Neue Möglichkeiten schaffen – Europäische Intel Forschung für Visual Computing, Exascale und Paralleles Rechnen

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Gliederung

- Intel Forschung in Europa
  - Intel Labs Europe
- Visual Computing
  - Intel Visual Computing Institute, Saarbrücken
- Paralleles Rechnen
  - Concurrent Collections und paralleles JavaScript
- HPC und Exascale
  - Herausforderung Exascale
  - Intel European Exascale Labs

INTEL FORSCHUNG IN EUROPA

Intel Corporation:
The World's Largest Semiconductor Manufacturer

- Leading Manufacturer of Computer, Networking & Communications Products
- 168 Sites and 578 Buildings in 63 Countries
- $54B in Annual Revenues from Customers in Over 120 Countries
- 25 Consecutive Years of Positive Net Income
- Over 100,000 Employees
- 80,000 technical roles, 10,400 Masters in Science, 5,200 PhD's, 4,000 MBA's
- One of the Top Ten Most Valuable Brands in the World for 11 Consecutive Years
- Ranked #46 on Fortune's 100 Best Companies to Work For List
- Invests $100 Million Each Year in Education Across More than 70 Countries
- The Single-Largest Voluntary Purchaser of Green Power in the United States
- More than One Million Hours of Volunteer Service in Our Communities in 2011

Intel Labs

Delivering Breakthrough Technologies to Fuel Intel's Growth

Strong Research Partnerships

UNIVERSITIES

GOVERNMENT

INDUSTRY

World Class Research

Processing & Programming

Energy & Sustainability

Security & Virtualization

Si Photonics & Wireless

User Experience & Interaction

... and much more!

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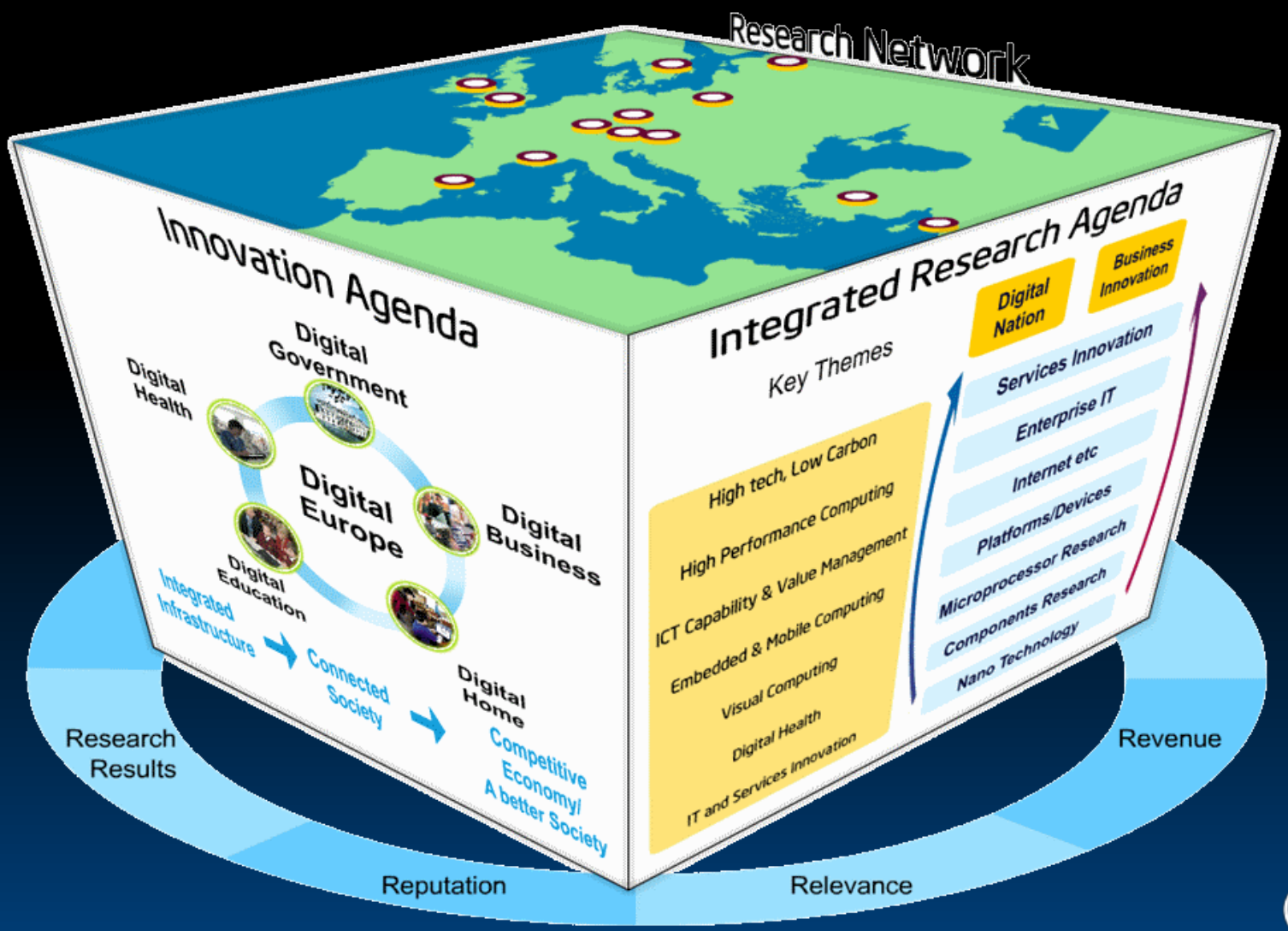
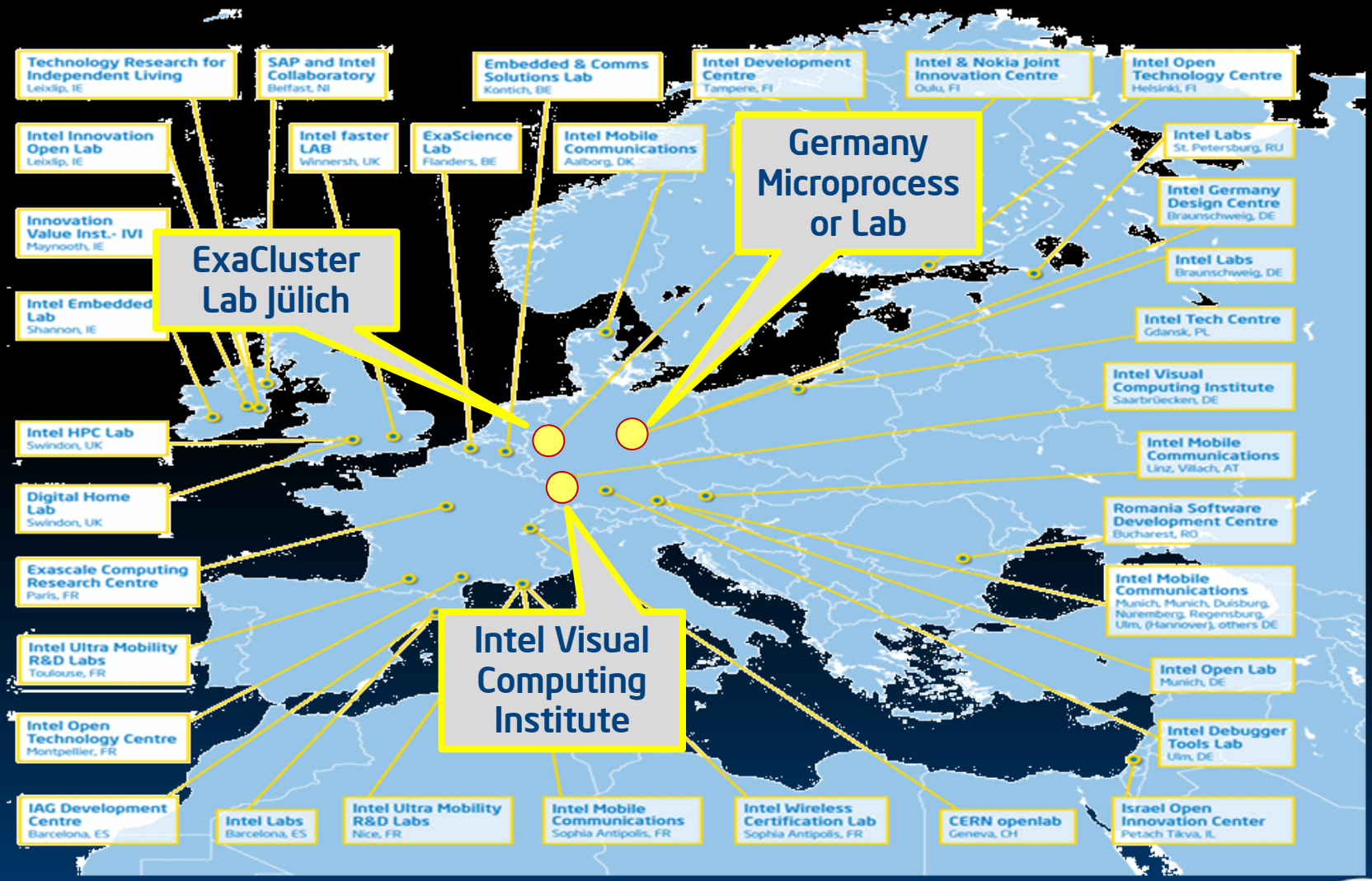
Intel Labs Europe Innovation and Research



