SIMPLIFYING HPC
FOR ENGINEERING SIMULATION WITH ANSYS
ACCELERATING RESEARCH THROUGH HIGH PERFORMANCE COMPUTING (HPC) SOLUTIONS

"THE COLLABORATIVE RELATIONSHIP WITH DELL PLAYS AN IMPORTANT ROLE IN OUR COMPUTE MODEL, HELPING US DEPLOY SYSTEMS FASTER THAT RUN FIRST-OF-KIND SIMULATIONS."

STANFORD UNIVERSITY
STEVE JONES
MANAGER OF HIGH-PERFORMANCE COMPUTING, FLOW PHYSICS AND COMPUTATIONAL ENGINEERING

RESEARCH, RESULTS, AND RETURN

THE DELL™ WAY

We are an acknowledged leader in academic supercomputing—including major HPC systems installed at the Cambridge University Innovation Centre, University College London, Stanford and the Hyperion system at Lawrence Livermore National Laboratory. Now Dell is using the knowledge and experience gained in this field to enable organizations to accelerate research by deploying high performance computing at a price that is affordable at a departmental level. Furthermore, the package is easy to deploy and manage, freeing you up to concentrate on your research.
SIMPLIFYING HPC FOR COMPUTER AIDED ENGINEERING

<table>
<thead>
<tr>
<th>NEEDS</th>
<th>DELL HPC ANSWERS</th>
<th>PACKAGED HPC SOLUTIONS FOR CAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple to deploy and use computational power to be competitive</td>
<td>Simplified HPC solutions that can support your computational demands</td>
<td>✓</td>
</tr>
<tr>
<td>Ease-of-everything</td>
<td>Reference architectures with pre-integrated, pre-tested, standards-based elements, plus the service levels you need</td>
<td>✓</td>
</tr>
<tr>
<td>Investment security</td>
<td>Intel Xeon Processors, standard operating systems and interconnects, and reference architecture, open standards</td>
<td>✓</td>
</tr>
<tr>
<td>Cluster Management complexity</td>
<td>Reference architectures pre-integrated and pre-tested, with the support of the Intel Cluster Ready Program</td>
<td>✓</td>
</tr>
<tr>
<td>Ability to grow fast</td>
<td>Accelerate HPC adoption with latest technologies and best practices</td>
<td>✓</td>
</tr>
</tbody>
</table>

SPEED, SCALE, SIMPLIFY

Focused computing power helps get the job done, faster, better and with less expense, delivering results more quickly and more often. Technology and applications form a system, a means to an end, and the greater the confidence in the computing system, the more the focus can be on the project and the results. Systems should be easy to deploy, manage, maintain and grow as needs change. They should ‘just work’.

We, at Dell, are committed to enabling discovery and accelerating research by providing the best computing systems available to researchers and scientists, focusing on platforms, partners, integration and use to deliver speed, scale and simplicity. At the core of our system is a modular HPC infrastructure stack built from industry-standard hardware and software components and other best-of-breed products. The Dell HPC system can help you achieve the performance and scalability required by the most demanding of applications using a fraction of the resources needed by proprietary systems.

THE CONFIDENCE OF THE INTEL® CLUSTER READY PROGRAM

Dell and Intel are collaborating to build Intel-based clusters that are tested and certified to achieve greater stability and portability of registered applications across an interoperable solution stack. The program enables organizations to deploy High Performance Computing Clusters with confidence, safe in the knowledge that they can reduce total cost of ownership (TCO) and risk, and maintain high quality levels of service over the lifetime of the cluster.

http://www.intel.com/go/cluster

POWERFUL CLUSTER MANAGEMENT SOFTWARE, READY TO SUPPORT YOUR APPLICATIONS

Dell HPC Solutions are available with Platform Cluster Manager-Dell Edition Software, to provide powerful yet simple cluster deployment and management. This powerful software stack includes all the tools you need to be up and running quickly.

