51
CAPACITA	18.38	26.83	17.96	16.83	19.94	16.98	21.56
CHANNEL2	102.78	272.72	84.26	85.39	122.19	105.71	84.83
DODUC	17.24	24.05	17.51	14.10	17.45	17.30	14.15
FATIGUE2	68.78	374.38	101.73	72.12	110.88	87.30	75.28
GAS_DYN2	84.14	320.04	86.71	69.01	107.03	66.20	84.39
INDUCT2	73.67	147.53	66.57	67.00	93.29	118.24	125.91
LINPK	5.57	6.21	5.77	4.88	5.67	5.37	5.11
MDBX	8.68	8.68	7.32	6.03	7.85	8.35	7.41
MP_PROP_DESIGN	74.41	419.95	103.67	60.22	126.05	86.13	161.97
NF	7.69	13.40	7.79	7.30	10.36	7.71	8.16
PROTEIN	19.88	27.43	20.33	18.12	35.68	20.75	20.44
RNFLOW	13.77	25.90	15.47	11.67	14.58	16.66	15.72
TEST_FPU2	72.11	103.38	42.94	43.73	61.17	42.77	57.41
TFFT2	55.10	60.04	54.16	53.49	55.74	55.38	55.07
Geometric Mean	22.18	43.13	22.94	18.95	26.07	23.25	25.04

Source: http://www.polyhedron.com
(additional details available at that web page)

Intel Family of Parallel Programming Models

Intel® Cilk™ Plus	Intel® Threading Building Blocks	Domain-Specific Libraries	Established Standards	Research and Development
C/C++ language extensions to simplify parallelism	Widely used C++ template library for parallelism	Intel® Integrated Performance Primitives	Message Passing Interface (MPI)	Intel® Concurrent Collections
		Intel® Math Kernel Library	OpenMP*	Offload Extensions
			Coarray Fortran	Intel® SPMD Parallel Compiler
			OpenCL*	
Open sourced & Also an Intel product	*Open sourced & Also an Intel product*			

Choice of high-performance parallel programming models

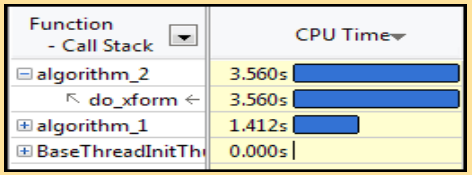
Applicable to Multicore and Many-core Programming *

*** Integrated Performance Primitives not available for Intel MIC Architecture**

Intel® VTune™ Amplifier XE
Performance Profiler

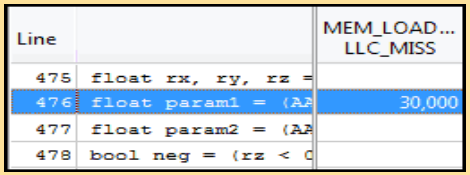
Where is my application…

Spending Time?



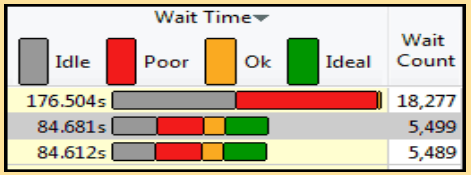
- Focus tuning on functions taking time
- See call stacks
- See time on source

Wasting Time?



- See cache misses on your source
- See functions sorted by # of cache misses

Waiting Too Long?



- See locks by wait time
- Red/Green for CPU utilization during wait

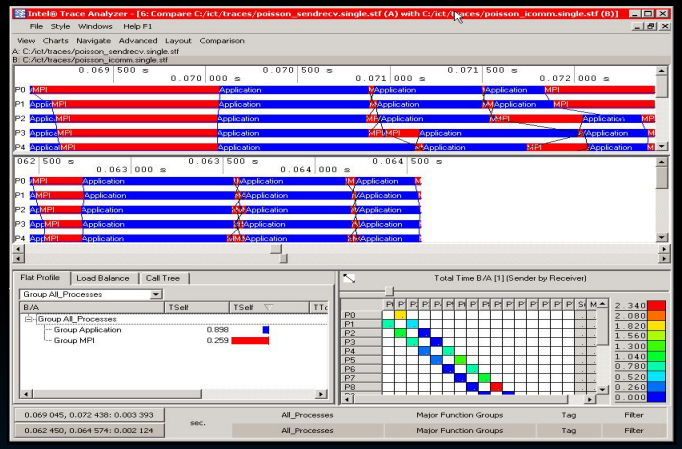
- **Windows & Linux**
- **Low overhead**
- **No special recompiles**

