Deploying Clusters at Electricité de France

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

Jean-Yves Berthou
Head of the Applied Scientific Computing Group
EDF R&D

October, 7 2003 Clamart EDF R&D
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

Commercial development

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

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

Cross-functional fields

Information technologies

The environment

Linux Cluster Workshop, EDF/INRIA/ORAP, Clamart, October 2003
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
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)
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
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
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)
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
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)
## DYMOKA

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

**Légende :**

- Temps (Efficacité)
- [Nombre de noeuds]
**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
CYRANO3 code

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

<table>
<thead>
<tr>
<th>Machine</th>
<th>Temps</th>
<th>Speedup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Ultra 2/200</td>
<td>6 heures</td>
<td>1</td>
</tr>
<tr>
<td>Pentium III 800</td>
<td>28 min 45 s</td>
<td>12,5</td>
</tr>
<tr>
<td>Cluster 16 PIII 800</td>
<td>5 min 29 s</td>
<td>65</td>
</tr>
</tbody>
</table>
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)
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)
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
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
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
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
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
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
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
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
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?