Microsoft Windows Compute Cluster Server 2003
Partner Solution Brief

Virtual engineering requires real-world high-performance computing

Overview

Region: Global
Industry: Manufacturing

Customer Profile
Fluent Inc. is a wholly owned subsidiary of ANSYS, Inc., a global innovator of simulation software and technologies designed to optimize product development processes. The FLUENT fluid flow simulation software is a vital part of the computer-aided engineering process for Fortune 500 companies, small and medium-size businesses, academic institutes, and government organizations around the world.

Business Situation
While simulation can greatly reduce the costs associated with physical testing, computational speed and capacity is critical for shortening product development lead-times. ANSYS, Inc.'s Microsoft Windows-based customers require HPC solutions that leverage their existing IT resources and expertise, while expanding their simulation capacity using cost-effective hardware.

Solution
FLUENT 6.3 running on the Microsoft Windows Compute Cluster Server 2003 operating system yields excellent parallel scaling.

- Higher-speed computing
- More detailed and accurate simulations
- Reduced design time and costs
- Familiar Windows environment for HPC
- Seamless scalable parallel processing
- Better, safer, lower-priced products

> Windows Compute Cluster Server 2003 represents a breakthrough in bringing high-performance computing into the mainstream of CAE.

Dr. Ferit Boysan, Vice President and General Manager, ANSYS Inc.

Understanding the behavior of liquids and gases is crucial to engineers who need to predict and improve the performance of new designs or processes. Engineering organizations around the world rely on the FLUENT® Computational Fluid Dynamics (CFD) software to gain this understanding through computer simulation. CFD is an integral part of the computer-aided engineering (CAE) environment, focused on predicting and improving the performance of new designs or processes, reducing time to market, and reducing overall engineering costs. However, to yield reliable results and impact engineering decisions, a CFD simulation must be sufficiently detailed with a rapid turnaround time. Today's detailed FLUENT simulations require high-performance computing (HPC) capacity, including 64-bit memory addressing to accommodate large models and parallel processing to ensure fast turnaround. Customers performing FLUENT simulations can achieve these goals by running on the 64-bit Microsoft® Windows® Compute Cluster Server (Windows CCS) 2003 operating system. The resulting solution provides HPC under Windows and enables FLUENT customers to decrease the time required for simulations while increasing the detail and accuracy of their predictions.

Windows Compute Cluster Server 2003

> If you try to process a large simulation on a single CPU, you may have to wait hours, days, or even weeks for your results. Parallel processing dramatically reduces that turnaround time by running the simulation on multiple CPUs, so cluster computing is a key technology for our customers.
>
> Barbara Hutchings, Director of Strategic Partnerships at Fluent, Inc.

Situation

In today's competitive manufacturing markets, companies strive to maintain their competitive edge by developing innovative designs without driving up costs, sacrificing quality, or delaying product delivery. CAE uses simulation to lead product development, with the incentive of developing new designs faster, and at lower cost, than through the traditional build-and-test approach. CFD is a rapidly growing area within CAE. CFD software is used to analyze liquid and gas flows in a wide range of industries and engineering applications. Accurate and rapid CFD simulations enable design engineers to optimize new product designs on their desktops far in advance of building physical prototypes. This approach translates into more innovative and imaginative products that are designed faster and at a lower cost than before.

FLUENT is used to perform CFD simulations by research and development teams in Fortune 500 companies, small and medium-size businesses, academia, and government organizations. FLUENT software is used for a variety of engineering applications. These range from analyzing air flow over an aircraft wing to assessing combustion efficiency in a furnace, from simulating blood flow through an artery to semiconductor manufacturing, from testing clean room designs to building wastewater treatment plants.

For a simulation to be as reliable as physical testing, it must be sufficiently detailed and accurate. An increase in detail creates a corresponding increase in the turnaround time for computations and in the computer memory requirements. FLUENT simulations can have extremely high memory requirements ranging from a few gigabytes (GB) of RAM for a typical simulation to as much as 100 GB of RAM for more detailed models. On a single CPU, a typical simulation might run for several hours or even days, and this turnaround time can be reduced almost linearly by running on multiple CPUs. Cluster computing therefore provides a great way to reduce turnaround time, and enables bigger, more detailed and accurate simulations. According to Barbara Hutchings, Director of Strategic Partnerships at Fluent Inc., "If you try to process a large simulation on a single CPU, you may have to wait hours, days, or even weeks for your results. Parallel processing dramatically reduces that turnaround time by running the simulation on multiple CPUs, so cluster computing is a key technology for our customers."

