

# Software Tools for Software Developers *and* Programming Models

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# Our Goals for Software Tools and Models



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- “Port of Choice”
  - Help IA continue as the biggest and best eco-system, a benefit for owners of IA as well as for software developers
  - This means: we want everything to run on IA, and run well



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- Support for open standards
  - Leadership in compliance, participation and strength of implementation

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- Add value, do not detract from value
  - Provide Intel solutions and leadership where we believe we have unique technology and/or value to the industry

# RAISING THE BAR



Picture credit: wikimedia.org

# RAISING THE BAR

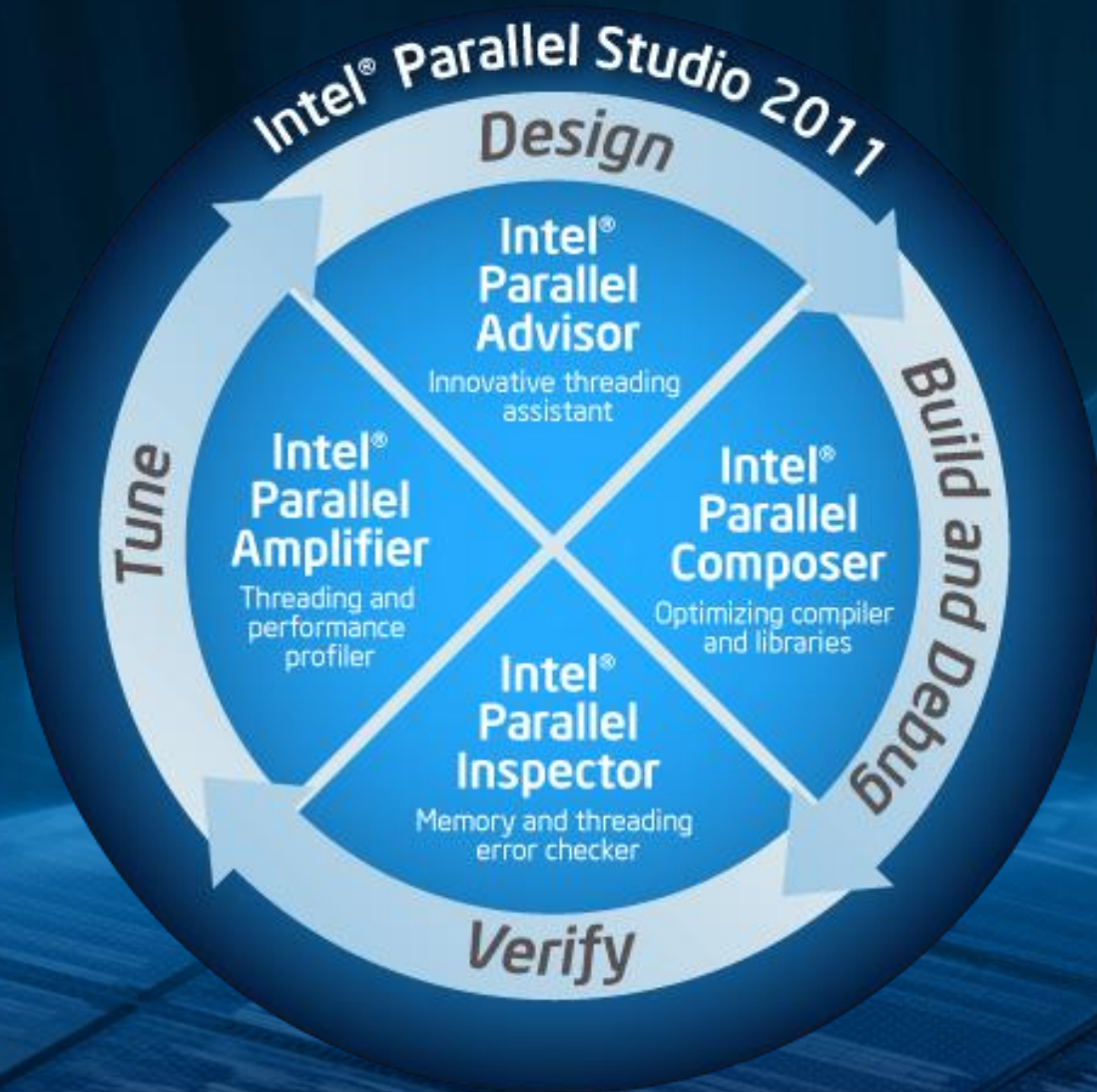
- **Tools** – NEW announcement today of Intel® Parallel Studio XE 2011 SP1
- Support for standards
  - For instance: radix 10 floating point support
- Tackling the TOUGH issues for parallelism
  - High scalability to HUGE machines
  - Programming models that *scale forward*

