# The Power of Integration and Democratization – HPC at Intel

Dr. Stephen Wheat

General Manager, HPC

Intel Corp.
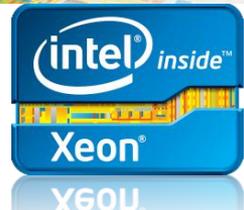
Today's Toughest Challenges Present the Greatest Compute Complexity

Scientific Research

Climate/weather modeling

Medical imaging

Energy exploration

Simulations

Industry competitiveness

Pharmaceutical research

Financial analyses

New product design

CAD/manufacturing

Digital content creation

National security

National security

Computational arms race

Total compute performance by country

(intel)
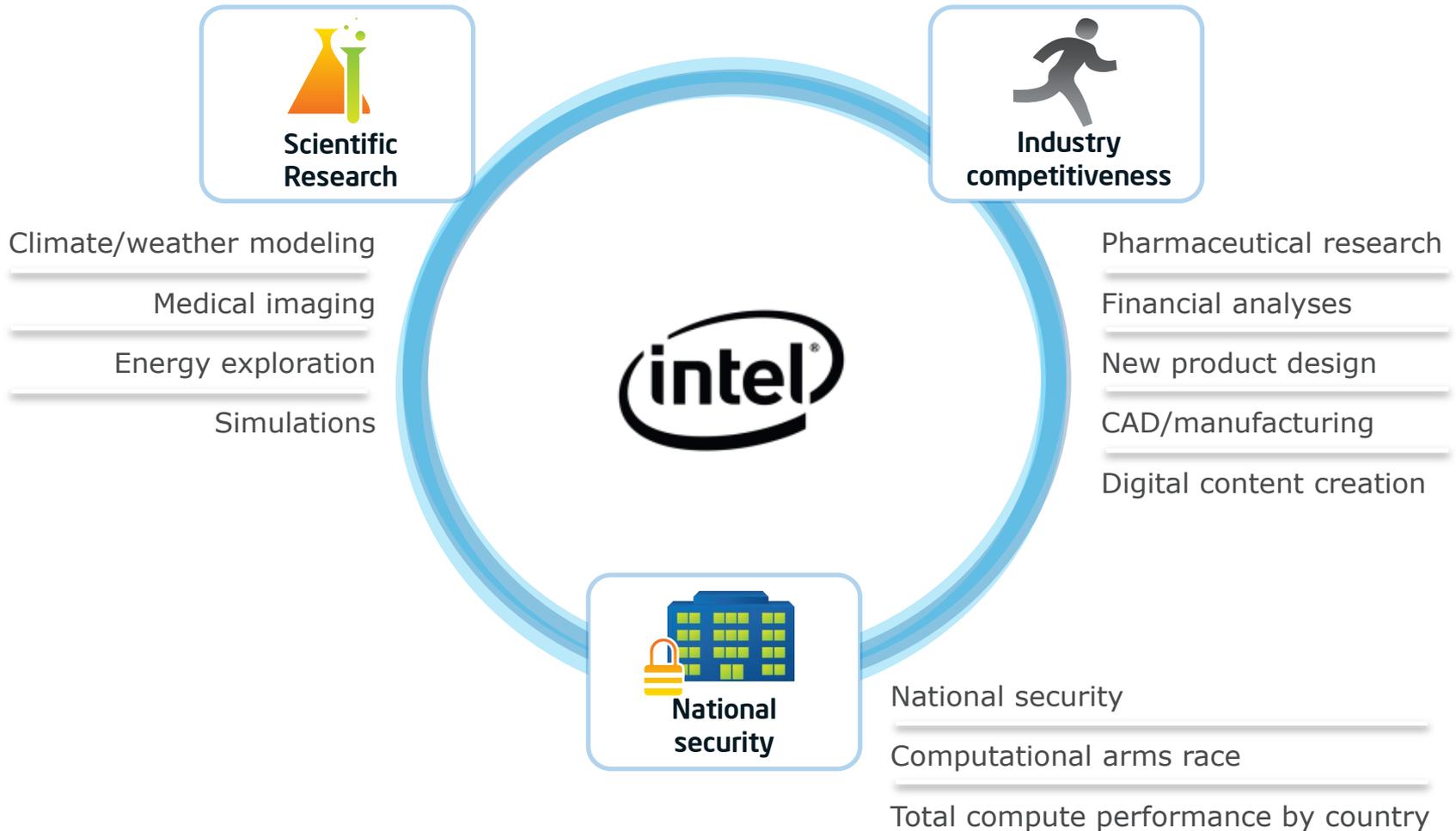
Technology Leadership Drives Global Competition
In order to compete, you must compute

Performance of Countries
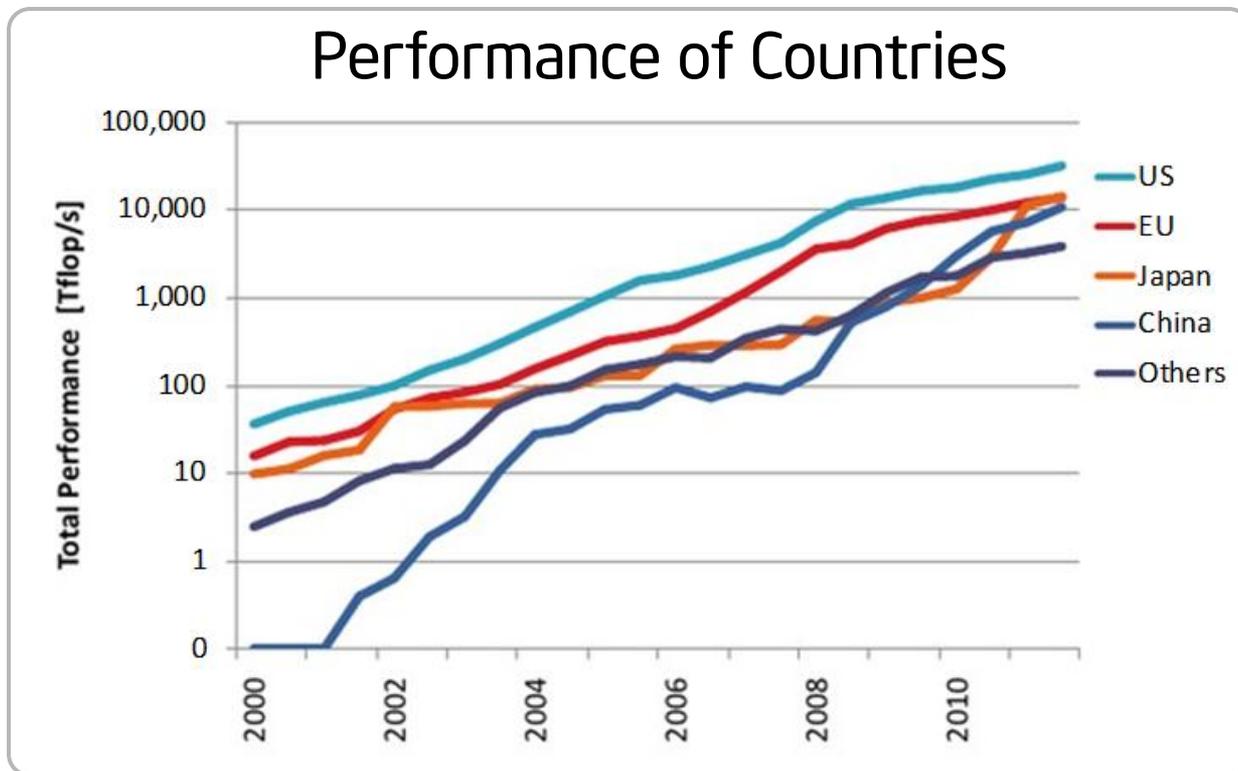
The Top 500 list of the most powerful computers in the world

Quest for Discovery and Innovation

All this computation. How does it help?