Cluster technology has a reputation for being challenging and expensive to implement. Engineers and development teams are usually under such tight time and cost constraints that the technical complexity of cluster technology or the associated costs represent barriers to HPC. These constraints can place cluster technology out of reach of many small to midsize operations, or any organization with a limited budget and scarce IT resources. Windows-based customers also want to exploit their existing Windows environment and resources. "Putting together a working cluster can be a challenge for our customers," says Hutchings. "With Windows CCS, we are excited by the opportunity to provide a cluster solution that allows our Windows customers—a large fraction of our installed base—to leverage their current IT resources and expertise, while expanding their simulation capacity using cost-effective hardware."

FLUENT customers require HPC capacity that is reliable, simple to deploy, integrates with existing infrastructure, exploits available IT resources and allows them to continue using the CFD analysis tools that are key to their success.

The combination of support for clustering and 64-bit memory addressing has made Windows a very viable option for our customers who need high-performance computing. The time savings for customers running FLUENT is almost directly proportional to cluster size.

Ferit Boysan, Vice President and General Manager, ANSYS Inc.

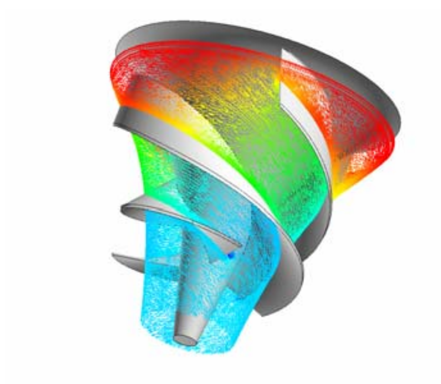

Figure 1— Flow around a vertical axis runner
Image courtesy of Alden Research Laboratory, Inc.

Solution

Windows CCS is a HPC platform for processing large-scale, complex computing problems. Windows CCS runs on commodity x64-based computers, and provides an inexpensive and highly scalable platform for HPC. Windows CCS is based on Windows Server 2003 Standard x64 Edition.

FLUENT 6.3 running on the Windows CCS operating system yields excellent parallel scaling. Providing multiple choices of solver options, combined with outstanding support for highly scalable parallel processing on clusters, FLUENT delivers optimum solution efficiency and accuracy for a wide range of engineering problem solving.

This technology combination offers a cost-effective parallel processing solution for CFD analysis. FLUENT 6.3 users running simulations on Windows can exploit the larger memory address space provided by 64-bit systems to run more detailed FLUENT simulations.

Success Story

Alden Research Laboratory, Inc., based in Holden, Massachusetts, is an acclaimed fluids flow engineering and environmental laboratory, providing analytical, computational, and physical flow-modeling services. When the CFD team at Alden wanted to expand its analysis capacity, it turned to a cluster running FLUENT 6.3 on Windows CCS. "We needed to increase our computing power in order to increase the number of FLUENT simulations we perform and in order to consider larger, more detailed models," said Dr. Dan Gessler, Alden's Director of Numeric Modeling.

Using FLUENT software, Alden engineers simulate flow in advanced hydro turbine designs. Flow modeling was used to maximize generating efficiency of the Alden/Concepts NREC fish-friendly turbine. The unique turbine design has the lowest fish mortality for turbines in its class. Figure 1 shows flow around the vertical axis runner.

According to Charles Ulrich, Alden's IT Manager, "the ability to deploy a cluster using Windows CCS was very attractive for us, as it leverages our expertise and fits into our current computing environment. The deployment was quite smooth: we had our cluster up and running FLUENT within two weeks. The integration of FLUENT with the Microsoft Job Scheduler is especially valuable, giving us the ability to manage and monitor multiple simulations on the cluster."

Benchmarks

The performance of 64-bit FLUENT on Windows CCS is excellent. FLUENT scales extremely well, and speed-up is nearly linear with the number of processors on a correctly sized cluster.

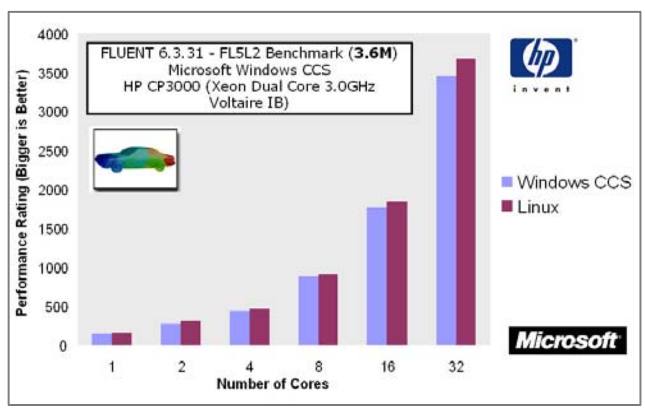

Figure 2— Performance of FLUENT 6.3 on a standard benchmark simulation of flow around an automotive sedan. As CPUs are added to the cluster, the simulation speed scales well, with excellent comparison to the same simulation running on a LINUX cluster. Results courtesy of Hewlett- Packard Company.

