European Exascale Software Initiative

April 12, 2010
Oxford, UK

Jean-Yves Berthou
European Exascale Software Initiative (EESI)

Context in Europe


**DEISA**, Distributed European Infrastructure for Supercomputing Applications

**PRACE**, Partnership for Advanced Computing in Europe (PRACE)
European Exascale Software Initiative (EESI)

Context in Europe

PRACE History and first steps

- 2004: HPCEUR
- 2005:
- 2006: HET
- 2007: PRACE MoU
- 2008: PRACE Preparatory

EU-Grant: INFSO-RI-211528, 10 Mio. €

Phase:
- 2009: PRACE Implementation Phase
- 2009-
- 2010-
- 2011-
- 2012-
- 2013:

Foreseen: PRACE Tier-0 centres providing HPC-capability service in a legal entity
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Context in Europe

PRACE – A Partnership with a Vision

- Provide world-class HPC systems for world-class science
- Support Europe in attaining global leadership in public and private research and development

... and a Mission

- Create a world-leading persistent high-end HPC infrastructure managed as a single legal entity
  - Deploy 3 – 6 systems of the highest performance level (Tier-0)
  - IBM BlueGene/P in Jülich will be the first European Tier-0 system
  - Ensure a diversity of architectures to meet the needs of European user communities
  - Provide support and training
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Performance Development in Top500

IESP Booth/SC'09, J. Dongarra
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Average Number of Cores Per Supercomputer
Top20 of the Top500

Exponential growth in parallelism for the foreseeable future

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Factors that Necessitate Redesign

- **Steepness of the ascent from terascale to petascale to exascale**
- Extreme parallelism and hybrid design
  - Preparing for million/billion way parallelism
- Tightening memory/bandwidth bottleneck
  - Limits on power/clock speed implication on multicore
  - Reducing communication will become much more intense
  - Memory per core changes, byte-to-flop ratio will change
- Necessary Fault Tolerance
  - MTTF will drop
  - Checkpoint/restart has limitations
- **Software infrastructure does not exist today**

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Exascale Computing

- Exascale systems are likely feasible by 2017±2
- 10-100 Million processing elements (cores or cores) with chips perhaps as dense as socket, clock rates will grow more slowly
- 3D packaging likely
- Large-scale optics based interconnects
- 10-100 PB of aggregate memory
- Hardware and software based fault management
- Heterogeneous cores
- Performance per watt — stretch goal 100 GF/watt of sustained performance ⇒ >> 10 - 100 MW Exascale system
- Power, area and capital costs will be significantly higher than for today’s fastest systems

Google: exascale computing study

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A Call to Action

- Hardware has changed dramatically while software ecosystem has remained stagnant
- Previous approaches have not looked at co-design of multiple levels in the system software stack (OS, runtime, compiler, libraries, application frameworks)
- Need to exploit new hardware trends (e.g., manycore, heterogeneity) that cannot be handled by existing software stack, memory per socket trends
- Emerging software technologies exist, but have not been fully integrated with system software, e.g., UPC, Cilk, CUDA, HPCS
- Community codes unprepared for sea change in architectures
- No global evaluation of key missing components

www.exascale.org
International Community Effort

- We believe this needs to be an international collaboration for various reasons including:
  - The scale of investment
  - The need for international input on requirements
  - US, Europeans, Asians, and others are working on their own software that should be part of a larger vision for HPC.
  - No global evaluation of key missing components
  - Hardware features are uncoordinated with software development

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IESP Goal

Improve the world’s simulation and modeling capability by improving the coordination and development of the HPC software environment.

Workshops:

Build an international plan for developing the next generation open source software for scientific high-performance computing

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## European Exascale Software Initiative (EESI)

### Where We Are Today:

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC08 (Austin TX) meeting to generate interest</td>
<td>Nov 2008</td>
</tr>
<tr>
<td>Funding from DOE’s Office of Science &amp; NSF Office of Cyberinfrastructure and sponsorship by Europeans and Asians</td>
<td>Apr 2009</td>
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<tr>
<td>US meeting (Santa Fe, NM) April 6-8, 2009</td>
<td>Jun 2009</td>
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<tr>
<td>65 people</td>
<td></td>
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<tr>
<td>NSF’s Office of Cyberinfrastructure funding</td>
<td></td>
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<tr>
<td>European meeting (Paris, France) June 28-29, 2009</td>
<td>Oct 2009</td>
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<tr>
<td>70 people</td>
<td></td>
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<tr>
<td>Outline Report</td>
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<tr>
<td>Asian meeting (Tsukuba Japan) October 18-20, 2009</td>
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<tr>
<td>Draft roadmap</td>
<td></td>
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<tr>
<td>Refine Report</td>
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<tr>
<td>SC09 (Portland OR) BOF to inform others</td>
<td>Nov 2009</td>
</tr>
<tr>
<td>Public Comment</td>
<td></td>
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<tr>
<td>Draft Report presented</td>
<td></td>
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[www.exascale.org](http://www.exascale.org)
European Exascale Software Initiative (EESI)

Motivations for launching EESI

Coordinate the European contribution to IESP

Enlarge the European community involved in the software roadmapping activity

Build and consolidate a vision and roadmap at the European Level, including applications, both from academia and industry
European Exascale Software Initiative (EESI)

EESI main Goals

Build a **European vision and roadmap** to address the **challenge of performing scientific computing** on the new generation of computers which will provide multi-Petaflop performances in 2010 and Exaflop performances in 2020.