Classic Scientific Method



Hypothesis → Prediction → Experimentation → Analysis Conclusion Refinement

New Computation has enabled a New Scientific Method*:

Hypothesis → Modeling and Simulation/Experiment Refinement → Experimentation → Analysis Conclusion Refinement

# The Power of Parallel Processing Realized

ROI on high performing applications
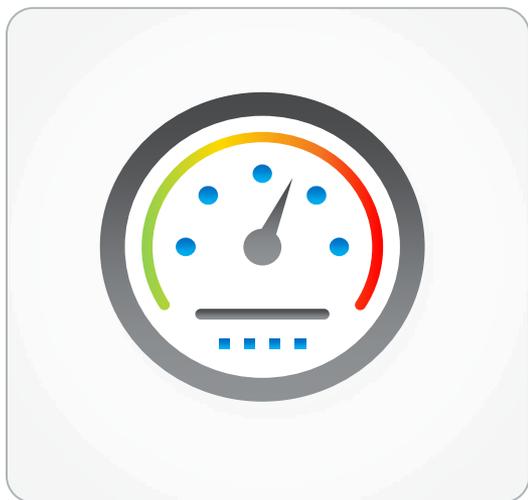
Go from concept to
results quickly

Energy efficiency
& lower cost
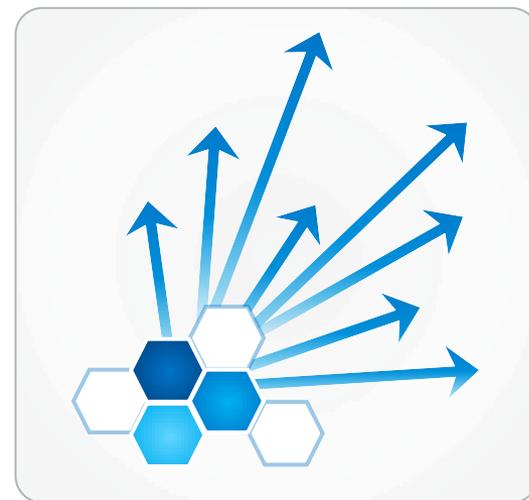
Scale for
growth

What's Intel Doing in 2012 in HPC?
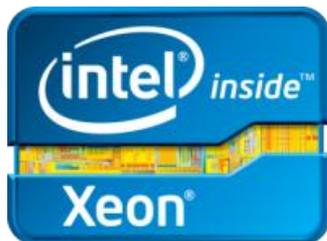
Intel® Xeon® processor E5-2600, E5-4600:
Now Launched
Leadership in HPC
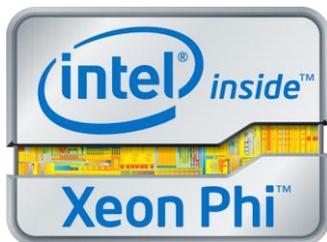
**Intel® MIC Architecture Knights Corner:**
In production in 2012

Intel®
TrueScale
Infiniband

Fabric Technology Portfolio:

Architecture for Discovery

Seamlessly solve your most important problems of any scale

Intel® Xeon Phi™ product family

Core (MIC) architecture

Leading performance for highly parallel workloads

Common Intel Xeon programming model

Seamlessly increases developer productivity

Intel® Xeon Processor

Ground-breaking real-world application performance

Industry-leading energy efficiency

Meet HPC challenges and scale for growth

Single Source

Compilers and Runtimes

The Foundation of High-performance Computing
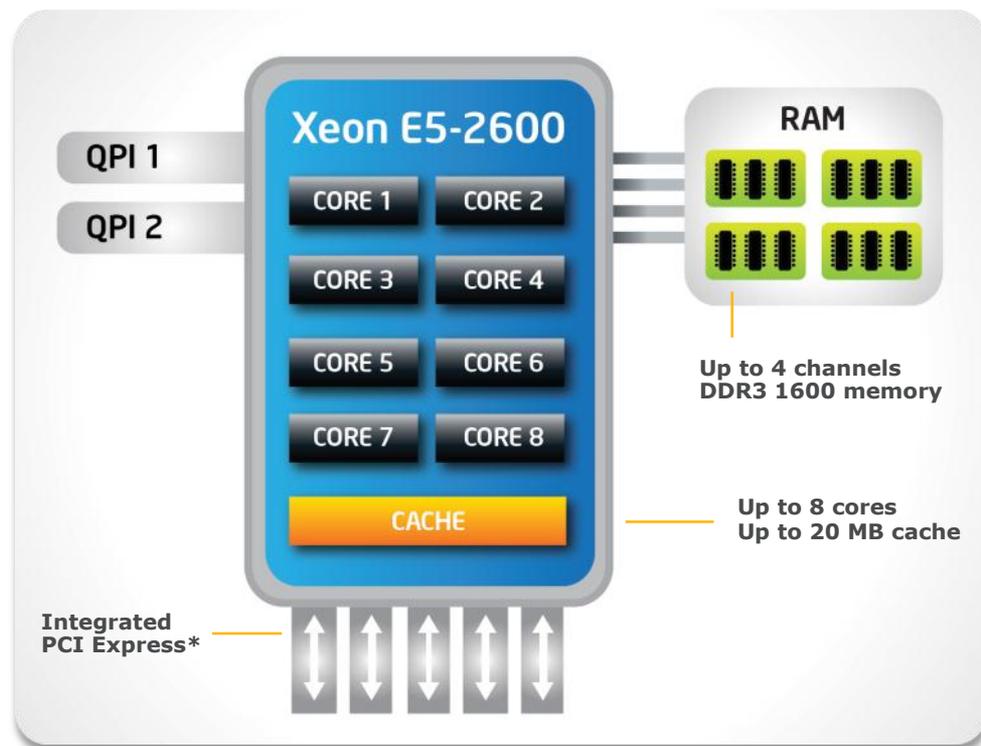
Up to **73% performance boost** vs. prior gen[1] on HPC suite applications

**Over 2X** improvement on key industry benchmarks

Significantly reduce compute time on large, complex data sets with Intel® Advanced Vector Extensions

Integrated I/O **cuts latency** while adding capacity & bandwidth

Diagram labels:
- QPI 1
- QPI 2
- Xeon E5-2600
- CORE 1, CORE 2, CORE 3, CORE 4, CORE 5, CORE 6, CORE 7, CORE 8
- CACHE
- RAM
- Up to 4 channels DDR3 1600 memory
- Up to 8 cores Up to 20 MB cache
- Integrated PCI Express*

Over previous generation Intel® processors. Intel internal estimate. For more legal information on performance forecasts go to http://www.intel.com/performance

Up to 1.7x Improvement for HPC
Intel® Xeon® Processor E5-2600

Intel® Xeon® Processor E5 Family

Relative Geometric Mean Scores by segment
Actual performance will vary by workload
Higher is better

Synthetic

Technical Computing Real-world applications

Higher is better

2.1

1.0

1.3

1.4

1.5

1.5

1.7

Intel® Xeon® Processor E5 Family (8C, 2.7 GHz)

X5690 Baseline (3.46GHz, 6C)

Matrix Multiplication (Linpack)

