Distributed ANSYS 14.5 benchmark on Intel SSDs

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ANSYS, Inc.
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Basic Hardware Configuration

Single Intel W2600CR Workstation

- CPU: Dual Intel Xeon E5-2687W (3.1Ghz, 8-core), total 16 cores
- Memory: 8 X 4GB DDR3-1333 MT/s, Reg. ECC, total 32GB
- OS: Windows 7 Professional x64 SP1
- RAID Controller: Intel Embedded Server RAID Technology II (ESRT2), 3Gb/s SATA
- Storage scenarios (Working directory and virtual memory):
  - 4 X Intel SSD DC S3700 400GB, RAID 0, SATA 3Gb/s
  - 2 X Intel SSD DC S3700 400GB, RAID 0, SATA 3Gb/s
  - 1 X Intel SSD DC S3700 400GB, SATA 6Gb/s
  - 1 X 1TB 7.2K RPM HD, SATA 6Gb/s
## Benchmark models

<table>
<thead>
<tr>
<th>Name</th>
<th>Solver</th>
<th>DOFs</th>
<th>Max. Memory (16-core DANSYS)</th>
<th>Analysis Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG-2</td>
<td>PCG</td>
<td>11.8 M</td>
<td>~25 GB</td>
<td>Static structural, linear</td>
</tr>
<tr>
<td>SP-3</td>
<td>SPARSE</td>
<td>2.3 M</td>
<td>~18 GB</td>
<td>Transient structural, nonlinear</td>
</tr>
<tr>
<td>SP-5</td>
<td>SPARSE</td>
<td>2.1 M</td>
<td>~48 GB (in-core)</td>
<td>Static structural, nonlinear (contact)</td>
</tr>
<tr>
<td>SP-6</td>
<td>SPARSE</td>
<td>4.9 M</td>
<td>~35 GB (out-of-core)</td>
<td>Static structural, nonlinear</td>
</tr>
</tbody>
</table>

**Images of benchmark models:**

- **CG-2**
- **SP-3**
- **SP-5**
- **SP-6**
CG-2 Benchmark Results, Rating

<table>
<thead>
<tr>
<th>Machine X</th>
<th>#Core</th>
<th>Memory</th>
<th>Rating (jobs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1</td>
<td>1</td>
<td>15.2GB</td>
<td>26</td>
</tr>
<tr>
<td>1X2</td>
<td>2</td>
<td>17.6GB</td>
<td>24</td>
</tr>
<tr>
<td>1X4</td>
<td>4</td>
<td>18.8GB</td>
<td>25</td>
</tr>
<tr>
<td>1X8</td>
<td>8</td>
<td>20.7GB</td>
<td>22</td>
</tr>
<tr>
<td>1X16</td>
<td>16</td>
<td>24.9GB</td>
<td>26</td>
</tr>
</tbody>
</table>

Comparison:
- 4XSSD-RAID-0-SATA-3Gb/s
- 2XSSD-RAID-0-SATA-3Gb/s
- 1XSSD-SATA-6Gb/s
- HD(7.2K RPM)-SATA-6Gb/s
SP-3 (in-core) Benchmark Results, Rating

- 4XSSD-RAID-0-SATA-3Gb/s
- 2XSSD-RAID-0-SATA-3Gb/s
- 1XSSD-SATA-6Gb/s
- HD(7.2K RPM)-SATA-6Gb/s

<table>
<thead>
<tr>
<th>#Machine X #Core Memory</th>
<th>Rating (jobs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1 10.4GB</td>
<td>109, 110, 109, 109</td>
</tr>
<tr>
<td>1X2 11.9GB</td>
<td>193, 193, 193, 187</td>
</tr>
<tr>
<td>1X4 13.5GB</td>
<td>336, 338, 336, 231</td>
</tr>
<tr>
<td>1X8 16.5GB</td>
<td>517, 514, 514, 635</td>
</tr>
<tr>
<td>1X16 17.9GB</td>
<td>631, 617, 223, 215</td>
</tr>
</tbody>
</table>
SP-5 (in-core) Benchmark Results, Rating

<table>
<thead>
<tr>
<th>Machine X</th>
<th>Core</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1</td>
<td>1</td>
<td>29GB</td>
</tr>
<tr>
<td>1X2</td>
<td>2</td>
<td>33GB</td>
</tr>
<tr>
<td>1X4</td>
<td>4</td>
<td>35.6GB</td>
</tr>
<tr>
<td>1X8</td>
<td>8</td>
<td>40.8GB</td>
</tr>
<tr>
<td>1X16</td>
<td>16</td>
<td>47.8GB</td>
</tr>
</tbody>
</table>

- 4XSSD-RAID-0-SATA-3Gb/s
- 2XSSD-RAID-0-SATA-3Gb/s
- SSD-SATA-6Gb/s
- HD(7.2K RPM)-SATA-6Gb/s

Rating (jobs/day)