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# Intel® Parallel Studio 2011



- All-in-one toolset for the software development lifecycle
- Multiplatform
- Standards Based

[intel.com/go/parallel](http://intel.com/go/parallel)

# Intel® Parallel Studio XE 2011 Service Pack 1

Intel continues to be the best choice for C/C++/Fortran development tools

- Performance

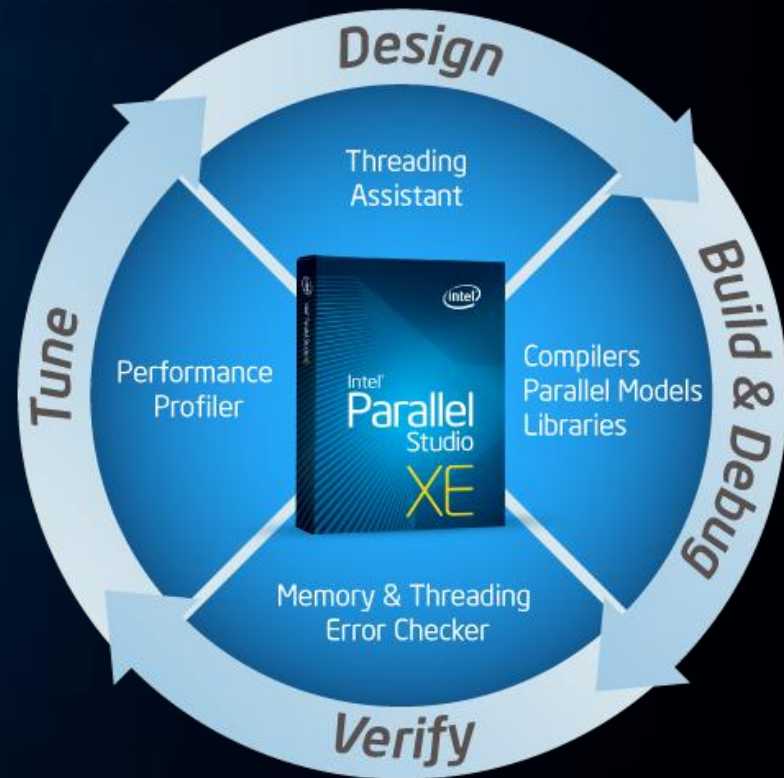
- Updated compilers and libraries produce industry leading performance.
  - o Up to 47% faster for C/C++ compiler, or more?
  - o Up to 24% faster for Fortran compiler, or more?
- Intel C++ Compiler 12.1 is first compiler for IA to support IEEE 754-2008 radix-10 and the related C++ TR 24732. And... High performance!
- The most popular Analysis Tools<sup>1</sup> just got better

- Forward scaling

- Intel® Threading Building Blocks 4.0, commercially supported. Code using TBB scales exceptionally well.
- Intel® Cilk™ Plus v1.1 implemented with commercial support; simplifies going parallel
- Advanced tools to develop code for Intel® Xeon® Processors (today), easily extends to Intel® MIC architecture (future)

- Tools that developers count on

- Expanded standards support
  - o OpenMP\* 3.1
  - o Leading support for key parts of the latest Fortran and C++ standards
- Enhanced compatibility
  - o Visual Studio\* 2010 Shell for Visual Fortran\*