ILE Network


Technology Research for Independent Living
Leixlip, IE
SAP and Intel Collaboratory
Belfast, NI
Embedded & Comms Solutions Lab
Kontich, BE
Intel Development Centre
Tampere, FI
Intel & Nokia Joint Innovation Centre
Oulu, FI
Intel Open Technology Centre
Helsinki, FI
Intel Innovation Open Lab
Leixlip, IE
Intel faster LAB
Winnersh, UK
ExaScience Lab
Flanders, BE
Intel Mobile Communications
Aalborg, DK
Germany Microprocessor Lab
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St. Petersburg, RU
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Intel Tech Centre
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Intel Visual Computing Institute
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Intel Mobile Communications
Linz, Villach, AT
Digital Home Lab
Swindon, UK
Romania Software Development Centre
Bucharest, RO
Exascale Computing Research Centre
Paris, FR
Intel Mobile Communications
Munich, Munich, Duisburg, Nuremberg, Regensburg, Ulm, (Hannover), others DE
Intel Ultra Mobility R&D Labs
Toulouse, FR
Intel Visual Computing Institute
Intel Open Lab
Munich, DE
Intel Open Technology Centre
Montpellier, FR
Intel Debugger Tools Lab
Ulm, DE
IAG Development Centre
Barcelona, ES
Intel Labs
Barcelona, ES
Intel Ultra Mobility R&D Labs
Nice, FR
Intel Mobile Communications
Sophia Antipolis, FR
Intel Wireless Certification Lab
Sophia Antipolis, FR
CERN openlab
Geneva, CH
Israel Open Innovation Center
Petach Tikva, IL

VISUAL COMPUTING

Intel Visual Computing Institute

- Kooperation von Intel Labs, Universität des Saarlandes, DFKI, MPI für Informatik, MPI für Softwaresysteme
- Kofinanzierung von Forschungsprojekten
- Zur Zeit 50 Forscher/innen, 19 Projekte
- Nächster RfP in für Mitte 2012 geplant
- Offen für alle Forschungspartner in Europa

http://www.intel-vci.uni-saarland.de/

IVCI Projekte – Interactive 3D Web Content

Prof. Philipp Slusallek, DFKI

- XML3D Scene Description
  - XHTML5 extension
  - Built into the browser
  - Supports Web APIs (DOM*, CSS, JS**)
- XFLOW Workflow Description
  - Parallel data processing
  - Fully programmable pipeline
  - Accessible from DOM
- Results
  - Firefox and Chromium demostrators
  - W3C standardization

*Domain Object Model
**JavaScript

www.xml3d.org

IVCI Projekte – Markerless Performance Capture

Prof. Christian Theobalt, MPI Informatik

- Reconstruction of detailed human animation models
  - In: Multi-view video without markers
  - Out: Detailed motion, shape and appearance
  - General clothing, modifiable performances, new animations

- Real-time performance capture
  - Fast full-body motion estimation from depth cameras
  - Interaction
  - Virtual mirror

Embree Photo-Realistic Ray Tracing Kernels

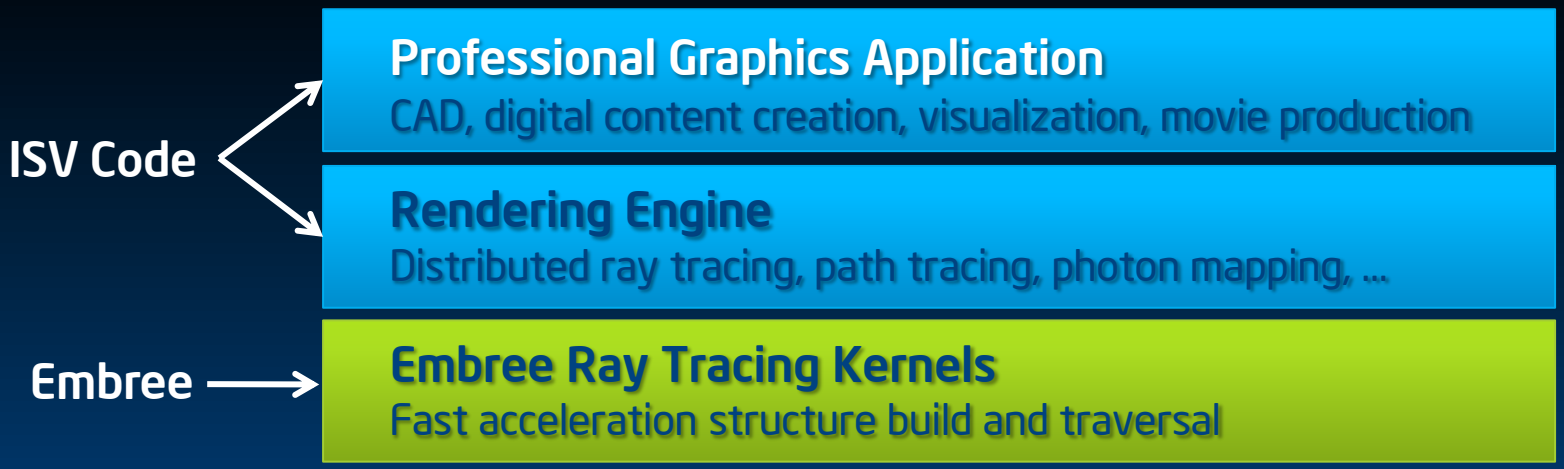
Dr. Manfred Ernst, Intel

What is Embree?

