High-Performance Cluster Configurations for ANSYS Fluid Dynamics

ANSYS IT Solutions Webcast Series
2012 webcast series from ANSYS and our partners

Our goal is to provide ANSYS customers with

• Recommendations on HW and system specification
• Best practice configuration, setup, management
• Roadmap and vision for planning

Upcoming Topics

• Storage and Data Management
• Remote Access / Centralized HPC
• Workstation Refresh ROI
• Cloud, mobile platforms, ...

ANSYS Focus on IT Solutions

IT is the enabler for more effective use of engineering simulation.

High Fidelity Results

Simulation allows engineering to know, not guess – but only if IT can deliver infrastructure suited for ever larger “mega”-simulations

Design Exploration / Optimization

Product integrity requirements drive automated execution of 100’s of simulations, with important implications for the IT infrastructure

Average HPC infrastructure for ANSYS in our largest customers is well over 10,000 cores – and growing very fast
Today’s Agenda and Speakers

High-Performance Cluster Configurations for ANSYS Fluid Dynamics

• Best Practice Cluster System Specification
  • Hari Reddy, Senior Technical Consultant, IBM

• IBM Solution Recommendations
  • Guarav Chaudhry, X-Server WW Marketing, IBM
  • William Lu, Product Management, Platform Computing, an IBM Company

• Question / Answer
Best Practice Cluster System Specification

Hari Reddy, Senior Technical Consultant, IBM
hnreddy@us.ibm.com
IBM IT Selection Guide for ANSYS Fluent

Decision Points

- Cluster
  - Collection of nodes
  - Blade, Rack, High Density
- Network/Interconnect
  - Interconnect type
- Processors/Socket/CPU
  - Cores per socket
- CPU Cores
  - Clock,
  - TURBO, Hyper-Threading
- Memory (DIMMS, Channels)
  - Size and distribution
- Storage
  - Types of storage
- Resource Management
- Recommended Configurations
  - Small, Medium, Large
CPU Clock

- **Decision point**
  - What CPU clock to use?
- **Xeon X5600 clock range**
  - 2.67 GHz to 3.47 GHz (3.6 GHz)
- **Always some improvement – 5% to 10%**
  - well short of 30% or more clock ratio
  - ANSYS Fluent specific
- **Improves utilization of fixed number of licenses**
- **Recommendation**
  - Use Xeon X5675 (3.06 GHz, 95 watt)
  - Consider other parts of cluster for further investment before choosing fastest clock
Turbo Boost

- Decision point
  - TURN TURBO Boost ON or OFF?
- Intel® Turbo Boost Technology 2.0 automatically allows processor cores to run faster than the base operating frequency if it is operating below power, current, and temperature specification limits
- More benefit when
  - less cores are active
  - the workloads are moderate
- TURBO gives Quad-core slightly more boost than 6-core
- In larger clusters, as the workload is spread over more nodes there are more opportunities for 6-core processors to achieve similar boost in performance as quad-core
- Recommendation
  - Turbo Boost should always be turned on to get more performance
Hyper-threading

- Decision point
  - Use Hyper-Threading or NOT?
- Intel® Hyper-Threading (HT) Technology uses processor resources more efficiently, enabling two threads to run on each core – App see twice the cores
- HT improves ANSYS Fluent performance by a small %
- Requires double the number of licenses
- Recommendation
  - If the license configuration permits
    - HT should be used to improve HW and SW utilization
  - If the number of licenses is limited
    - HT is not an efficient utilization of the licenses and is not recommended (HT may turned on but is used by ANSYS Fluent)
Decision Point
- Use 2-socket or 4-socket systems?
- 2-socket based system use X5600 series
  - up to maximum of 12 cores per system
- 4-socket systems use e7-8800 series
  - up to a maximum of 40 cores per system; good scalability
  - 32 cores (one 4-socket system) give performance equivalent to 24 cores (two 2-socket systems)

