Designed for Maximum Accelerator Performance

A dense, GPU-accelerated cluster supercomputer that delivers up to 329 double-precision GPU teraflops in one rack. This power- and space-efficient system can be combined with Cray’s optimized software stack to meet your demanding workload needs. Built by Cray — the world leader in supercomputing systems.
Cray CS-Storm Powers Application Performance

A “perfect storm” is brewing. Data volumes are increasing exponentially and mathematical models are growing ever more sophisticated and computationally intensive, but power and cooling limit the size of systems that can be deployed. These considerations are driving the use of GPUs as accelerators for computationally-intense workloads.

Accelerators are commonly deployed in 1:1 or 2:1 configurations in blade systems with conventional CPUs. Applications typically run across the two types of processors, with 95% on the conventional CPU and the computationally-intense 5% on the accelerator. However, many applications in sectors such as financial services, oil and gas, defense and law enforcement are well suited to running almost entirely on GPUs. For this class of applications, the conventional processor’s role is often restricted to housekeeping functions and being a conduit that carries data into the accelerator to be processed. The benefits are immense: a single, high-density rack dedicated to GPU computation can deliver double-precision performance up to 1/3 petaflop with very low power consumption. Cray’s CS-Storm system is designed specifically for these demanding applications and delivers the compute power to quickly and efficiently convert large streams of raw data into actionable information. The CS-Storm system is able to drive the most powerful NVIDIA® Tesla® K80 GPUs at full speed with no throttling for power or cooling, and with demonstrated reliability month after month.

Cray CS-Storm Accelerator-Optimized Cluster Solution

System Overview

The Cray® CS™ series of cluster supercomputers offers a scalable architecture of high performance servers, network and software tools that can be fully integrated and managed as stand-alone systems. The CS-Storm cluster, an accelerator-optimized system built from multi-GPU server nodes, is designed for massively parallel computing workloads.

Each Cray CS-Storm cluster rack can hold up to 22 2U rack-mounted CS-Storm server nodes. Each of these servers integrates eight accelerators and two Intel® Xeon® processors, delivering double-precision compute performance of up to up to 329 GPU teraflops in one 48U rack. The system can support both single- and double-precision floating-point applications.

The Cray CS-Storm system provides a high performance software and hardware infrastructure running parallel MPI, OpenMP Unified Parallel C (UPC) or OpenSHMEM tasks with maximum efficiency. The system provides optimized I/O connectivity and flexible user login capabilities. It is available with a comprehensive HPC software stack compatible with open-source and commercial compilers, debuggers, schedulers and libraries. The system is also available with the optional Cray Programming Environment for Cluster Systems (Cray PE on CS), which includes the Cray Compiling Environment, Cray Scientific and Math Libraries, and Performance Measurement and Analysis Tools. The system can be easily managed with Cray’s Advanced Cluster Engine (ACE™) management software, which provides network, server and cluster capabilities with easy system administration and maintenance for scale-out environments.

HPC Workloads

The CS-Storm system is well suited for HPC workloads in the defense, oil and gas, financial services, life sciences and business intelligence sectors. Typical applications include cybersecurity, geospatial intelligence, signal processing, portfolio and trading algorithm optimization, pattern recognition, machine learning and in-memory databases.

Global Leader in Supercomputing

Cray’s ability to turn pioneering hardware and software technologies into world-renowned supercomputing solutions is the result of decades of dedication to high performance computing. From technical enterprise- to petaflops-sized solutions, our systems enable tremendous scientific achievement by increasing productivity, reducing risk and decreasing time to solution.

For More Information

To learn more about the Cray CS-Storm cluster visit www.cray.com/cs-storm or contact your Cray representative.