Advanced Profiling for Scalable Multicore Performance

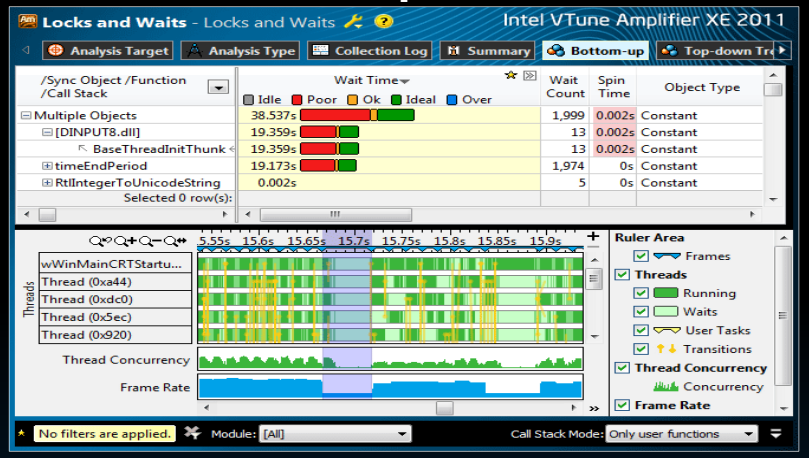
Scale Performance

Tune Hybrid Cluster MPI and Thread Performance

Intel®
Trace Analyzer and Collector



Intel®
VTune™ Amplifier XE



Tune cross-node MPI

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

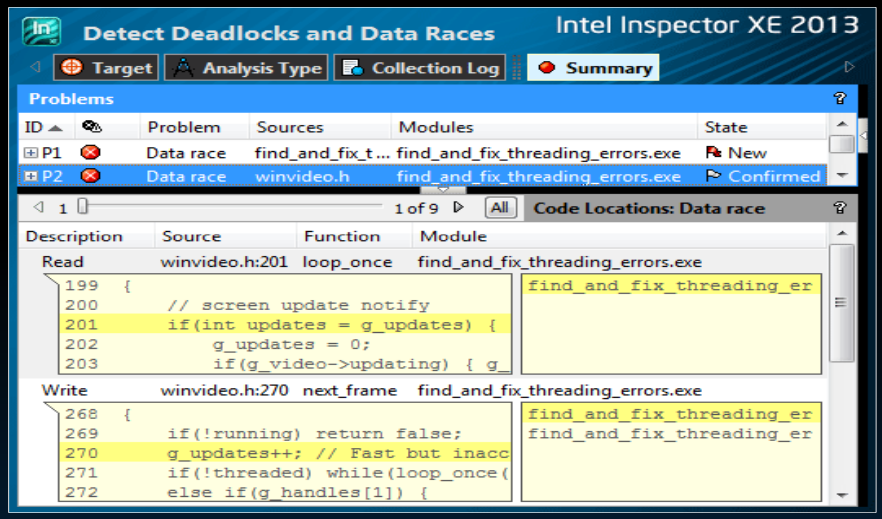
Tune single node threading

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

Dynamic Analysis Finds Memory & Threading Errors

Intel® Inspector XE 2013

- **Find and eliminate errors**
  - Memory leaks, invalid access…
  - Races & deadlocks
  - Analyze hybrid MPI cluster apps
  - Heap growth analysis
- **Faster & Easier to use**
- Debugger breakpoints
  - Break on selected errors
  - Run faster to known error
- Pause/resume collection
  - Narrow analysis focus
  - Better performance
  - Improved error suppression



Find Errors Early When They are Less Expensive

Static Analysis Finds Coding and Security Errors

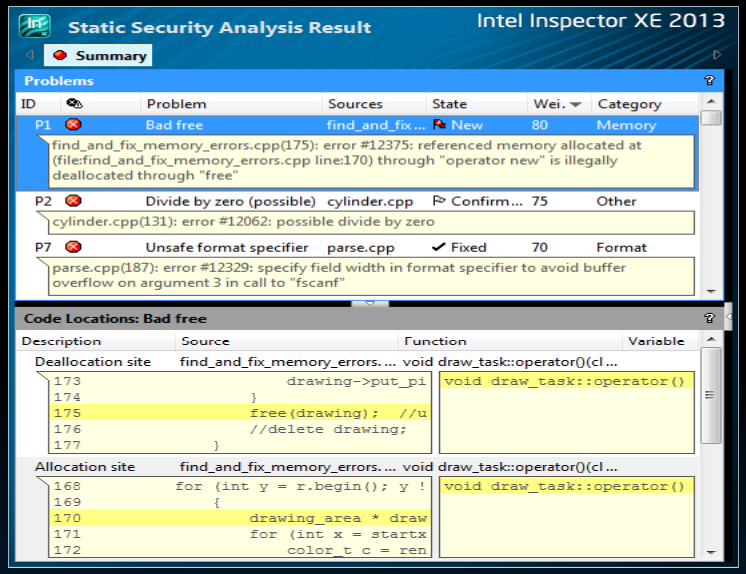
Intel® Parallel Studio XE

Intel® Cluster Studio XE

- **Find over 250 error types e.g.:**
  - Incorrect directives
  - Security errors
- **Easier to use**
  - Choose your priority:
    - Minimize false errors
    - Maximize error detection
- **Increased Accuracy & Speed**
  - Detect errors without all source files
  - Better scaling with large code bases

Code Complexity Metrics

- Find code likely to be less reliable



Find Errors and Harden your Security

Static Analysis is only available in Studio XE bundles. It is not sold separately.