Also included is Platform MPI, one of the better and more mature MPI implementations and an essential element in accelerating complex computational problems. To further enhance the performance and ease of use of applications, Platform MPI provides custom built kits for individual CAE applications to ensure the cluster is able to exploit the full potential of your investment.

Platform LSF, the world’s leading Workload Manager, is also available on all new Dell Clusters. This powerful scheduler provides seamless integration with your CAE applications to present users with an easy-to-use web interface to place workloads onto the system.
ANSYS, Inc. provides engineering simulation software that helps product development teams understand and predict how products will behave in real-world environments. With unparalleled breadth and depth for comprehensive multiphysics simulation, technologies from ANSYS can be deployed throughout all stages of product development. ANSYS helps product developers deliver innovative products and processes that meet customer requirements, with faster time-to-market and reduced engineering costs. Using simulation, designs can be optimized at early stages of development, reducing the number of physical prototypes and tests required, leading to a faster and more cost-effective design process.

ANSYS HPC

High Performance Computing (HPC) and parallel processing with ANSYS® HPC add significant value to simulation by enabling enhanced insight into product performance and improving the productivity of the design process. ANSYS solutions are engineered for scalability, allowing simulation to be applied at the appropriate level of detail, whether for simple initial design studies or highly detailed optimization work. As simulation complexity increases, ANSYS HPC solutions ensure that turn-around times remain low and that results become available in time to impact engineering decisions. ANSYS HPC delivers parallel processing capability for the full spectrum of its simulation software, supporting structural, fluids, thermal, and electromagnetic simulations in a single HPC solution.

ENHANCED INSIGHT AND PRODUCTIVITY

Parallel processing with ANSYS HPC allows you to consider higher-fidelity models, including more geometric detail, larger systems, and more complex physics. The resulting enhanced insight into product performance cannot be gained any other way.

This detailed understanding can yield enormous business benefits by revealing design issues that might otherwise lead to product failure or troubleshooting delays. Using ANSYS HPC to understand detailed product behavior gives you confidence in your design and helps ensure that your product will succeed in the market.

ANSYS HPC also increases throughput by speeding up turn-around times for individual simulations, enabling you to consider multiple design ideas and make the right design decisions early in the design cycle. ANSYS HPC makes your engineering staff, and your product development process, more productive and efficient since you won’t be waiting for answers or making design decisions based on single point solutions.

PERFORMANCE AND EASE OF USE

ANSYS has made a sustained investment in HPC software innovation and development, culminating in the ANSYS HPC performance you can take advantage of today.

Tuned for optimum speed on the fastest multicore processors, ANSYS HPC solutions deliver nearly linear scaling efficiency. From typical simulations using 8, 16, 32, or 64 cores to grand challenge problems running on thousands of cores, ANSYS HPC is designed for ease of use. A few simple menu options allow you to set up and launch ANSYS HPC and start benefiting from the value of a work group cluster.
SIMPLIFYING HPC END-TO-END

The fundamental objective of our departmental HPC solutions is to make it simple for organizations to acquire the maximum amount of computing power for the budget available. We achieve this by simplifying the process of acquiring, implementing and maintaining every component of the HPC deployment across its entire lifespan, through a single accountable source.

VALIDATED CONFIGURATIONS

Our expert consultants have used proven methodologies to define pre-configured 32 (4 Node), 128 (16 Node), and 256 (32 Node) Core packages, all of which have been verified by our Solutions Engineering team. You therefore have the reassurance that each package can deliver defined levels of performance and reliability, while still providing you with the flexibility to scale by adding or subtracting cores as required. For each deployment the HPC design architects team reviews the type of processing the HPC cluster will be required to perform and verifies that the proposed equipment stack is the optimal solution for that particular environment.