Source: NVIDIA analysis of GPU-accelerated codes
Features and Benefits

**Scalable System with Maximum Performance**
- Up to eight NVIDIA Tesla K40 or K80 GPU accelerators per node (PCIe Gen3 cards, up to 300W each)
- With K40 accelerators, double-precision performance of up to 11.4 GPU teraflops per node
- With K80 accelerators, double-precision performance of up to 15 GPU teraflops per node
- Completely air-cooled platform without compromising system performance
- Available with liquid-cooled rear-door heat exchangers, to maximize server density with minimal thermal impact to the datacenter
- Multiple interconnect topology options including fat tree, single/dual rail, QDR/FDR/EDR InfiniBand
- Cray Programming Environment on Cluster Systems (Cray PE on CS)
- Compatible with Cray Tiered Adaptive Storage (TAS) and Cray® Sonexion® storage solutions
- Customizable HPC cluster software stack options including multiple Linux® OS distributions, message passing (MPI) libraries, compilers, debuggers and performance tools

**Simplified Management Using Cray ACE Software**
- Simplifies manageability for scale-out systems
- Manages network, server, cluster and storage
- Manages diverse node types with different OS environments
- Fine-grain system power and temperature monitoring
- Export and import system configurations and images
- Detects hardware, fabric topology configuration errors
- Version control and ability to roll back changes
- Supports most commonly-deployed open-source and commercial resource managers and job schedulers

**Reliable, Efficient and Serviceable**
- Multiple levels of redundancy and fault tolerance can be configured to meet uptime needs
- Worldwide Cray support and service options

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**Intel® Xeon® Host Processors**
The Cray CS-Storm cluster supercomputer is available with Intel Xeon E5 2600 v3 (up to 145 watts) host processors.
These flexible CPUs, designed for technical computing and datacenter deployment, can address a wide range of application, performance and energy efficiency requirements.

**NVIDIA® Tesla® K40 and K80 GPU Computing Accelerators**
GPU-accelerated computing offers unprecedented application performance by offloading the compute-intensive portions of the application to the GPU. The NVIDIA Tesla K40 GPU accelerator combines 2,880 cores and 12 GB of QDDR5 memory to deliver 1.43 TF of double precision performance. The NVIDIA Tesla K80 GPU accelerator combines a total of 4,992 cores and 24 GB of QDDR5 memory to deliver up to 1.87 TF of double precision performance. GPU Boost uses available power headroom to potentially deliver additional performance. The Cray CS-Storm system can deliver a full 300W to each GPU, enabling them to operate continuously at the highest level of performance.
Cray HPC Cluster Software Stack

<table>
<thead>
<tr>
<th>HPC Programming Tools</th>
<th>Development &amp; Performance Tools</th>
<th>Cray PE on CS</th>
<th>Intel® Parallel Studio XE Cluster Edition</th>
<th>PGI Cluster Development Kit®</th>
<th>GNU Toolchain</th>
<th>NVIDIA® CUDA®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Libraries</td>
<td>Cray® LibSci™, LibSci_ACC</td>
<td>Intel® MPI</td>
<td>IBM Platform MPI</td>
<td>MVAPICH2</td>
<td>OpenMPI</td>
<td></td>
</tr>
<tr>
<td>Debuggers</td>
<td>Rogue Wave TotalView®</td>
<td>Allinea DDT, MAP</td>
<td>Intel® IDB</td>
<td>PGI PGDBG®</td>
<td>GNU GDB</td>
<td></td>
</tr>
<tr>
<td>File Systems</td>
<td>Lustre®</td>
<td>NFS</td>
<td>GPFS</td>
<td>Panasas PanFS®</td>
<td>Local (ext3, ext4, XFS)</td>
<td></td>
</tr>
<tr>
<td>Cluster Management</td>
<td>Cray® Advanced Cluster Engine (ACE™) Management Software</td>
<td></td>
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<tr>
<td>Operating Systems and Drivers</td>
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</tr>
<tr>
<td>Drivers &amp; Network Mgmt.</td>
<td>Accelerator Software Stack &amp; Drivers</td>
<td></td>
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<td></td>
<td>OFED</td>
<td></td>
</tr>
<tr>
<td>Operating Systems</td>
<td>Linux® (Red Hat, CentOS)</td>
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</tbody>
</table>
Cray Advanced Cluster Engine (ACE™)
Management Software Designed for all Cray CS Cluster Supercomputers

What is ACE?
Cray's Advanced Cluster Engine (ACE) management software is part of Cray's HPC cluster software stack. ACE eliminates the complexity of managing an HPC cluster while simplifying manageability for scale-out environments. ACE software includes command line (CLI) and graphical user interfaces (GUI), providing flexibility for the cluster administrator. An intuitive and easy-to-use ACE GUI connects directly to the ACE Daemon on the management server and can be executed on a remote system running Linux, Windows or Mac operating systems. The management modules include network, server, cluster and storage management.