- The fastest ray tracing kernels for Intel® CPUs
- A photo-realistic renderer for demo purposes

Integrating Embree

- Replaces a small component of ISV code
- Has a large performance impact



Embree Photo-Realistic Ray Tracing Kernels

Dr. Manfred Ernst, Intel

1000 x 1200 pixel, rendered on four Intel® Xeon® Processor E7-4860
Model courtesy of Martin Lubich, www.loramel.net

- Source code and example scenes freely available at

http://software.intel.com/en-us/articles/embree-photo-realistic-raytracing-kernels

PARALLELES RECHNEN

Intel Software Development Tools

Choice of parallel programming models

- OpenMP*
  - Pragma- based approach to threading geared towards array—dominated processing
- Intel® Cilk™ Plus
  - C/C++ language extensions enable simple, task-based programming
  - New: comprehensive notation for array operations simplifies SIMD programming
- Intel® Threading Building Blocks
  - Generic implementations of parallel performance patterns, concurrent data structures, sync primitives and scalable memory allocators
- Intel® MPI Library
  - Highly scalable message--passing library for distributed memory systems, excellent performance and adaptability

Coming up

- OpenCL* for explicit offload programming
- Offload pragmas for MIC

```
#pragma omp parallel for
for (i=0; i<N; i++)
  Foo(array[i]);
```

```
cilk_spawn qsort(begin, middle);
qsort(middle+1, end);
cilk_sync;
```

```
If (mask[:])
  a[:] = b[:] + m[:];
m[:] = foo(a[:]);
```

```
tbb::concurrent_queue <int> q;
MyType <char, tbb::tbb_allocator<char>> data;
Tbb::parallel_sort(data.begin(), data.end());
```

```
MPI_Send(&a[0],  count, MPI_FLOAT, dest, tag
  MPI_COMM_WORLD);
MPI_Reduce(&b, &sum, 1, MPI_FLOAT, MPI_SUM,
  MPI_COMM_WORLD);
```

http://software.intel.com/en-us/intel-sdp-home/

Concurrent Collections

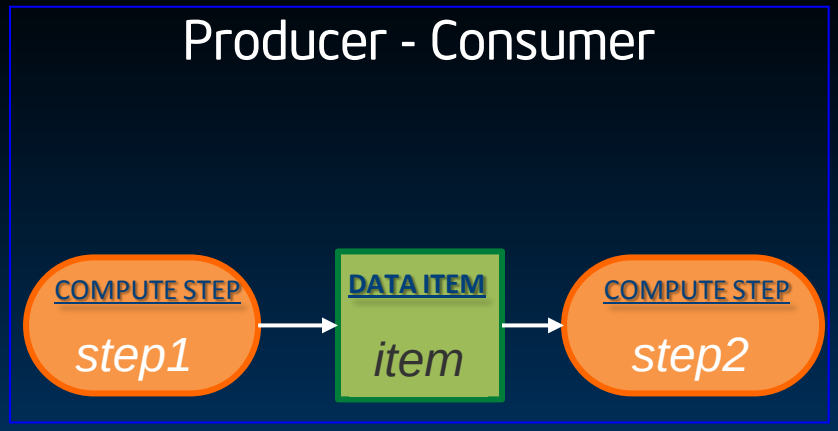
Frank Schlimbach, Intel

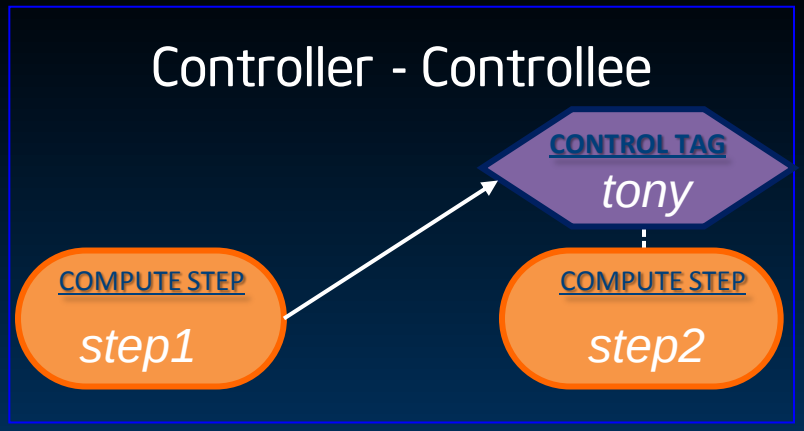
Conventional (distributed memory) models require

- Specification which operations must run in parallel
- Mapping of these to hardware resources

