Why ANSYS Users Need HPC
Insight you can’t get any other way

HPC enables high-fidelity
• Include details - for reliable results
• Be sure your design is “right”
• Innovate with confidence

HPC delivers throughput
• Consider multiple design ideas
• Optimize the design
• Ensure performance across range of conditions
Today’s multi-core / many-core hardware evolution makes HPC a software development imperative. ANSYS is committed to maintaining performance leadership.
HPC – A Software Development Imperative

- Clock Speed – Leveling off
- Core Counts – Growing
  - Exploding (GPUs)
- Future performance depends on highly scalable parallel software

Systems keep improving: faster processors, more cores
• Ideal rating (speed) doubled in two years!

Memory bandwidth per core and network latency/BW stress scalability
• 2008 release (12.0) re-architected MPI – huge scaling improvement, for a while...
• 2010 release (13.0) introduces hybrid parallelism – and scaling continues!
Extreme CFD Scaling - 1000’s of cores

Enabled by ongoing software innovation

Hybrid parallel: fast shared memory communication (OpenMP) within a machine to speed up overall solver performance; distributed memory (MPI) between machines.
Parallel Scaling ANSYS Mechanical

Focus on bottlenecks in the distributed memory solvers (DANSYS)

- Sparse Solver
  - Parallelized equation ordering
  - 40% faster w/ updated Intel MKL

- Preconditioned Conjugate Gradient (PCG) Solver
  - Parallelized preconditioning step
Architecture-Aware Partitioning

Original partitions are remapped to the cluster considering the network topology and latencies

Minimizes inter-machine traffic reducing load on network switches

Improves performance, particularly on slow interconnects and/or large clusters

Partition Graph
3 machines, 8 cores each
Colors indicate machines

Original mapping
New mapping
File I/O Performance

Case file IO
• Both read and write significantly faster in R13
• A combination of serial-IO optimizations as well as parallel-IO techniques, where available

Parallel-IO (.pdat)
• Significant speedup of parallel IO, particularly for cases with large number of zones
• Support for Lustre, EMC/MPFS, AIX/GPFS file systems added

Data file IO (.dat)
• Performance in R12 was highly optimized. Further incremental improvements done in R13

<table>
<thead>
<tr>
<th>Parallel Data write</th>
<th>R12 vs. R13</th>
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<tbody>
<tr>
<td>BMW</td>
<td>-68%</td>
</tr>
<tr>
<td>FL5L2 4M</td>
<td>-63%</td>
</tr>
<tr>
<td>Circuit</td>
<td>-97%</td>
</tr>
<tr>
<td>Truck 14M</td>
<td>-64%</td>
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</tbody>
</table>
What about GPU Computing?

CPUs and GPUs work in a **collaborative** fashion

**CPU**

- Multi-core processors
  - Typically 4-6 cores
  - Powerful, general purpose

**GPU**

- Many-core processors
  - Typically hundreds of cores
  - Great for highly parallel code, within memory constraints
ANSYS Mechanical SMP – GPU Speedup

From NAFEMS World Congress
May 2011 Boston, MA, USA

"Accelerate FEA Simulations with a GPU"
-by Jeff Beisheim, ANSYS

Solver Kernel Speedups

Overall Speedups

Tesla C2050 and Intel Xeon 5560
R14: GPU Acceleration for DANSYS

R14 Distributed ANSYS Total Simulation Speedups for R13 Benchmark set

- 4 CPU cores
- 4 CPU cores + 1 GPU

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Speedup 4 CPU cores</th>
<th>Speedup 4 CPU cores + 1 GPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>V13cg-1 (JCG, 1100k)</td>
<td>1.52</td>
<td>2.24</td>
</tr>
<tr>
<td>V13sp-1 (sparse, 430k)</td>
<td>1.16</td>
<td>1.44</td>
</tr>
<tr>
<td>V13sp-2 (sparse, 500k)</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>V13sp-3 (sparse, 2400k)</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>V13sp-4 (sparse, 1000k)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V13sp-5 (sparse, 2100k)</td>
<td></td>
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</tbody>
</table>

