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Deploying Clusters at Electricité de France

Workshop

Operating Systems, Tools and Methods for High Performance Computing on Linux Clusters

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Outline

EDF Group's R&D

Scientific Computing at EDF R&D

Cluster Computing at EDF R&D

Cluster technology at EDF : perspectives

Concluding remarks

EDF Group's R&D

Key figures

- 2570 employees
  - **2/3 researchers and executives**
  - **96 teaching researchers**
  - **55 doctorates**

Participation in 70 European projects

- 4 main research sites

  Clamart (France) Chatou (France)
  Karlsruhe (Germany) Les Renardières (France)

  One branch in California (USA)

EDF Group's R&D

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Commercial development

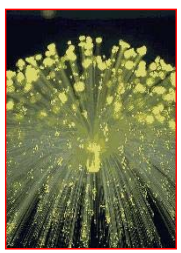
Electricity generation

- Nuclear power
- Fossil-fired power
- Hydro power
- Renewable energies
- Forecast optimisation and management of the Company's generation assets

Power networks

- Transmission network infrastructures
- Transmission network development
- System operation and control
- Distribution networks and facilities

Cross-functional fields

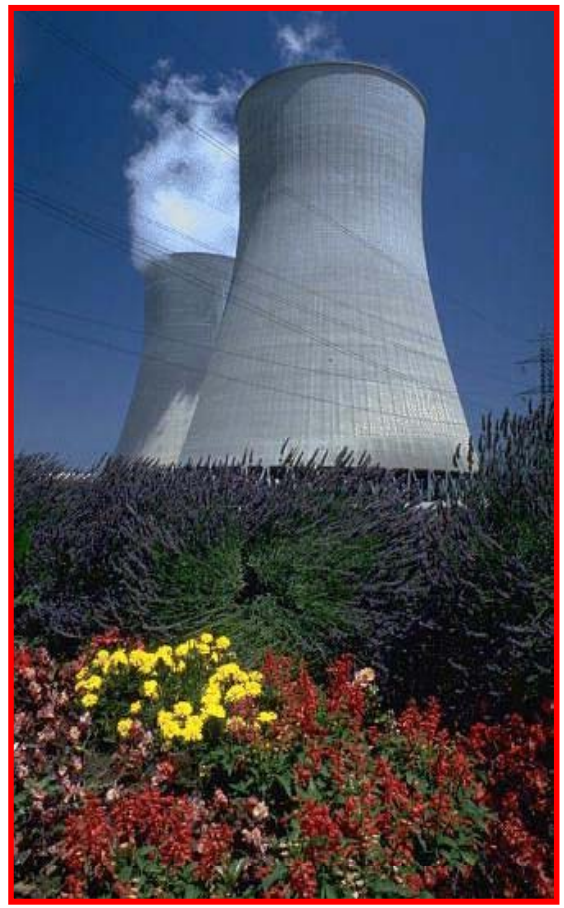


Information technologies

The environment

Why is the R&D Division working in the nuclear power field?

- Competitiveness
  - To keep maintenance expenses down
  - To improve generation performance
  - To improve the present availability of generating facilities
- Lifetime of power plants
  - To improve the lifetime of critical components and the knowledge of ageing mechanisms
  - To optimise the management of a unit's life cycle
- Downstream part of the cycle and future of nuclear waste
- Reactors of the future



Results and projects concerning research on hydro power and the other renewable energies

Some examples

- Forecast studies of the profitability of offshore wind power farms (project)
- Construction of a demonstration building combining the use of renewable energies and the power network (project)
- A new numerical method for complex hydraulic flows

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Scientific Computing at EDF R&D

Large number of disciplinary applications :

Thermomechanic : ASTER

Thermohydraulic : NEPTUNE , SATURNE, THYC

Neutronic Diffusion : DESCARTES, COCCINELLE

Molecular Dynamic : REVE, SINERGY/PERFECT

Global Power Plant functioning : LEGO(ENEL), CATHARE, SCAR simulator

Financial Mathematics : Value at risk computation, spot price model, Energy Derivatives Visual Pricing