For CnC, all that's necessary is

- Specification of the *semantic ordering* constraints





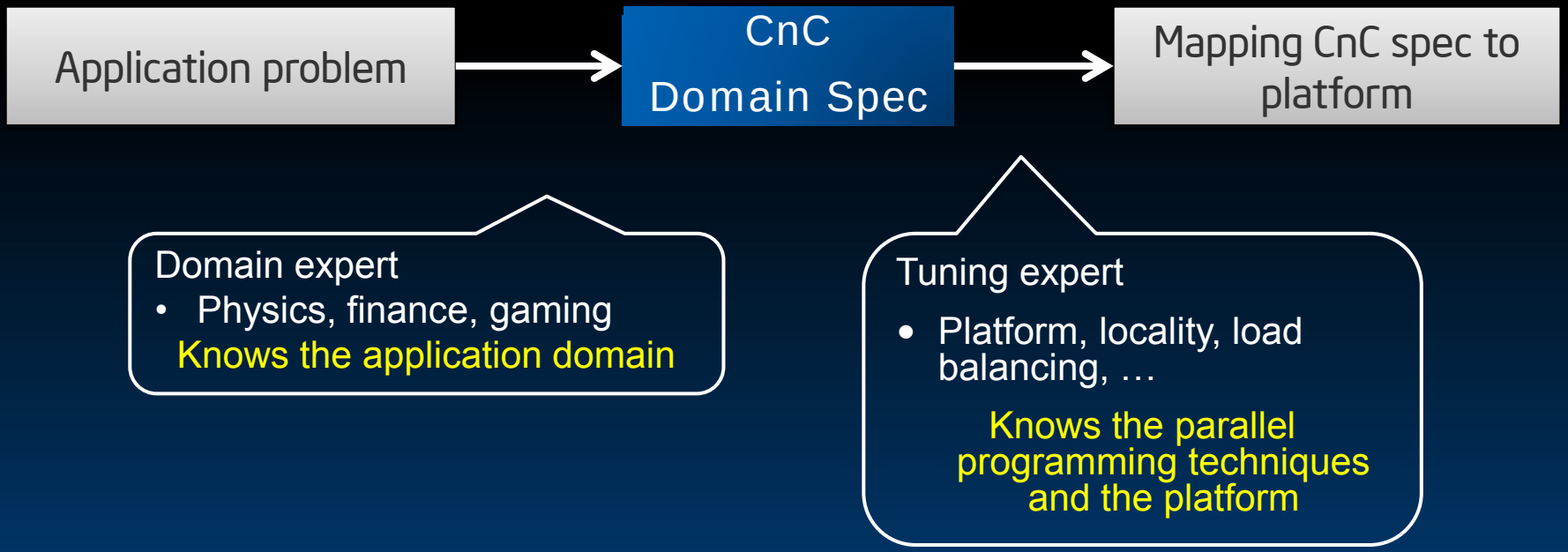
Concurrent Collections

Frank Schlimbach, Intel

CnC is a coordination language

- Works together with a compute language (C++, Java, Python, Scala, …)

Facilitates separation of concerns



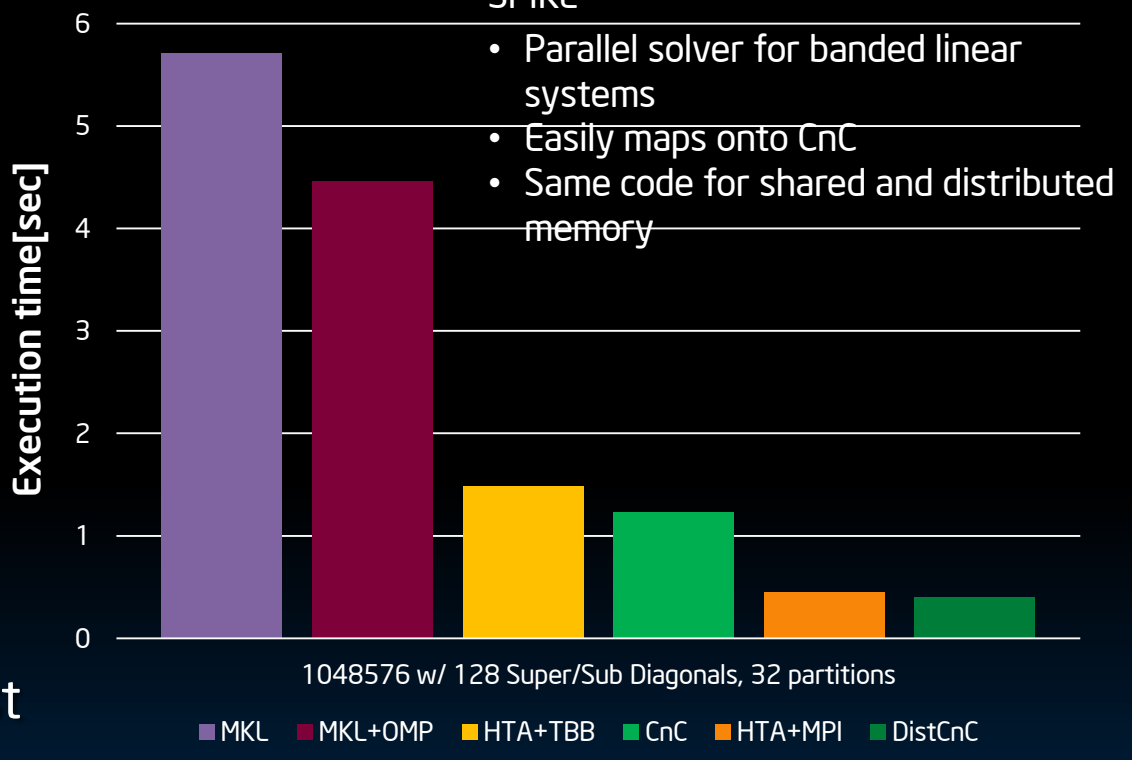
Concurrent Collections

Frank Schlimbach, Intel

(Surprisingly) good performance

Support for distributed memory

- Data distribution orthogonal to everything else
- Can tune distributions without disturbing the rest of the code



http://software.intel.com/en-us/articles/intel-concurrent-collections-for-cc/

http://habanero.rice.edu/cnc

River Trail: Parallel Javascript

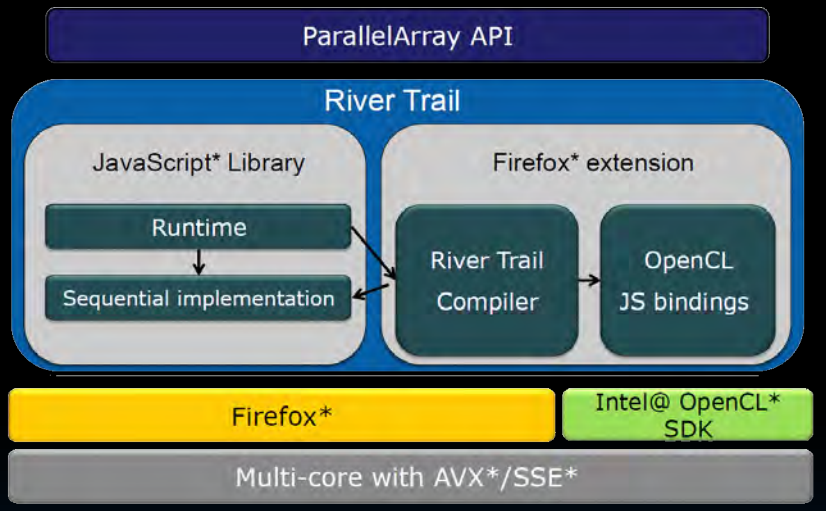
Tatiana Shpeisman, Intel

- Javascript executes sequentially – takes no advantage of multicore hardware
- Web Workers implements low level, thread based model
  - Parallel programming the had way …
- River Trail extends Javascript language by *data parallelism*
  - Concurrent, independent operations on elements of parallel arrays
  - Runtime system maps to parallel HW and devises schedules
  - Deterministic execution, no race conditions, no deadlock

