

# HPC at INRIA

*Michel Cosnard*  
*INRIA President and CEO*

INSTITUT NATIONAL  
DE RECHERCHE  
EN INFORMATIQUE  
ET EN AUTOMATIQUE



# French Institute for Research in Computer Science and Control

## Information and Communication Sciences and Technologies

- Research
- Experiment
- Transfer and innovate
- Share and disseminate
- Create references

A public institution of a scientific and technological character, and under the dual authority of the Ministry of Research and the Ministry of Industry



# INRIA today

**3,900 people**

**A budget of €190 M before taxes**  
Of which more than 20% from external resources



**2,800 scientists**

1300 researchers and teaching-researchers

1000 Ph.D. students

500 postdoctoral fellows

8 research centers in France

80 associated teams throughout the world

4 300 scientific publications

24 international conferences

230 active patents

96 innovative companies created

60 software deposited in 2008

*On 1<sup>st</sup> January 2009*

# INRIA's Research Centers

The map shows the following research centers with their corresponding photos:

- INRIA Lille Nord Europe**: Photo of a modern building with the INRIA logo on the facade.
- INRIA Paris Rocquencourt**: Photo of a large, modern white building with a glass facade.
- INRIA Nancy Grand Est**: Photo of a modern white building with a curved facade.
- INRIA Saclay Île-de-France**: Photo of a modern building with a glass facade and a parking lot.
- INRIA Grenoble Rhône-Alpes**: Photo of a modern building with a curved facade and a pool in the foreground.
- INRIA Sophia Antipolis Méditerranée**: Photo of a modern building with a pool in the foreground.
- INRIA Rennes Bretagne Atlantique**: Photo of a modern building at night with blue lighting.
- INRIA Bordeaux Sud-Ouest**: Photo of a modern building with a glass facade.

# An original research model: The INRIA Project-Teams

- From 15 to 20 people, with a scientific leader
- A focused scientific theme
- A limited lifespan: 8 years on average
- Medium-term objectives and work program
- Joint projects with industrial and scientific partners in France and around the world
- Financial and scientific autonomy
- From research to transfer
- A priori and a posteriori evaluation

170 INRIA Project-Teams in 2009

An organization that complements the universities



# Technological developments

Experimentation and development services

Technological development actions

Software development operations

Experimental platforms

Support for standardization



# Industrial partnerships

## Small and Medium - Sized Firms Pact

A long experience in relations with the economic world

- Software distribution (contract and « open source »)

Co-founder or partner of about twenty competitiveness clusters

- Aerospace Valley, Minalogic, System@tic, SCS, Images et réseaux, Medicen, PICOM...

Strategic partnerships

- Alcatel Lucent Bell Labs, ST Microelectronics, Microsoft Research, Orange, EDF...

Joint laboratories

- Microsoft Research
- ALU Bell Labs

Spin off Companies stemming out from INRIA

- 96 companies created, with fifty alive
- Effective start-up support structures, seed-financing, partnership and networking

Partnership with SME

- INRIA support programme in favour of joint projects with SME (I-lab)
- Network of INRIA partners



# European partnerships



Actor in the construction and the development on the European space of the research

- Involvement in more than 180 European projects in the 6<sup>th</sup> and 7<sup>th</sup> FP

Founding member and driving force of ERCIM  
(European Research Consortium for Informatics and Mathematics)

- Post-doctoral grant program

Development of relations with big European Industrial groups

- AIR&D, joint virtual ambient intelligence laboratory (INRIA, Philips, Thomson, Fraunhofer)
- Scilab, Objectweb consortia

Implementation of bilateral collaboration with other European Countries

Development of cross-border exchanges with the nearby regions





# International relations

## A joint research laboratory

- LIAMA: French-Chinese computer science, control and applied mathematics laboratory



## Collaboration agreements

- MITACS (Mathematics of Information Technology and Complex Systems Canada)