Recommendation
- If the application can run within a single 4-socket
  - Use 4-socket based cluster
  - No high-speed network is needed
- Otherwise use clusters made out of 2-socket based system
  - High speed network needed

Fluent Rating = Number of Benchmark jobs that can be run in 24 hours
(higher values are better)
Processor Core Density Selection

- Decision Point
  - Use quad-core or 6-core processors?
- Processors come in Quad and Hex cores
- Quad core processors have higher per core cache and memory bandwidth
  - ANSYS Fluent runs 20% to 30% faster on quad-core based systems
    - Improves productivity of fixed number of licenses
  - Costs 50% more than 6-core based systems for the same total core count

- Recommendation
  - If the primary goal is to improve productivity of licenses
    - Used quad-core based systems
  - If the total cluster cost is a primary consideration
    - Use 6-core based systems

Fluent Rating = Number of Benchmark jobs that can be run in 24 hours
(higher values are better)
Memory Configuration

- **Decision Point**
  - What is the most efficient memory config?
- Faster memory improves performance of ANSYS Fluent – about 10%
- Xeon 5600 Series Processors/Memory can run at the maximum speed of 1333 MHz
- Memory should be configured properly
  - Otherwise the memory may run at slower speeds of 1066 MHz or even at 800 MHz
- **Recommendation**
  - To operate at maximum speed all memory channels in both processors should be populated with equal amounts of memory
    - memory guidelines specify that total memory is in discrete amounts of 24 GB, 36 GB, 48 GB … per node.
    - 24 GB memory per node is sufficient
**Networks**

- **Decision Point**
  - What network to use?
- **Choices are 10 Gigabit and Infiniband**
- **Measures to evaluate**
  - Latency and bandwidth
  - ANSYS Fluent is more sensitive to latency than bandwidth
    - messages <1K can be as high as 80% on large networks
- **ANSYS Fluent performance is comparable on both 10-Gigabit and Infiniband for small clusters**
  - Use direct access (e.g., iWARP) protocols for 10-Gigabit networks
- **Infiniband will optimize application performance resulting in better scalability for larger clusters**

- **Recommendation**
  - Use 10G for small clusters
  - Infiniband for larger clusters

---

<table>
<thead>
<tr>
<th>Network</th>
<th>Protocol</th>
<th>Latency (micro sec)</th>
<th>Bandwidth (Mbytes/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gigabit</td>
<td>TCP/IP</td>
<td>26</td>
<td>110</td>
</tr>
<tr>
<td>10-Gigabit</td>
<td>iWARP</td>
<td>8.4</td>
<td>1150</td>
</tr>
<tr>
<td>4X QDR Infiniband</td>
<td>VERBS or PSM</td>
<td>1.6</td>
<td>3200</td>
</tr>
</tbody>
</table>
Decision Point
- What type of Infiniband network?

Several types of IB networks
- DDR, QDR, FDR so far, EDR next
- Bandwidth is the main differentiator
  - Some improvement in latency
- ANSYS Fluent is more sensitive to latency than bandwidth
  - Performance of FDR may not be commensurate with its cost

ANSYS Fluent does not seem to be sensitive to blocking in Infiniband

Recommendation
- Use 4X QDR Infiniband
- A blocking factor of 2:1 or even 4:1
- PSM for qLogic/Intel
- VERBs for Voltaire/Mellanox

Model | Fluent Rating (Higher Values are better) |
--- | --- |
| | Non-blocking | 4:1 Blocking | 8:1 Blocking |
Truck_14m | 329 | 327 |
Eddy_417k | 16255 | 16225 |

Source: Intel/qLogic
Cluster Size (nodes)

- Decision Point
  - How to determine number of nodes in the cluster?
- Depends on a number of factors:
  - Business value, budget
  - Environment (space, power etc)
- Cluster size can be highly scalable but not feasible due to total cost and other factors
- Recommendation
  - Determine the Feasible Performance-Price Spectrum
    - Eliminating some obvious infeasible choices
      - e.g. too big, too small, does not fit in the existing data center
    - Conduct ROI Analysis on the promising candidates
Storage Options