River Trail: Parallel Javascript

Tatiana Shpeisman, Intel

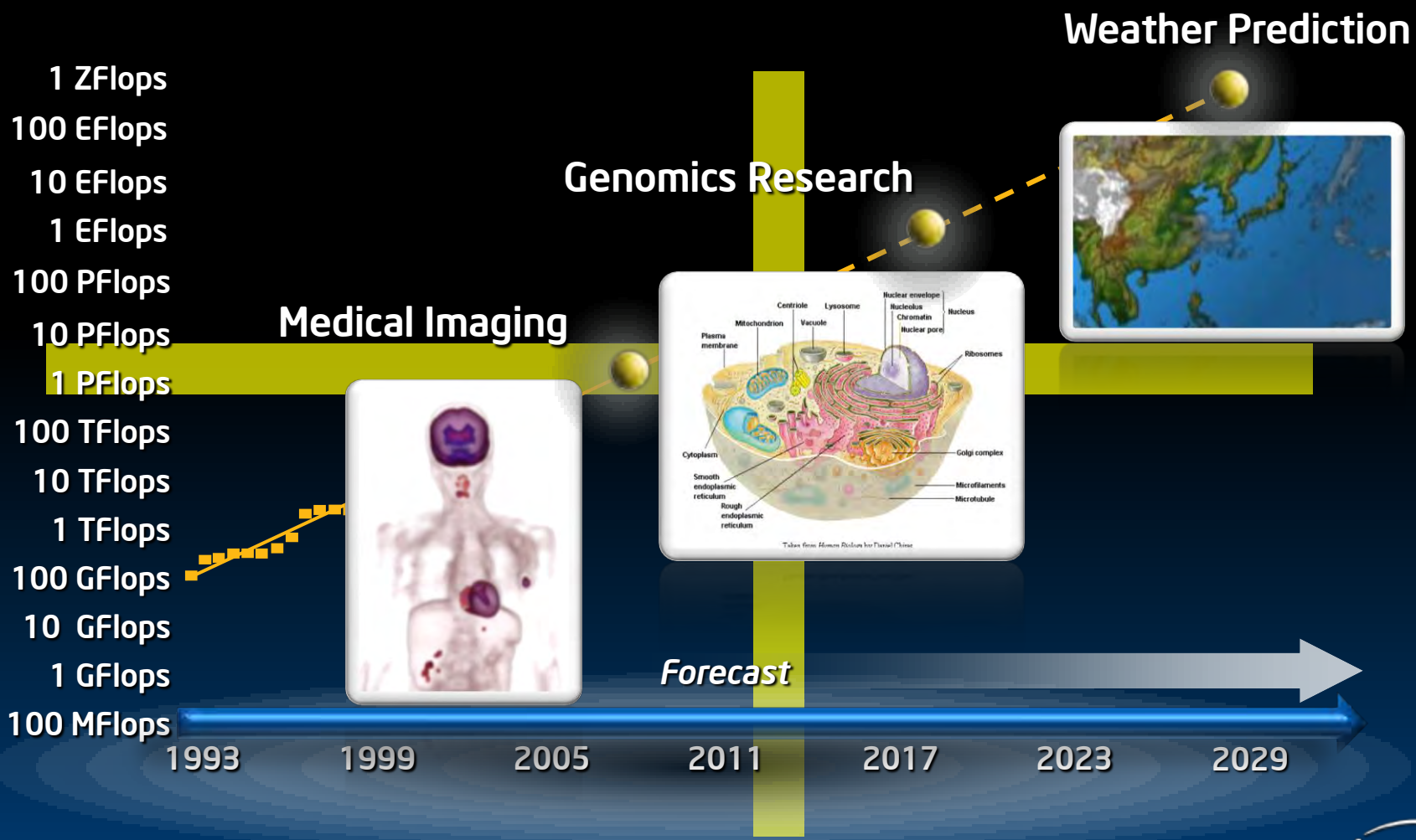
- New **`ParallelArray`** data structure
  - Immutable, dense, homogeneous
- Six methods provide basic skeletons for parallel computing
  - **`Map`**, **`combine`**, **`reduce`**, **`scan`**, **`filter`**, **`scatter`**
- Side—effect free elemental functions
  - Compute one element of the array



https://github.com/RiverTrail/RiverTrail

HPC UND EXASCALE

Still An Insatiable Need For Computing



The Challenge to Exascale Systems Starts with Power

Operation	Approx Energy Today
Instruction Execution	5-10 pJ
FP operation	200 pJ
Byte read from cache	10-20 pJ
Byte read from DRAM	1.5 nJ
Byte over IC fabric	5 pJ/hop—250 pJ+

9.89MW | 8.773PF | 1.1GW | 151MW* | $1M

* Assuming 18% Power/Perf CAGR

Source: http://www.top500.org/lists/2011/06

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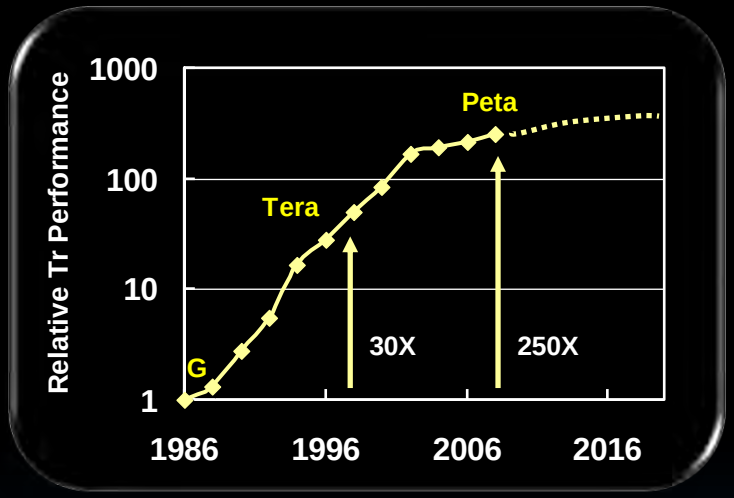
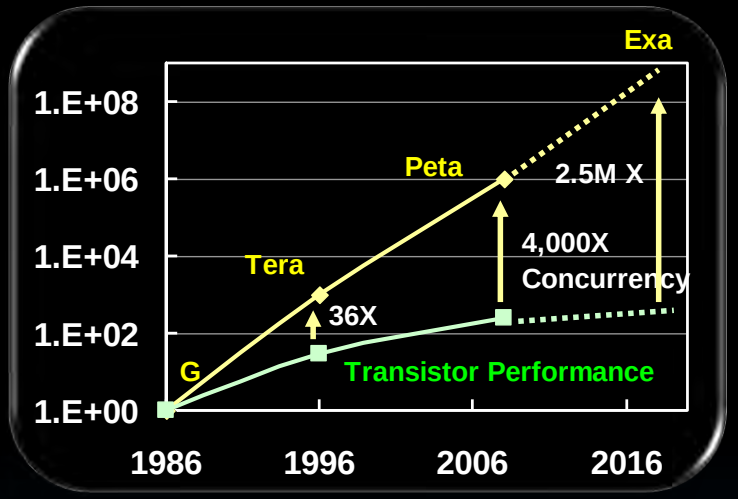
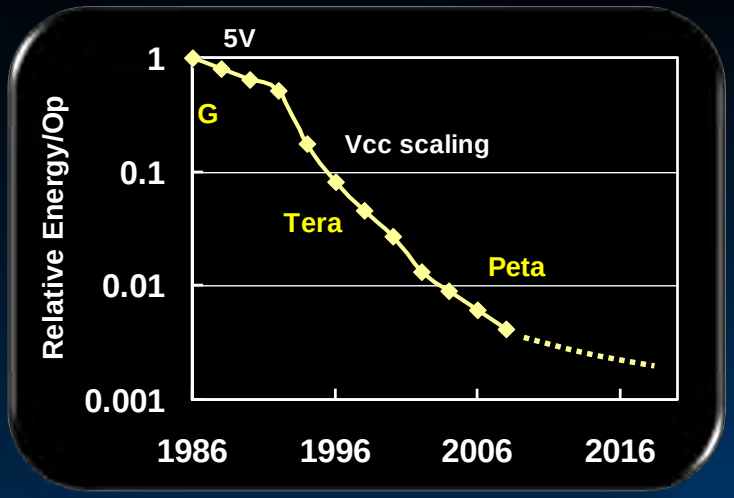
Technologies and Solutions That Got Us to Petascale…