80 INRIA project-teams linked with foreign teams as a part of the INRIA Partner Teams program

Reception of 1,743 scientists from other countries

Mobility program

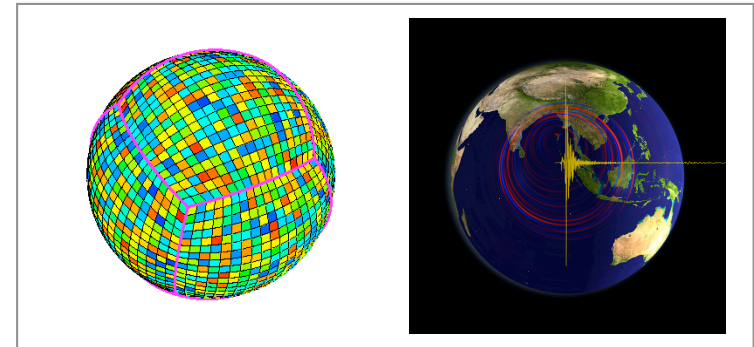


# Why HPC is important at INRIA

- HPC is identified as a **structuring topic** for the future of IST
  - **Moore's law** => strong trend in multi (or many) chips, cores, servers
  - Trend toward **re-centralization** (Cloud, DataCenters, and Supercomputing Centers)
  - New applications (ex: transactional HPC)
  - **Commonalities with other computer science domains** (large data sets, scalability)
- National and international efforts for coordination & organization
  - **Creation of GENCI** and **participation of INRIA to GENCI**
  - International initiatives (**PRACE**, IESP, etc.)
- INRIA has the research potential to be a leader of HPC in Europe
  - Simulation *and* design
  - **2/3 of the ANR (French NSF) projects** related to HPC include INRIA researchers
  - More than **1/2 of the INRIA teams** are involved in HPC related research
  - Culture of **multidisciplinary research**
  - Culture of **mixing methodologies** within computer science (**Strong collaborations** between theoretical and experimental research)
  - Culture of **exploration tools (testbed)**

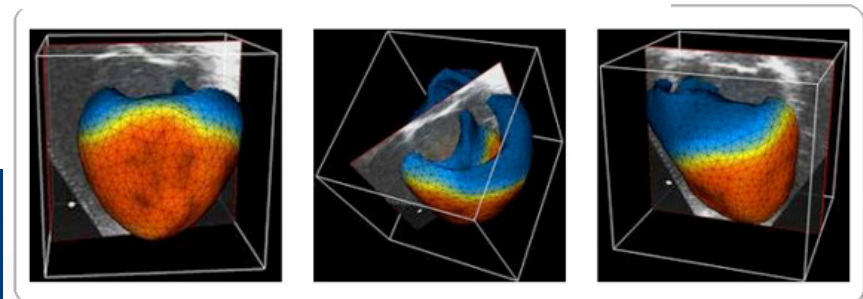
# HPC Research Approach at INRIA

- Driven by Grand challenges in applications
- Three dimensions of HPC at INRIA:
  - From applied Mathematics to Computer Science
  - Continuum from hardware&software design to simulation
  - Research, Development AND Transfer to Industry
- Main research areas:
  - Modeling and numerical methods for very high performance
  - Scalable Algorithms and Solvers (adapted for multi-core CPUs and GPGPUs)
  - Visualization and Steering of Simulation
  - Middleware
  - Processor Architecture and Compilers



High-Frequency Simulations of  
Global Seismic Wave Propagation  
Using SPEC-FEM3D\_GLOBE  
(32,888 cores on TACC Ranger)  
*Finalists of the 2008 Gordon Bell  
competition*

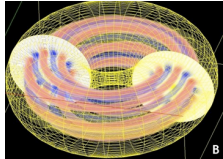
Electro-mechanical modeling of the heart