AN INTEGRATED APPROACH

Our HPC solutions are based on tightly integrated solution stacks, configured and tested for both Linux® and Microsoft® Windows® environments. Dell integrates best-of-breed server and storage technologies with leading open source and proprietary middleware to deliver highly sophisticated and scalable platforms that deliver outstanding price/performance, scalability and manageability. Dell High-performance computing (HPC) solutions based on the new Intel® Xeon® processor 5500 series deliver intelligent, energy-performance for a full range of HPC applications. Capitalize on dynamic performance capabilities, significantly greater memory bandwidth, and energy-efficiency features to create, simulate, analyze, and visualize more information—faster than ever before.

IMPLEMENTATION SERVICES

When implementing HPC solutions Dell’s technical architects work hard to understand your specific computing environment in terms of functional, technical and operational requirements. Dell solutions are based on existing, validated architectures employing best practices. So whether you take a pre-configured solution or use one as a base to build a customized deployment, we greatly reduce the consultancy and implementation time and cost involved in meeting your needs.

DELL HPC IMPLEMENTATION SERVICES INCLUDE:

- Full solution project management through to completion
- Detailed planning and design documentation including timelines
- Hardware configuration and installation
- Implementation of the hardware, Storage Area Network and HPC cluster management software stack
- Product orientation to familiarize users with hardware, software and implementation resources

CHOICE OF OPERATING SYSTEMS

You can choose your operating environment from any of the leading operating systems, including Red Hat Enterprise Linux or the Microsoft Windows cluster products, with out-of-the-box functionality improving productivity and reducing complexity.

HPC SUPPORT SERVICES

The Dell ProSupport service provides a “single point of entry” for all hardware and operating system problems, ensuring that any issues can be escalated and dealt with quickly and efficiently. ProSupport provides you with the level of service your organization needs and also includes Fast-Track dispatch, enabling trained and certified customers to log their own problem tickets, initiate the repair cycle, and even arrange dispatch of hardware replacement units.

FINANCE

Leasing rather than purchasing can enable you to achieve smoother and far more cost-efficient acquisition, management, replacement and disposal of the technology on which your research depends. Dell Financial Services can help you to acquire the technology you need more economically, turning large upfront costs into more manageable payments over time.
Until now many users have been deterred from deploying HPC at a workgroup/department level by the complexity and cost of acquiring, deploying and managing a cluster. Now we have combined our knowledge and experience in supercomputing to provide an entry-level HPC solution that answers the computational needs of workgroups and departments.

To simplify comparison of the HPC packages available from Dell, we have shown top line benchmarks, validated configurations and component details for each, as detailed below and on the following pages.

<table>
<thead>
<tr>
<th></th>
<th>Master Node</th>
<th>Slave Nodes</th>
<th>Cores</th>
<th>Infiniband Switch</th>
<th>Master Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLAVE NODES</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROCESSORS</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CORES</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INFINIBAND SWITCH</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MASTER NODE</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“WITH THE NEW INTEL-BASED DELL SYSTEMS WE HAVE INCREASED OUR CPU PERFORMANCE BY SEVERAL HUNDRED PERCENT”

TRW
RÜDIGER EHRHARD
IS ENGINEERING SYSTEMS

[Intel Xeon Inside] Powerful Intelligent
FLUID SIMULATION WORKLOAD

This entry-level 4-node / 32 core system is capable of running several simultaneous ANSYS® FLUENT® or ANSYS CFX® simulation models in the size range of 2-3M cells. Fully utilizing the 24GB of system memory per compute node, this configuration can handle simulation model sizes up to 40-50M cells.

APPLICATION BENCHMARK

For the latest benchmarks visit DELL.COM/hpc

STRUCTURES SIMULATION

This cluster can run several simultaneous ANSYS® Mechanical™ in the size range of 1M to 10M DOF. Depending on solution type and memory configuration, model sizes up to 50 MDOF can be considered.

APPLICATION BENCHMARK

For the latest benchmarks visit DELL.COM/hpc

ANSYS FLUENT 12.0 BENCHMARK RESULT

For Aircraft_2M (External flow over an aircraft wing, hexahedral mesh)

For Truck_14M (External flow over a truck body, mixed cell type)

For Truck_Poly_14M (External flow over a truck body with polyhedral mesh)

The performance results below show that the amount of time needed to complete the benchmarks mentioned decreases almost linearly with the increase of the amount of nodes. This is achieved due to the efficient implementation of software from ANSYS on the distributed computational resources.