Pointer Checker

- Finds buffer overflows and dangling pointers before memory corruption occurs
- Powerful error reporting
- Integrates into standard debuggers (Microsoft, gdb, Intel)

Dangling pointer

```
{
   char *p, *q;
   p = malloc(10);
   q = p;
   free(p);
   *q = 0;
 }
```

Buffer Overflow

```
{
   char *my_chp = "abc";
   char *an_chp = (char *) malloc (strlen((char *)my_chp));
   memset (an_chp, '@', sizeof(my_chp));
}
```

CHKP: Bounds check error

```
Traceback:
./a.out(main+0x1b2) [0x402d7a] in file mems.c at line 13
```

Pointer Checker Highlights Programming Errors For More Secure Applications

Conditional Numerical Reproducibility

- Intel® Math Kernel Library:
  - New deterministic task scheduling and code path selection options
- OpenMP:
  - New deterministic reduction option
- Intel® Threading Building Blocks
  - New parallel deterministic reduce option

Help Achieve Reproducible Results,
Despite Non-associative Floating Point Math

Win a Lenovo Notebook

- Come to our stand and fill in Raffle card
- Join the Raffle Drawing

  Tuesday 6th August

  3:45 PM

  @ Intel Stand
- You need to be present at Drawing in order to win

Legal Disclaimer

INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH INTEL PRODUCTS. NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. EXCEPT AS PROVIDED IN INTEL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, INTEL ASSUMES NO LIABILITY WHATSOEVER AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO SALE AND/OR USE OF INTEL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS OTHERWISE AGREED IN WRITING BY INTEL, THE INTEL PRODUCTS ARE NOT DESIGNED NOR INTENDED FOR ANY APPLICATION IN WHICH THE FAILURE OF THE INTEL PRODUCT COULD CREATE A SITUATION WHERE PERSONAL INJURY OR DEATH MAY OCCUR.

Intel may make changes to specifications and product descriptions at any time, without notice. Designers must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." Intel reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The information here is subject to change without notice. Do not finalize a design with this information.

The products described in this document may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request.

All products, computer systems, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice.

Contact your local Intel sales office or your distributor to obtain the latest specifications and before placing your product order.

**Other names and brands may be claimed as the property of others.*

Legal Disclaimers: Performance

- *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 on the performance of Intel products, Go to: http://www.intel.com/performance/resources/benchmark_limitations.htm.*
- *Intel does not control or audit the design or implementation of third party benchmarks or Web sites referenced in this document. Intel encourages all of its customers to visit the referenced Web sites or others where similar performance benchmarks are reported and confirm whether the referenced benchmarks are accurate and reflect performance of systems available for purchase.*
- *Relative performance is calculated by assigning a baseline value of 1.0 to one benchmark result, and then dividing the actual benchmark result for the baseline platform into each of the specific benchmark results of each of the other platforms, and assigning them a relative performance number that correlates with the performance improvements reported.*
- *SPEC, SPECint, SPECfp, SPECrate. SPECpower, SPECjAppServer, SPECjEnterprise, SPECjbb, SPECompM, SPECompL, and SPEC MPI are trademarks of the Standard Performance Evaluation Corporation. See http://www.spec.org for more information.*
- *TPC Benchmark is a trademark of the Transaction Processing Council. See http://www.tpc.org for more information.*
- *SAP and SAP NetWeaver are the registered trademarks of SAP AG in Germany and in several other countries. See http://www.sap.com/benchmark for more information.*
- *INFORMATION IN THIS DOCUMENT IS PROVIDED "AS IS". NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. INTEL ASSUMES NO LIABILITY WHATSOEVER AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO THIS INFORMATION INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.*
- *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 on the performance of Intel products, reference www.intel.com/software/products.*

Optimization Notice

Intel® compilers, associated libraries and associated development tools may include or utilize options that optimize for instruction sets that are available in both Intel® and non-Intel microprocessors (for example SIMD instruction sets), but do not optimize equally for non-Intel microprocessors. In addition, certain compiler options for Intel compilers, including some that are not specific to Intel micro-architecture, are reserved for Intel microprocessors. For a detailed description of Intel compiler options, including the instruction sets and specific microprocessors they implicate, please refer to the "Intel® Compiler User and Reference Guides" under "Compiler Options." Many library routines that are part of Intel® compiler products are more highly optimized for Intel microprocessors than for other microprocessors. While the compilers and libraries in Intel® compiler products offer optimizations for both Intel and Intel-compatible microprocessors, depending on the options you select, your code and other factors, you likely will get extra performance on Intel microprocessors.

Intel® compilers, associated libraries and associated development tools may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include Intel® Streaming SIMD Extensions 2 (Intel® SSE2), Intel® Streaming SIMD Extensions 3 (Intel® SSE3), and Supplemental Streaming SIMD Extensions 3 (Intel® SSSE3) instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors.

While Intel believes our compilers and libraries are excellent choices to assist in obtaining the best performance on Intel® and non-Intel microprocessors, Intel recommends that you evaluate other compilers and libraries to determine which best meet your requirements. We hope to win your business by striving to offer the best performance of any compiler or library; please let us know if you find we do not.

Notice revision #20101101

Thank You.