- The options are numerous
  - Ranging from simple local disks to enterprise level storage
  - Simple local file system to NFS to parallel file system (GPFS)
- One solution does not fit all
- NFS has some limitations but simple
- GPFS scalable and more complex
- A full webcast is planned to discuss the choices and recommendations
  - Coming up in June

![Graph: ANSYS/FLEUNT I/O Performance on different storage solutions]

Cluster: dx360 M3 (Intel Xeon x5670, 2.93 GHz)
Multiple simultaneous jobs - Each job using 96 cores
Westmure/Sandy Bridge Comparison

<table>
<thead>
<tr>
<th></th>
<th>Westmure</th>
<th>Sandy Bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>X5600 series</td>
<td>E5-2600 series</td>
</tr>
<tr>
<td>Cores/processor</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Cores/system</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Specfp Rate (single system)</td>
<td>1.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Specint Rate (single system)</td>
<td>1.0</td>
<td>1.85</td>
</tr>
<tr>
<td>Fluent (single system)</td>
<td>1.0</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Source: Intel.com

- **Pack more compute power (performance)**
  - 32 nodes (12 cores each) of Westmere – 384 cores
  - 32 nodes (16 cores each) Sandy bridge – 512 cores
    - ~40 to 50% faster *(estimate)*
    - More licenses

- **Reduce the size of cluster (cost)**
  - 32 nodes (12 cores each) of Westmere – 384 cores
  - 24 nodes (16 cores each) Sandy bridge – 384 cores
    - ~10% to 20% faster *(estimate)*
    - Same number of licenses
Cluster Packaging

**Decision Point**
- Rack, Blade, High Density server?
- ANSYS Fluent performance is not affected by what packaging you select
- Total freedom to choose the right packaging based on other factors
  - Data center environment
  - Budget

**A Recommendation**
- For low entry point (one or two servers)
  - Use rack server
- Small and Medium
  - Use blade configuration
- Large
  - Use high density configuration

<table>
<thead>
<tr>
<th>Capability</th>
<th>Rack</th>
<th>Blade</th>
<th>High Density</th>
<th>ANSYS Fluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (servers/sq ft floor space)</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Not a factor</td>
</tr>
<tr>
<td>Node Capabilities</td>
<td>Lots of I/O options, memory</td>
<td>Much less</td>
<td>Much less</td>
<td>Not a factor</td>
</tr>
<tr>
<td>Processors speeds</td>
<td>Top speed slightly more</td>
<td>Little less</td>
<td>Little less</td>
<td>Not a factor</td>
</tr>
<tr>
<td>Integration</td>
<td>Less</td>
<td>Moderate</td>
<td>High</td>
<td>Not a factor</td>
</tr>
</tbody>
</table>
Recap

Cluster Selection
• Concepts
• Decision points
  – Best Practices
    • Precise where possible
    • Guidelines otherwise
    • ANSYS Fluent specific
      – Take other coexisting apps into consideration
• Technology Transition
  – Intel Westmere
  – Intel Sandy Bridge

Next Steps
• Translate into real products
• Manage the cluster resources
IBM System Recommendations

Gaurav Chaudhry, System-X Worldwide Marketing, IBM
gaurav@us.ibm.com

William Lu, Product Management, Platform Computing, an IBM Company
wlu@ca.ibm.com
Recommended Configurations

SMALL – 2-Socket based
- Typical Users
  - Several simultaneous single node jobs
    - High speed interconnect is not required
  - Size of each job under a few million cells
- Blade Center S (BC-S) with up to 6 HS22 blades
  - HS22 - two Xeon X5675 3.06 GHz 6C - 48GB
- File System/Storage is through up to 12 SAS Drives in BC-S, NFS
- OS Support: RedHat, SuSe and Windows
- Access: through ANSYS Remote Simulation Manager, Platform LSF

