



Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG



DKRZ

DEUTSCHES
KLIMARECHENZENTRUM

HPC projects

Grischa Bolls



Outline

- Why projects?
- 7th Framework Programme
- Infrastructure stack
- IDataCool, CoolMuc
- Mont-Blanc Project
- Deep Project
- Exa2Green Project

Why projects?

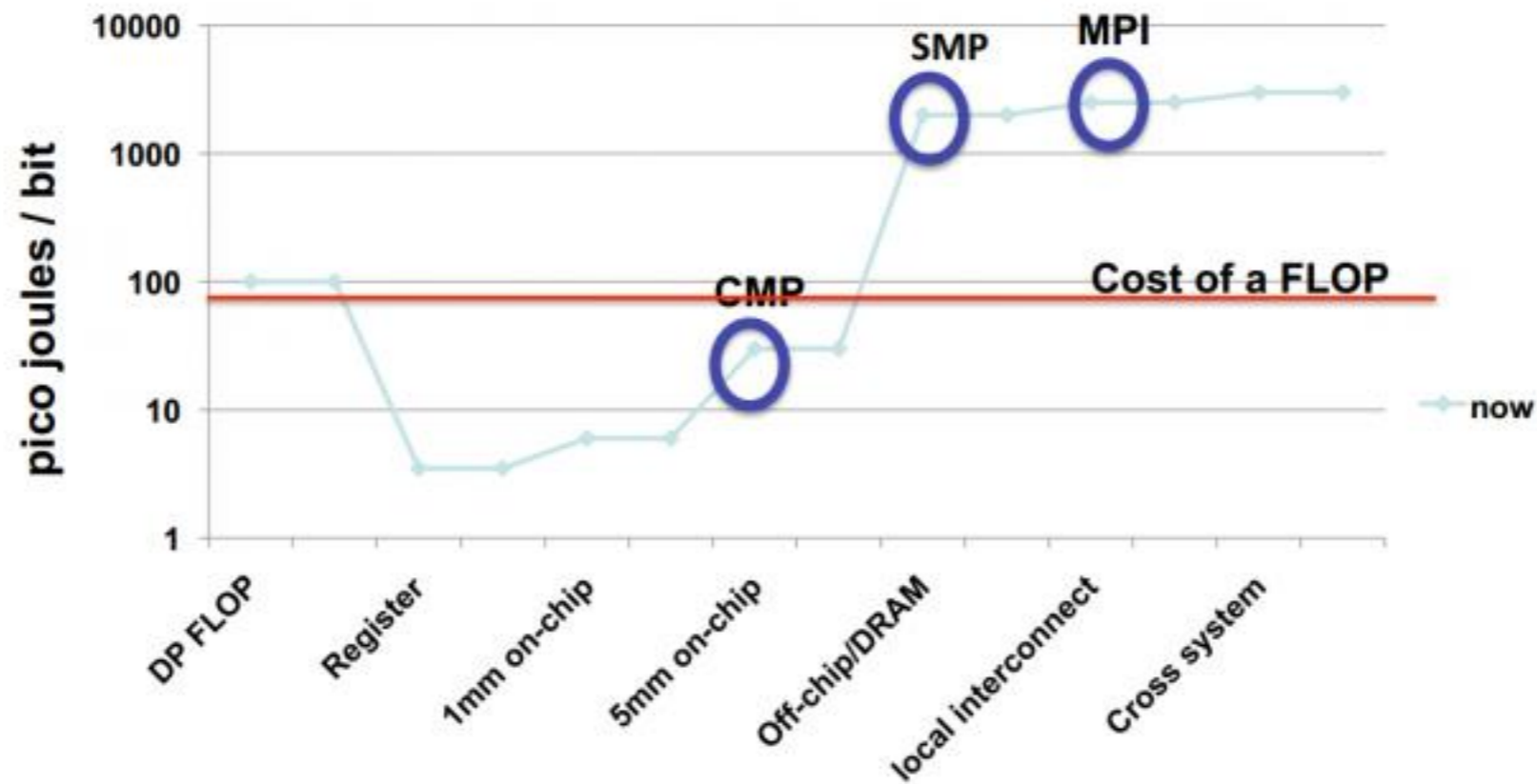
- Pave the way for exascale Computing
- Hypothetical exascale HPC today: 1GW power consumption
- Cooling and power is listed as number one challenge

Rank	Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	National Super Computer Center in Guangzhou China	Tianhe-2 (MilkyWay-2) - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P NUDT	3,120,000	33,862.7	54,902.4	17,808

Why projects?

- Power required to share the data across the chip, node, and cluster.

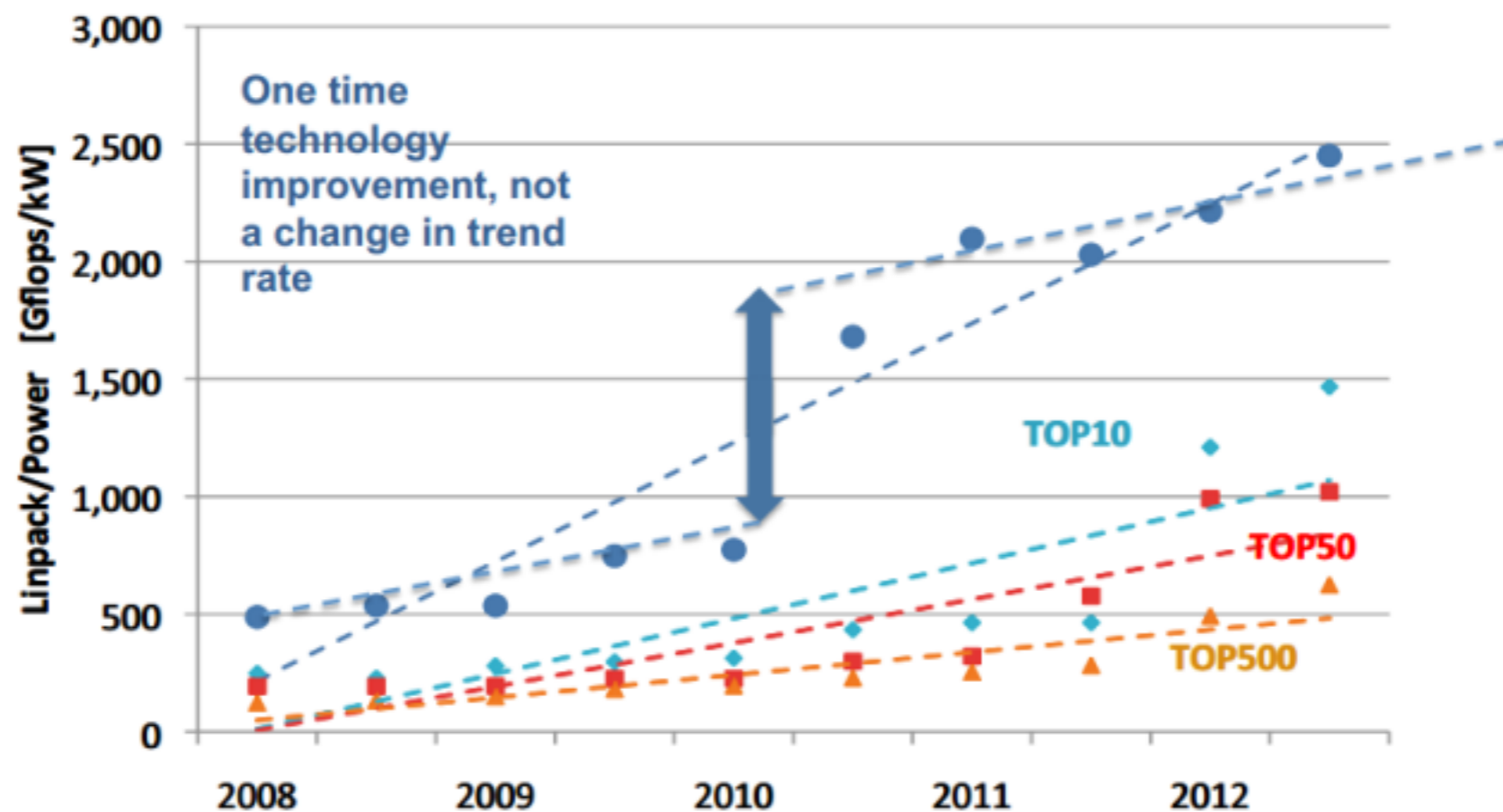
The Cost of Data Movement



Why projects?

- Many-core architectures are the solution to the short-term scaling problem.