…Will Not Get Us To Exascale

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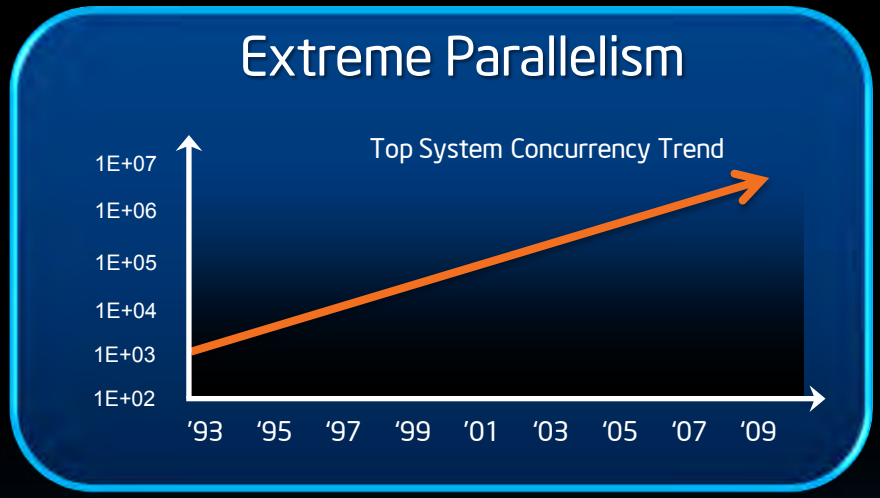
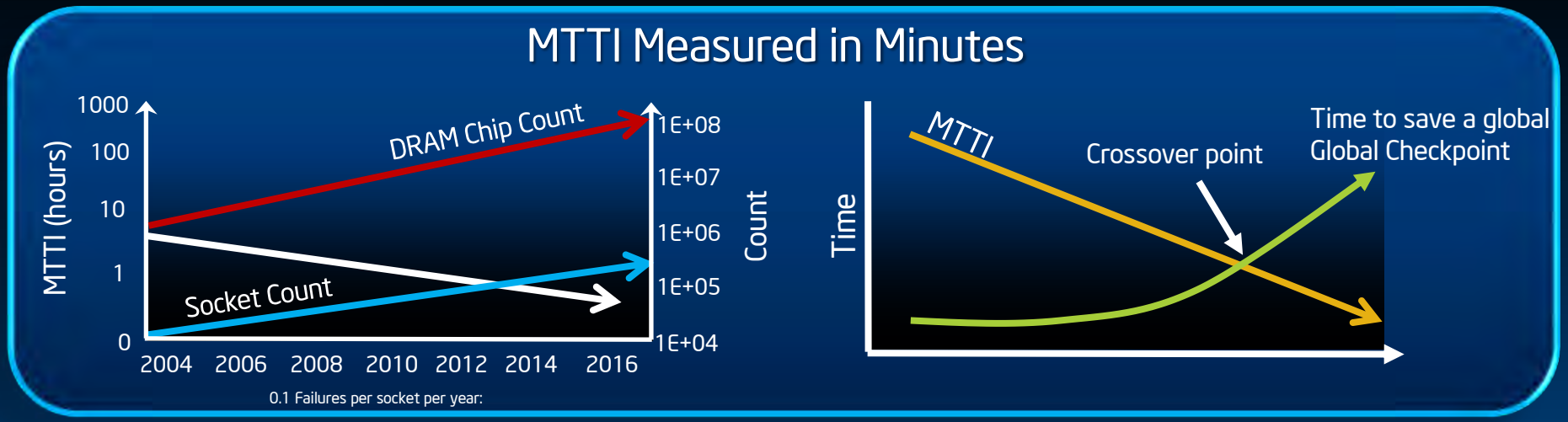
The Reliability and Concurrency Challenge to Exascale





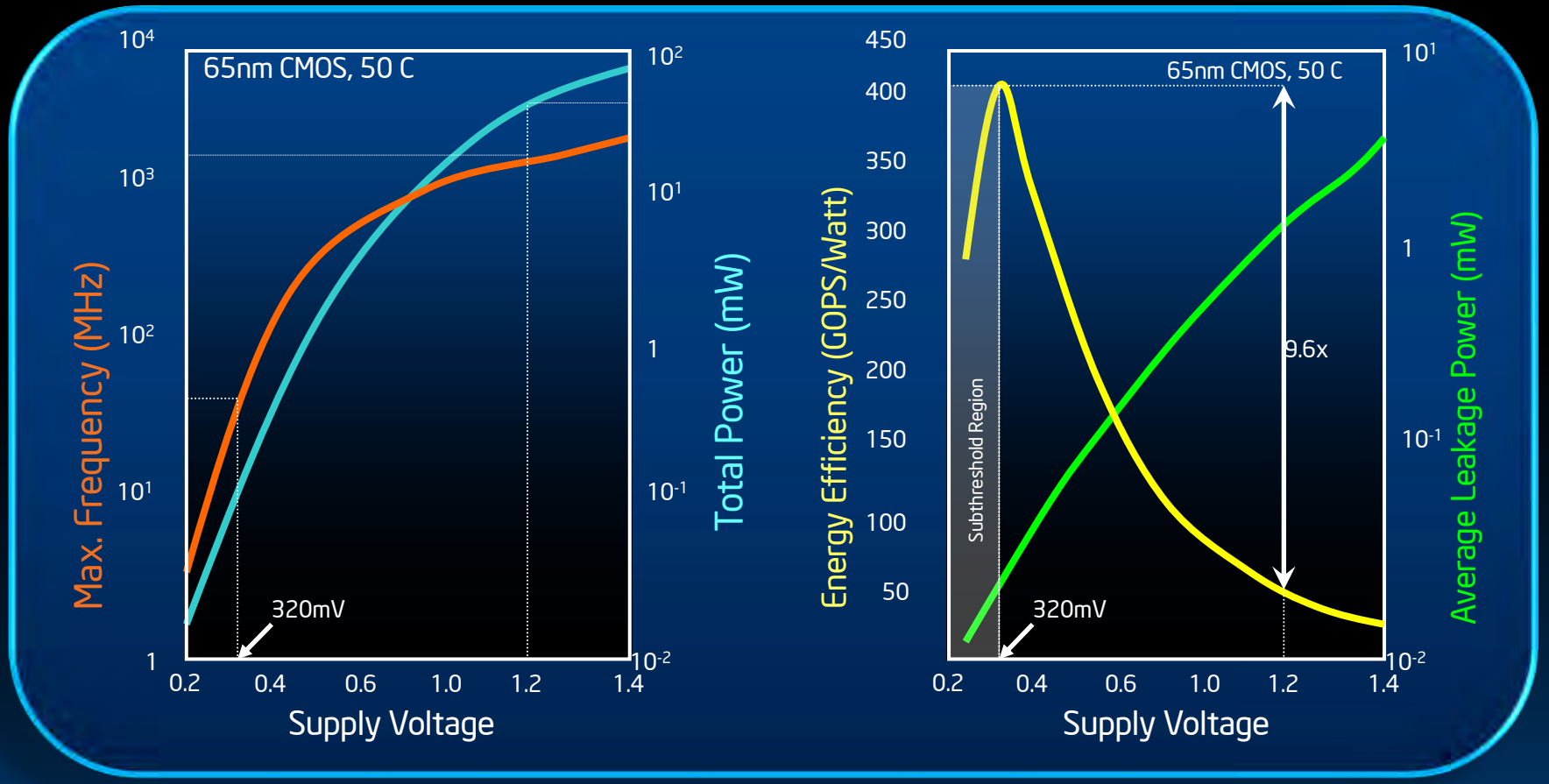
Source: Exascale Computing Study: Technology Challenges in achieving Exascale Systems (2008),