Life Sciences

CAE

Energy

FSI

Numerical Weather

# New Integrated I/O
Intel® Xeon® Processor E5 Family

1st server processor
with **integrated PCIe***

Reduces I/O latency

Improves IO bandwidth
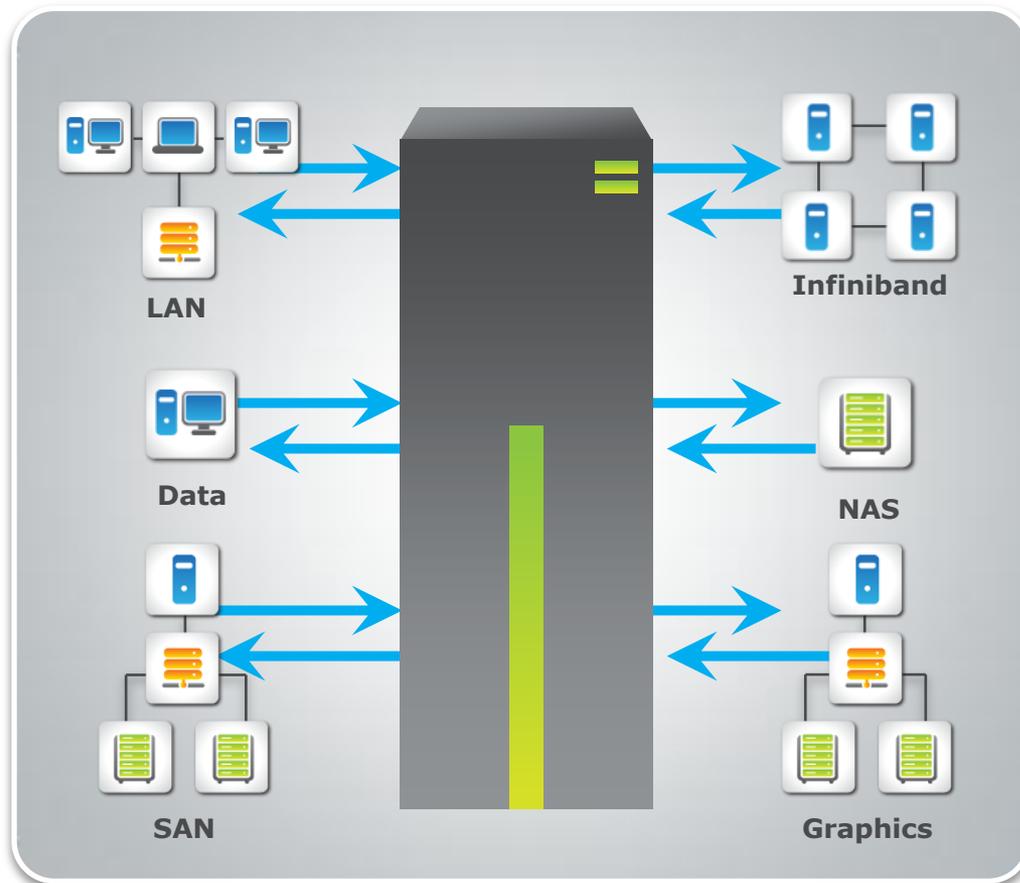
LAN

Infiniband

Data

NAS

SAN

Graphics

Introducing Intel® MIC Architecture

Optimized for highly parallel performance

Groundbreaking differences

> 50 Smaller, less power consuming cores

High memory bandwidth

Highly parallel architecture

Wider vector processing units for greater floating point performance/watt

Leading to Groundbreaking results

>1 Teraflop of LINPACK per product

New performance demonstrations in manufacturing, life sciences and energy

Groundbreaking Software Development
Minus the learning curve

Use existing programming models, methods, tools

C, C++, and FORTRAN source code

Optimized math libraries

Intel® software developer tools

Third-party tools coming soon

Drive innovation, reduce time and costs

All the advantages of code re-use

Minimal costly training and potential detours

Focus shifted from engineering to problem solving

Intel® High-performance Computing
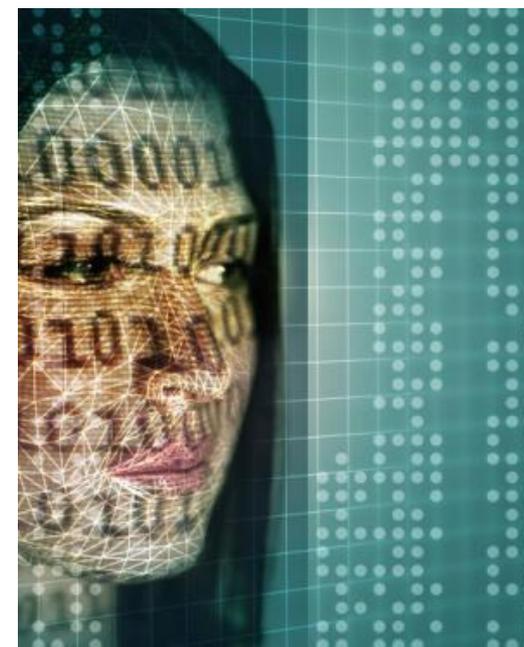
Intel® Xeon Phi™ - Game Changer for HPC

Build your applications on a known compute platform…and watch them take off sooner.

Without Intel® Xeon Phi™

New learning → Complex code porting

With Intel® Xeon Phi™

Familiar tools & runtimes
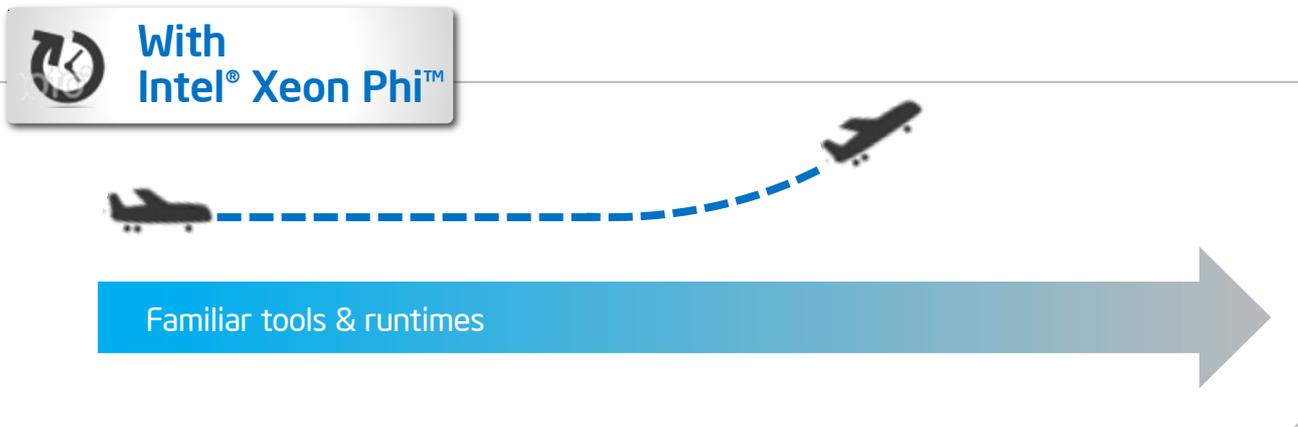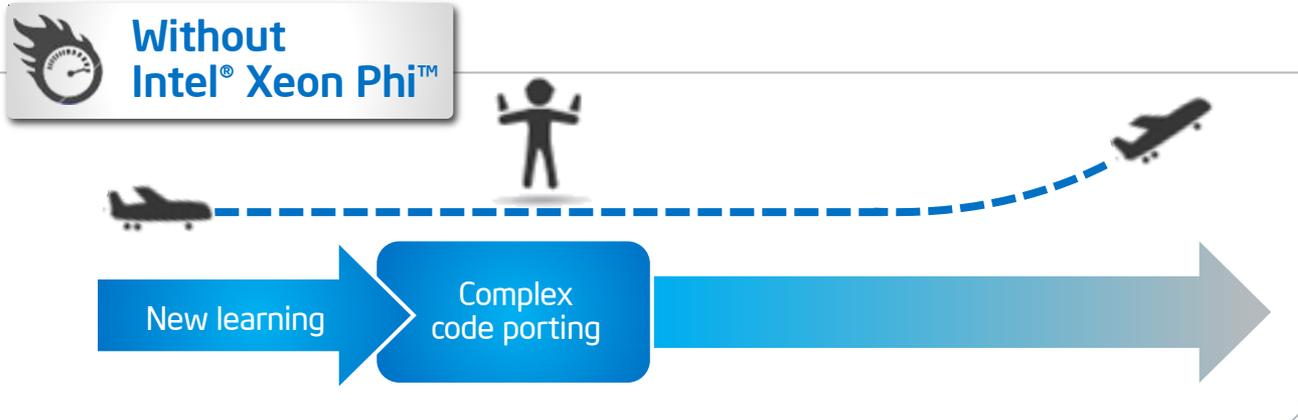
"Unparalleled productivity… most of this software does not run on a GPU".