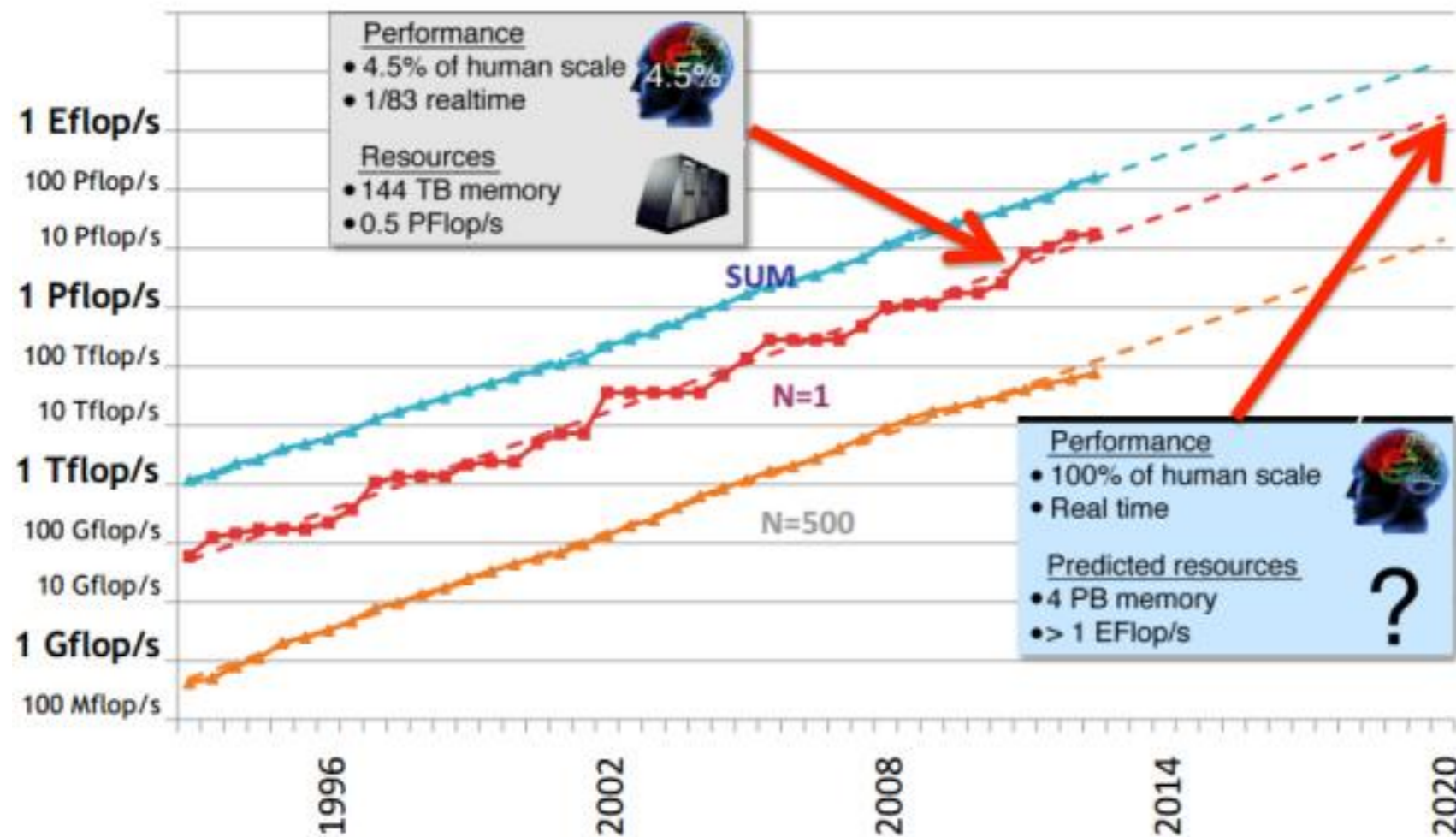
Power Efficiency over Time



Why projects?

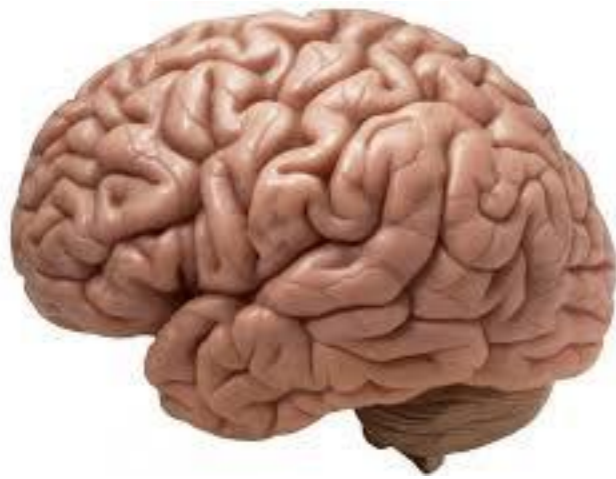
- Exascale processing is important

Towards Exascale



Why projects?

20 W



vs

20-30 MW



2020



7th Framework



- Supporting research and development in science, engineering and technology
- Launched in 1984
- Must involve European partners
- Overall 53 billion Euro



Infrastructure stack

Board Level



Blade Level

Machine / Rack Level



Room Level

Building Level





Cooling

- Air-cooled systems
- Indirectly liquid-cooled systems
- Directly liquid-cooled systems



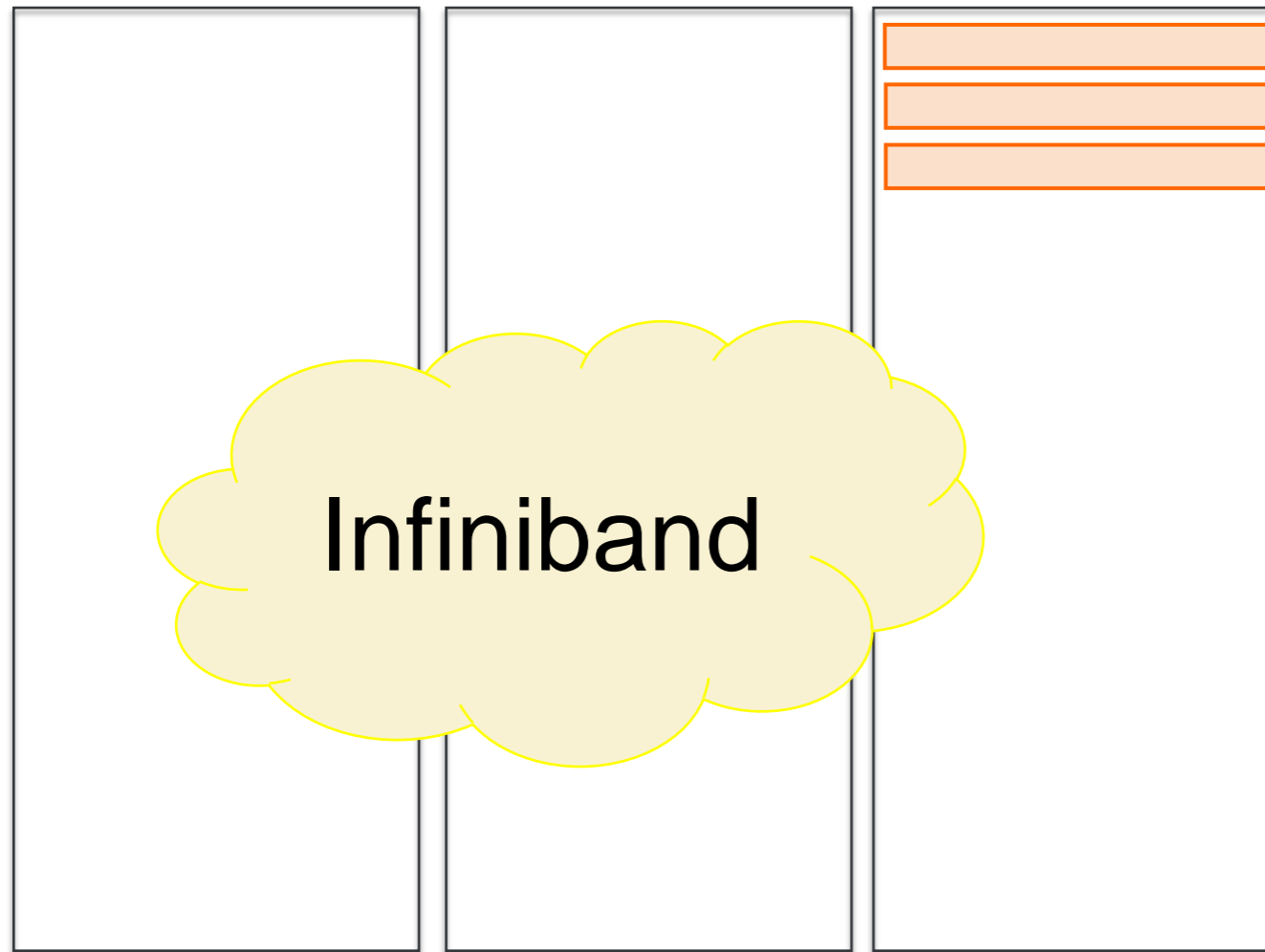


iDataCool

- IBM Research team and University of Regensburg
- Energy Reuse Effectiveness (ERE) less than one
- Recover a significant part of the waste heat
- Water-cooled at temperature at or above 65°C
- Design of a prototype for future development