The benchmarks are performed on a Dell M1000e blade chassis with 16 M610 blade servers, each equipped with two Intel XEON X5570 CPUs and 24GB of memory each. The servers are connected with a Mellanox M3601Q QDR Infiniband switch in the blade chassis. When using different CPUs in the same platform, the scaling will be similar.

(For these benchmarks we used Red Hat Enterprise Linux 5U3 with the OFED 1.4 IB stack)

*Benchmarking for 256 core available on request.
VALIDATED CONFIGURATION
FOR 32 CORE HPC CLUSTER

TURNKEY

Our 4 node cluster example is based on Dell PowerEdge R410 compute nodes equipped with two powerful energy-efficient Intel Xeon L5520 quad-core processors with 2.26 GHz CPU clock rate and 24 GB of main memory (6x 4GB). For parallel applications spanning more than one compute node a Gigabit Ethernet interconnect is supplied to facilitate adequate message passing functionality for a large class of parallel applications. A separate fast Ethernet network has been configured for administrative use. Benchmark performed with InfiniBand interconnect.

The master node and NFS File server is a Dell PowerEdge R710 (2U) with Intel Xeon L5520 quad-core processors with 2.26 GHz clock rate and 48GB (12x 4GB) of main memory, and 4 TB RAID 5 mass storage for the compute nodes to access through NFS. A retractable 1U LCD display with keyboard and mouse completes this capable standalone cluster. The price includes full installation by Dell in a 24" rack (also included). A choice of operating system is available – either Linux or Microsoft Cluster Server.

For more information about other Dell cluster options contact your Dell Account Manager or visit DELL.COM/hpc

THE DELL AND INTEL APPROACH TO ENERGY EFFICIENCY
Dell PowerEdge servers, based on the latest 45 nm-intel Xeon technology with Intel CoreTM architecture are designed with both energy efficiency and performance in mind. Choose a certified Intel® Cluster Ready system and registered Intel Cluster Ready applications and make it simple to access the intelligent, energy-efficient performance of the Intel® Xeon® processor 5500 series. With Intel Cluster Ready, gain the confidence that HPC hardware and software will work together, right out of the box.
For departments running a wide range of parallel applications and therefore requiring more compute power, we have designed and validated a 16 node cluster utilizing Dell’s recently introduced state-of-the-art blade system.

To simplify comparison of the HPC packages available from Dell, we have shown top line benchmarks, validated configurations and component details for each, as detailed below and on the following pages.

<table>
<thead>
<tr>
<th>SLAVE NODES</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROCESSORS</td>
<td>32</td>
</tr>
<tr>
<td>CORES</td>
<td>128</td>
</tr>
<tr>
<td>INFINIBAND SWITCH</td>
<td>1</td>
</tr>
<tr>
<td>MASTER NODE</td>
<td>1</td>
</tr>
</tbody>
</table>

"By putting the Dell Blade Cluster onboard the Endeavor we've eliminated at least two months of wait time for the customer."

GEOTRACE.
MATT GASKAMP
DATA CENTER OPERATIONS MANAGER
ANSYS ENGINEERING SIMULATION WORKLOADS

**FLUID SIMULATION WORKLOAD**
This 16-node / 128 core system is capable of running 12 or more simultaneous ANSYS FLUENT® or ANSYS CFX® simulation models in the size range of 2-3M cells, and several simulations in the size range of 10M cells. Fully utilizing the 24GB of system memory per compute node, this configuration can handle simulation model sizes up to 200M cells.

**APPLICATION BENCHMARK**
For the latest benchmarks visit DELL.COM/hpc

**STRUCTURES SIMULATION**
This cluster can run multiple simultaneous ANSYS® Mechanical simulations in the size range of 1M to 10M DOFS. Depending on solution type and memory configuration, model sizes up to 100 MDOF can be considered.