SMALL – 4-Socket based
- Typical Users
  - Several simultaneous larger single node jobs
    - High speed interconnect is not required
  - Size of each job up to ~10 million cells
- Blade Center S (BC-S) with up to 3 HX5 blades
  - HX5 – four Xeon E7-8837 3.06 GHz 8C - 128GB
- File System/Storage is through up to 12 SAS Drives in BC-S, NFS
- OS Support: RedHat, SuSe and Windows
- Access: through ANSYS Remote Simulation Manager, Platform LSF

BladeCenter S
- Head Node/ File Server/ Compute Node1
  - Compute Node 2
  - Compute Node 3
  - Compute Node 6
  - Shared (NFS) BladeCenter S Storage
Recommended Configurations

Medium - 2-Socket based

- Typical Users
  - Several simultaneous multi-node jobs
  - Size of each job up to ~10 million cells
- Blade Center H (BC-H) with up to 14 HS22 blades (up to 168 cores)
  - HS22 - two Xeon X5675 3.06 GHz 6C - 48GB
- Network: Gigabit, 10-Gigabit
- File System/Storage
  - External DS3500 disk system with SAS connectivity
  - NFS
- OS Support
  - RedHat, SuSe and Windows
- Access: through ANSYS Remote Simulation Manager, Platform LSF
Recommended Configurations

Large - 2-Socket based

- Typical Users
  - A large number of simultaneous multi-node ANSYS Fluent Solver Phase jobs
  - One extreme-scale Solver Phase job using all nodes (using up to 828 cores)
  - The size of each job can range from a few million to hundreds of millions

- iDataplex with up to 72 dx360 M3 nodes
  - Dx360 M3 - two Xeon X5675 3.06 GHz 6C - 48GB

- Network: Gigabit, Infiniband

- File System/Storage
  - External disk DCS3700 with SAS connectivity
  - GPFS

- OS Support: RedHat, SuSe and Windows HPC

- Access: through ANSYS Remote Simulation Manager, Platform LSF
IBM BladeCenter HS23

Do more now in the datacenter you own today

Benefits

• **Lower cost**
  Up to 30% savings for the solution

• **Enhanced performance**
  62% more compute power, 20% more VMs

• **Simple setup**
  Accelerate time to value for deployment

• **Breakthrough networking flexibility**
  Built in support for multiple technologies

• **Complete investment protection**
  Add capability to existing investments

Key Features

• Integrated 10GbE Virtual Fabric for high speed networking

• Includes latest compute, network, and storage technology

• IBM FastSetup wizard tool for day 0 deployments

• Up to 18 networking ports of Ethernet, FCoE, and iSCSI

• Support for existing chassis infrastructure

---

3 Using integrated Virtual Fabric solution vs. separate components.
4 Source: Intel Corp.
IBM System x3650 M4

Benefits

• Performance Leadership in its class
• Business flexibility
  Optimize for performance and cost
• Advanced networking
  Optimize for performance and connectivity
• Reliable IT
  Highest level quality to safely run your business

Key Features

• Up to 80% more performance\(^5\) for customers’ critical applications and top scores for SAP, OLTP and virtualization
• 2.6x memory with up to 768 GB memory, full set of processors, 2.5” or 3.5” drives
• Twice the 1GbE ports and slotless 10GbE Virtual Fabric upgrade from multiple vendors and protocols
• #1 customer satisfaction from TBR\(^6\) due to features like Predictive Failure Analysis and Light Path Diagnostics

---

\(^5\) Source: Intel Corp.