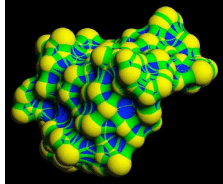
# HPC research at INRIA

## From Computer Arithmetic to Scientific Platform

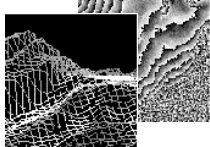
Scientific Visualization  
(e.g. Plasma Physic)



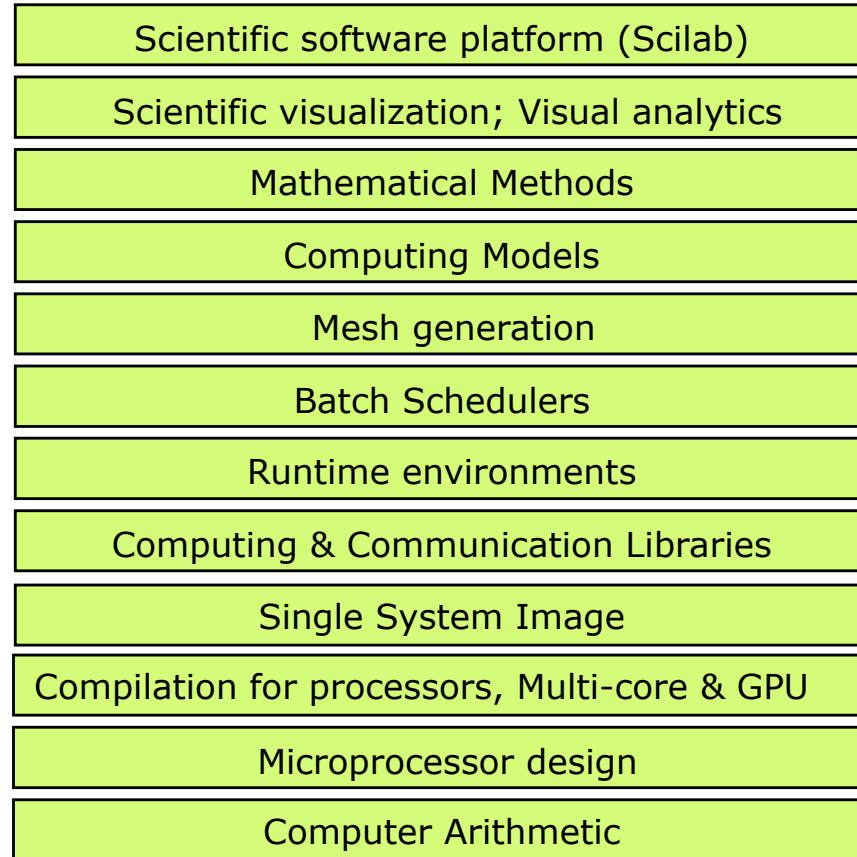
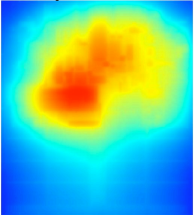
Modeling molecules



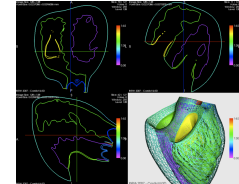
Earth reconstruction  
(inverse problems)



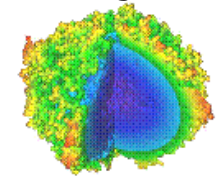
Modeling microprocessor temperature



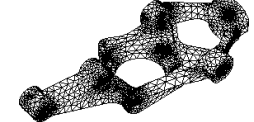
Cardiac imaging and simulation



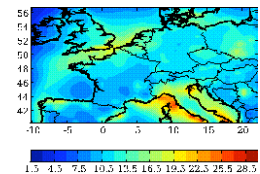
Modeling Tissue Growth



Automatic Mesh Generation



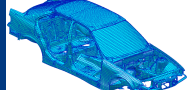
Modeling Air quality



Platform for numerical computation



MUMPS Parallel sparse direct Solver



general purpose library



PM2 Runtime Environment



Kerrighed Single System Image



Fault tolerant MPI



Batch Scheduler



Middleware for Cyber infrastructures



# INRIA Strategic Activities in HPC

- Member of the [French Strategic Committee on HPC](#) and of [GENCI](#)
- Collaborate in the establishment of the « [House of Simulation](#) », Grand Paris
- Executive committee member of [IESP](#)
  