A Paradigm Shift Is Needed

Past Priorities	
Single thread performance	Through Frequency
Programming productivity	Architecture features for productivity
Constraints	(1) Cost (2) Reasonable Power/Energy

Future Priorities	
Throughput performance	Parallelism
Power/Energy	Architecture features for energy Simplicity
Constraints	(1) Programming productivity (2) Cost/Reliability

Extreme Voltage Scaling



Source: Intel

Re-think System Level Memory Architecture

Emerging memory technologies

New levels of memory hierarchy

Minimize data movement across hierarchy

Innovative packaging and IO solutions

Dealing with Parallelism and Locality Challenges

Programming
Today's Mindset Needs to Change

Software
Limitations With the Entire SW Stack

Architecture
Better Mapping of Code onto Architecture

Intel European Exascale Labs

Strong Commitment To Advance Computing Leading Edge:

Intel collaborating with HPC community & European researchers

4 labs in Europe - Exascale computing is the central topic

ExaScale Computing Research Lab, Paris

Performance and scalability of Exascale applications

Tools for performance characterization

ExaCluster Lab, Jülich

Exascale cluster scalability and reliability

ExaScience Lab, Leuven

Space weather prediction

Architectural simulation

Scalable kernels and RT

Intel and BSC Exascale Lab, Barcelona

Scalable RTS and tools

New algorithms

http://www.exascale-labs.eu

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Intel European Exascale Labs

Role

- Understand requirements for Exascale apps
- Provide feedback to Intel HW architects
- Provide guidance to application developers
- Build Exascale HW and SW prototypes
- Contribute to European and national projects

Status

- Started 2010/2011 as co-design centers
- With leading European HPC R&D organizations
- In total ~70 researchers
- Joint R&D program with partners
- Part of Intel Labs Europe network with >1,500 R&D profesionals