<sup>1</sup> Evans Data Corp. North American Development Survey 2011 Volume I

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

# Updated compilers and libraries produce industry leading performance

- Intel v12.1 compilers improve performance compared with:
  - Competitive compilers
  - Previous version Intel compilers

	Intel v12.1 Compiler on Windows* vs. nearest competitor	Intel v12.1 Compiler on Linux* vs. nearest competitor	Intel v12.1 Compiler on Windows vs. v12.0	Intel v12.1 Compiler on Linux vs. v12.0
C/C++ Integer <sup>1</sup>	47% faster	12% faster	11% faster	6% faster
C/C++ Floating Point <sup>1</sup>	21% faster	9% faster	3% faster	1% faster
Fortran <sup>2</sup>	24% faster	17% faster	22% faster	27% faster

Notes:

<sup>1</sup> C/C++ performance measured using SPECint@\_base2006 estimated RATE benchmark running on a 64 bit operating system

<sup>2</sup> Fortran performance measured using Polyhedron\* benchmark running on a 64 bit operating system. In this performance measurement, “faster” refers to percent reduction in time-to-completion.

## Industry Leading Performance using the Intel® C/C++ Compiler Intel® Xeon™ Processor running on Windows\* 64 (Higher is Better)

Estimated SPECint\*\_base2006\_rate C/C++ floating point benchmark

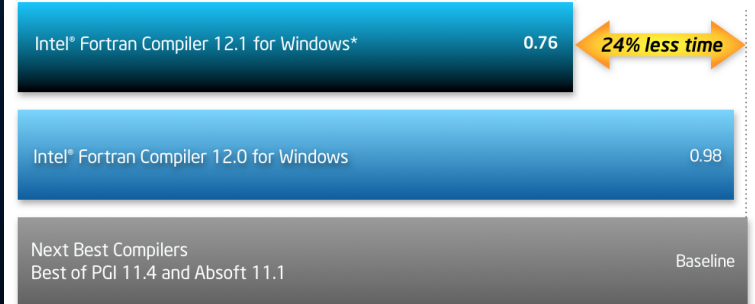


Configuration Info - SW Versions: Intel® C/C++ version 12.1; Hardware: Intel® Xeon® CPU X5670 @ 2.93GHz, 2x2.93GHz, RAM 4GB, CACHE 12288KB; Operating System: Windows 2008 x64 SP2; Benchmark Source: Intel Corp.  
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## Industry Leading Performance using the Intel® Fortran Compiler Intel® Core™ i7 Processor running on Windows\* 64 (Lower is Better)