iDataCool



72 Nodes

3 x IBM System x IDataPlex





iDataCool



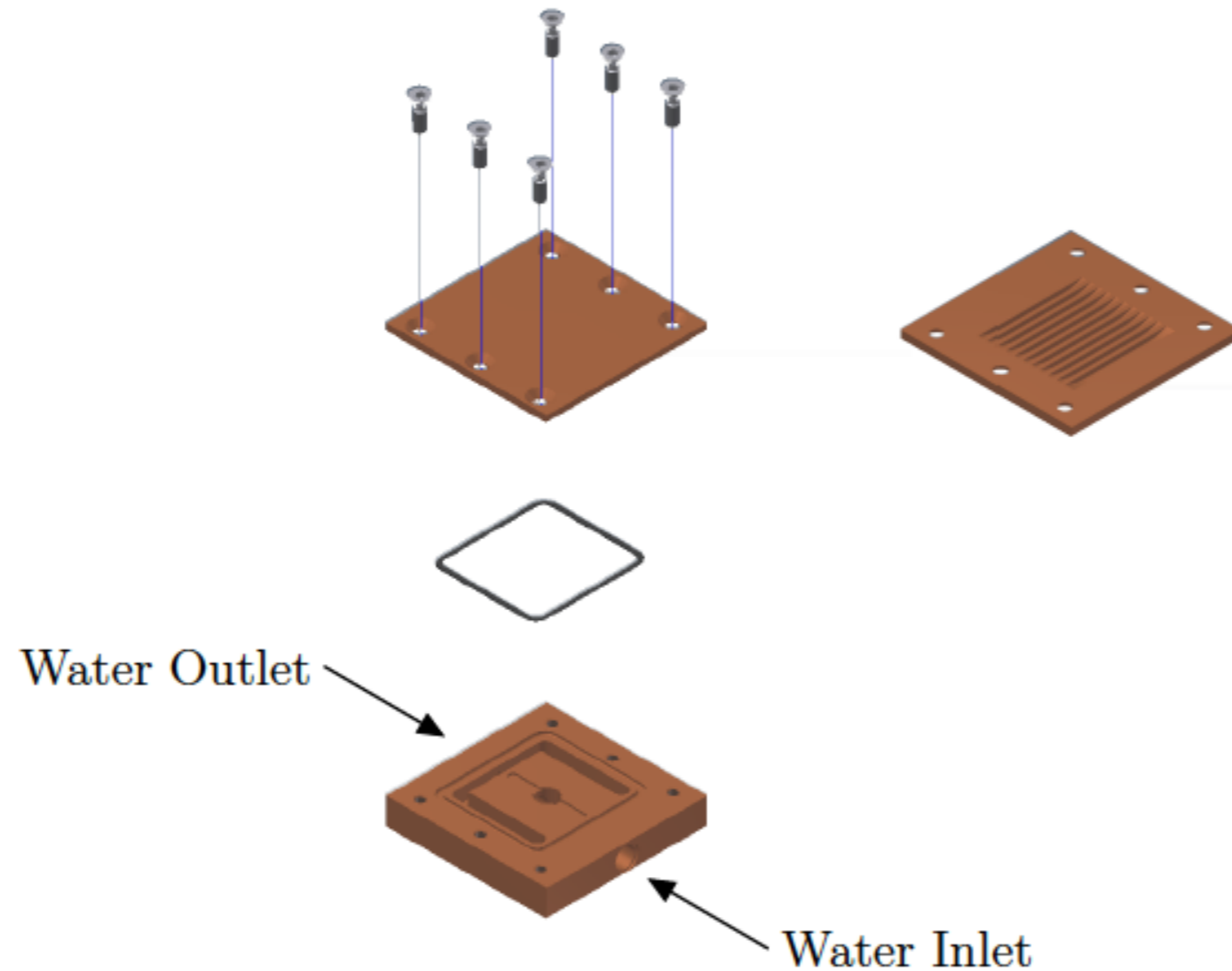
original



modified



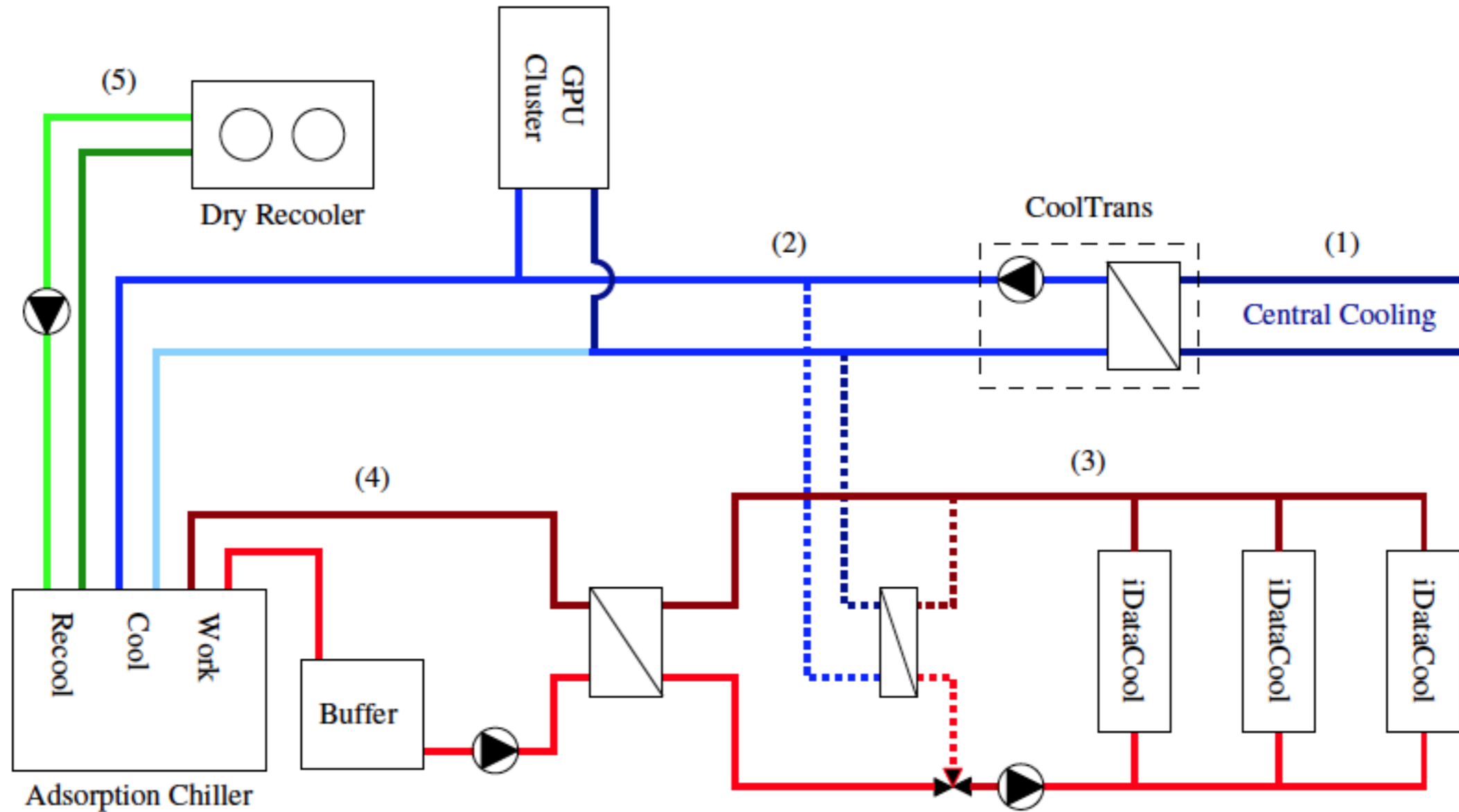
iDataCool



Design of the iDataCool heat sink.



iDataCool



Liquid-cooling installation



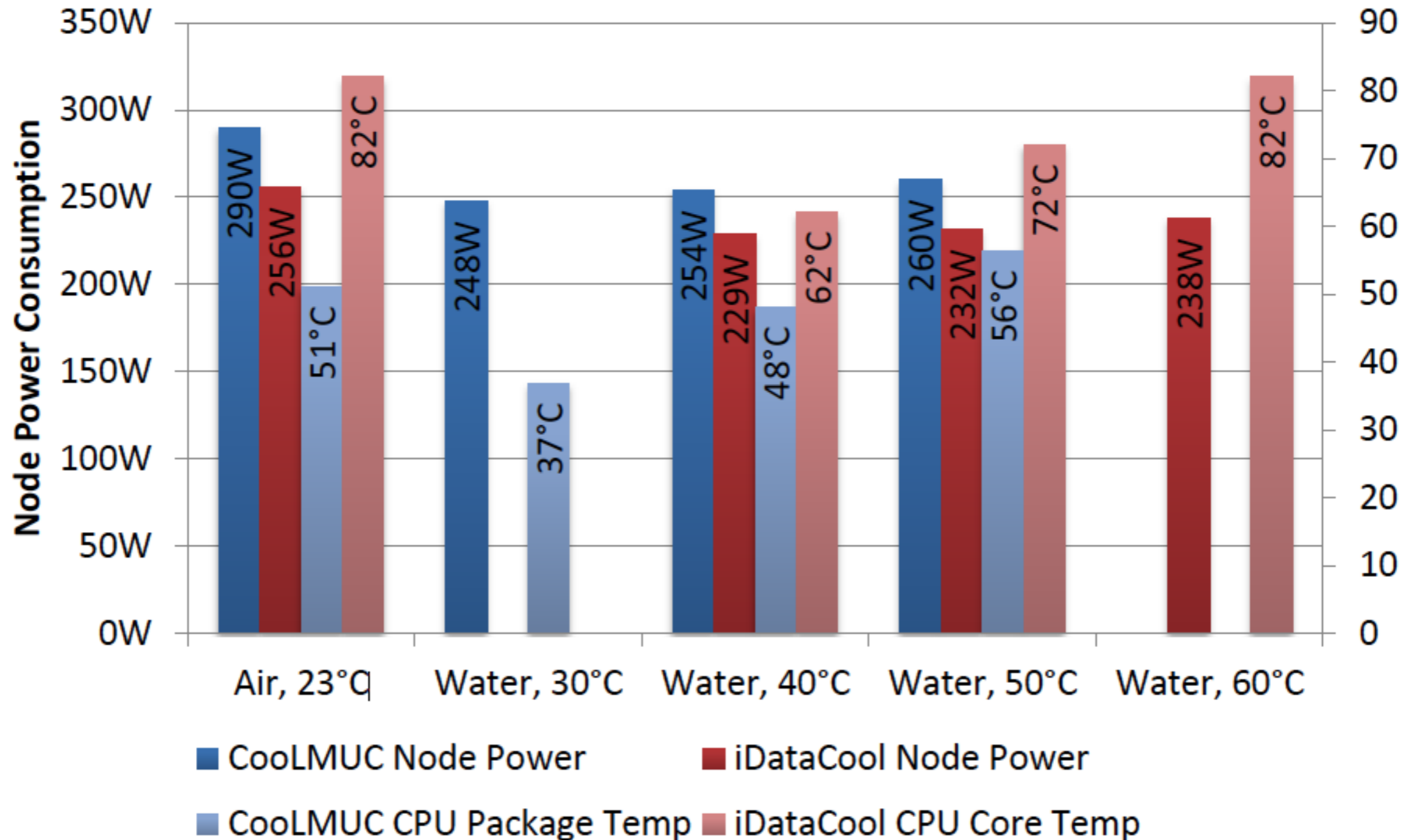
CoolIMUC

- Leibniz Supercomputing Centre (Munic)
- Assess benefits of direct warm-water cooling
- In Service since July 2011
- Waste-heat reuse



