Microsoft Windows Compute Cluster Server 2003
Partner Solution Brief

Altair Engineering
Innovation Intelligence

Finite Elements — Infinite Possibilities. Virtual Simulation and High-Performance Computing

Microsoft Windows Compute Cluster Server Runs RADIOSS Finite-Element Solver Technology

Overview

Region: Global
Industry: Manufacturing

Customer Profile

Altair is a leading global provider of computer-aided engineering technology and services that increase innovation for more than 3,500 customers worldwide. Altair is the developer of the Altair HyperWorks technology suite that includes the RADIOSS finite-element solver.

Business Situation

High-performance computing is a crucial capability for industries that rely on virtual simulation to model complex problems involving structural, mechanical, and fluid-structure interaction phenomena. Engineers are continually challenged to simulate more complex problems, increase the accuracy and frequency of their simulations, and reduce simulation run times to shorten product development timelines. These challenges require a solution that combines sophisticated simulation technology with HPC capacity that is cost-effective and simple to deploy, as well as operate and integrate with existing infrastructure.

Solution

Altair optimized its finite-element solver technology RADIOSS to run on Microsoft Windows Compute Cluster Server 2003.

Benefits

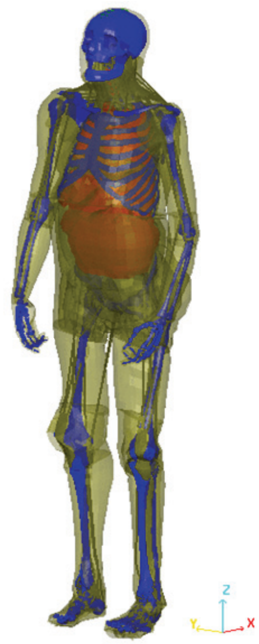
- Extended simulation capability
- Increased modeling accuracy
- Greater product innovation
- Reduced product development time
- Accelerated engineering insight
- Simplified cluster deployment, operation and integration

Engineers no longer need to sacrifice ease-of-use for performance. With RADIOSS running on Windows CCS they can increase productivity and focus on innovation instead of IT administration.

Shawn Hansen, Director of High Performance Computing Marketing, Microsoft Corporation.

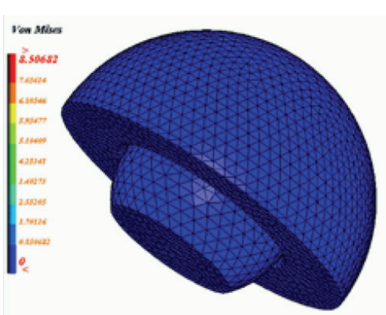
Finite Element Analysis (FEA) techniques have been applied to a broad variety of problems that arise in almost all areas of science and engineering including structural, mechanical, bio-engineering, multi-physics, and process automation. Today, engineers and scientists working to simulate these complex phenomena are continually challenged by the need for greater modeling capacity and greater computing power. Until now, high-performance computing (HPC) solutions have been too complex, expensive, and problematic for many smaller engineering organizations to implement and operate. For companies that rely on virtual engineering to lead their product design and development, the challenge is to realize a combined simulation and HPC solution that is cost-effective, as well as simple to deploy, operate, and integrate with existing infrastructure and leading simulation tools. Engineers worldwide rely on Altair's RADIOSS finite-element solver technology to efficiently simulate and predict complex phenomena. To exploit the full potential of virtual simulation and HPC, RADIOSS is optimized to run on Microsoft® Windows® Compute Cluster Server (Windows CCS) 2003.

Windows Compute Cluster Server 2003



Human finite-element models facilitate virtual investigations of the human body and further understanding of the causes of injury.

Image courtesy of Altair.



Osteoarticular prosthesis model.

Image courtesy of LABM and Altair.

Situation

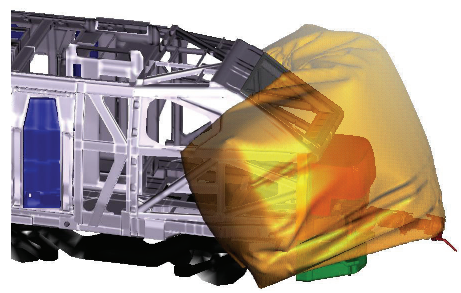
FEA has been a cornerstone of computer-aided engineering (CAE) for decades. FEA techniques have been applied to a broad variety of problems that arise in almost every area of science and engineering including structural, mechanical, bio-engineering, multi-physics, and process automation. As FEA usage has matured, its increased use has broadened its user base and application. This expansion has fed the demand for greater analysis capability and advances in simulation ability such as more complex material characterizations, sophisticated geometry models, accurate simulation algorithms, and realistic contact definitions.