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Charles Ulrich, IT Manager, Alden Research Laboratory, Inc.

Solution Architecture

Windows CCS leverages the functionality of several components to provide authentication and authorization mechanisms, simple and familiar interfaces for managing and administering the cluster, and tools for cluster setup, deployment, job management, CPU efficiency and more.

A Windows CCS cluster of servers, shown in Figure 3, includes a single head node and one or more compute nodes. The head node controls and mediates all access to the cluster resources and is the single point of management, deployment, and job scheduling for the compute cluster.

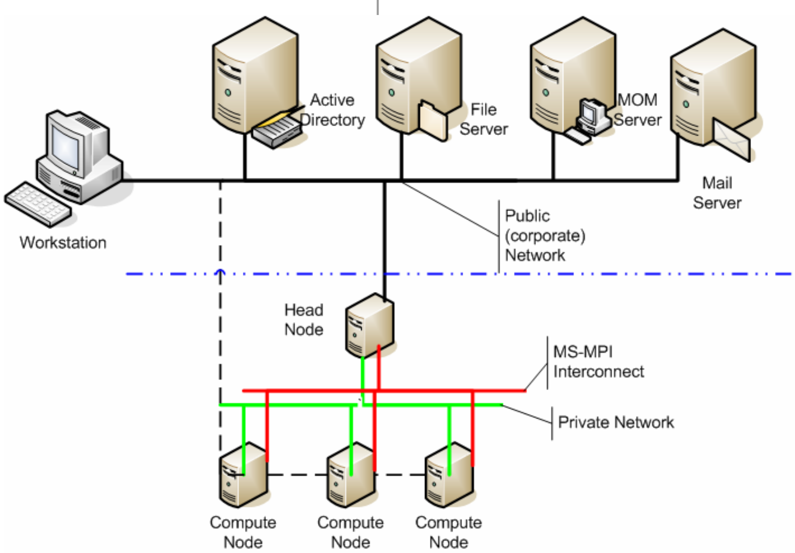

Figure 3: Typical Windows Compute Cluster Server 2003 network

Job Scheduling

Fluent integrated FLUENT 6.3 with the Microsoft Compute Cluster Job Scheduler, which is a core job management component in the Windows CCS architecture. Job scheduling ensures that the operating system allocates the necessary resources to the simulations, tracks the processors associated with the job, partitions the large scaled-out system to the size required by the simulation job, and de-allocates the resources after producing the result. FLUENT 6.3 users can use either a command-line protocol or a graphical user interface (GUI), as shown in Figure 4, to effectively manage and monitor the progress of their simulations on the cluster.

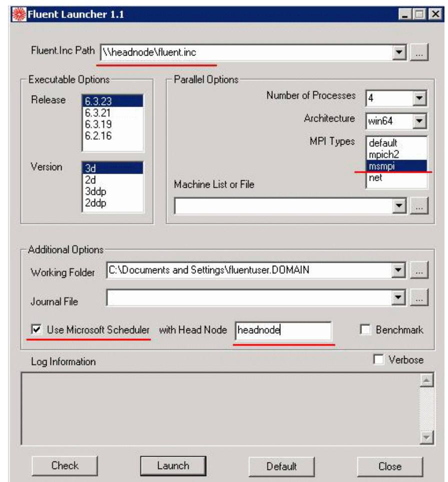

Figure 4—FLUENT Launcher GUI provides job scheduling for CFD simulations running on Windows CCS. Image courtesy of ANSYS, Inc.

Microsoft Message Passing Interface

FLUENT 6.3 uses the Microsoft Message Passing Interface (MS-MPI) as the communication software layer between compute nodes on the cluster. Windows CCS provides end-to-end security over secure and encrypted channels throughout the job process when using MS-MPI. As the node manager schedules and assigns the job, the job always runs in the context of the scheduling users. MS-MPI runs over Gigabit Ethernet, InfiniBand, or any network that provides a Microsoft Windows Sockets 2 (Winsock) Direct-enabled driver. MS-MSPI is based on and compatible with the Argonne National Labs MPICH2 implementation of MPI2.

Windows CCS System Requirements

CPU Requirement: 64-bit architecture computer Intel Pentium, or Xeon family with Intel Extended Memory 64 Technology (EM64T) processor architecture, or AMD Opteron family, AMD Athlon family, or compatible processor(s).	
Minimum RAM: 512 megabytes (MB)	
Maximum RAM: 32 gigabytes (GB)	
Multiprocessor Support: Up to 4 processors per node.	
Disk Space for Setup: 4 GB	
Disk Volumes: Head node requires a minimum of two volumes (C:\ and D :\ ). For additional roles, additional partitions are recommended. Compute node requires a single volume. RAID 0/1/5 may be used, but is not required.	
Network Interface Cards: All nodes require at least one network interface card (NIC). Each node may require additional NICs as appropriate for the network topology, for public network access or in support of an MPI network.	