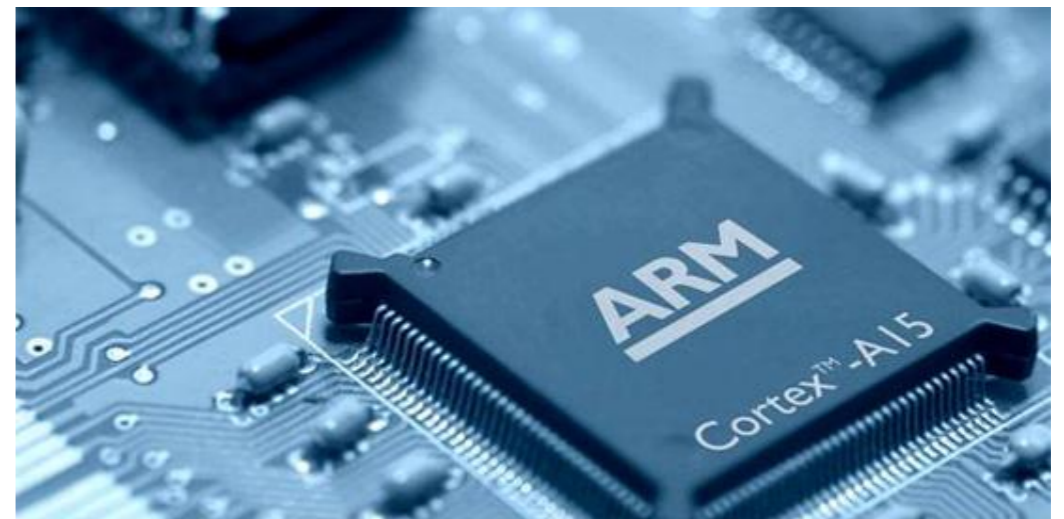


Comparison



Overview

- Low-power components (ARM)
- Port, co-design and optimise up to 11 scientific applications
- Barcelona Supercomputing Center (BSC)
- Budget of over 15 million
- Oct. 2011 – Sep. 2016



Scientific applications

- Used by academia and industry
- Wide range of scientific domains
- Part of the PRACE benchmark

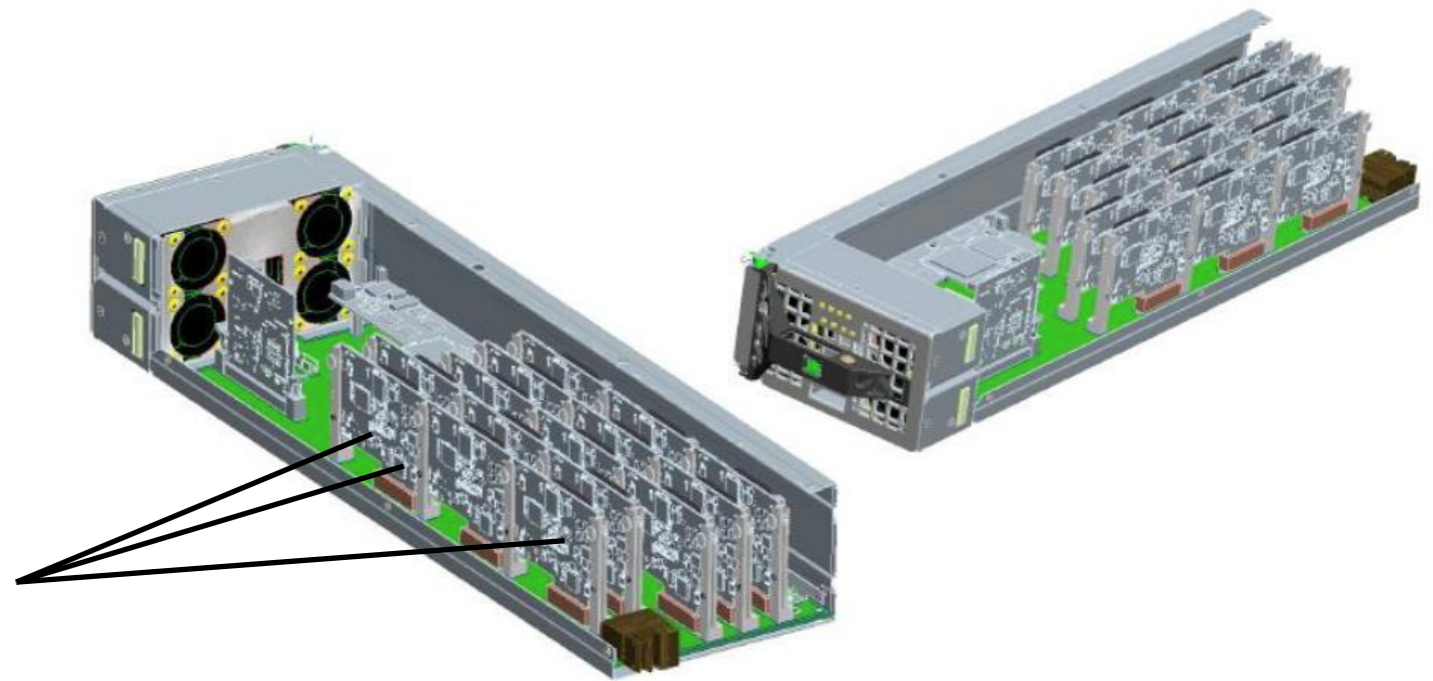
Code	Sc. Domain	Contact	Institution
YALES2	Combustion	V. Mouveau	CNRS/CORIA
EUTERPE (P)	Fusion	X. Saez	BSC
SPECFEM3D (P)	Geophysics	D. Komatitsch	Univ. Marseille
MP2C	Multi-particle collision	G. Sutmann, A. Schiller	JSC
BigDFT	Elect. Structure	B. Videau	IMAG

Prototype

- Reference SoC: Samsung Exynos 5250
- Dual core ARM 1,7 Ghz
- Full SoC offers 3.2 Gflops/W peak power/performance ratio.

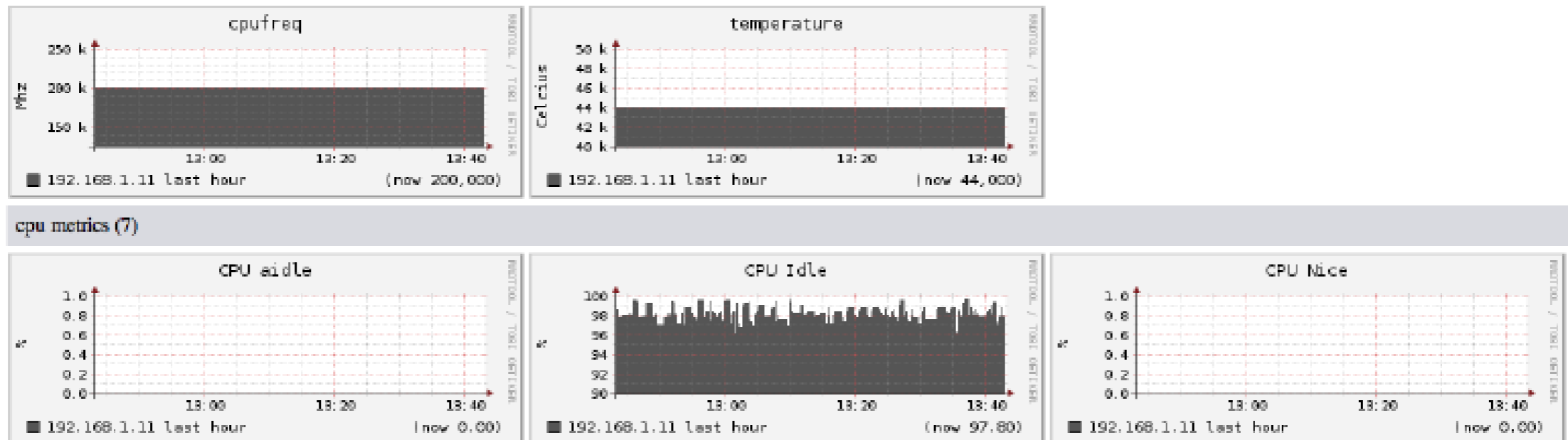
Blade:

- Up to 15 sockets



Deliverables

- Power Gating:
 - Allows for reducing the energy by putting parts into standby or sleep modus.
- Monitoring Software (Ganglia)