\(^6\) IBM has been ranked #1 in x86 server satisfaction from Technology Business Research for 10 straight quarters.
IBM System x3550 M4

Dense 1U for business critical workloads

Key Features

• Up to 80% more performance for customers’ critical applications for up to 24:1 consolidation of 3 year old servers¹

• 2.6x memory with up to 768 GB memory, full set of processors, 2.5” or 3.5” drives

• Twice the 1GbE ports and slotless 10GbE Virtual Fabric upgrade from multiple vendors and protocols

• #1 customer satisfaction from TBR² due to features like Predictive Failure Analysis and Light Path Diagnostics

Benefits

• High Performance
  Run more applications than ever before

• Business flexibility
  Optimize for performance and cost

• Advanced networking
  Optimize for performance and connectivity

• Reliable IT
  Leadership quality for distributed environments running critical workloads


² Source: TBR
IBM System x3500 M4

Ideal for distributed locations

Key Features

- Up to 80% more performance for customers’ critical applications for up to 24:1 consolidation of 3 year old servers
- 4x memory with up to 768 GB memory, full set of processors, 2.5” or 3.5” drives
- Twice the 1GbE ports and 10GbE Virtual Fabric upgrade from multiple vendors and protocols
- Up to 32 2.5” hard drives with flexible RAID in a tower or 5U rack design

Benefits

- High Performance
  Run more applications than ever before
- Business flexibility
  Optimize for performance and cost
- Advanced networking
  Optimize for performance and connectivity
- Room to grow
  Massive internal storage and I/O for distributed environments

IBM System x iDataPlex dx360 M4

High performance for power and cooling constrained environments

Benefits

• High Performance
  Run more applications than ever before

• Designed for HPC
  Outstanding performance for computationally intensive workloads

• High efficiency
  Up to 40% efficiency advantage over air cooled systems

• Business flexibility
  Outstanding flexibility and performance for support of high performance solutions

Key Features

• Up to 120% more performance for HPC applications

• Up to 4 GPUs per chassis, 1.5x memory capacity, slotless InfiniBand networking

• Industry leading node level optional direct warm water cooling technology

• Available slotless InfiniBand or 10Gb Ethernet upgrade with a variety of vendors and protocols

---

9 Compared with iDataPlex dx360 M4 systems without warm-water cooling.
10 Source: Intel Corp.
IBM Intelligent Cluster

Integrated Solution

Servers

Interconnect

Storage

Operating Systems

IBM Services

IBM Intelligent Cluster combines all hardware, software, services and support into a single integrated product offering, providing clients the benefit of a single point-of-contact for the entire cluster that is easily deployed and managed.

- System x servers
- OEM IO Interconnects
- Storage
- Cabling
- Integration, configuration and testing
- Delivery, on-site setup and support

1/10/40Gb Eth QDR/FDR IB

GPFS
Fully integrated cluster management software for ease of deployment, ease of use, and ease of operation.
Integration with ANSYS applications

**ANSYS Remote Solver Manager**
- Submit and manage ANSYS FLUENT jobs through ANSYS RSM with the integration of Platform LSF and Platform MPI

**Remote Visualization Integration**
- Schedule and launch remote visualization sessions using Platform LSF and Platform Application Center
Wrap Up / Next Steps

Specifying a cluster for ANSYS simulation can be challenging; Let ANSYS and IBM help you succeed!

Contact us:

• hpcinfo@ansys.com
• hnreddy@us.ibm.com
• gaurav@us.ibm.com
• wlu@ca.ibm.com

And look for our invitation to download the “IBM IT Guide for ANSYS Fluent Customers”
### Confidence by Design Workshops