89 89 88 88
145 146 144 124
180 180 180 118
301 275 283 95
419 384 368 52
SP-6 (out-of-core) Benchmark Results, Rating

<table>
<thead>
<tr>
<th>#Machine X #Core</th>
<th>Memory</th>
<th>Rating (jobs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1</td>
<td>10.2GB</td>
<td>43</td>
</tr>
<tr>
<td>1X2</td>
<td>13.5GB</td>
<td>67</td>
</tr>
<tr>
<td>1X4</td>
<td>16GB</td>
<td>102</td>
</tr>
<tr>
<td>1X8</td>
<td>21.9GB</td>
<td>168</td>
</tr>
<tr>
<td>1X16</td>
<td>34.4GB</td>
<td>208</td>
</tr>
</tbody>
</table>

Options:
- 4XSSD-RAID-0-SATA-3Gb/s
- 2XSSD-RAID-0-SATA-3Gb/s
- SSD-SATA-6Gb/s
- HD(7.2K RPM)-SATA-6Gb/s
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  ▪ SP-6

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  ▪ SP-6

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  ▪ SP-5
  ▪ SP-6

• Observations & Conclusions
64 vs. 32 vs. 16 GB Memory, SP-5, Rating

SP-5
(32GB & 64GB, in-core)
(16GB, out-of-core)

Memory eater program could only run on 1 core, so the load balance was drastically altered and is the reason for this run being so slow.
64GB vs. 32GB Memory, SP-6, Rating

<table>
<thead>
<tr>
<th>#Machine X</th>
<th>#Core (Memory Used in-core/out-of-core)</th>
<th>Rating (jobs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1</td>
<td>(56.1/10.2GB)</td>
<td>49/43</td>
</tr>
<tr>
<td>1X2</td>
<td>(59.5/13.5 GB)</td>
<td>80/67</td>
</tr>
<tr>
<td>1X4</td>
<td>(63.9/16 GB)</td>
<td>134/111</td>
</tr>
<tr>
<td>1X8</td>
<td>(70.1/21.9 GB)</td>
<td>212/168</td>
</tr>
<tr>
<td>1X16</td>
<td>(81.5/34.4 GB)</td>
<td>302/260/208</td>
</tr>
</tbody>
</table>

Key:
- 4XSAS-15K-128GB-Memory (in-core)
- 4XSSD-64GB-Memory (in-core)
- 4XSSD-32GB-Memory (out-of-core)
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  ▪ SP-6
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  ▪ SP-6
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  ▪ SP-6
• Observations & Conclusions
6Gb/s vs. 3Gb/s SATA, SP-5, in-core, Rating

SP-5 (32 GB Memory)

<table>
<thead>
<tr>
<th>Machine X</th>
<th>#Core</th>
<th>Memory</th>
<th>Rating (jobs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1</td>
<td>1</td>
<td>29GB</td>
<td>89, 88</td>
</tr>
<tr>
<td>1X2</td>
<td>2</td>
<td>33GB</td>
<td>145, 144</td>
</tr>
<tr>
<td>1X4</td>
<td>4</td>
<td>35.6GB</td>
<td>180, 183</td>
</tr>
<tr>
<td>1X8</td>
<td>8</td>
<td>40.8GB</td>
<td>301, 302</td>
</tr>
<tr>
<td>1X16</td>
<td>16</td>
<td>47.8GB</td>
<td>419, 443</td>
</tr>
</tbody>
</table>
6Gb/s vs. 3Gb/s, SP-6, out-of-core, Rating

SP-6 (32GB Memory)

- 4XSSD-RAID-0-3Gb/s
- 4XSSD-RAID-0-6Gb/s

<table>
<thead>
<tr>
<th>#Machine X #Core Memory</th>
<th>1X1 10.2GB</th>
<th>1X2 13.5GB</th>
<th>1X4 16GB</th>
<th>1X8 21.9GB</th>
<th>1X16 34.4GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating (jobs/day)</td>
<td>43</td>
<td>67</td>
<td>111</td>
<td>168</td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>71</td>
<td>112</td>
<td>183</td>
<td>230</td>
</tr>
</tbody>
</table>
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  ▪ SP-6
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  ▪ SP-5
  ▪ SP-6
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  ▪ SP-5
  ▪ SP-6
• Working Directory on HD, Virtual Memory on HD vs. on 4XSSD
  ▪ SP-5
  ▪ SP-6
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Virtual memory on 7.2K HD vs. 4XSSD RAID 0 SP-5, Rating