Code coupling : 1-3 new coupled applications each year (30 coupled applications currently)

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Scientific Computing at EDF R&D

Small History of Computing Facilities at EDF R&D

Until the end of 1990 :

- desktop computers for small studies
- centralized computers for large studies

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Scientific Computing at EDF R&D

Small History of Computing Facilities at EDF R&D

AIST Project **1999** : computing power adapted to each needs, no more EDF R&D computer center :

- Desktop workstation (SUN, HP, …)
- Departmental/Project computer (SUN SMP, SGI SMP, HP SMP, COMPAQ MPP, Fujitsu VPP)
- HPC machines : cooperation with CEA CCR

=> PC CLUSTER : a possible project target machine

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Cluster technology at EDF R&D

CALIBRE Project 1999-2002

Initial goal : Spreading PC Cluster technology at EDF

Objectives :

- Study of the technical feasibility
- Developing expertise
- Developing tools adapted to users needs
- Building a target architecture for internal EDF projects
- Building a service offer with the Direction du Système d'Information et de l'Informatique of EDF-GDF (EDF DSII)

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Cluster technology at EDF R&D

CALIBRE Project 2000-2002 : experimental results

- REVE project : Simulation of the irradiation damage (pressure vessel steels)
- CYRANO3 code : simulation of fuel rod thermomechanical behaviour
- ECOSS code : studying the Flashing phenomenon, vaporisation of a liquid due to depressurization

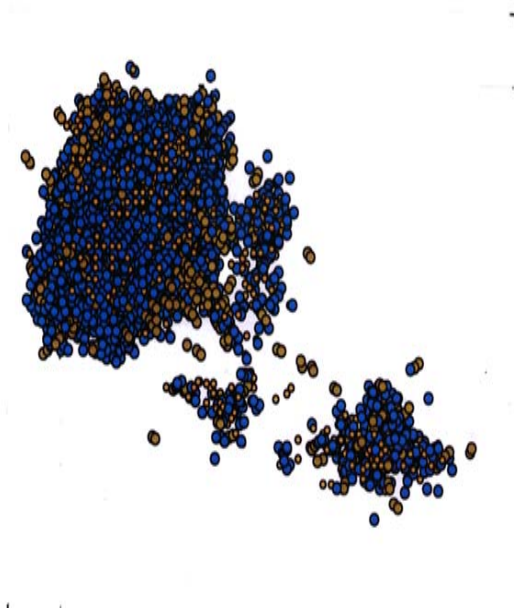
REVE project: REacteur Virtuel d'Etude

Applications (MMC) : Simulation of the irradiation damage (pressure vessel steels)

Services : tools available on a HPC computer

Experimental results : **DYMOKA** (EDF code), Molecular dynamics using empirical interatomic potentials (EAM)

Cascade de déplacement dans Fer (20 keV)



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REVE project: REacteur Virtuel d'Etude

DYMOKA

Nombre de CPU	Performance (coût/atome/pas (µs))					
	Cray T3E	IBM SP3	Compaq SC232		Cluster PC	
1	128	38,2	16,6		23,4	
2	63 (100%)	20,4 (94%)	8,3 (100%) [1]	10,4 (80%) [2]	12,9 (90%) [1]	12,0 (97%) [2]
4	32,5 (100%)	10,7 (89%)	4,2 (99%) [1]	5,3 (78%) [2]	6,9 (85%) [2]	6,3 (93%) [4]
8	16,5 (101%)	6,6 (72%)	2,97 (70%) [2]	2,9 (72%) [4]	3,7 (79%) [4]	3,3 (89%) [8]
16	8,4 (95%)	N/A	1,57 (66%) [4]	1,84 (57%) [8]	2,16 (67%) [8]	