While these advances enable more accurate modeling of mechanical, structural, and fluid-structure interaction (FSI) problems, they also escalate the computing capacity required by complex simulations. Today, engineers and scientists working to simulate these phenomena are continually challenged by the need for more computing capacity.

When HPC is coupled with simulation technology, it dramatically extends the range of problems engineers can study and increases the frequency of simulation. These gains accelerate engineering insight, foster product innovation, shorten product design and development timelines, and accelerate time to market. However, most HPC solutions are complex, expensive, and require a dedicated staff of IT professionals to maintain and operate. Until now, these barriers placed HPC out of reach of many engineering organizations.

Organizations that rely on virtual engineering to efficiently simulate and predict finite-element problems require a combined simulation and HPC solution that is cost-effective and simple to deploy, operate, and integrate with existing infrastructure and leading simulation tools. For FEA software makers, the challenge is to meet the needs of the engineering community for greater analysis and simulation capability while optimizing simulation software for HPC environments.

Responding to these challenges, Altair optimized its RADIOSS finite-element solver technology to run on Windows CCS. Combined, these technologies enable RADIOSS clients to fully exploit HPC capacity, extend the range of problems they can study, increase the accuracy and frequency of their simulations, and improve productivity by using a reliable, familiar Windows HPC platform that integrates with existing infrastructure and tools.



Simulation of train crash on an obstacle.

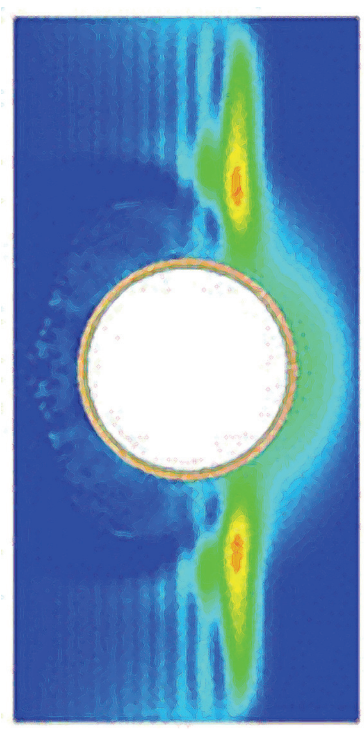
Image courtesy of SNCF.

“Throughout the manufacturing industry, HPC clusters are accelerating innovation as they become more readily available. We’re pleased to be working with Altair to show RADIOSS running on Windows CCS with best-in-class performance. Scientists and engineers no longer need to sacrifice ease-of-use for performance. With RADIOSS running on Windows CCS they can increase productivity and focus on innovation instead of IT administration.”

Shawn Hansen, director HPC marketing, Windows Server division, Microsoft Corporation.

Our recent test of RADIOSS running on Windows CCS resulted in a significant performance gain. The combined technologies could reduce our calculation time by 75 percent and more critically — could shorten our development time.

Mechanical analysis, MBDA France



Simulation of underwater explosion.

Image courtesy of Altair.

Solution

Windows CCS is an HPC platform for processing large-scale, complex computing problems. Windows CCS runs on industry-standard 64-bit computers, and provides an inexpensive and highly scalable platform for HPC. Windows CCS is based on Microsoft Windows Server™ 2003 Standard x64 Edition and contains wizard-based setup procedures and an integrated Job Scheduler. These features simplify deployment and the workflow process, and allow engineers to allocate their time toward product innovation rather than IT administration.

RADIOSS Solver Technology

RADIOSS is a finite-element solver technology for explicit or implicit analysis. As part of Altair® HyperWorks® CAE technology suite, RADIOSS delivers a robust solver solution for mechanical, structural, and fluid-structure interaction (FSI) problems for static, dynamic, or transient loading conditions.

RADIOSS is well known for its performance in parallel computing, scalability, and compatibility, as well as its versatile material laws. RADIOSS handles a wide variety of CAE problems ranging from structural behavior simulation to safety, biomechanics, manufacturing processes, and multi-physics simulation. For example, in vehicle manufacturing the use of high-strength steel parts is not a common practice. However, their increasing use introduces potential risks of rupture. The ability to simulate and predict these risks efficiently is a major advantage of RADIOSS with vehicle manufacturers. The more detailed the simulation, the greater the requirement for HPC. “High-performance computing is a crucial capability for the automotive industry for testing structural integrity, airflow around vehicles and the motions of its components and systems” says Eric Lequiniou, manager of solver technology and quality assurance, Altair.