Microsoft Active Directory

Windows CCS uses the existing corporate infrastructure and the Microsoft Active Directory® directory service to provide authorization and authentication services. Each node of the cluster must be a member of an Active Directory domain. The Active Directory domain can be independent of the cluster, or can run within the cluster.

Head Node

The head node provides deployment and administration user interfaces (UIs) as well as management services for the compute cluster. The UIs provided by the head node include the Compute Cluster Administrator, the Compute Cluster Manager, and the Command Line Interface (CLI). The management services provided by the head node include job scheduling as well as job and resource management.

Compute Node

Any computer configured to provide computational resources as part of the compute cluster is a compute node. Compute nodes allow users to run computational jobs. These nodes must run a supported operating system, but they do not require the same operating system or even the same hardware configuration. Optimally, compute nodes include a similar configuration to simplify deployment, administration, and resource management.

FLUENT 6.3 System Requirements

Typical cluster sizes for FLUENT vary widely, from 8-16 cores up to 64 or 128 cores or more. The ideal number of CPUs (or cores) in the cluster depends on the size of the analysis model (measured in terms of number of computational cells) and on the number of simultaneous analysis jobs to be run on the core. The recommended memory requirement for FLUENT is 1-2 GB per core. The total memory requirement for one FLUENT simulation on the cluster will scale linearly with the FLUENT model size. The following specifications are guidelines only and are NOT hard requirements or limits.

Cluster size (number of CPUs or cores)	CFD model size (number of cells)	RAM
4	Up to 2M	2-3 GB
8	2M up to 5M	6-8 GB
16	4M up to 10M	10-15 GB
32	4M up to 20M	20-30 GB
64	30M up to 40M	40-60 GB
128	70M up to 100M	100-150 GB

For More Information

For more information about Microsoft products and services, call the Microsoft Sales Information Center at (800) 426-9400. In Canada, call the Microsoft Canada Information Centre at (877) 568-2495. Hearing-impaired customers can reach Microsoft text telephone (TTY/TDD) services at (800) 892-5234 in the United States or (905) 568-9641 in Canada. Outside the 50 United States and Canada, please contact your local Microsoft subsidiary. To access information using the World Wide Web, go to: www.microsoft.com.

For more information about Windows Compute Cluster Server 2003, please visit: http://www.microsoft.com/hpc

To join the HPC Community, please visit http://www.windowshpc.net

For more information about Fluent Inc., and FLUENT 6.3 software, please visit http://www.fluent.com

For more information about ANSYS, Inc., and its simulation software and technologies please visit http://www.ansys.com

For more information about Alden Research Laboratory Inc., and its flow modeling capabilities, please visit http://www.aldenlab.com

For information about purchasing Microsoft Windows Compute Cluster Server 2003, please email hpcinfo@microsoft.com

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Benefits

By porting FLUENT 6.3 software to the Windows CCS operating system, ANSYS, Inc. is providing its customers with increased computing power on industry-standard processors. The increase in computing power allows its customers to quickly solve more complicated CFD simulations, easily set up and maintain compute clusters, improve productivity, and reduce administration and technical support time and costs.

Increased Computing Power Speeds Up Computations

By porting FLUENT 6.3 software to the Windows CCS operating system, ANSYS, Inc. enables its customers to increase the computing power available to them while remaining within the Windows environment. With 64-bit cluster technology on industry-standard processors and Windows CCS, customers will obtain more realistic simulation capabilities on Windows and receive a performance boost that achieves faster computations.

More Detailed and Accurate Simulations Reduce Design Time and Costs

With the increased computing power of Windows CCS, ANSYS, Inc.'s customers will be able to run more detailed simulations and analyze more design options than before. With more detailed simulations, engineers can reduce design time and expense by reducing the amount of physical testing of prototypes. More detailed simulations and increased computing power translates into better, safer, lower-priced products, that are designed faster and at lower cost than before.

Simple Cluster Setup and Management Increases Productivity

The tight integration between the Windows CCS operating system, the Job Scheduler, and the Message Passing Interface results in an off-the-shelf process for customers setting up clusters. Because Windows CCS works with the Active Directory service, any Windows administrator can set up a cluster as easily as adding any other network resource.

> Clusters have been a critical enabling technology for our CFD simulation tools…More people can now afford the kind of computing power you really need to take advantage of FLUENT software.
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> Dr. Ferit Boysan, Vice President and General Manager, ANSYS, Inc.