**APPLICATION BENCHMARK**
For the latest benchmarks visit DELL.COM/hpc

PERFORMANCE

As an example of how the pre-configured clusters perform with real-world applications, we include benchmark results for the following three well-known ANSYS FLUENT benchmarks:

- Aircraft_2M (External flow over an aircraft wing, hexahedral mesh)
- Truck_14M (External flow over a truck body, mixed cell type)
- Truck_Poly_14M (External flow over a truck body with polyhedral mesh)

The performance results below show that the amount of time needed to complete the benchmarks mentioned decreases almost linearly with the increase of the amount of nodes. This is achieved due to the efficient implementation of software from ANSYS on the distributed computational resources.

The benchmarks are performed on a Dell M1000e blade chassis with 16 M610 blade servers, each equipped with two Intel XEON X5570 CPUs and 24GB of memory each. The servers are connected with a Mellanox M3601Q QDR Infiniband switch in the blade chassis. When using different CPUs in the same platform, the scaling will be similar.

(For these benchmarks we used Red Hat Enterprise Linux SU3 with the OFED 1.4 IB stack)

*Benchmarking for 256 core available on request.*
VALIDATED CONFIGURATION
FOR 128 CORE HPC CLUSTER

POWERCONNECT 6224 GIGE SWITCH PLUS INFINIBAND SWITCH
for administrative and file serving purposes
R710
Head/Master Node
M1000e CHASSIS
With 16 x M610 Servers
And QDR Infiniband switch

1U 17” LCD MONITOR
KEYBOARD AND MOUSE

128 CORE (16 node) cluster example is based on our recently introduced state-of-the-art PowerEdge M610 Blade Servers. This M1000e Chassis has been configured with 16 x M610 blades and QDR Infiniband switch, each blade having two Intel Xeon L5520 quad-core processors with 2.26 GHz CPU clock rate and 24 GB (6 x 4GB) of main memory. For parallel applications spanning more than one compute node a Gigabit Ethernet interconnect is supplied to facilitate adequate message passing functionality for a large class of parallel applications. A separate fast Ethernet network has been configured for administrative use. This configuration is extremely compact (128 cores in a 10U chassis), has best-of-class power consumption characteristics and needs very little external cabling. Benchmark performed with InfiniBand interconnect.

The master node and NFS File server is a Dell PowerEdge R710(2U) with Intel Xeon L5520 quad-core processors with 2.26 GHz clock rate and 72GB (18x 4GB) of main memory and 8 TB of mass storage which the compute nodes access through NFS. A retractable 1U LCD display with keyboard and mouse completes this capable stand alone cluster. The price includes full installation by Dell in a 24” rack (also included). A choice of operating system is available – either Linux or Microsoft Cluster Server.

For more information about other Dell cluster options contact your Dell Account Manager or visit DELL.COM/hpc

THE DELL AND INTEL APPROACH TO PERFORMANCE

Dell PowerEdge servers, based on the latest 45 nm-Intel Xeon technology with Intel Turbo Boost Technology automatically and intelligently adjust server performance according to your application needs for an up to 9x performance gain over single-core servers. So you’ll get maximum performance when you need it and gain big energy savings when you don’t.
## 256 CORE HPC CLUSTER

For departments requiring additional message passing capability for a wide range of large class parallel applications, we have designed and validated a 32 node cluster utilizing Dell's highly scalable R610 and R710 PowerEdge servers powered by Intel.