Two versions of RADIOSS are available for Windows: Shared Memory Parallelization (SMP) for single-image machines, and Single Program Multiple Data stream (SPMD) for distributed-memory and cluster machines. RADIOSS SPMD is optimized to run on Windows CCS and provides a robust platform for RADIOSS customers who need to perform highly realistic structural simulations rapidly and easily while using a reliable, familiar Windows HPC platform that integrates with existing infrastructure and tools.

“Our close collaboration with Microsoft has resulted in a solution that combines supercomputing scalability and performance along with ease-of-use through integration with existing Windows infrastructure,” says Eric Lequiniou.

Performance

RADIOSS running on Windows CCS scales extremely well. RADIOSS initial benchmark studies (shown in Figure 1) used a cluster based on two dual-core AMD processors. The performance of RADIOSS on Windows CCS is comparable to the performance of the Linux operating system. As cores are added to the cluster, the simulation speed increases linearly on a correctly sized cluster.

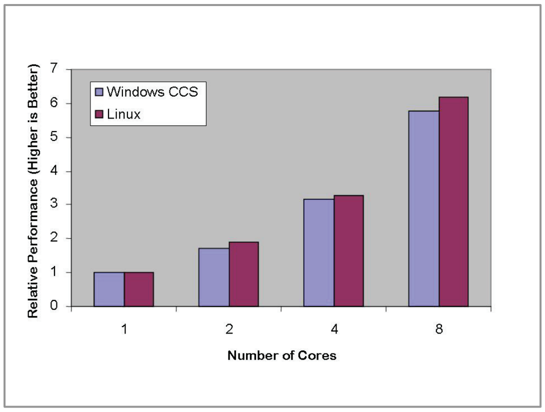


Figure 1—Performance of RADIOSS on Windows CCS compared to Linux operating system.

CIMES

SPÉCIALISTES EN SIMULATION NUMÉRIQUE

The integration of RADIOSS running on Windows CCS allows us to fully exploit the power of HPC, reduce our simulation runtimes, and remain in the familiar and intuitive environment that Windows provides.

Arnaud Ringeval, structural calculations manager, CIMES

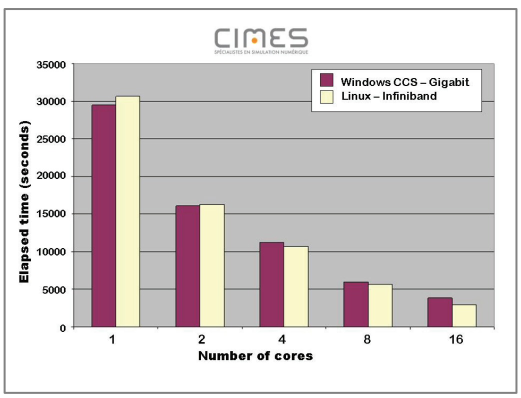


Figure 2—The performance of RADIOSS on Windows CCS is excellent and comparable to the performance of a Linux operating system. As CPUs are added to the cluster, the simulation speed scales well on a correctly sized cluster.

Customer Success Story

CIMES LLC in Valenciennes, France, is an innovative design firm with international customers including Arcelor Mittal, Alstom, and Bombardier. Responding to their customer needs for more accurate finite-element models and more simulation power, CIMES acquired a new supercomputer–based on Intel® Xeon® dual-core processors and a Gigabit Ethernet interconnection network. After comprehensive tests, CIMES implemented a cluster running Windows CCS. Running Windows CCS, CIMES is experiencing performance levels comparable to systems based on Linux (shown in Figure 2) and also is benefiting from the ease of operation and use associated with the Windows environment.

"Now we can easily access the computation power that was previously inaccessible to us. Cost and the heavy operational burden of Linux or UNIX systems and the skill acquisition associated with those systems were barriers to realizing HPC capacity in our company. The release of Windows CCS removed those barriers. We're also benefiting from comprehensive and efficient support from Microsoft," says Arcangelo Schena, general manager of CIMES.

The new cluster, based on Dell PowerEdge™ 1950 blade servers running Windows CCS, includes 16 cores. CIMES has six servers in an extensible chassis: one server runs the Microsoft Active Directory® directory service coupled to the head node that manages and allocates tasks on the four compute nodes. Each server includes two dual-core Intel Xeon 5160 processors, for a total of 16 cores delivering peak performance.