- Investigate how Europe is located, its strengths and weaknesses, in the overall international HPC landscape and competition
- Identify priority actions
- Identify the sources of competitiveness for Europe induced by the development of Peta/Exascale solutions and usages
- Investigate and propose programs in education and training for the next generation of computational scientists
- Identify and stimulate opportunities of worldwide **collaborations**
**European Exascale Software Initiative (EESI)**

**EESI main tasks**

**Coordination** of the European participation in IESP
- Make a thorough assessment of needs, issues and strategies
- Develop a coordinated software roadmap
- Provide a framework for organizing the software research community
- Engage and coordinate vendor community in crosscutting efforts
- Encourage and facilitate collaboration in education and training

**Cartography** of existing HPC projects and initiatives in Europe, US and ASIA

**Coordination of** “disciplinary working groups” at the European level
- *Four groups* “Application Grand Challenges”
- *Four groups* “Enabling technologies for Petaflop/Exaflop computing”

**Synthesis**, dissemination and **recommendation** to the European Commission
EESI expected outputs

A **roadmap** and **set of recommendations** to the funding agencies shared by the European HPC community, on software - tools, methods and applications - to be developed for this new generation of supercomputers.
European Exascale Software Initiative AGENDA

**Initial International workshop**
- Constitution of WG, Setup of guidelines, organisation modes
- Initial cartography of existing HPC projects, initiatives in Europe, US and ASIA

**Enabling technologies for Exaflop computing**
- Hardware roadmap, links with vendors
- Software eco-systems
- Numerical, libraries, solvers and algorithms
- Scientific software engineering

**Application Grand Challenges**
- Industrial and Engineering Applications (Transport, Energy)
- Weather, Climatology and Earth Sciences
- Fundamental Sciences (Chemistry, Physics)
- Life science, Health, BPM

**Internal workshop: presentation of each working group results and roadmaps**
- Synthesis of all contributions and production of a set of recommendations
- Presentation of EESI results to the EC

**Updated cartography of existing HPC projects, initiatives in Europe, US and ASIA**

**Final conference: public presentation of project result**

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T0: June 1, 2010
T0+5: October 2010
T0+12: 1 month
T0+13: 3 months
T0+16: 1 month
T0+17: 1 month
T0+18: November 2011
European Exascale Software Initiative AGENDA

Industrial and Engineering Applications (Transport, Energy)
Chair: Philippe Ricoux/TOTAL
Vice-Chair: Jean-Claude André/CERFACS

- 5 months
- 8 months
- 1 month
- 3 months
- 1 month
- 1 month

June 1, 2010
October 2010
June 2011
December 2011
European Exascale Software Initiative AGENDA

Weather, Climatology and Earth Sciences
Chair: Giovanni Aloisio / ENES-CMCC
Vice-Chair: Massimo Cocco/ INGV

T0 5 months
June 1, 2010

T0+5 8 months
October 2010

T0+12 1 month
June 2011

T0+13 3 months

T0+16 1 month

T0+17 1 month

T0+18 1 month
December 2011

June 2011
European Exascale Software Initiative AGENDA

Fundamental Sciences
(Chemistry, Physics)
Chair: Godehard Sutmann/CECAM
Vice-Chair: Jean-Philippe Nominé/CEA

Timeline:
- T0: June 1, 2010
- T0+5: October 2010
- T0+12: June 2011
- T0+17: December 2011
European Exascale Software Initiative AGENDA

Life science, Health, BPM
Chair: Modesto Orozco/ BSC
Vice-Chair: Janet Thorton/EMBL-EBI

T0 5 months  T0+5  8 months  T0+12  1 month  T0+13  3 months  T0+16  1 month  T0+17  1 month  T0+18

June 1, 2010  October 2010  June 2011  December 2011
European Exascale Software Initiative AGENDA

Hardware roadmap, links with Vendors
Chair: Herbert Huber/STRATOS-LRZ
Vice-Chair: Sanzio Bassini/CINECA

June 1, 2010  October 2010  June 2011  December 2011
European Exascale Software Initiative AGENDA

Software eco-systems
Chair: Franck Cappello/INRIA-NCSA
Vice-Chair: Bernd Mohr/JSC

INRIA

Jülich Forschungszentrum

T0
T0+5
T0+12
T0+13
T0+16
T0+17
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5 months
8 months
1 month
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June 1, 2010
October 2010
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European Exascale Software Initiative AGENDA

Numerical, libraries, solvers and algorithms
Chair: Iain Duff/ STFC-Rutherford Appleton Laboratory
Vice-Chair: Andreas Grothey/ Edinburgh University

T0
June 1, 2010

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October 2010

T0+12
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T0+16
December 2011

T0+18
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T0+8
T0+7
T0+6
T0+5
T0+4
T0+3
T0+2
T0+1
T0

5 months
8 months
1 month
3 months
1 month
1 month
3 months
1 month

European Exascale Software Initiative AGENDA

Scientific software engineering
Chair: David Emerson/STFC-Daresbury Lab.
Vice-Chair: Andrew Jones/NAG

June 1, 2010
October 2010
June 2011
December 2011
European Exascale Software Initiative AGENDA

Link with US and ASIA

Joint IESP/EESI workshops: present EESI Working Groups outputs, include inputs from US and ASIA, identification of US, ASIA and European cross actions.

Initial International workshop: presentation of each working group results and roadmaps

Synthesis of all contributions and production of a set of recommendations

Final conference: public presentation of project results

Weather, Climatology and Earth Sciences
Industrial and Engineering Applications (Transport, Energy)
Life science, Health, BPM
Fundamental Sciences (Chemistry, Physics)
Scientific software engineering
Software eco-systems
Hardware roadmap, links with vendors
Numerical, libraries, solvers and algorithms

Enabling technologies for Exaflop computing

Application Grand Challenges

Joint IESP/EESI workshops: present EESI Working Groups outputs, include inputs from US and ASIA, identification of US, ASIA and European cross actions

June 1, 2010
October 2010
June 2011
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EESI Partners around the world