Polyhedron\* Fortran benchmark

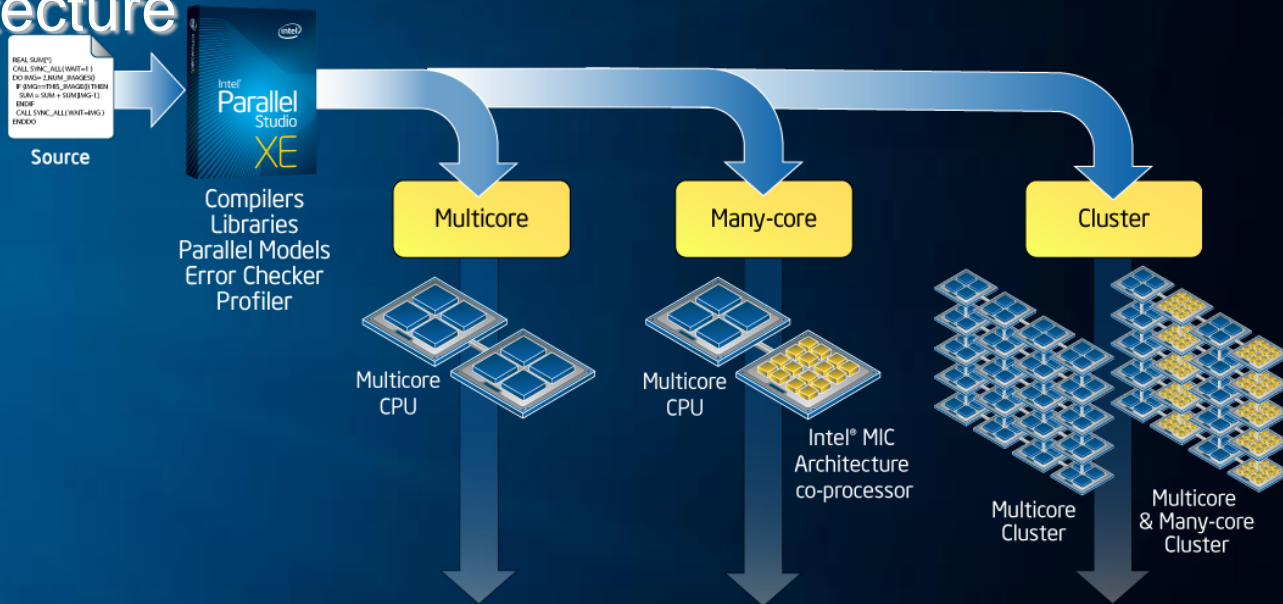


Configuration Info - SW Versions: Intel® C/C++ version 12.1; Hardware: Intel® Core™ i7-2600 CPU @ 3.40GHz 3.40GHz; RAM 16.0 GB (1-socket Desktop); Operating System: Windows Server 2008 R2 Enterprise; Benchmark Source: Intel Corp.

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# Advanced tools to develop code for Intel® Xeon® Processors today that easily extends to Intel® MIC architecture



“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.” – Hongsuk Yi, Heterogeneous Computing Team Leader, KISTI Supercomputing Center

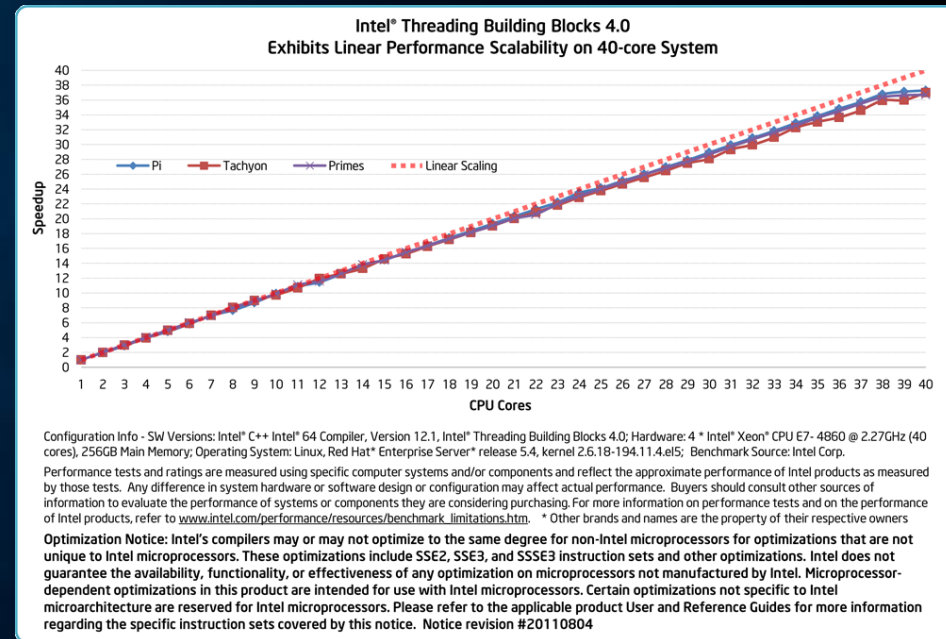


“SGI understands the significance of inter-processor communications, power, density and usability when architecting for exascale. Intel has made the leap towards exaflop computing with the introduction of Intel® Many Integrated Core (MIC) architecture. Future Intel® MIC products will satisfy all four of these priorities, especially with their expected ten times increase in compute density coupled with their familiar X86 programming environment.” – Dr. Eng Lim Goh, SGI CTO