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newark</td>
<td>April 19</td>
</tr>
<tr>
<td>Orlando</td>
<td>May 2</td>
</tr>
<tr>
<td>Minneapolis</td>
<td>May 8</td>
</tr>
<tr>
<td>Seattle</td>
<td>May 15</td>
</tr>
<tr>
<td>Chicago</td>
<td>June 14</td>
</tr>
<tr>
<td>Phoenix</td>
<td>April 26</td>
</tr>
<tr>
<td>Salt Lake City</td>
<td>May 4</td>
</tr>
<tr>
<td>San Diego</td>
<td>May 8</td>
</tr>
<tr>
<td>Boston</td>
<td>May 17</td>
</tr>
<tr>
<td>Houston</td>
<td>June 20</td>
</tr>
<tr>
<td>Denver</td>
<td>May 2</td>
</tr>
<tr>
<td>Baltimore</td>
<td>May 7</td>
</tr>
<tr>
<td>San Jose</td>
<td>May 10</td>
</tr>
<tr>
<td>Detroit</td>
<td>June 5</td>
</tr>
</tbody>
</table>

**Register Now:**

[www.ansys.com/Confidence](http://www.ansys.com/Confidence)
Interested in Live Training Sessions with ANSYS Experts?

Training classes are offered both locally and online.

View the entire schedule at:
http://www.ansys.com/Support/Training+Center

Topics include:
• Introduction to ANSYS Mechanical
• Introduction to ANSYS DesignModeler
• Introduction to ANSYS FLUENT
• Introduction to ANSYS Icepak
• Introduction to ANSYS HFSS
• Introduction to ANSYS Explicit Dynamics
• Introduction to ANSYS ICEM CFD
• And Many More…
To Ask a Question:

Click on the Q&A tab in the WebEx Toolbar

Webinar Recording:
Available in one week’s time in the ANSYS Resource Library at www.ansys.com/resource+library
Trademarks and disclaimers

Intel, Intel logo, Intel Inside, Intel Inside logo, Intel Centrino, Intel Centrino logo, Celeron, Intel Xeon, Intel SpeedStep, Itanium, and Pentium are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries. Linux is a registered trademark of Linus Torvalds in the United States, other countries, or both. Microsoft, Windows, Windows NT, and the Windows logo are trademarks of Microsoft Corporation in the United States, other countries, or both. IT Infrastructure Library is a registered trademark of the Central Computer and Telecommunications Agency which is now part of the Office of Government Commerce. ITIL is a registered trademark, and a registered community trademark of the Office of Government Commerce, and is registered in the U.S. Patent and Trademark Office. UNIX is a registered trademark of The Open Group in the United States and other countries. Java and all Java-based trademarks and logos are trademarks or registered trademarks of Oracle and/or its affiliates. Other company, product, or service names may be trademarks or service marks of others. Information is provided "AS IS" without warranty of any kind.

The customer examples described are presented as illustrations of how those customers have used IBM products and the results they may have achieved. Actual environmental costs and performance characteristics may vary by customer.

Information concerning non-IBM products was obtained from a supplier of these products, published announcement material, or other publicly available sources and does not constitute an endorsement of such products by IBM. Sources for non-IBM list prices and performance numbers are taken from publicly available information, including vendor announcements and vendor worldwide homepages. IBM has not tested these products and cannot confirm the accuracy of performance, capability, or any other claims related to non-IBM products. Questions on the capability of non-IBM products should be addressed to the supplier of those products.

All statements regarding IBM future direction and intent are subject to change or withdrawal without notice, and represent goals and objectives only.

Some information addresses anticipated future capabilities. Such information is not intended as a definitive statement of a commitment to specific levels of performance, function or delivery schedules with respect to any future products. Such commitments are only made in IBM product announcements. The information is presented here to communicate IBM’s current investment and development activities as a good faith effort to help with our customers’ future planning.

Performance is based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user’s job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput or performance improvements equivalent to the ratios stated here.

Prices are suggested U.S. list prices and are subject to change without notice. Starting price may not include a hard drive, operating system or other features. Contact your IBM representative or Business Partner for the most current pricing in your geography.

Photographs shown may be engineering prototypes. Changes may be incorporated in production models.

© IBM Corporation 2012 All rights reserved.
References in this document to IBM products or services do not imply that IBM intends to make them available in every country.