—*Robert Harrison, NICS, ORNL*

Backward Compatibility Equals Happy Customers

RADIOSS™ : complete finite element solver for structural analysis

Programming continuity between Intel® Xeon® E5 and Knights Corner = major advantage

![Intel inside Xeon Phi logo]

![Altair logo]
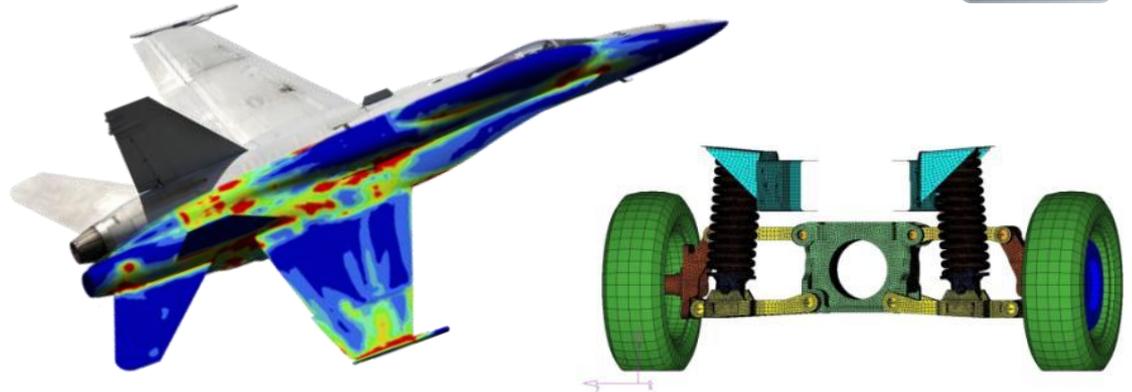
"It was a big plus not to have to learn a new language like CUDA or OpenCL."
– *Altair*

"… we were able to take advantage of the many core architecture to drastically reduce time to solution."
– *Altair*

![sgi logo]

"We are already seeing requests for MIC in customer quotes…"
– *SGI*

![intel logo]

End-users Are Excited Too

Programming models are the key to harness the computational power of massively parallel devices. Obviously, Intel has realized this trend and substantially supports open standards and invests in innovative programming models. LRZ and TUM are using Intel hard- and software for many years and know the tool chain by heart. MIC Execution: Straightforward. First version within a few hours, optimized version took 2 days

"By just utilizing standard programming on both Intel® Xeon processor and Intel® MIC architecture based platforms, the performance met multi-threading scalability expectations and we observed near-theoretical linear performance scaling with the number of threads."

"The CERN openlab team was able to migrate a complex C++ parallel benchmark to the Intel MIC software development platform in just a few days."

"Moving a code to MIC might involve sitting down and adding a couple lines of directives that takes a few minutes. Moving a code to a GPU is a project" (4/21/11)

Dan Stanzione, Deputy Director at TACC

Broad Support and Availability

Industry support for Intel® MIC Architecture

Intel Fabric Environment & Acqusitions

HPC Expertise
Intellectual Property
World-class Interconnects

CRAY THE SUPERCOMPUTER COMPANY

HPC Expertise
Fabric Management & Software
Highest Performance, Scalable IB Products

QLOGIC The Ultimate · Performance

Low-latency Ethernet Switching
Data Center Ethernet Expertise
High Radix & Low Radix Switch Products

FULCRUM microsystems

Market Leading Compute & Ethernet Products
Platform Expertise

intel

Intel's Comprehensive Connectivity and Fabric Portfolio

The Most Versatile Set of Interconnect Capabilities Available

Intel's Unique Fabric Advantages

HPC Clusters

Public SaaS

Enterprise Appliances

Microservers

Data Center Management and Security Solutions

HPC Tools and Technology – API, Libraries, Compilers; Fabric Management Tools and Products

World-Class Optical, PHY, Logic Design, and Networking Protocol Development Expertise

Leading Ethernet, InfiniBand, and HPC Interconnect IP With a Unmatched View on Technology and Market Need

World-Class Process Technology – Power & Performance

Intel® Xeon® Processor

Intel® Xeon Phi™ Co-Processor

**Intel® Atom™ Processor**

and

Fabric Integration Capabilities

A Total Solutions Approach to Data Center Fabrics

(intel)

The Advantages of Fabrics Integration

Intel® Processor ←→ 32 GB/sec ←→ **Fabric Controller** ←→ 10-20 GB/sec →

System IO Interface (PCIe) Fabric Interface

Today

Intel® Processor
Fabric Controller ←→ 100+ GB/sec →

Fabric Interface

Tomorrow
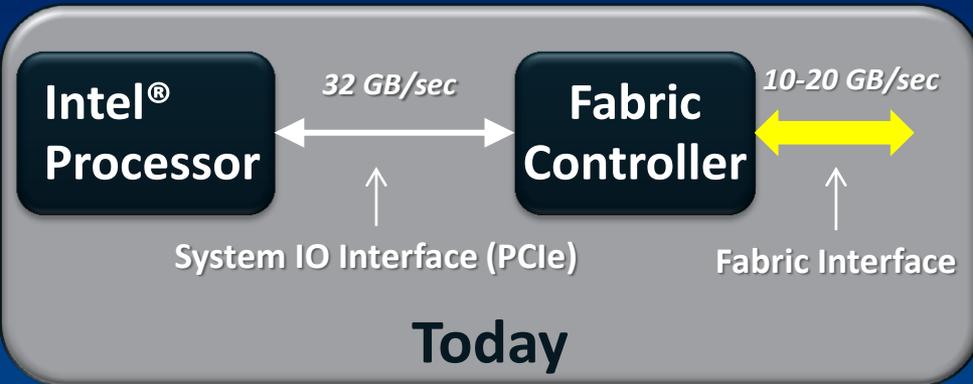
Problem:

- **Power** – System IO Interface Adds "10s Of Watts" Incremental Power

- **Cost & Density** – More Components On A Server Node

- **Scalability** – Processor Capacity & Fabric Bandwidth Scaling Faster Than System IO Bandwidth
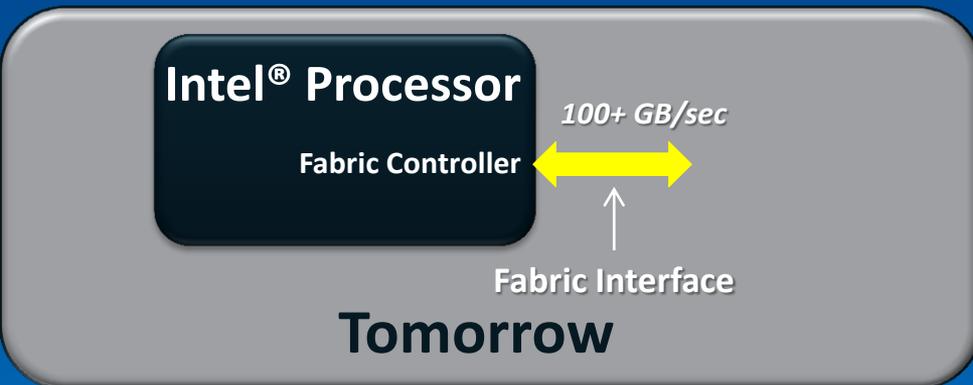
Solution:

- Removing The System IO Interface From The Fabrics Solution *Reducing Power*

- An Integrated Fabrics Results In *Fewer Components On The Server Node*

- An Integrated Fabric *Balances Fabric and Compute, Scaling Application Performance & Efficiency*

Fabrics Integration Required to Scale Performance & Power

(intel)

On the Democratization of HPC
Addressing the Missing Middle – An update on This
Initiative

High Performance Computing underlies much of Modern Science and Engineering
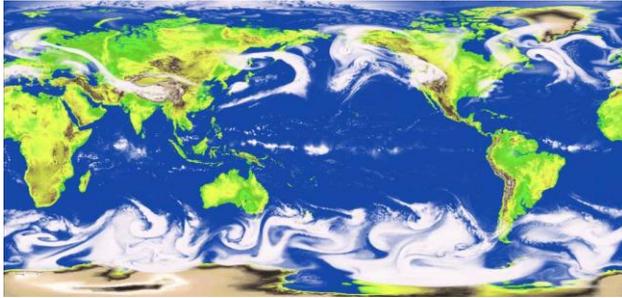
Global Mesoscale Circulation model at the Geophysical Fluid Dynamics Laboratory
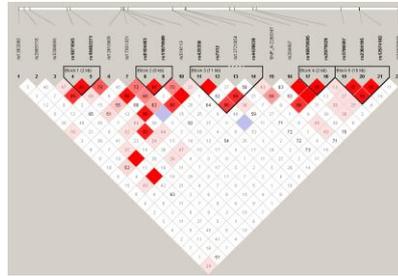
Susceptibility Gene for Sporadic Late-Onset Alzheimer's Disease Keith D. Coon, et. Al. - TGEN

A simulated neuron from a rat brain - Courtesy of the Blue Brain Project at EPFL

Digital Manufacturing
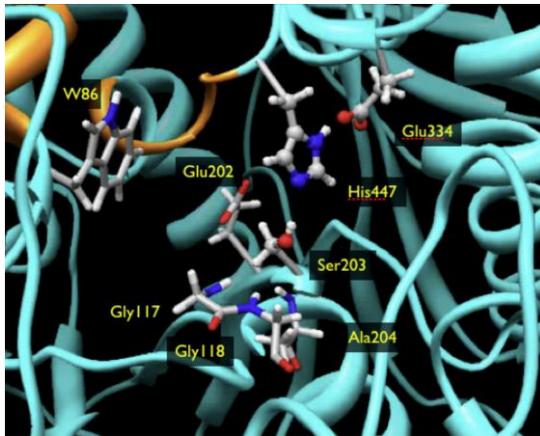
Christopher Hadad, OSU, antidote to organophosphorus nerve agents
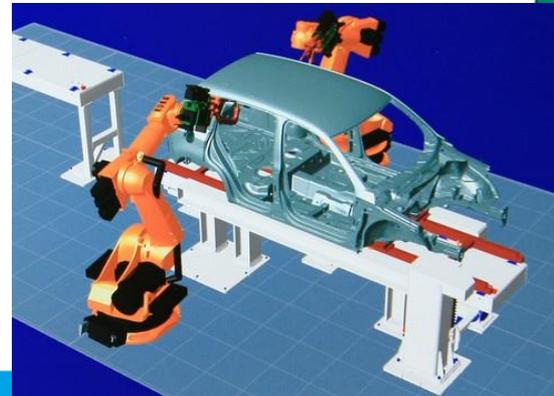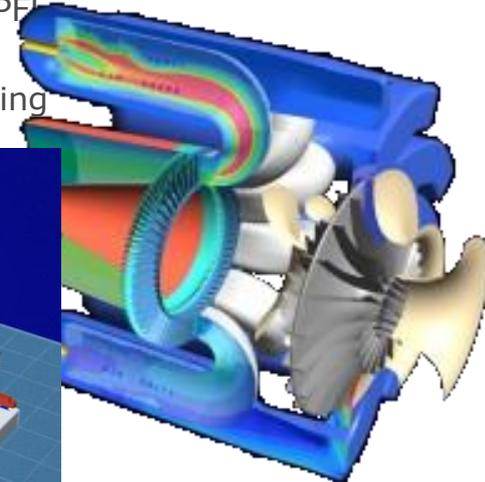
The Missing Middle?
What's that?

Most of the preceding examples come from large computing laboratories

- Those who already know how and have access to the wide range of required expertise

Manufacturing

- 300,000 US manufacturers
- About 50% would use HPC for design/manufacturing
- Only about 4% actually do
- Leaving tens of 1000' …

Attempts to reach these 1000's

- Current "affiliates" programs reach at most dozens

Computer size (proc)

4 8 16 32 64   128

HPC Transition

the "Missing Middle"
Those who would if they could

USERS

Desktop Computer Users

High-End HPC Users

TASK COMPLEXITY
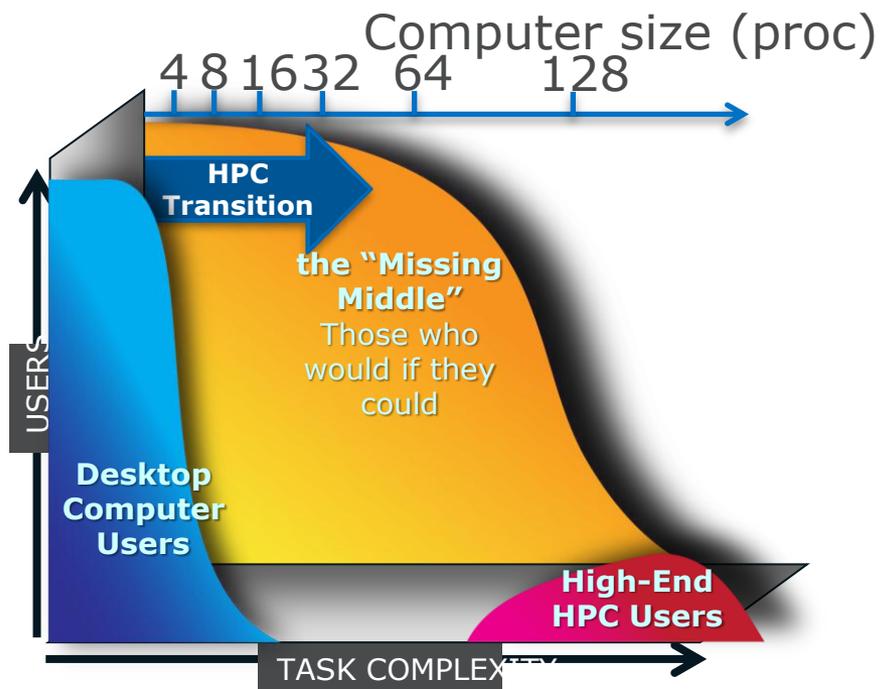
If to drive a truck you had to be able to design the truck, where would logistics be today?

(intel)

The Technology of Manufacturing has attracted National Attention

Administration's Advanced Manufacturing Initiative

"a national effort bringing together industry, universities and the federal government to invest in the emerging technologies that will create high quality manufacturing jobs and enhance our global competitiveness."

PCAST (Presidential Committee on Science and Technology) issued: American Leadership in Advanced Manufacturing :

"powerful computational tools and resources for modeling and simulation could allow many U.S. manufacturing firms to improve their processes, design, and fabrication."

America Competes Act directs the Department of Commerce to

"study barriers to use of high-end computing simulation and modeling by small- and medium-sized U.S. manufacturers, including access to facilities and resources, availability of software and technologies, and access to expertise, and tools to manage costs."

(intel)

Big Assumptions

We assumed if we solved the cost and access issue we solved the problem….not the case!