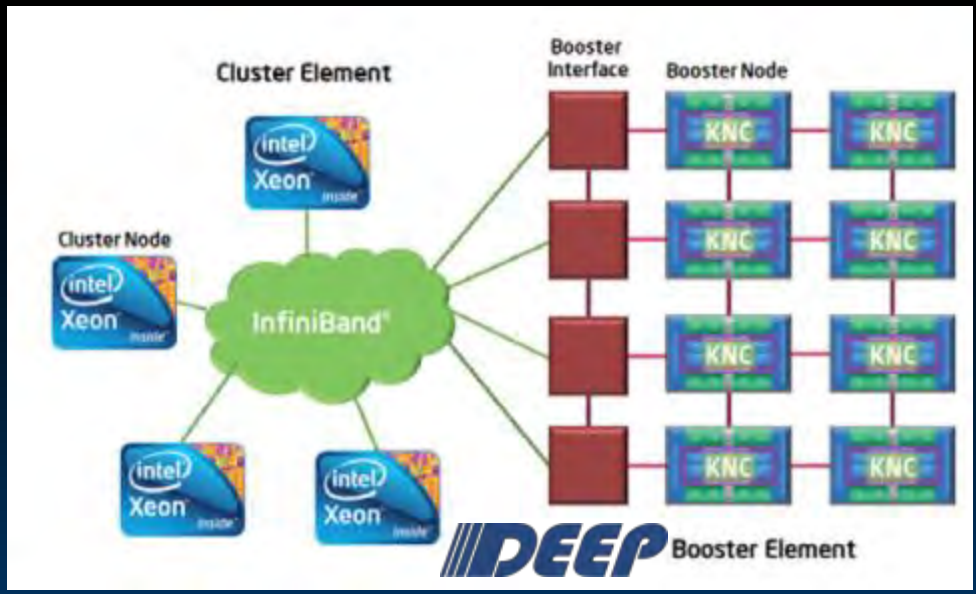
Jülich ExaCluster Laboratory

SW Scalability and Resilience

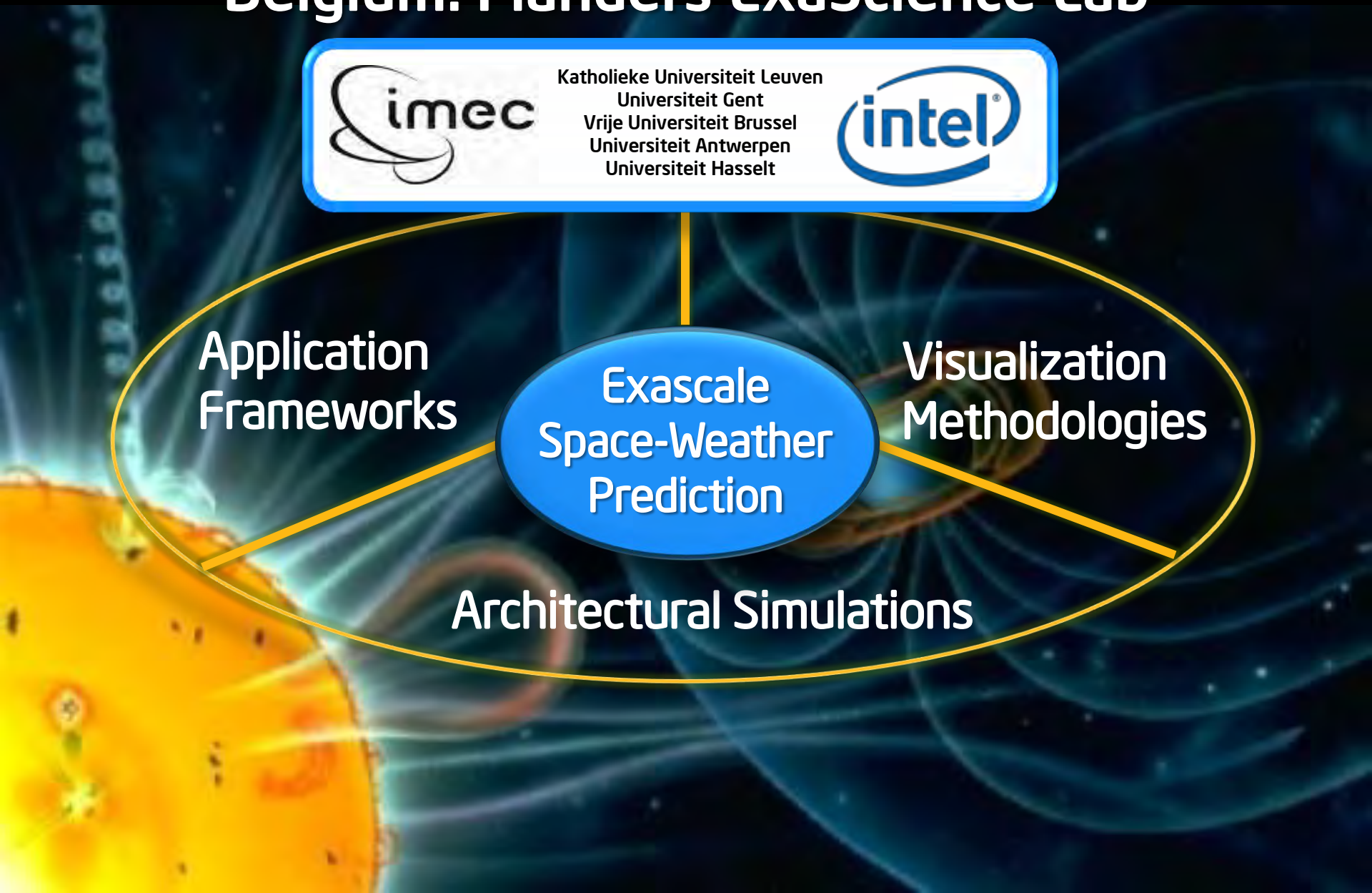
Exascale Cluster Architecture

Exascale Simulation and Tools

The DEEP Architecture



Belgium: Flanders ExaScience Lab



France: Exascale Computing Research Center

Application Scalability

Application Performance Characterization/Optimization - from Core to Platform level

Geoscience, Life sciences, Energy/Environment

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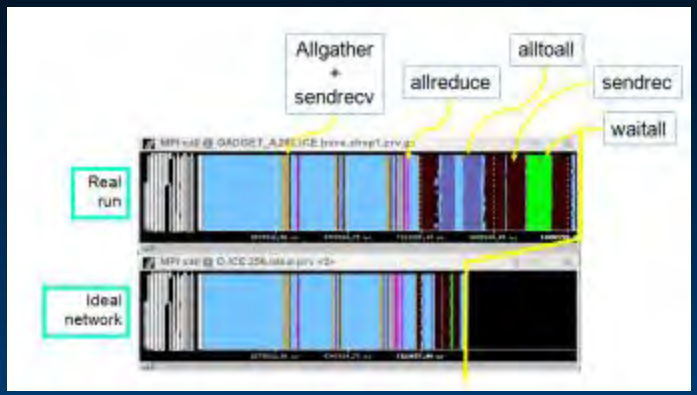
Barcelona: Intel and BSC Exascale Lab

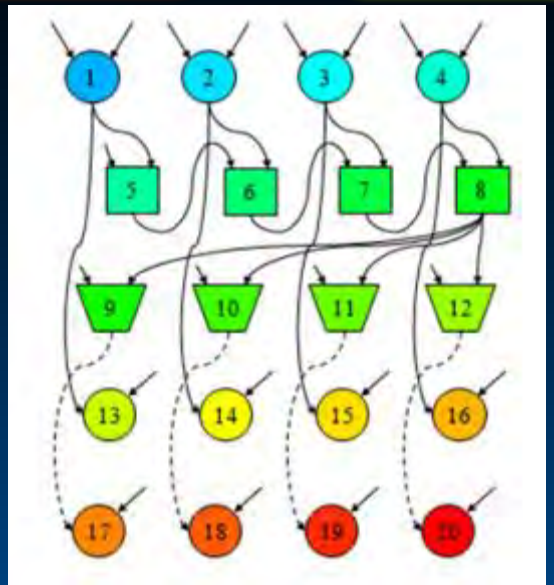
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

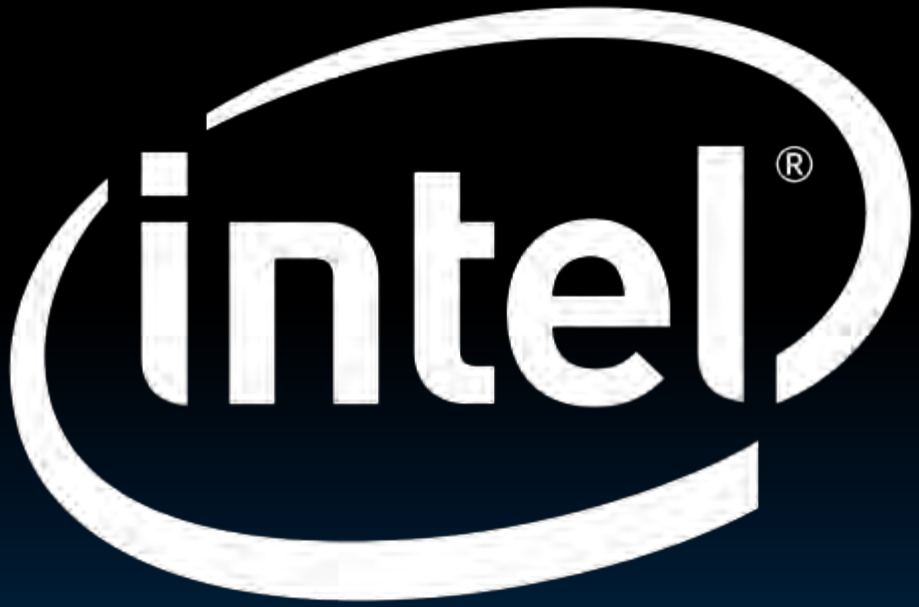
Scalable Performance tools

Scalable Run-time System

New Algorithms



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