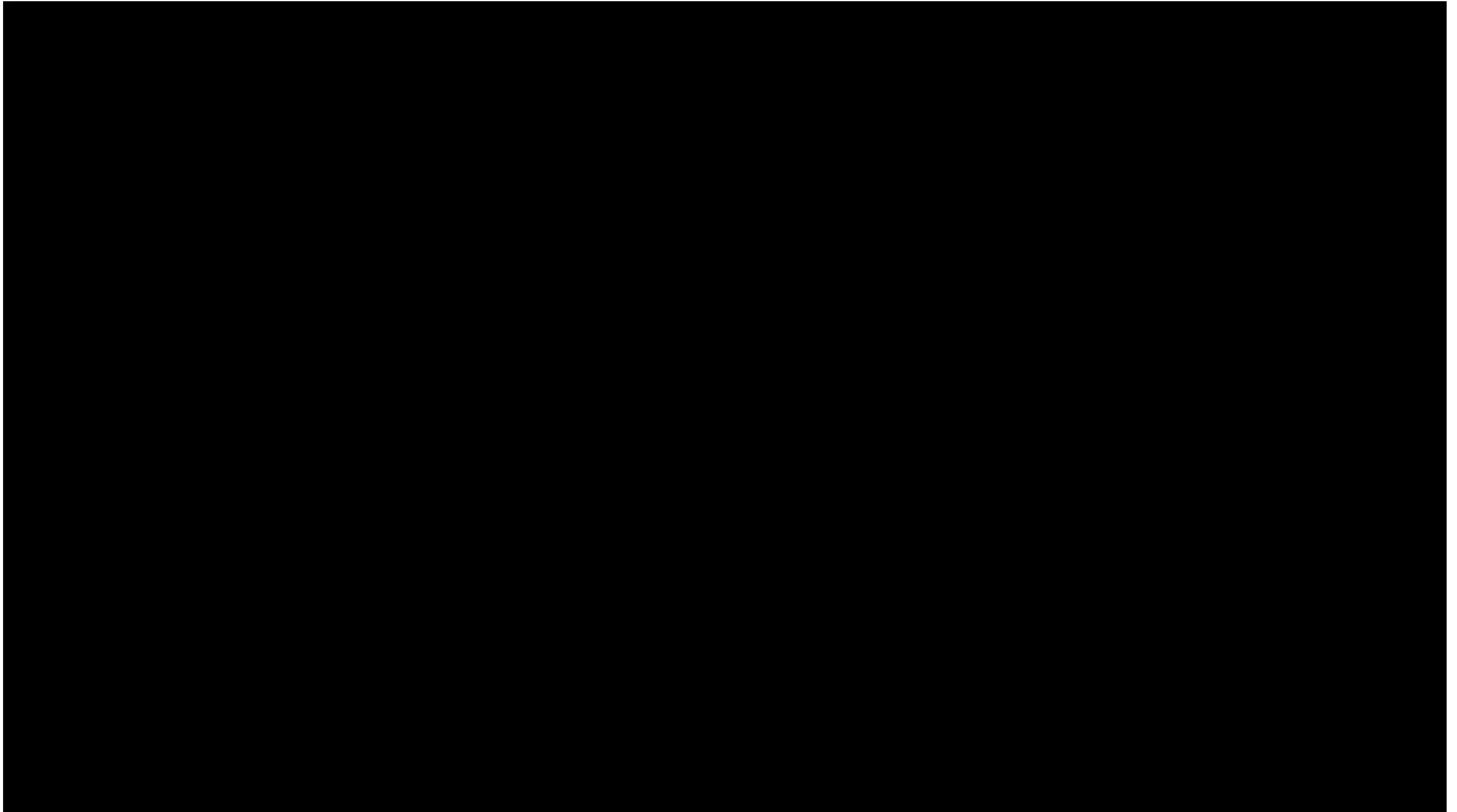
Human Brain Project

- Aims to simulate the complete human brain
- Budget: 1.190 billion Euro
- 86 institutions are involved
- 2017/18 peak performance of 50 Pflops and power consumption of < 4 MW
- 2021/22 1 ExaFlop