Assumptions are Upside-down

Skills, Education, Experience, Community

ROI

Cost and Access
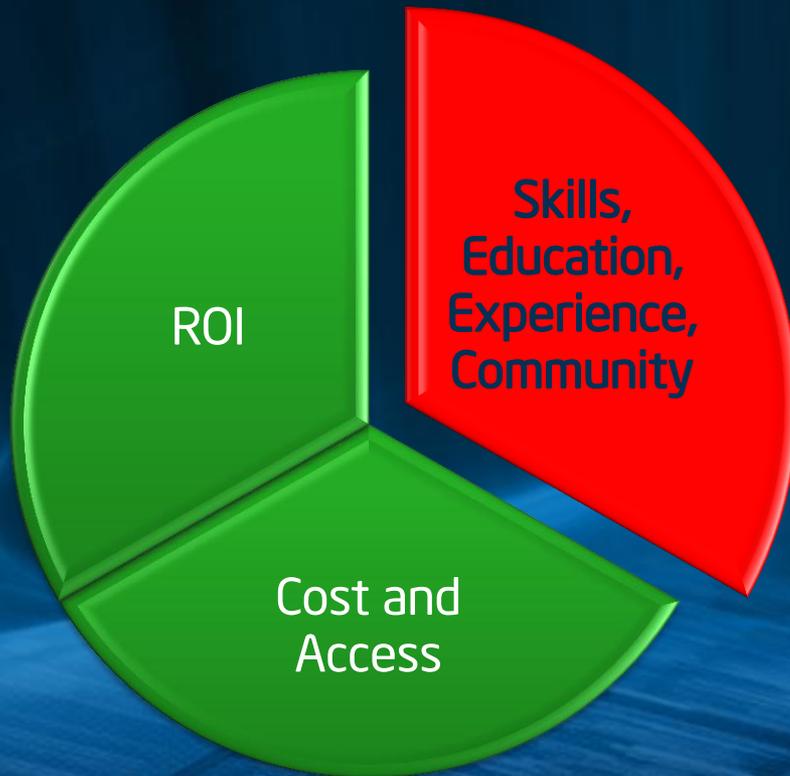
- Infrastructure is the easy piece
- Solving the skill gap; creating a pipeline of students, workers...that is the hard part
- Re-tooling the workforce – it's hard
- Community matters...ALOT

(intel)

Why Wheeling?

- **Demographics:** mfg. density, STEM HS, strong local government, engaged industrial community

- **Location:** heartland of manufacturing

- **Demonstrated success:** experience in driving innovative concepts to fruition. Strong leadership

- **Strong ecosystem:** Broad capabilities across Universities, Community Colleges, National Labs, STEM HS, ISVs, Tier 1 OEMs, State/Local government

(intel)

Manufacturing Jobs (1000's of workers)
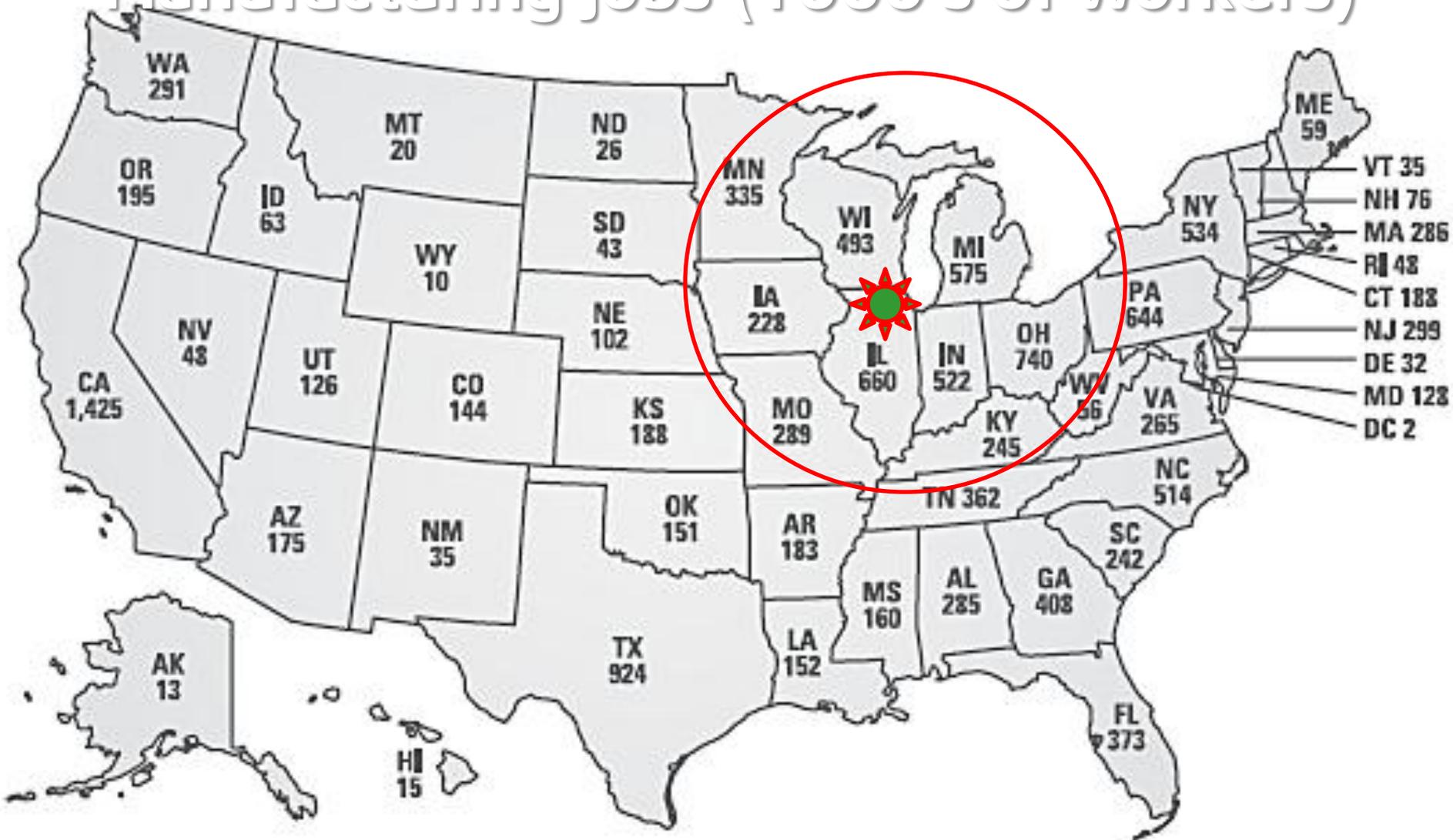
Source: U.S. Bureau of Labor Statistics, 2008

How do you facilitate a transformation?

Intel-HP Wheeling Innovation Initiative

Advance the adoption of digital manufacturing for small and medium-size businesses thru targeted programs providing access to HPC resources and tools, training, and outreach

Three key pillars

- *Community outreach*
- *Student competition*
- *Local industry enablement*

(intel)

Intel-HP Wheeling Innovation Initiative

Outreach	Student competition	Industry enablement
Tell the story, build the community, raise awareness	Launch competition to accelerate student skill development, expertise, and excitement to be part of digital manufacturing through hands-on HPC/ engineering competition	Stimulate direct engagement with small/medium mfgs. to assist them in utilizing advanced computing technologies for design, engineering and process manufacturing

(intel)

Where are we today?

Phase One

- Micro-pilot with Angiotech very successful

- Student Challenge phenomenal experience

- We learned a lot
  - Planning matters
  - IP concerns are real
  - Students crave the challenge
  - Community wants in

SHOWCASE EVENT
Midwest Research Competition
April 13, 2012
8:45am–10:45am
Wheeling High Performance Computing Challenge
Sponsored by Intel

Positive Impact Project: Optimization of a surgical biopsy needle

Through the cooperation of Angiotech and ANSYS engineers, students are developing 3D models of the BioPince instrumentation and utilizing ANSYS simulation environments to test the instrument's performance. This simulation process involves the remote use of supercomputers provided by Intel, where students will utilize high performance computing to optimize the design of the biopsy system. Students will report on the findings and process of their simulation-based optimization for consideration by Angiotech engineers and executives.