Légende : Temps (Efficacité)
[Nombre de noeuds]

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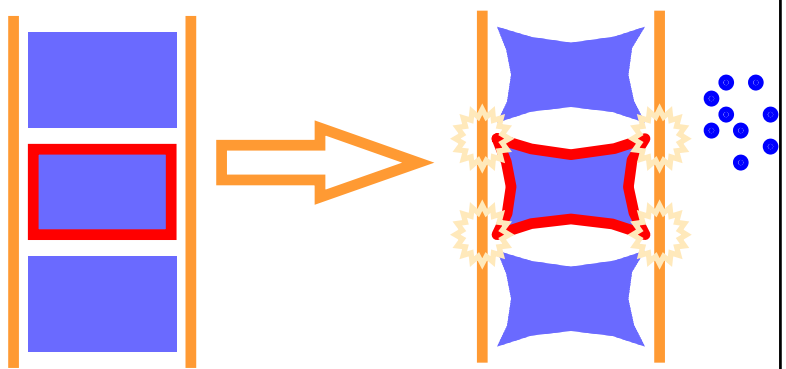
CYRANO3 code

Applications (MMC) : simulation of fuel rod thermomechanical behaviour

The French safety authorities check the integrity of fuel rods against a mechanical criterion



Thousand of scénarios studied in parallel

Sequential throughput under UNIX

- Solveur EF 1D

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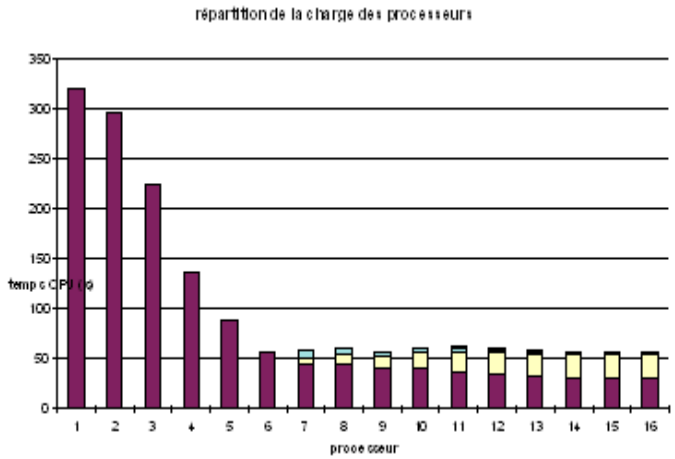
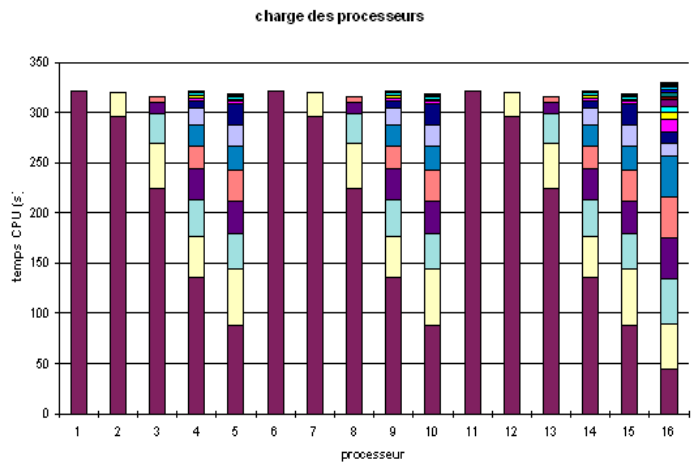
CYRANO3 code

- Use-case : 30 and 90 scénarii
  Target : 4000 scénarii
- Very high imbalance in execution time : 30s to 350s





Machine	Temps	Speedup
Sun Ultra 2/200	6 heures	1
Pentium III 800	28 min 45 s	12,5
Cluster 16 PIII 800	5 min 29 s	65