**Windows workstation**: Two Intel Xeon 5560 processors (2.8 GHz, 8 cores total), 32 GB RAM, NVIDIA Tesla C2070, Windows 7, TCC driver mode
ANSYS Mechanical – Multi-Node GPU

- Solder Joint Benchmark (4 MDOF, Creep Strain Analysis)

**Linux cluster**: Each node contains 12 Intel Xeon 5600-series cores, 96 GB RAM, NVIDIA Tesla M2070, InfiniBand

Results Courtesy of MicroConsult Engineering, GmbH
First capability for “specialty physics”
- view factors, ray tracing, reaction rates, etc.

R&D focus on linear solvers, smoothers – but potential limited by Amdahl’s Law

Radiation viewfactor calculation (ANSYS FLUENT 14 - beta)
Case Study
HPC for High Fidelity CFD

- 8M to 12M element turbocharger models (ANSYS CFX)
- Previous practice (8 nodes HPC)
  - Full stage compressor runs 36-48 hours
  - Turbine simulations up to 72 hours
- Current practice (160 nodes)
  - 32 nodes per simulation
  - Full stage compressor 4 hours
  - Turbine simulations 5-6 hours
  - Simultaneous consideration of 5 ideas
  - Ability to address design uncertainty – clearance tolerance

“ANSYS HPC technology is enabling Cummins to use larger models with greater geometric details and more-realistic treatment of physical phenomena.”

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Case Study
HPC for High Fidelity CFD

EURO/CFD

- Model sizes up to 200M cells (ANSYS FLUENT)
- 2011 cluster of 700 cores
  - 64-256 cores per simulation

Increase of:

- Spatial-temporal Accuracy
- Complexity of Physical Phenomenon
Case Study

HPC for High Fidelity Mechanical

Microconsult GmbH

Solder joint failure analysis
• Thermal stress 7.8 MDOF
• Creep strain 5.5 MDOF

Simulation time reduced from 2 weeks to 1 day
• From 8 – 26 cores (past) to 128 cores (present)

“HPC is an important competitive advantage for companies looking to optimize the performance of their products and reduce time to market.”
Case Study
HPC for Desktop Productivity

• Cognity Limited – steerable conductors for oil recovery
• ANSYS Mechanical simulations to determine load carrying capacity
• 750K elements, many contacts
• 12 core workstations / 24 GB RAM
• 6X speedup / results in 1 hour or less
• 5-10 design iterations per day

“Parallel processing makes it possible to evaluate five to 10 design iterations per day, enabling Cognity to rapidly improve their design.

http://www.ansys.com/About+ANSYS/ANSYS+Advantage+Magazine/Current+Issue
Case Study
Skewed Waveguide Array (HFSS)

- 16X16 (256 elements and excitations)
- Skewed Rectangular Waveguide (WR90) Array
  - 1.3M Matrix Size
- Using 8 cores
  - 3 hrs. solution time
  - 0.4GB Memory total
- Using 16 cores
  - 2 hrs. solution time
  - 0.8GB Memory total
- Additional Cores
  - Faster solution time
  - More memory.

Unit cell shown with wireframe view of virtual array
NVIDIA - Case study on the value of HW refresh and SW best-practice

Deflection and bending of 3D glasses

- ANSYS Mechanical – 1M DOF models

Optimization of:

- Solver selection (direct vs iterative)
- Machine memory (in core execution)
- Multicore (8-way) parallel with GPU acceleration

Before/After:

77x speedup – from 60 hours per simulation to 47 minutes.

Most importantly: HPC tuning added scope for design exploration and optimization.
“Take Home” Points / Discussion

ANSYS HPC performance enables scaling for high-fidelity

- What could you learn from a 10M (or 100M) cell / DOF model?
- What could you learn if you had time to consider 10 x more design ideas?
- Scaling applies to “all physics”, “all hardware” (desktop and cluster)

ANSYS continually invests in software development for HPC

- Maximized value from your HPC investment
- This creates differentiated competitive advantage for ANSYS users

Comments / Questions / Discussion