# Intel® Threading Building Blocks 4.0, commercially supported code using TBB scales exceptionally well

- Flow Graph
  - API Extends applicability of Intel® TBB to event-driven/reactive programming models
- Concurrent Unordered Set
  - Thread-safe container to store and access user objects
- Memory Pools
  - Enables greater flexibility and performance by getting thread-safe and scalable object allocation
- Generic GCC\* Atomics Support
  - Library portability enables development of Intel® TBB-based solutions on a broader range of platforms



# Intel® Cilk™ Plus v1.1 implemented with commercial support; simplifies going parallel

- Enhanced performance and utilization of future Intel CPU features
- SIMD pragma loops, vector length, and elemental functions support
- Mac OS\* X support

```
cilk_for (int i=0; i<n; ++i) {  
    Foo(a[i]);  
}
```

Parallel loops made  
easy

```
int fib(int n)  
{  
    if (n <= 2)  
        return n;  
    else {  
        int x,y;  
        x = fib(n-1);  
        y = fib(n-2);  
        return x+y;  
    }  
}
```

Turn serial code

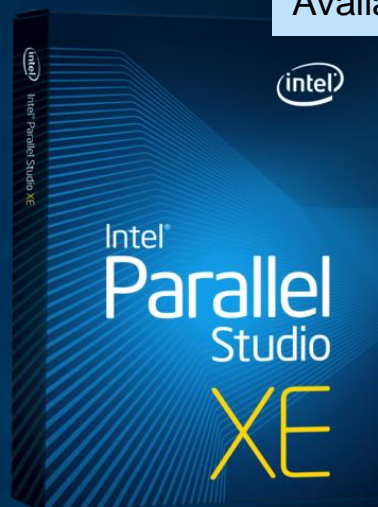
```
int fib(int n)  
{  
    if (n <= 2)  
        return n;  
    else {  
        int x,y;  
        x = cilk_spawn fib(n-1);  
        y = fib(n-2);  
        cilk_sync;  
        return x+y;  
    }  
}
```

Into parallel code

Open spec at: [cilkplus.org](http://cilkplus.org)

# Pricing and availability

Available Today (9/8)!



	Includes	C/C++ compiler	Fortran compiler	For Linux*	For Windows*
Intel® Parallel Studio XE 2011 SP1		•	•	\$2249	\$1899
Intel® C++ Studio XE 2011 SP1		•		\$1499	\$1499
Intel® Fortran*Studio XE 2011 SP1			•	\$1799	\$1599
Intel® Visual Fortran Composer XE 2011 with IMSL* for Windows*			•	NA	\$1699

Additional configurations including floating and academic are available at [www.intel.com/software/products](http://www.intel.com/software/products)



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OpenMP\* 3.1, C++11,  
Fortran 2003, Fortran 2008,  
LAPACK for C, OpenCL\*, IEEE FP...



# IEEE 754-2008 and ISO/IEC TR 24732:2009

0.1 (decimal)

=

0.00011001100110011001100110011... (binary)

## Example from the CASE FILE for “Floating-point disasters”

*Patriot missile accident.* On February 25, 1991 an American Patriot missile failed to track and destroy an Iraqi Scud missile. Instead it hit an Army barracks, killing 28 Americans. The cause was later determined to be an inaccurate time caused by incrementing time in tenths of a second. Couldn't represent 0.1 exactly (single-precision floating point); error accumulated over about 100 hours before firing.



Photo credit: U.S. Dept. of Defense (<http://www.defense.gov/photos/newsphoto.aspx?newsphotoid=685>)  
Story credit: Federation of American Scientists (<http://www.fas.org/spp/starwars/gao/im92026.htm>)