SP-5, 32 GB Memory
Working directory on 4XSSD RAID 0, 6Gb/s SATA

<table>
<thead>
<tr>
<th>Machine X</th>
<th>Core (Memory Used out-of-core/in-core)</th>
<th>Rating (jobs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1 (4.1/29 GB)</td>
<td>88.0/85.5/88.1</td>
<td>149.7/144.2</td>
</tr>
<tr>
<td>1X2 (6.4/33 GB)</td>
<td>149.7/148.7/175.3</td>
<td>302.1</td>
</tr>
<tr>
<td>1X4 (9.3/35.6 GB)</td>
<td>148.7/183.1</td>
<td>288.0</td>
</tr>
<tr>
<td>1X8 (13.3/40.8 GB)</td>
<td>100.7</td>
<td>389.2</td>
</tr>
<tr>
<td>1X16 (20.6/47.8 GB)</td>
<td>65.5</td>
<td>443.1</td>
</tr>
</tbody>
</table>
Virtual memory on 7.2K HD vs. 4XSSD RAID 0 SP-6, Rating

<table>
<thead>
<tr>
<th>#Machine</th>
<th>#Core</th>
<th>(Memory Used out-of-core/in-core)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1</td>
<td>1</td>
<td>(10.2/56.1GB)</td>
</tr>
<tr>
<td>1X2</td>
<td>2</td>
<td>(13.5/59.5 GB)</td>
</tr>
<tr>
<td>1X4</td>
<td>4</td>
<td>(16.0/63.9 GB)</td>
</tr>
<tr>
<td>1X8</td>
<td>8</td>
<td>(21.9/70.1 GB)</td>
</tr>
<tr>
<td>1X16</td>
<td>16</td>
<td>(34.4/81.5 GB)</td>
</tr>
</tbody>
</table>

**SP-6, 32GB Memory working directory on 4XSSD RAID 0, 6Gb/s SATA**

- SWAP on 7.2K RPM HD, out-of-core
- SWAP on 7.2K RPM HD, force in-core
- SWAP on 4XSSD RAID 0, SATA 6Gb/s, out-of-core
- SWAP on 4XSSD RAID 0, SATA 6Gb/s, force in-core
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  ▪ SP-6
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  ▪ SP-6
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  ▪ SP-5
  ▪ SP-6
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Virtual Memory on 7.2K HD vs. on SSD RAID 0
SP-5, in-core, Elapsed Time

<table>
<thead>
<tr>
<th>#Machine X</th>
<th>#Core (Memory Used in-core)</th>
<th>SWAP on SATA 6Gb/s 7.2K HD</th>
<th>SWAP on 4XSSD RAID 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1 (29GB)</td>
<td></td>
<td>987</td>
<td>981</td>
</tr>
<tr>
<td>1X2 (33GB)</td>
<td></td>
<td>697</td>
<td>746</td>
</tr>
<tr>
<td>1X4 (35.6GB)</td>
<td></td>
<td>732</td>
<td>693</td>
</tr>
<tr>
<td>1X8 (40.8GB)</td>
<td></td>
<td>912</td>
<td>691</td>
</tr>
<tr>
<td>1X16 (47.8GB)</td>
<td></td>
<td>1673</td>
<td>674</td>
</tr>
</tbody>
</table>

SP-5 (32GB, in-core)
Working directory on 7.2K RPM HD
Virtual Memory on 7.2K HD vs. on SSD RAID 0 SP-6, Elapsed Time

SP-6, 32GB
Working directory on 7.2K RPM HD

<table>
<thead>
<tr>
<th>Machine X</th>
<th>Core (Memory Used out-of-core/in-core)</th>
<th>Elapsed Time (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X1</td>
<td>(10.2/56.1)</td>
<td>3078</td>
</tr>
<tr>
<td>1X2</td>
<td>(13.5/59.5)</td>
<td>3507</td>
</tr>
<tr>
<td>1X4</td>
<td>(16/63.9)</td>
<td>3747</td>
</tr>
<tr>
<td>1X8</td>
<td>(21.9/70.1)</td>
<td>3848</td>
</tr>
<tr>
<td>1X16</td>
<td>(34.4/81.5)</td>
<td>4704</td>
</tr>
</tbody>
</table>

- SWAP on SATA 6Gb/s 7.2K HD
- SWAP on 4XSSD RAID 0 (force in-core)
Max. disk I/O rate, virtual memory on 4 X SSD RAID 0 6Gb/s

Peak I/O rate reached ~1.8GB/s, captured ~1.5GB/s
Observations and Conclusions

• SSDs helps DANSYS reduce elapsed time and scale better with multi cores

• Max. 33% performance improvement from 4XSSD RAID 0, 3Gb/s SATA to 1 SSD, 6Gb/s SATA (SP-6, 16 cores, out-of-core)

• Up to 10% performance improvement from 3Gb/s to 6Gb/s SATA RAID Controller (SP-6, 16 cores, out-of-core)

• More memory, more chance to run in-core to improve DANSYS performance

• Set both virtual memory (1~2X physical memory) and working directory to SSD RAID 0 to achieve best performance.

• SSD RAID 0 or PCI-E SSD with high sustained read/write rate and low latency is highly recommended for ANSYS Mechanical users.