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Cluster technology at EDF R&D

CALIBRE Project 1999-2002 : industrial results

- LINUX is part of the supported OS at EDF/GDF
- Development of a EDF “distribution”
- Specialization of EDF “distribution” for particular project needs
- End of 2002 : 5 clusters at EDF R&D installed
- 2003 : dissemination of cluster technology outside EDF R&D (Study engineering structures)

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Cluster technology at EDF R&D

CALIBRE Project 1999-2002 : research results

PhD EDF/IRISA/Claude Bernard Univ (Lyon) :
Global scheduling in the Gobelins system

Kerrighed (PARIS Project) :

- Providing a Single System Image for clusters : make usable CPUs, memories, devices and disks as a global resource
- Execution platform for sequential and parallel applications (shared memory or message passing)

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Cluster technology at EDF R&D

CALIBRE Project 1999-2002 : side effects

Introduction to LINUX as a workstation :

- PC LINUX : a alternative to proprietary workstation supported at EDF
  - 180 engineers at EDF R&D, 120 engineers at RTE
  - 2003-2004 : 400 engineers at EDF R&D, 150 engineers at SEPTEN, …
- PC LINUX/VMWARE : 1 PC for 2 machines

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Cluster technology at EDF R&D

CALIBRE Project 1999-2002 : side effects

Introduction to Open Source culture :

- Open source software : more and more used
- EDF proprietary software are/became free :
  - Code_Aster (10/2001) : 1 million code, tens of developpers (www.code-aster.org)
  - P@L/SALOME (2001-2005) : generic software component based architecture, 150 eng.year (EDF : 50 eng.year), (www.opencascade.org/SALOME/Salome.html)
  - CALIBRE

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Cluster technology at EDF : perspectives

CALIBRE2 Project 2003-2004 : research objectives

- Kerrighed on industrial applications
- Enterprise Grid for Scientific Computing : aggregating enterprise computing power and Data and make them usable as a global resource

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Cluster technology at EDF : perspectives

OSIS Project 2003-2005 : industrial objectives

- Linux on workstation and clusters part of the enterprise technical referential
- Organizing support and administration of Linux solutions
- Support to the reorganization of Scientific Computing infrastructure for EDF divisions
- Training of administrators and users

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Cluster technology at EDF : perspectives

NAIST Project 2003-2005

- Reorganization of Scientific Computing infrastructure of SEPTEN (engineering division)
- Deploying LINUX Workstation and Cluster for the SEPTEN EDF Engineering division
- Cartography of scientific codes and planning of LINUX platforms porting
- Training of administrators and users

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Cluster technology at EDF : perspectives

AIST Project 2003-2005 : first conclusions

- Speed-up of parametric studies : between 12 and 15 on the test cluster (16 processors)
- Some examples :
  - 100 CATHARE2 parametric simulations : 100 days on existing Sun, 2 days on the test cluster
  - New fuel management studies :
    - Target : reduce elapse time from 18 months to 3 months (parametric studies)
    - Expected gain : 3Meuros/year each time 20% of study elapse time is saved

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Cluster technology at EDF : perspectives

NAIST Project 2003-2005

Targets and planning :

- 2003, needs expression and tests : 10 workstations, 1 cluster
- 2004-2005 : deployment phase
  - Porting of scientific codes (100 codes)
  - 100 workstations, 3 clusters

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Concluding remarks

- Clusters are now proved industrial target machines
- Clusters are part of a continuum of computing power : between workstation and HPC computers
- Offer a solution independent of strategy vendors : the evolution of such computing facilities does not depend of vendors roadmap

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Concluding remarks

- EDF produce and maintain an “EDF Linux Distribution” available from workstations to clusters
- Use of standard Linux kernel and non proprietary software suite guaranty independence from any vendors : portability is improved
- BUT, how to combine :
  1. one Linux distribution for Workstations and clusters AND,
  2. possibility to by and use market clusters ?