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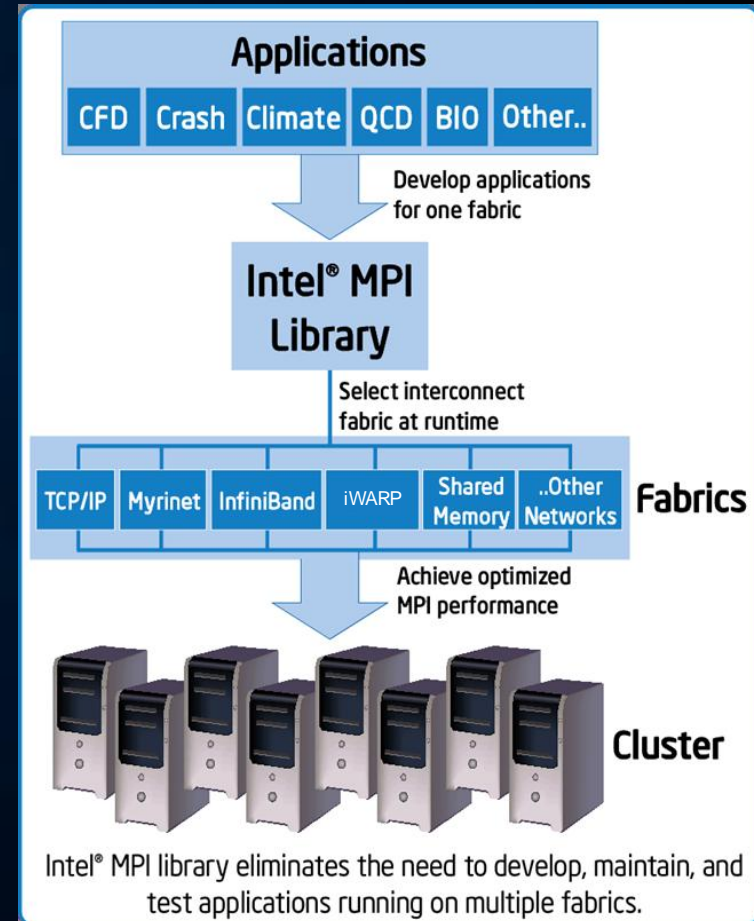


# Scaling Models for Massive Numbers of Cores

# Driving Scalability in Intel MPI

New v4 architecture leads to very high scalability

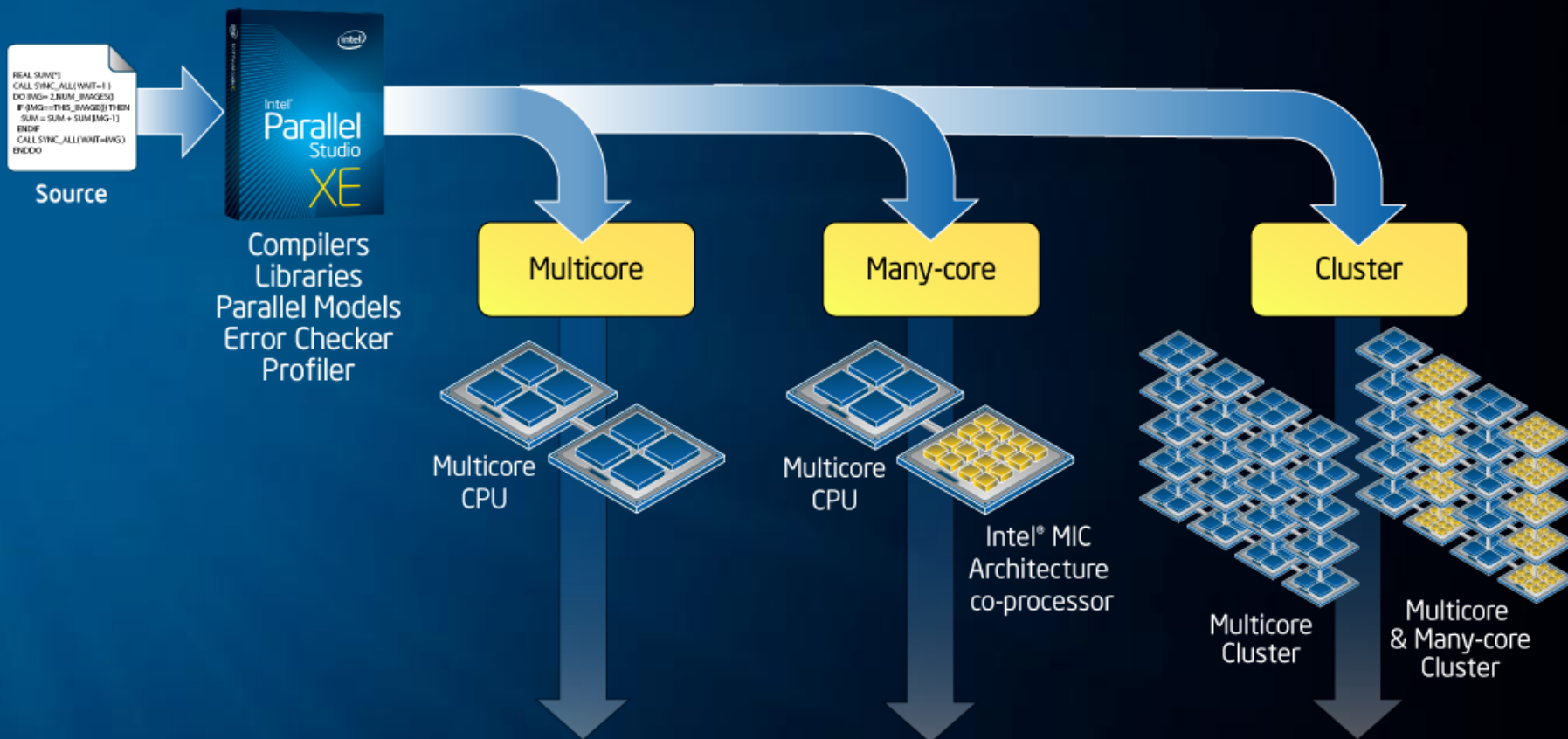
- Fast startup and shutdown of large runs
- Reduced memory footprint
- Dynamic, progressive “connections”
- Remains binary compatible
- Maintains network independence
- Forward-looking focus:
  - Extreme scalability
  - Performance in every dimension
  - Tracking emerging standards