Human Brain Project

Human Brain Project

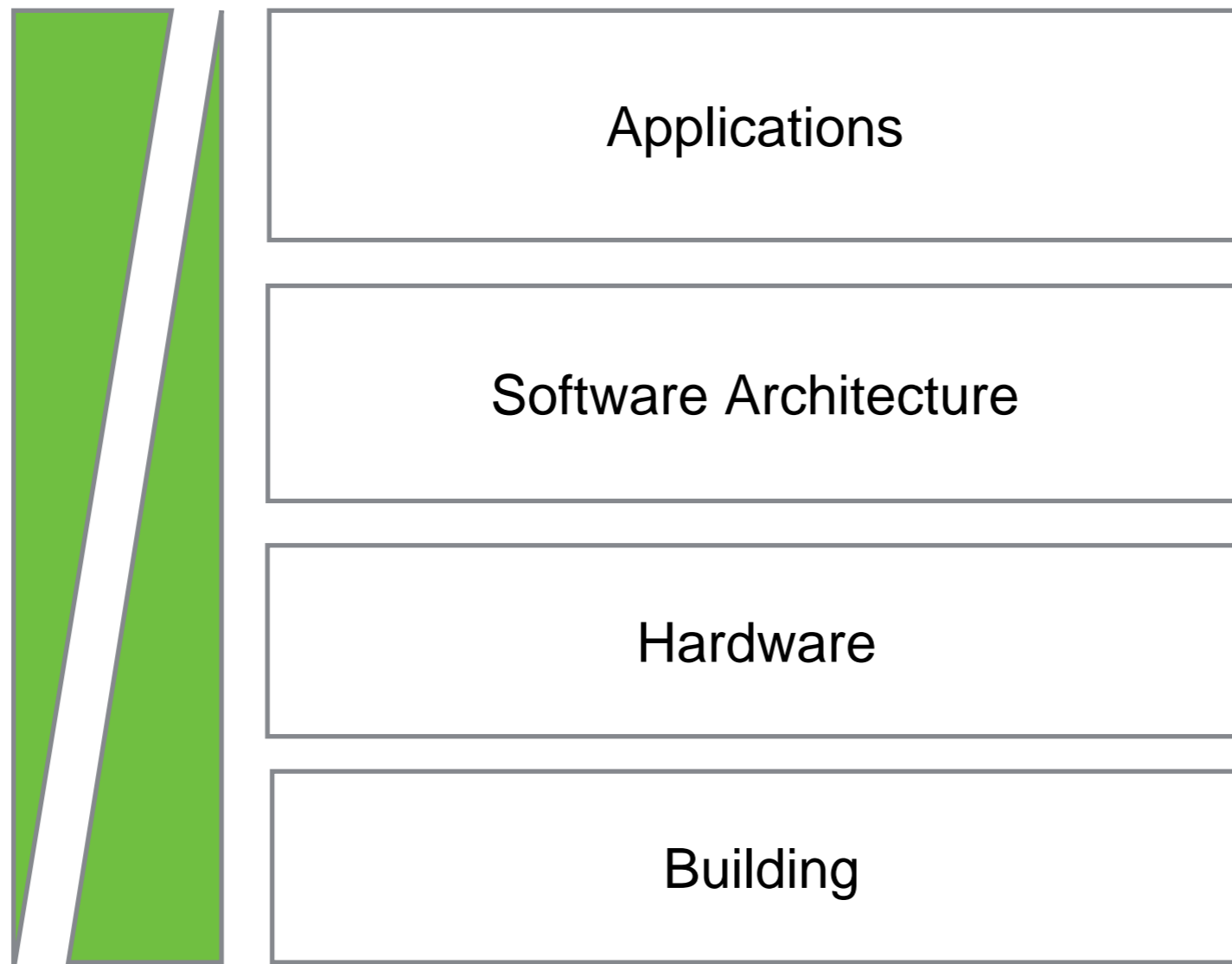


Overview

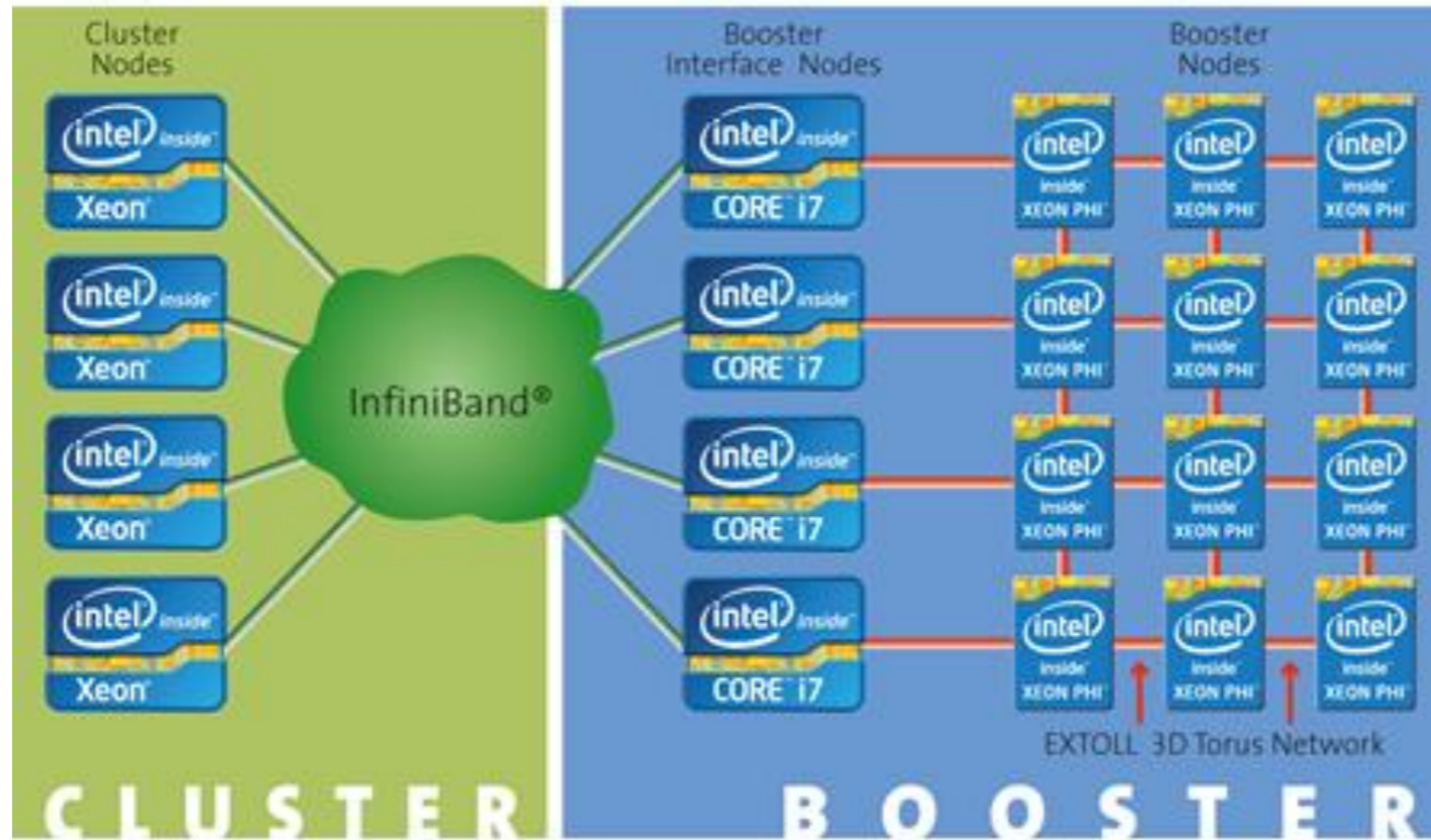
- Funding:
 - The Deep project is supported through the European Community's 7th Framework Programme.
- Project duration:
 - 36 months (Started in December 2011)
 - Total project budget: 18.500.000 Euro