To simplify comparison of the HPC packages available from Dell, we have shown top line benchmarks, validated configurations and component details for each, as detailed below and on the following pages.

| SLAVE NODES | 32 |
| PROCESSORS  | 64 |
| CORES       | 256 |
| INFINIBAND SWITCH | 1 |
| MASTER NODE  | 1 |

"WE NOW CONSIDER DELL TO BE MUCH MORE THAN A SERVICES PROVIDER. IT HAS BECOME A TRUSTED PARTNER. WE HAVE ACCESS TO A NETWORK OF DELL EXPERTS AROUND THE CLOCK. SO WHETHER WE EXPERIENCE ANY PROBLEMS WITH THE DELL OR INTEL TECHNOLOGY, WE CAN NOW BE CONFIDENT THAT IT WILL BE RESOLVED QUICKLY AND WITHOUT INCIDENT."
FLUID SIMULATION WORKLOAD

This 32-node / 256 core system is capable of running a dozen or more simultaneous ANSYS® FLUENT® or ANSYS® CFX® simulation models in the size range of 4-6M cells, and several simulations in the size range of 10-20M cells. Fully utilizing the 24GB of system memory per compute node, this configuration can handle simulation model sizes up to 400M cells.

APPLICATION BENCHMARK

For the latest benchmarks visit DELL.COM/hpc

STRUCTURES SIMULATION

This cluster can run many simultaneous ANSYS® Mechanical™ simulations in the size range of 1M to 10M DOFS. Depending on solution type and memory configuration, model sizes up to 200 MDOF can be considered.

APPLICATION BENCHMARK

For the latest benchmarks visit DELL.COM/hpc

As an example of how the pre-configured clusters perform with real-world applications, we include benchmark results for the following three well-known ANSYS FLUENT benchmarks:

- Aircraft_2M (External flow over an aircraft wing, hexahedral mesh)
- Truck_14M (External flow over a truck body, mixed cell type)
- Truck_Poly_14M (External flow over a truck body with polyhedral mesh)

The performance results below show that the amount of time needed to complete the benchmarks mentioned decreases almost linearly with the increase of the amount of nodes. This is achieved due to the efficient implementation of software from ANSYS on the distributed computational resources.

The benchmarks are performed on a Dell M1000e blade chassis with 16 M610 blade servers, each equipped with two Intel XEON X5570 CPUs and 24GB of memory each. The servers are connected with a Mellanox M3601Q QDR Infiniband switch in the blade chassis. When using different CPUs in the same platform, the scaling will be similar.

(For these benchmarks we used Red Hat Enterprise Linux SU3 with the OFED 1.4 IB stack)

*Benchmarking for 256 core available on request.
Our 256 Core (32 node) cluster example is based on our recently introduced state-of-the-art PowerEdge M610 Blade Servers. This M1000e Chassis has been configured with 32 M610 blades, each blade having two Intel Xeon L5520 quad-core processors with 2.26 GHz CPU clock rate and 24 GB (6 x 4GB) of main memory. For parallel applications spanning more than one compute node a Gigabit Ethernet interconnect is supplied to facilitate adequate message passing functionality for a large class of parallel applications. A separate fast Ethernet network has been configured for administrative use. This configuration is extremely compact (256 cores in a 20U chassis), has best-of-class power consumption characteristics and needs very little external cabling. Benchmark performed with InfiniBand interconnect.

The master node and NFS File server is a Dell PowerEdge R710 (2U) with Intel Xeon L5520 quad-core processors with 2.26 GHz clock rate and 72GB (18x 4GB) of main memory and 20 TB of mass storage for the compute nodes to access through NFS. A retractable 1U LCD display with keyboard and mouse completes this capable standalone cluster. The price includes full installation by Dell in a 42” rack (also included). A choice of operating system is available – either Linux or Microsoft Cluster Server.

For more information about other Dell cluster options contact your Dell Account Manager or visit DELL.COM/hpc

THE DELL AND INTEL APPROACH TO BALANCED HPC
Dell High-performance computing solutions based on the new Intel® Xeon® processor 5500 series deliver groundbreaking, energy-efficient performance to help HPC users meet today’s complex challenges. By improving both computational resources and aggregate system bandwidth, the new microarchitecture helps to create balanced HPC systems that produce a dramatic increase in total application performance while increasing cluster density and energy efficiency.