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# Scaling Programmability



*Standard Programming Models Democratizes Usage  
...Avoid Costly Detours*

There are many parallel programming models for C,  
C++ and Fortran.

--- support all established standards ---



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## Intel® Parallel Building Blocks...

### Intel® Cilk™ Plus

Language extension to simplify task, data and vector parallelism.

### Intel® Threading Building Blocks

Widely used C++ template library for data and task parallelism.

### Domain Specific Libraries

Intel® Integrated Performance Primitives.

Intel® Math Kernel Library.

### Established Standards

Message Passing Interface (MPI)

OpenMP\*

Coarray Fortran

OpenCL\*

### Exploration

Intel® Concurrent Collections

Offload Extensions

Intel Array Building Blocks

# Intel® Threading Building Blocks (TBB)

- Outfits C++ for parallelism
- More popular than *any* other abstraction for parallelism
- Created by Intel
- Open Specification
- Open Source
- Adopted by industry
- Supported by community

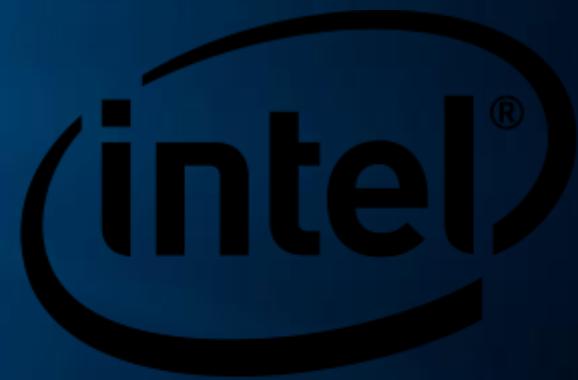
# Intel® Cilk™ Plus

- Augments TBB three ways:
  1. Addresses needs of C programmers (and C++)
  2. Compiler can help, because keywords used
  3. Data parallelism is made explicit (important!)
- Created by Intel
- Open Specification
- Open Source **NEW**  
*Simplicity of only 3 new keywords is surprisingly powerful.*

**We are really onto something here  
(again)! Watch: Cilk™ Plus**

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Software



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