Mission



Hardware



128 x



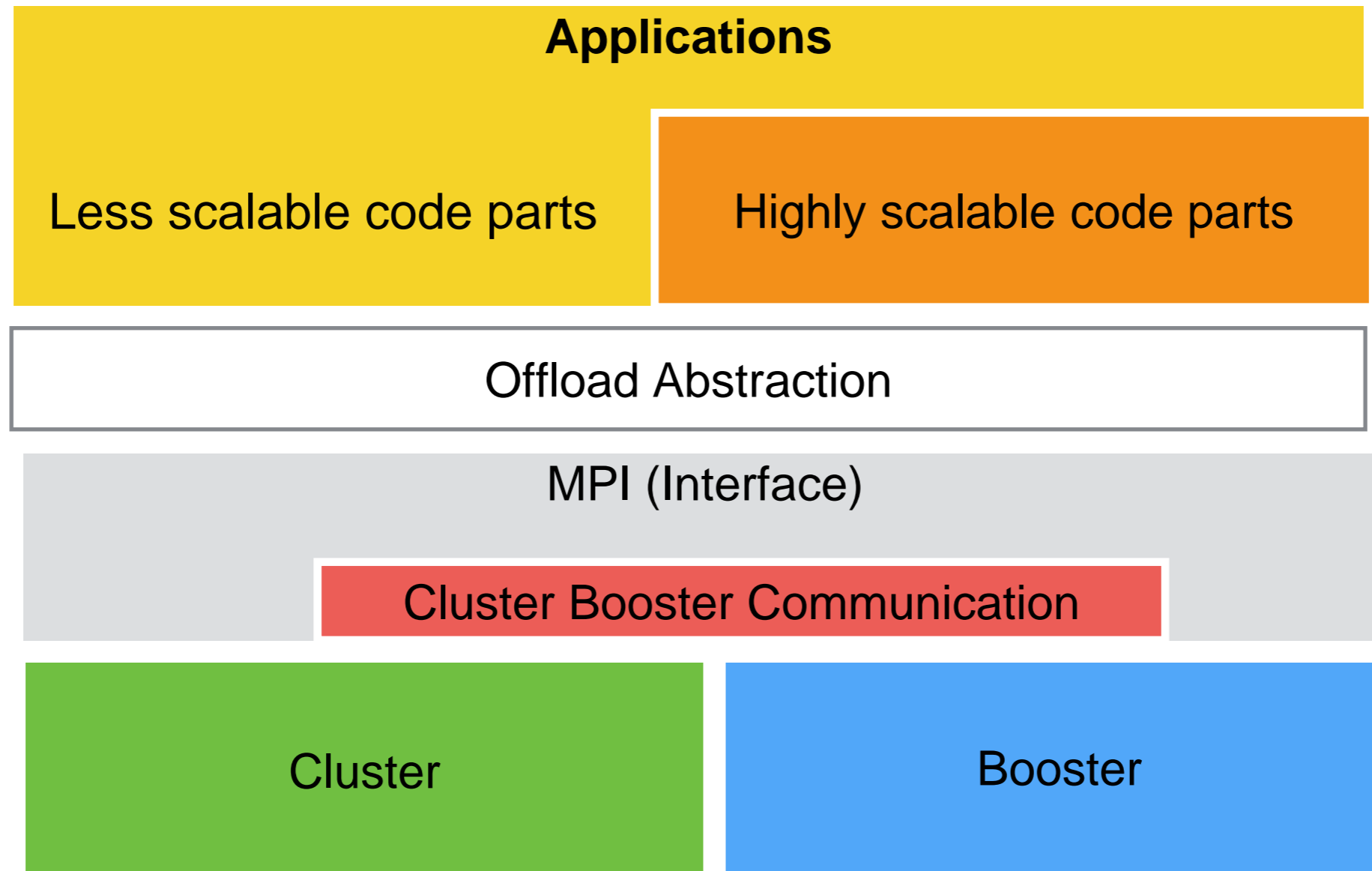
Intel Xeon

512 x



Intel Xeon Phi

Software



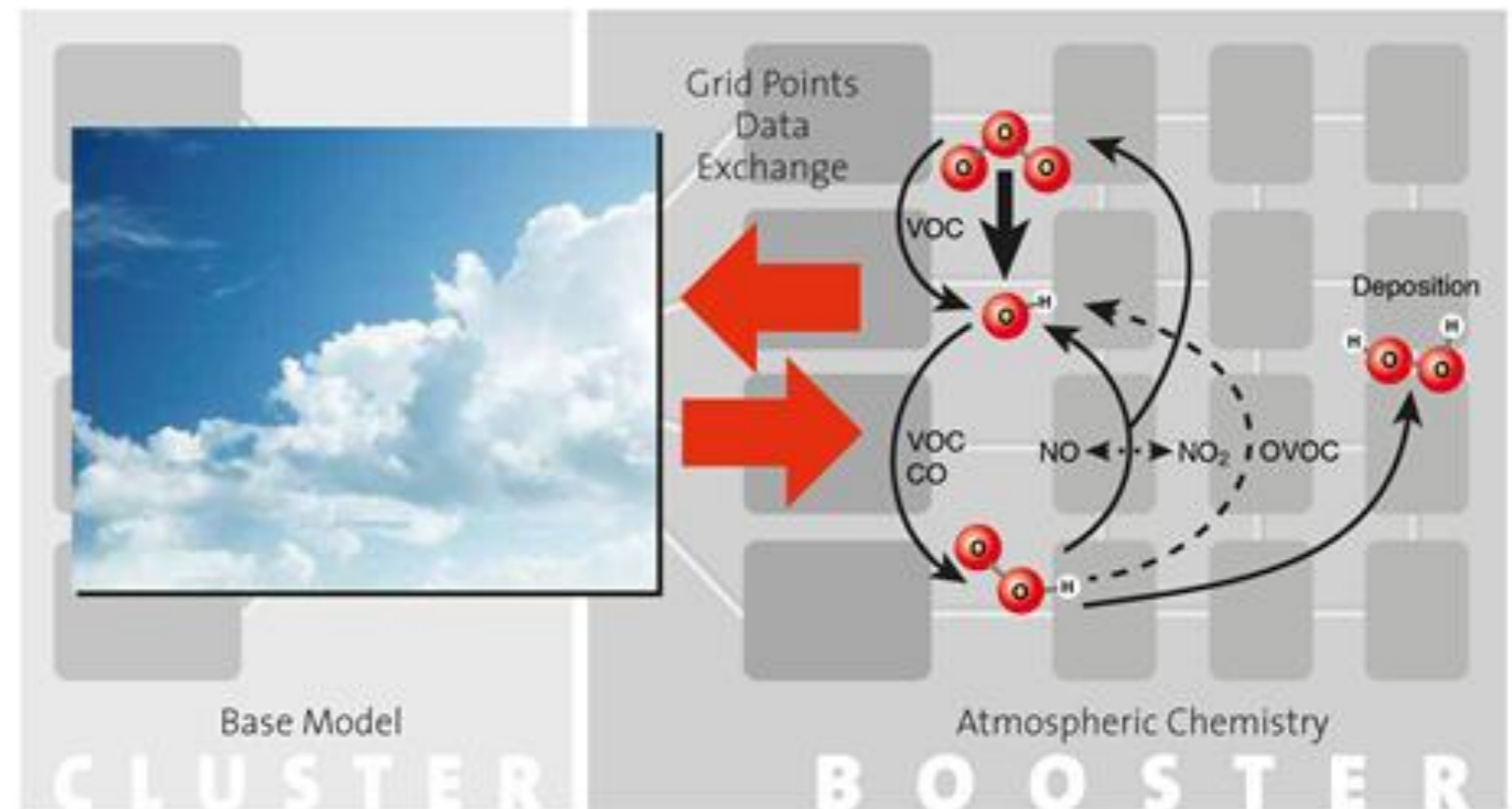
Application

Climate simulation

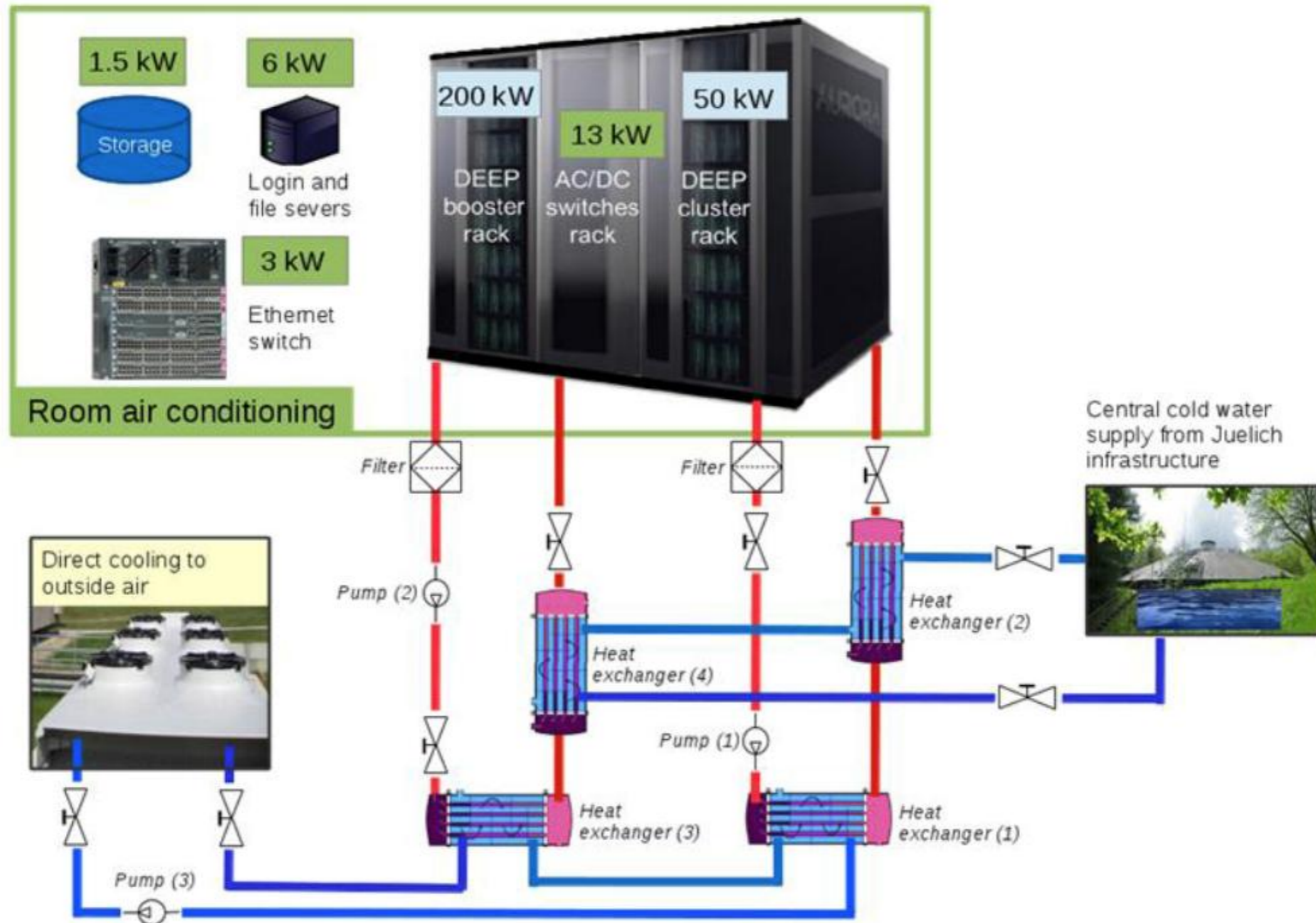
Seismic imaging

Brain simulation

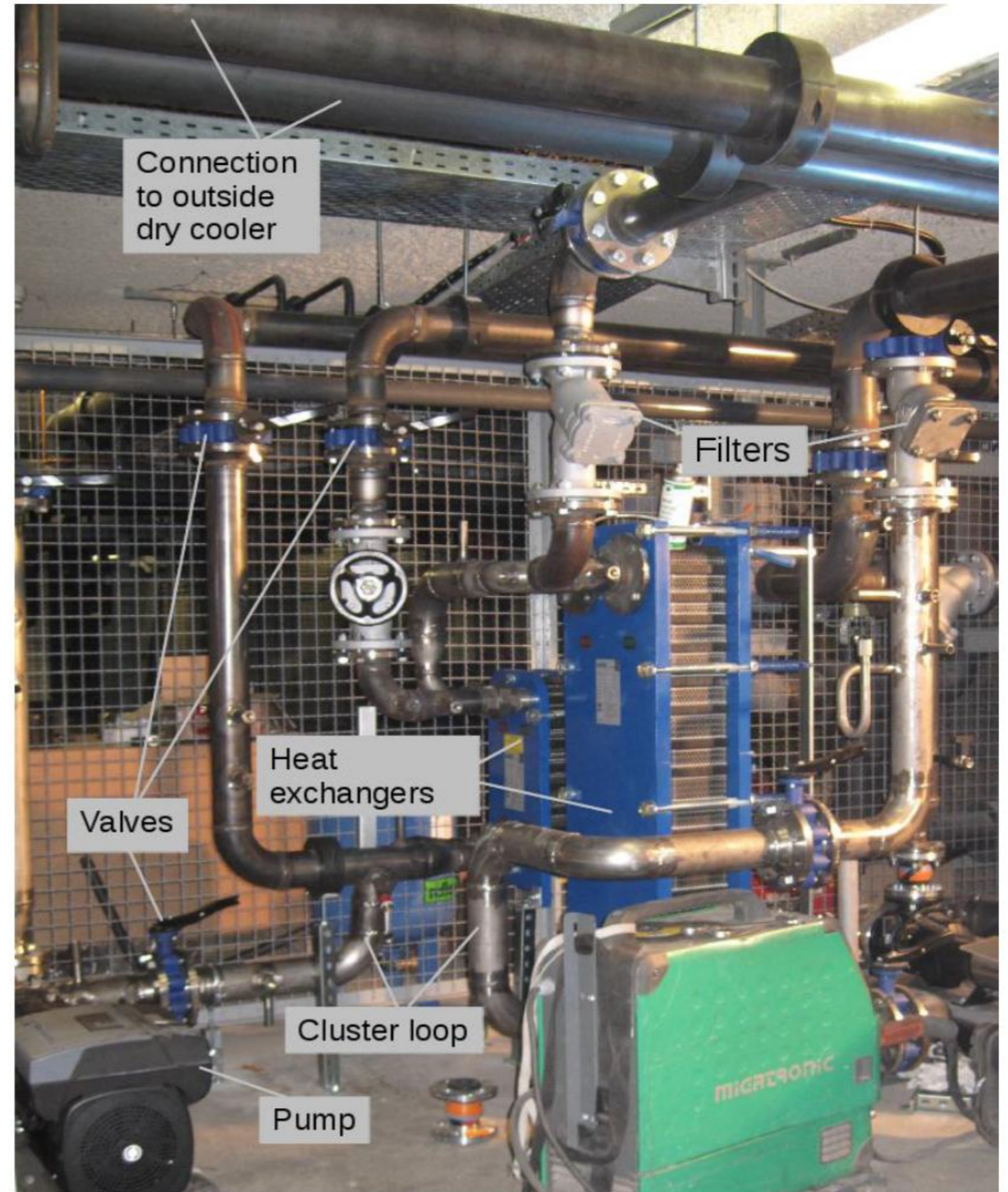
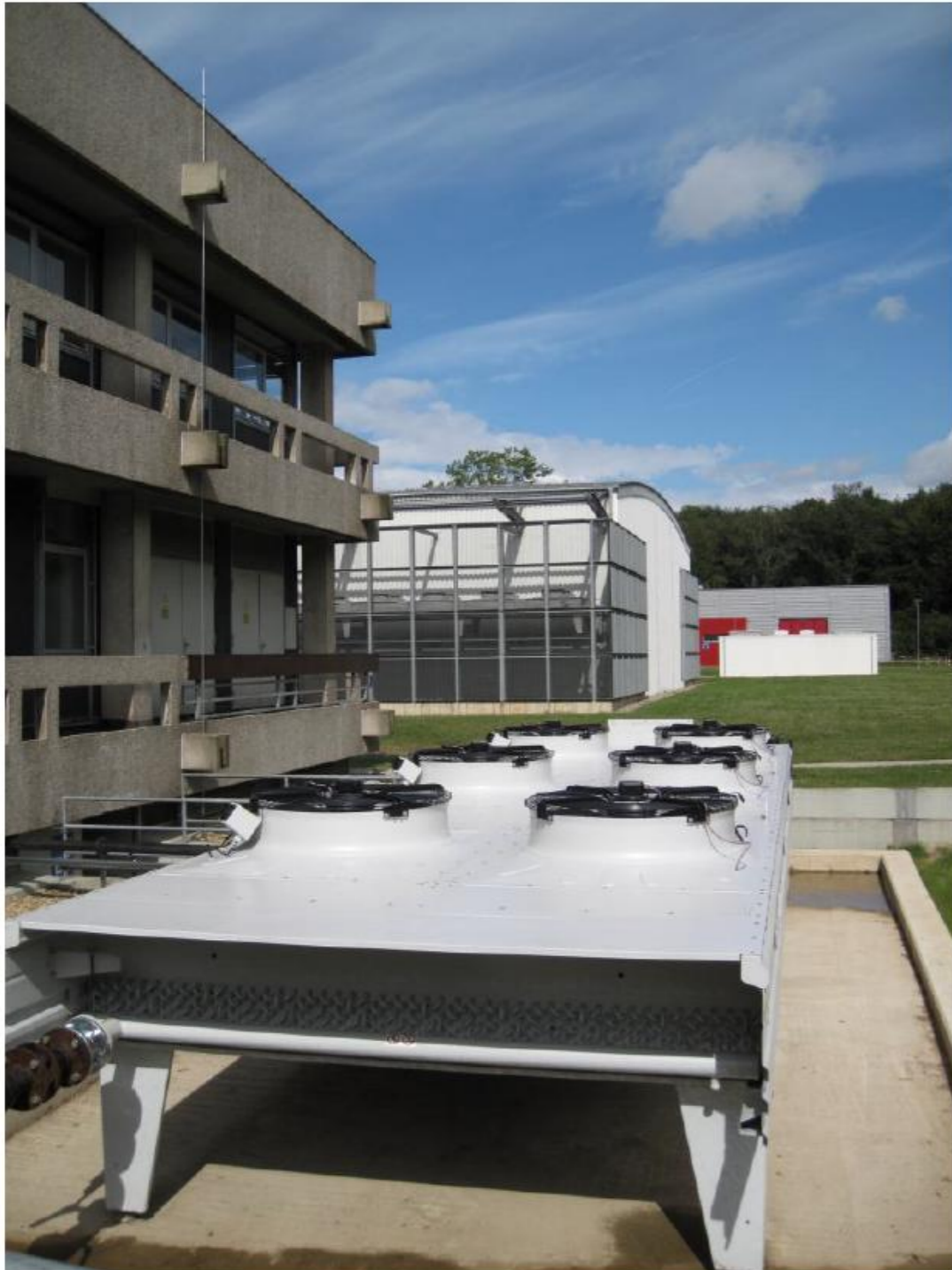
Space weather simulation