CIMES uses RADIOSS to perform dynamic analysis on a range of models, including models that simulate the mechanical strength of structures under shock — such as trains and passenger vehicles in crash scenarios, FSI models of tank wagons for transport vehicles, and bio-mechanical models.

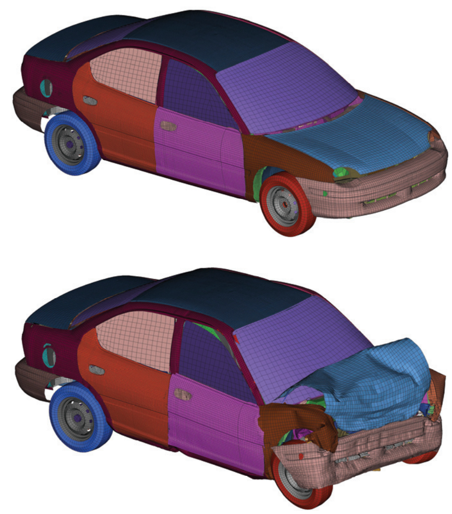


Image courtesy of CIMES.

Prior to implementing RADIOSS on the Windows CCS cluster, CIMES was limited to a single workstation and four processors for calculation. With simulations ranging in size from 750,000 up to 1 million finite elements, the long run times required by such a setup had a negative impact on productivity. CIMES needed to reduce simulation run times. "The integration of RADIOSS running on Windows CCS allows us to fully exploit the power of HPC, reduce our simulation runtimes and remain in the familiar and intuitive environment that Windows provides," says Arnaud Ringeval, structural calculations manager, CIMES.

Most importantly for CIMES, the new cluster solution gives CIMES "an advantage in the face of growing competition and allows us to anticipate and respond to our customers' need for more simulation and computational power," concludes Schena.

Our close collaboration with Microsoft has resulted in a solution that combines supercomputing scalability and performance along with ease-of-use through integration with existing Windows infrastructure.

Eric Lequiniou, manager of solver technology and quality assurance, Altair.

Solution Architecture

RADIOSS has been optimized to run on Windows CCS and has been parallelized by using two methods: SMP for single-image machines, and SPMD for distributed-memory and cluster machines. Both methods share the same source code, but they are not coupled. This means that a customer must choose between running RADIOSS SMP or RADIOSS SPMD on a given architecture. RADIOSS SPMD is optimized for cluster environments.

RADIOSS SPMD includes two executables: RADIOSS Starter sequential program and RADIOSS Engine parallel program. The description that follows focuses on the calculation process to explain the communication and tasks accomplished between RADIOSS SPMD programs and Windows CCS in a typical RADIOSS and Windows CCS cluster.

Figure 3 shows a typical RADIOSS SPMD and Windows CCS cluster architecture that includes a head node running the Microsoft Compute Cluster Job Scheduler (CCS Job Scheduler) and multiple compute nodes.

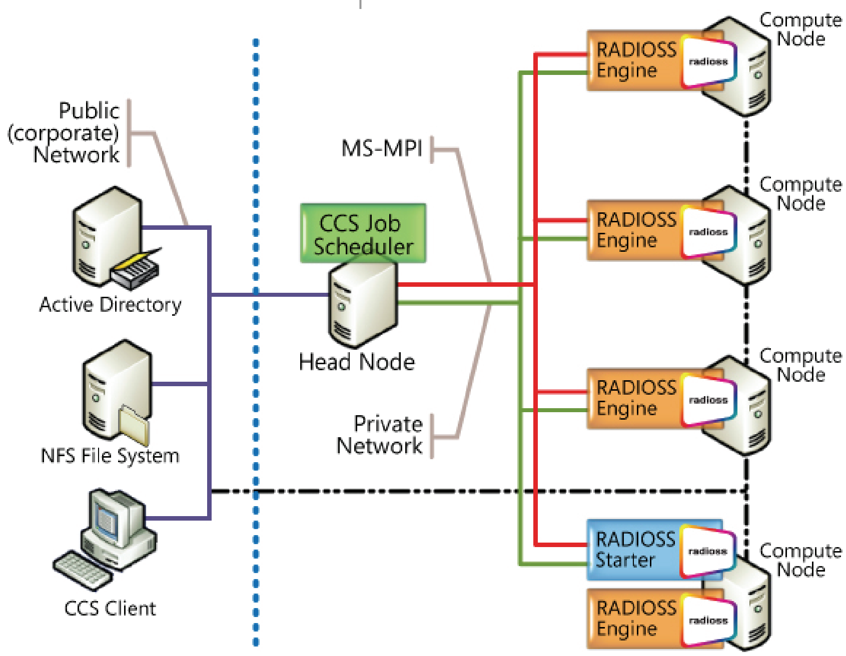


Figure 3—Illustrates a typical RADIOSS SPMD and Windows CCS architecture showing the distribution of the CCS Job Scheduler, RADIOSS Starter, and RADIOSS Engine programs on a cluster.