The project engages seven different student design teams, consisting of 19 students from Wheeling High School, who will work to optimize the design of Angiotech's BioPince Full Core Biopsy Instrument. The BioPince instrument is a disposable automatic instrument that is used to obtain multiple core samples from soft tissue such as the liver, kidney, and abdominal masses for use in cancer and other medical screenings.

This project is a collaboration between Wheeling High School in partnership with Angiotech Pharmaceuticals, Intel Corporation, and ANSYS Inc.

Angiotech is a global specialty pharmaceutical and medical devices company that discovers, develops, and markets innovative technologies and medical products primarily for local diseases or for complications associated with medical device implants, surgical interventions and acute injury. Angiotech is a global engineering and manufacturing company with facilities in Wheeling.

ANSYS Inc. is company that designs industry standard engineering simulation software. The software utilizes finite element analysis, a numerical technique in mathematical approximations that describes the physics within a complex physical system.

Where are we today?

Phase Two

- Scale Student Challenge
  - PLTW / STEM
- Broaden community support
- Expand Pilot engagements
- Enable the ecosystem
  - ISVs, engineering services organizations, HPC providers, Universities etc.

OFFICE OF GOVERNOR PAT QUINN   **NEWS**

FOR IMMEDIATE RELEASE:
Friday, September 14, 2012

CONTACT: Brooke Anderson (o. 312-814-3158; c. 312-590-0195)
Annie Thompson (o. 217-782-7355; c. 217-720-1853)

Illinois launches new 'STEM' learning exchanges to prepare students for 21st Century workforce

$10.3 million public-private partnership to boost careers in Science, Technology, Engineering and Math (STEM)

CHICAGO – September 14, 2012. Governor Pat Quinn today unveiled a unique $10.3 million public-private partnership that will better prepare thousands of Illinois students for careers in Science, Technology, Engineering and Math (STEM) fields. Joined by Illinois business, high-tech and education leaders at the innovative "1871" digital start-up center in Chicago's Merchandise Mart, Governor Quinn announced that eight organizations will be awarded contracts to develop "STEM Learning Exchanges" that link educational opportunities with business resources to prepare students to compete in the global economy. The partnership is part the governor's commitment to improve education in Illinois.

"Our mission is to prepare our students for the 21st Century workforce," Governor Quinn said. "These new Learning Exchanges will provide students with real-world experience and advanced educational opportunities to ensure they are ready to compete for the jobs of tomorrow."

The funding package is comprised of $2.3 million in federal Race to the Top (RTTT) funds, which leveraged another $8 million in business resources. The eight STEM Learning Exchanges, coordinated through multiple state agencies in partnership with the Illinois Business Roundtable, will be established through contracts with the Illinois State Board of Education. Applicants were required to commit cash or in-kind donations, bringing more than $10.3 million of business resources and cash to this unique public-private partnership.

The eight learning exchange organizations were selected by an expert review committee that considered each applicant's plan and experience in coordinating statewide public-private partnerships, and the matching or in-kind matching contribution. These statewide Learning Exchanges will work together with regional, educational and business networks to aggregate curricular resources, assessment tools, professional development systems, work-based learning opportunities and problem-based learning challenges. They will support performance evaluation across the P-20 education and workforce system, and result in better prepared students for a 21st century workforce. For the complete list, see attached document.

"This exemplifies a great public-private partnership as education and business forces work together to pave the way for a brighter future in Illinois," said State Superintendent of Education Christopher A. Koch. "Giving students access to professionals and showing them how knowledge can be applied on the job is a proven strategy for keeping students engaged in high school and mindful of their future."

-MORE-

The "Missing" Piece
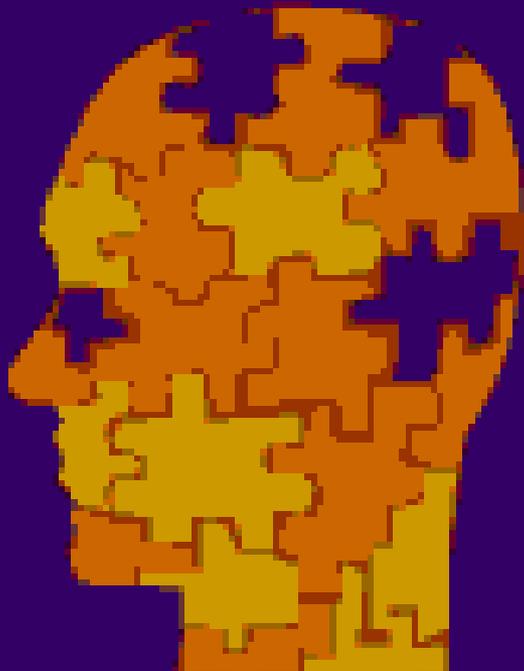
- Create the fabric to drive a transformation through partnerships with national and regional technical institutes, community colleges, non-profits, policy organizations
  - DeVry Institute
  - Manufacturing Institute/NAM
  - AACC
  - SME
  - PLTW
- Build the community and ecosystem: connect people to each other

(intel)

An Example:
Zipp produced a market changing product

Intelligent Light guided Zipp in the use of CFD for wheel design. Their new wheel "changed the game" in bicycle racing, won int'l races and topped the consumer market. Race on Sunday – sell on Monday $3000/pr. ROI?

A consortium consisting of:

Zipp Speed Weaponry of Indiana

Leading manufacturer of racing bicycle wheels – small mfg business

Intelligent Light of Rutherford, NJ

Independent Software Vendor, maker of Fieldview, data analysis and scientific visualization software

### CD-Adapco of Melville, NY

Independent software vendor, maker of Star-CCM+, Computational Fluid Dynamics software

Dell Clusters/Intel, TX/CA

R-Systems of Champaign, Illinois

commercial scientific data center

cross flow

FIELDVIEW
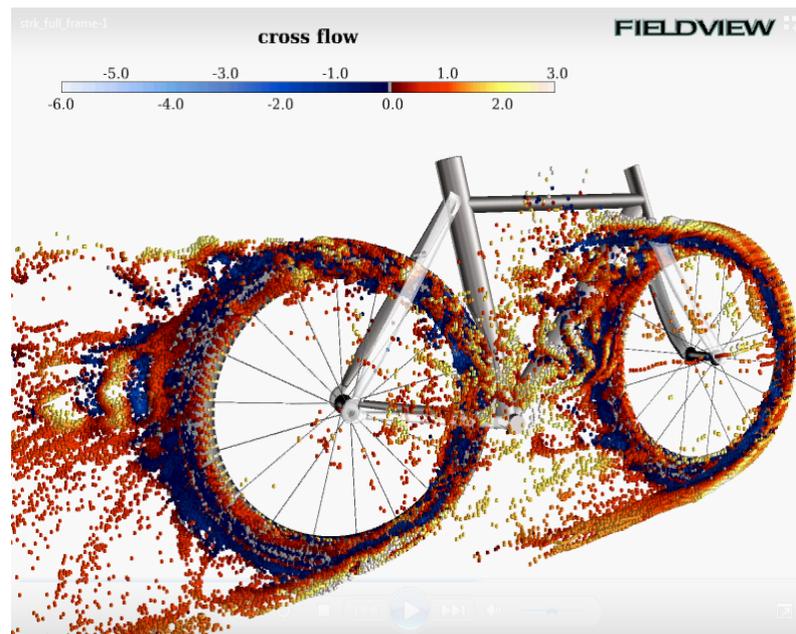
http://www.digitalmanufacturingreport.com/dmr/2011-12-09/bicycle_racing_on_the_computer_modeling_and_simulation_for_a_small_business.html?featured=top