Liquid cooling system



Liquid cooling system



Overview

- Funding:
 - The EXA2GREEN project is supported through the European Community's 7th Framework Programme. 
- Project duration:
 - 36 months (November 1st, 2012 – October 31st, 2015)
- Total project costs: 2.958.898 Euro
- EU contribution: 2.100.000 Euro
- Minimizing Energy Consumption of Computing to the limit

Mission



VS

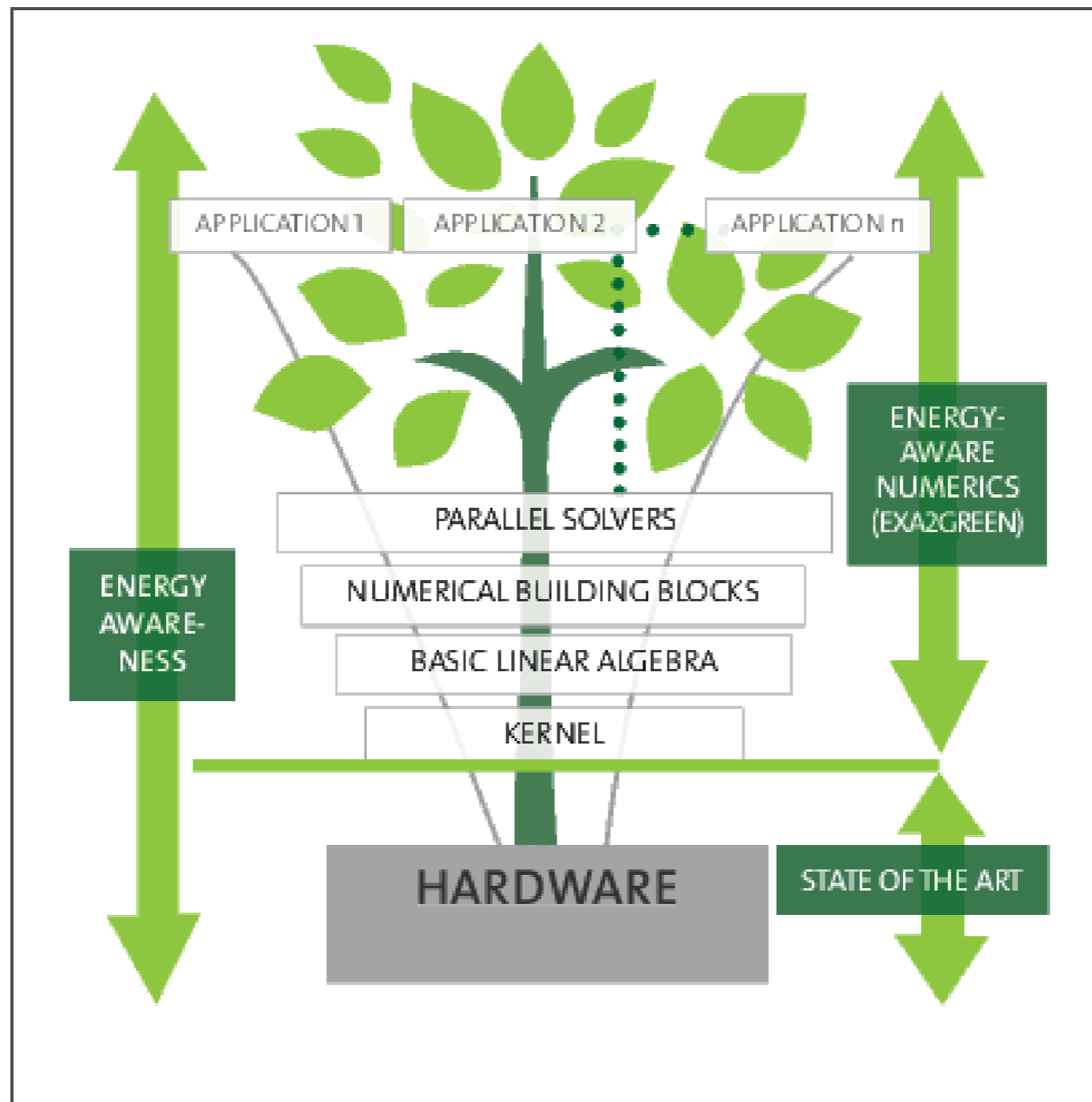


Algorithm

```

TABLE t ←
for i ← 1 t
  RE
  if two
    then update r's to-rate
  do {
    else update r's from-rate
    if r has no child node
      then break
    t ← r's child node
  }
  annotate packet with r's from-rate and to-rate (1)
  if (r's from-rate > threshold
  or r's to-rate > threshold)
  and t is not a node in deepest level of tree
  then create child table r' under r
  
```


Mission



4 Key achievements

- Power-aware kernels for energy-efficient High Performance Computing (HPC)
- Power-aware linear algebra libraries for energy-efficient HPC
- Linear system solvers optimized for energy consumption on the respective hardware platform
- Energy-optimised aerosol chemistry packages

Summary

- HPC offers potential solutions to a wide range of critical challenges
- Ultimate signifier of talent and scientific prestige
- HPC will move into Exascale by 2020.
- Exascale feasibility depends on the rise of energy efficient technology

Sources

- **Mon-Blanc Project:** <http://www.montblanc-project.eu/deliverables> - download June 2014.
- **Exa2Green:** <http://exa2green-project.eu> - download June 2014.
- **DEEP Project.** Project and Deliverables: http://www.deep-project.eu/deep-project/EN/Deliverables/_node.html - download June 2014.
- **iDataCool:** HPC with Hot-Water Cooling and Energy Reuse: <http://arxiv.org/pdf/1309.4887.pdf> - download June 2014
- **CoolMuc.** Direct water Water cooled Linux Cluster Munich: http://inside.hlr.de/htm/Edition_01_12/article_26.html - download June 2014
- **7th Framework Programme:** http://cordis.europa.eu/fp7/home_de.html
- **The European Union's Seventh Framework Programme (FP7):** http://www.esrc.ac.uk/funding-and-guidance/funding-opportunities/6250/The_European_Unions_Seventh_Framework_Programme_FP7_.aspx - download June 2014

Sources

- **Future of High-Performance-Computing:** <http://ec.europa.eu/digital-agenda/futurium/en/content/future-high-performance-computing-supercomputers-rescue> - download June 28, 2014.
- Human Brain Project: <https://www.humanbrainproject.eu/de> - download June 28, 2014.
- Top500 list: <http://www.top500.org/lists/2014/06/> - download June 28, 2014.