In a calculation scenario, when a client submits jobs to the CCS Job Scheduler on the cluster head node, the following tasks occur:

- A RADIOSS Starter job is submitted to the CCS Job Scheduler. This job is started on one available compute node by the CCS Job Scheduler.
- The RADIOSS Starter program reads the input file (.rad) to verify the input and prepares the data structure for RADIOSS Engine.
- RADIOSS Starter prepares the data structures by performing a "domain decomposition" process that splits the initial model input deck into subdomains that are load-balanced according to the number of compute nodes in the cluster. The RADIOSS Starter writes each domain to a separate restart (.rst) file. The .rst files and output listing information files are specified as job parameters and are stored in a Network File System (NFS) directory.
- After the RADIOSS Starter has completed its tasks, a parallel job is submitted to the CCS Job Scheduler to run on RADIOSS Engine(s).
- The Job Scheduler starts each RADIOSS Engine parallel executable running on each compute node in the cluster.
- Each RADIOSS Engine accesses the NFS directory to read its .rst file and acquire additional input data stored in .rad files, such as simulation time.
- Each RADIOSS Engine will concurrently solve the initial problem, exchanging boundary information during the run by using Microsoft Message Passing Interface (MS-MPI).
- At the end of the simulation, output results are written in the NFS directory (including updated .rst files). If the scenario requires, the new restart files can be used as input of a new RADIOSS Engine job to further solve the simulation.

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 four 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.	

Windows CCS 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 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.

Job Scheduling

The CCS Job Scheduler resides on the head node server and is the 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.

Microsoft Message Passing Interface

MS-MPI is used 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 Socket 2 (WinSock) Direct-enabled driver. MS-MPI is based on and compatible with the Argonne National Labs MPICH2 implementation of MPI2.

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.

For More Information

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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 Altair and its simulation software and technologies please visit http://www.altair.com

For more information about CIMES LLC please visit http://www.cimesfrance.com

For more information about MBDA Inc. please visit http://www.mbda-systems.com

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

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Benefits

Windows CCS combined with RADIOSS solver technology provides a powerful, scalable, parallel processing solution that is easy to deploy and use, and provides the processing speed necessary to run complex simulations on clusters of affordable, industry-standard 64-bit hardware. Moreover, running RADIOSS on Windows CCS allows customers to exploit their existing Windows infrastructure, tools, and expertise. This combination translates into more innovative, safer, and affordable products that are designed faster and at lower cost than before.

Extended Simulation Capability Accelerates Engineering Insight

Simulation technologies that are optimized for parallel computing environments dramatically extend the range of problems engineers can study, and increase the frequency of simulation. The ability to run more complex simulations more frequently accelerates engineering insight.

Increased Computing Power Reduces Costs

By running RADIOSS on Windows CCS, Altair 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 solutions. The ability to leverage existing Windows infrastructure and IT resources yields substantial time and cost savings to Windows CCS customers.

More Detailed and Accurate Simulations Reduce Design Time and Costs

With the increased computing power of Windows Compute Cluster Server 2003, RADIOSS clients 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 more innovative, safer, and affordable products that are designed faster and at lower cost than before.

Secure, Scalable Parallel Clustering

RADIOSS running Windows CCS yields excellent parallel scaling. Windows CCS provides the additional benefit of enhancing security. By leveraging the existing Windows infrastructure, Windows CCS can integrate with Active Directory for user authorization and authentication services. Additionally, Windows CCS provides end-to-end security over secure and encrypted channels throughout the job process when using MS-MPI.

Simple Cluster Setup, Management, and Integration Increases Productivity

Windows CCS contains wizard-based setup procedures and an integrated job scheduler. The tight integration between the Windows CCS operating system, the CCS 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 directory service, any Windows administrator can set up a cluster as easily as adding any other network resource. These features simplify deployment and the workflow process, and allow engineers to allocate their time toward product innovation rather than IT administration.