(intel)

The Edison Welding Portal packaged analysis software and reached 500 welding companies

Predictor Portal

Allows a welder to computationally design a weld

Encapsulates finite element and thermal analysis

Significantly reduces solution time for automotive, energy, and other weld parameters
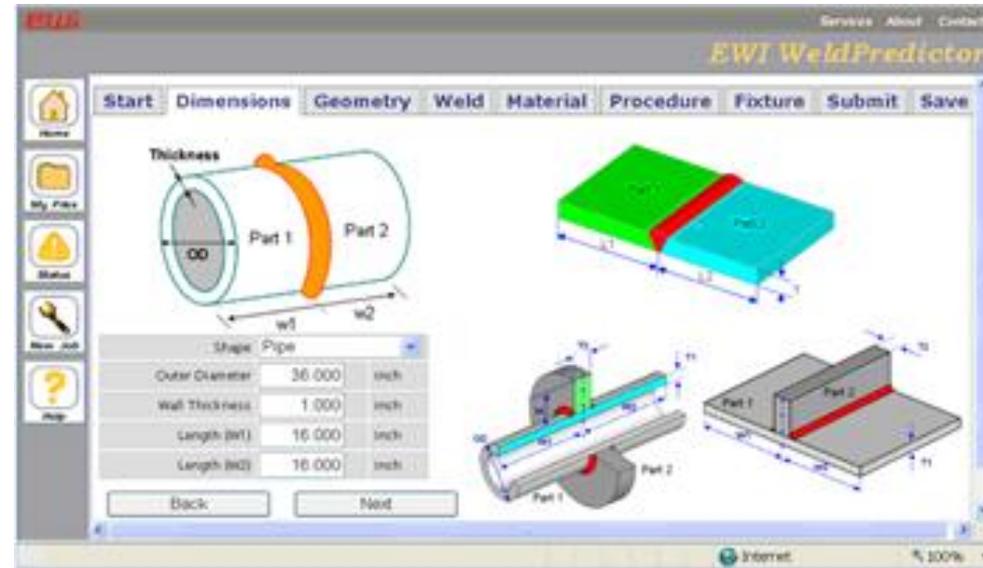
EWI won the 2009 International Institute of Welding Sossenheimer Award for this innovative modeling software

Scaling - reaches many more users than a typical "affiliates program"

(intel)

Accio Energy

- Modeling and Simulation was the only way that Accio Energy of Michigan could explore design concepts for a bladeless wind energy system that exploits modularity and the mass production techniques learned in the auto industry

- Accio is a small startup company of nine employees
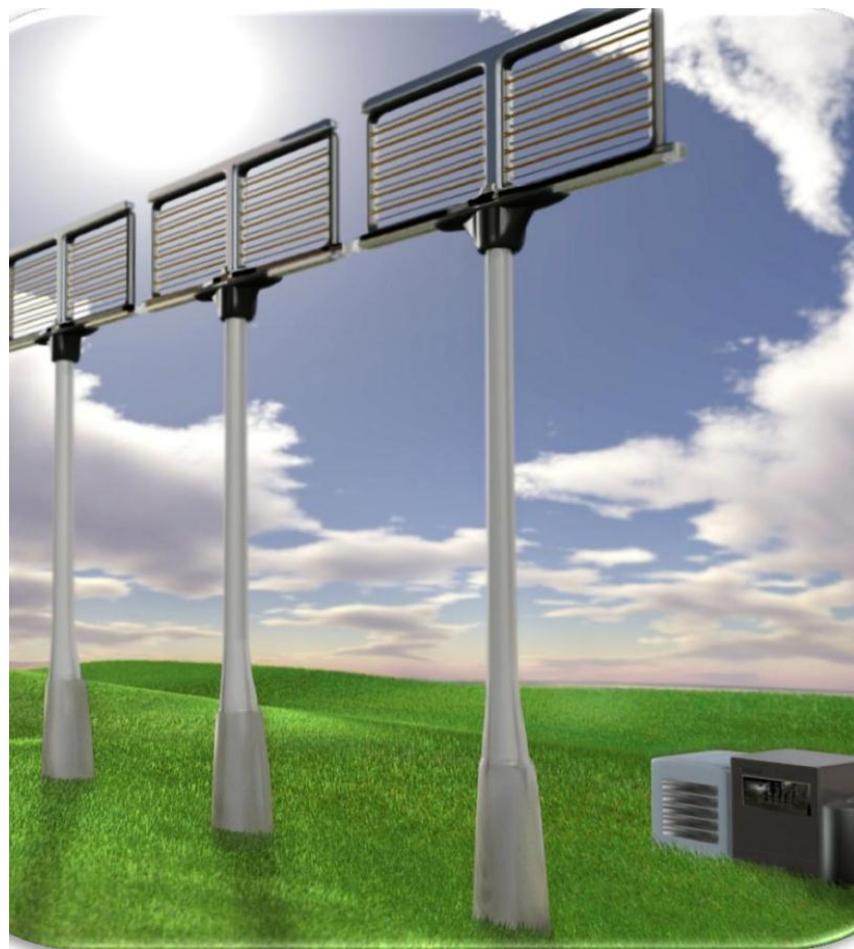
Intel® High-performance Computing


stephen.r.wheat@intel.com

On the Red River Rivalry 2012

Close game

On the Red River Rivalry 2012

Close game, but OU wins – 20-17
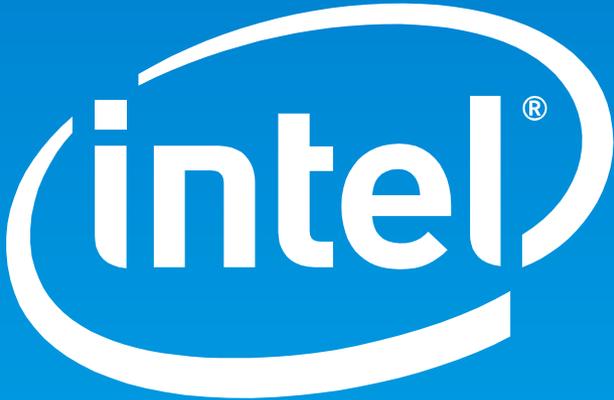
Intel® High-performance Computing

Legal Disclaimers

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

Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. Go to: http://www.intel.com/products/processor_number

Intel, processors, chipsets, and desktop boards 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.

Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM). Functionality, performance or other benefits will vary depending on hardware and software configurations. Software applications may not be compatible with all operating systems. Consult your PC manufacturer. For more information, visit http://www.intel.com/go/virtualization

No computer system can provide absolute security under all conditions. Intel® Trusted Execution Technology (Intel® TXT) requires a computer system with Intel® Virtualization Technology, an Intel TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). Intel TXT also requires the system to contain a TPM v1.s. For more information, visit http://www.intel.com/technology/security

Requires a system with Intel® Turbo Boost Technology capability. Consult your PC manufacturer. Performance varies depending on hardware, software and system configuration. For more information, visit http://www.intel.com/technology/turboboost

Intel® AES-NI requires a computer system with an AES-NI enabled processor, as well as non-Intel software to execute the instructions in the correct sequence. AES-NI is available on select Intel® processors. For availability, consult your reseller or system manufacturer. For more information, see http://software.intel.com/en-us/articles/intel-advanced-encryption-standard-instructions-aes-ni/

Intel product is manufactured on a lead-free process. Lead is below 1000 PPM per EU RoHS directive (2002/95/EC, Annex A). No exemptions required

Halogen-free: Applies only to halogenated flame retardants and PVC in components. Halogens are below 900ppm bromine and 900ppm chlorine.

Intel, Intel Xeon, Intel Core microarchitecture, the Intel Xeon logo and the Intel logo are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

Intel® High-performance Computing

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.

Intel® High-performance Computing

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