Experiences with HPC on Windows

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Experiences with HPC on Windows

18.04.2008 – C. Terboven

Agenda

- Windows-Cluster @ Aachen
  - Hardware & Software
  - Deployment & Configuration

- Case Studies
  - Dynamic Optimization: AVT
  - Bevel Gears: WZL

- Top500 submission

- Summary
Experiences with HPC on Windows

HPC on Windows

- We do HPC on Unix for many years - why try Windows?
  - Third party cooperations sometimes depend on Windows
  - Some users look out for the Desktop-like HPC experience
  - Windows is a great development platform

- Early adopters:
  - 03/04: Intel ThreadingTools GUI only available on Windows
  - 2004: Visual Studio 2005 with OpenMP support (beta program)
  - 2005: Windows Compute Cluster Server (beta program)
  - 2007: Windows (HPC) Server 2008 (beta program)

- Windows High Performance Cluster Competence Center
  - Cooperation with Microsoft since 04/2008: WinHP3C
  - Focus on Computational Engineering Science
Recently installed Cluster:

- **Fujitsu-Siemens Primergy RS 200 S4 servers**
  - 2x Intel Xeon 5450 (quad-core, 3.0 GHz)
  - 16 / 32 GB memory per node
  - 4x DDR InfiniBand:
    - MPI latency: 2.7 us
    - MPI bandwidth: 1250 MB/s

Hosting: Clusters in the Cluster (RWTH institutes)

Installation-on-demand: Linux + Windows
Windows: Deploying a 256 node cluster

- Setting up the Head Node: approx. 2 hours
  - Microsoft SQL Server 2005 + Microsoft HPC Pack

- Installing the compute nodes:
  - Installing 1 compute node: 50 minutes
  - Installing n compute nodes: 50 minutes! (Multicasting)

- Linux & Windows in one cluster infrastructure:
  - DHCP on Linux, PXE-Boot on both Linux and Windows
Windows: Software Environment

- Complete Development Environment
  - Visual Studio 2005 Pro + Microsoft Compute Cluster Pack
  - Subversion Client, X-Win32, Microsoft SDKs, ...
  - Intel Tool Suite:
    - C/C++ Compiler, Fortran Compiler
    - VTune Performance Analyzer, Threading Tools
    - MKL library, Threading Building Blocks
    - Intel MPI + Intel Tracing Tools
  - Java, Eclipse, ...

- Growing list of ISV software
  - ANSYS, HyperWorks, Fluent, Maple, Mathematica, Matlab, MS Office 2003, MSC.Marc, MSC.Adams, ...
  - User-licensed software hosting, e.g. GTM-X
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Case Study: Dynamic Optimization (AVT)

- Dynamic optimization in chemical industry

Composition of A und B \(\Rightarrow\) unfeasible material

Task: Changing the product specification (from A to B) of a plastic manufactory in ongoing business:
- Minimize the junk (composition of A and B)
- Search for economic and ecologic optimal operational mode!

This task is solved by the DyOS (Dynamic Optimization Software) tool, developed at the chair for process systems engineering (AVT: Aachener Verfahrenstechnik) at RWTH Aachen University.
Case Study: Dynamic Optimization (AVT)

- Challenge: Commercial software component depending on Visual Studio 6, only one instance per machine allowed → outsourced into DLL
- One simulation typically takes up to two weeks and requires a significant amount of memory (>4GB) → MPI parallelization

Project compute time requirements reduced from 10 months (desktop) to three weeks!
Case Study: KegelToleranzen (WZL)

- Contact analysis simulation of Bevel Gears
  - Written in Fortran, using Intel Fortran 10.1 compiler
  - Very cache-friendly → runs at high Mflop/s rates

Laboratory for Machine Tools and Production Engineering, RWTH Aachen
Case Study: KegelToleranzen (WZL)

- Comparing Linux and Windows Server 2003:

Performance of KegelToleranzen

- Linux 2.6: 4x Opteron dual-core, 2.2 GHz
- Windows 2003: 4x Opteron dual-core, 2.2 GHz

Comparison between Linux and Windows Server 2003:

- Linux: 24% better than Windows

Graph showing performance metrics for different thread counts.
Experiences with HPC on Windows

Case Study: KegelToleranzen (WZL)

- Comparing Linux and Windows Server 2008:

Performance gain for the user: Speedup of 5.6 on one node. Even better from starting point (desktop: 220 MFlop/s). MPI parallelization is work in progress.
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The Top500 List: Windows clusters

Operating system Family share for 11/2007

In addition to the table below, you can view the visual charts using the TOP500 charts page. A direct link to the charts is also available.

<table>
<thead>
<tr>
<th>Operating system Family</th>
<th>Count</th>
<th>Share %</th>
<th>Rmax Sum (GF)</th>
<th>Rpeak Sum (GF)</th>
<th>Processor Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linux</td>
<td>426</td>
<td>85.20 %</td>
<td>4897046</td>
<td>7956758</td>
<td>970790</td>
</tr>
<tr>
<td>Windows</td>
<td>6</td>
<td>1.20 %</td>
<td>47495</td>
<td>86797</td>
<td>12112</td>
</tr>
<tr>
<td>Unix</td>
<td>30</td>
<td>6.00 %</td>
<td>408378</td>
<td>519178</td>
<td>73532</td>
</tr>
<tr>
<td>BSD Based</td>
<td>2</td>
<td>0.40 %</td>
<td>44783</td>
<td>50176</td>
<td>5696</td>
</tr>
<tr>
<td>Mixed</td>
<td>34</td>
<td>6.80 %</td>
<td>1540037</td>
<td>1900361</td>
<td>580693</td>
</tr>
<tr>
<td>Mac OS</td>
<td>2</td>
<td>0.40 %</td>
<td>28430</td>
<td>44816</td>
<td>5272</td>
</tr>
<tr>
<td>Totals</td>
<td>500</td>
<td>100%</td>
<td>6966169.82</td>
<td>10558086.75</td>
<td>1648095</td>
</tr>
</tbody>
</table>

- Why add just another Linux cluster? → Top500 on Windows!
- Results are still preliminary: Not all issues solved yet...
Parameter Tuning – Going the Windows way

Excel application on a laptop controlled the whole cluster!

We easily reached 76.69 GFlop/s on one node.
Peak performance is: 8 cores * 3 GHz * 4 results per cycle = 96 Gflop/s
→ That is 80% efficiency!
Windows HPC Server 2008 in Action

- Job startup comparison – 2048 MPI processes:
  - Our Linux configuration: Order of Minutes
  - Our Windows configuration: Order of Seconds

Video: Job startup on Windows 2008

- Current result:
  - 18.81 TFlop/s with 256 nodes
  - 195 Mflop/s per Watt
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Einladung zum 1. Treffen der
Windows High Performance Computing
Nutzergruppe im deutschsprachigen Raum

21./22. April 2008
Rechen- und Kommunikationszentrum, RWTH Aachen

http://www.rz.rwth-aachen.de/winhpcug
Summary & Outlook

- The Windows-HPC environment has been well accepted
  - Growing interest and need of compute power on Windows.

- Windows HPC Server 2008 (beta) is pretty impressive!!!
  - Deploying and Configuring 256 nodes.
  - Job Startup and Job Management.
  - Performance improvements & Linpack efficiency.

- Interoperability in heterogeneous environments got easier.
  - E.g. WDS can interoperate with Linux DHCP and PXE-Boot.
The End

Thank you for your attention!

User Group: [http://www.rz.rwth-aachen.de/winhpcug](http://www.rz.rwth-aachen.de/winhpcug)

21./22. April, RWTH Aachen