- Joint laboratory with [UIUC-NCSA](#)
- Joint laboratory with [CERFACS](#)
- Strategic Partnership with [EDF](#) on simulation
- Collaboration with [Bull](#) on Supercomputer design
- Collaboration with [CEA](#) on key system software ([Kadeploy](#)) for Supercomputers
  
- Member of the [OpenMPI consortium](#) and [MPI Forum](#)
- A stream of Spin-offs: [Kerlabs](#) (OS), [Caps Entreprise](#) (GPGPUs compiler), [ActiveEon](#) (distributed objects for HPC)
- INRIA/GENCI Initiative, with French competitiveness clusters, « [national coordinated HPC program for SMEs](#) »



# An Example of INRIA Specificity

ALADDIN/Grid'5000: Nation wide experimental platform

Developed since 2003:

- A nationwide experimental platform for **Large scale** experiments

The number of nodes provided every

Many success stories in combinatorial optimizations:

- solve the n-Queens problem for  $n=25$ , in 2005
- solve (exact solution) of the flowshop Ta056-50-20 instance

one of the most remarkable one, in 2008:

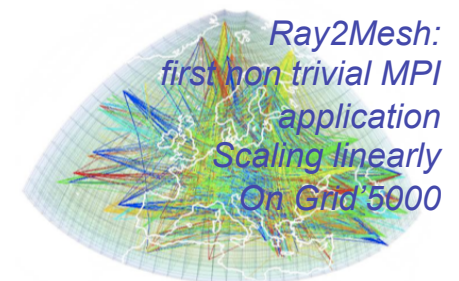
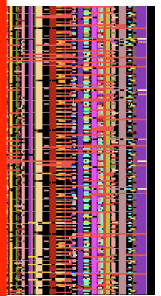
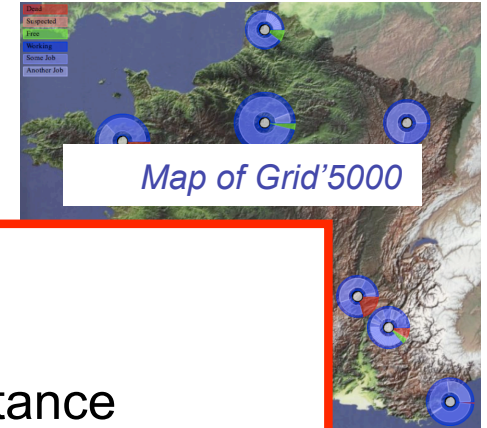
- >400 → Grid'5000 was used to design and improve the algorithm used
- >400 in the **first computer victory against a professional Go player**
- >400 (9x9) in the last Paris tournament!

applications)

External impacts:

- Used for testing of *OpenMPI*
- *Kadeploy* to be used as the deployment tool for *TERA100*

[www.grid5000.fr](http://www.grid5000.fr)



# INRIA and the Joint-Lab on PetaScale Computing

- Research and development in for Peta-ExaScale HPC **needs international collaborations**
  - PetaScale Software design is already raising **many significant research problems**
  - ExaScale system design will **open a very large domain of research** and will require a huge effort from the community
  - Projects like PRACE in Europe and IESP at the international level help establishing **clear roadmaps and focusing on the right problems**
  - The **economic situation** is a threat for very large, single country, projects
  
- **UIUC and NCSA with the BlueWaters project are in the forefront** of research and development for Sustained PetaScale
  - **Strong opportunity for INRIA researchers** to participate and contribute to the research on Key algorithmic and software challenges in PetaScale computing.
  - **Sustained PetaScale means a clear understanding** of the applications and the design of truly scalable software
  - May increase at INRIA the facet of **HPC Research related to production**