ACE Software:
- Supports multiple network topologies and diskless configurations with optional local storage
- Provides network failover with high scalability when network redundancy option is chosen
- Integrates easily with a customizable HPC development environment for industry-standard platforms and software configurations
- Manages heterogeneous nodes with different software stacks
- Monitors nodes, networks, power and temperature
# Cray CS-Storm Rack and System-Level Specifications

## Architecture
- Supported rack options and corresponding maximum number of server nodes:
  - 24" rack, 42U and 48U options – 18 and 22 nodes, respectively
  - 19" rack, 42U and 48U options – 10 and 15 nodes, respectively

## Processors and Accelerators (Per Node)
- Support for up to two Intel® Xeon® host processors, 145W max per CPU
- Support for up to 8 NVIDIA® Tesla® K40 or K80 GPU computing accelerators

## Memory
- Up to 1,024 GB SDRAM per compute node
- 12/24 GB onboard memory per K40/K80 GPU (96/192 GB onboard GPU memory)

## Interconnect
- QDR or FDR InfiniBand with Mellanox ConnectX®-3/Connect-IB, or Intel True Scale Host Channel Adapters
- Options for single or dual-rail fat tree

## System Administration
- Advanced Cluster Engine (ACE™): complete remote management capability
- Graphical and command line system administration
- System software version rollback capability
- Redundant management servers with automatic failover
- Automatic discovery and status reporting of interconnect, server and storage hardware
- Cluster partitioning into multiple logical clusters, each capable of hosting a unique software stack
- Remote server control (power on/off, cycle) and remote server initialization (reset, reboot, shut down)
- Scalable fast diskless booting for large-node-count systems and root file systems for diskless nodes
- Multiple global storage configurations

## Resource Management and Job Scheduling
- Options for SLURM, Altair PBS Professional, IBM Platform™ LSF, Adaptive Computing Torque, Maui and Moab, and Univa Grid Engine
- Optional redundant networks for interconnect and management (InfiniBand, GbE and 10GbE) with failover

## File System
- Cray® Sonexion®, NFS, Local FS (Ext3, Ext4 XFS), Lustre®, GPFS and Panasas® PanFS available as global file systems

## Operating System
- Red Hat or CentOS available on compute nodes
- ACE Management Servers delivered with Red Hat Linux®

## Performance Monitoring Tools
- Open-source packages such as HPCC, Perfctr, IOR, PAPI/IPM, netperf

## Compilers, Libraries and Tools
- Options for Open MPI, MVAPICH2, Intel® MPI, MKL and IBM Platform MPI libraries
- Cray Programming Environment on Cluster Systems (Cray PE on CS), PGI, Intel® Parallel Studio, NVIDIA® CUDA®
- OpenCL, DirectCompute Toolkits, GNU, DDT, TotalView, OFED programming tools and many others

## Rack Power
- Up to 75 kW in a 48U rack, depending on configuration
- Optional 480 V power distribution with 200-277 VAC power supplies

## Cooling Features
- Air cooled
- Airflow: front intake, back exhaust
- Optional rear-door heat exchangers; can cool up to 7,000 CFM per rack depending on configuration

## Cabinet Dimensions
- 19" or 24" 42U and 48U racks

## Cabinet Weight (Empty)
- Without optional rear door heat exchanger, empty rack weight only:
  - 24" 42U rack: 520 lbs. (hosts up to 18 compute nodes)
  - 24" 48U rack: 550 lbs. (hosts up to 22 compute nodes)
  - 19" 42U rack: 295 lbs. (hosts up to 10 compute nodes)
  - 19" 48U rack: 329 lbs. (hosts up to 15 compute nodes)

## Support and Services
- Turnkey installation services with worldwide support and service options
Cray CS-Storm High-Density, Hybrid Rackmount Server

The Cray CS-Storm high-density rackmount server node is an industry standard 2U, high-density, multi-GPU platform. Each server features up to eight GPU accelerators (up to 300W each), two Intel® Xeon® processors (up to 145W each), up to 1,024 GB memory and up to six enterprise-grade SSD drives.

Two principal variants of the server are offered, a compute node and a service node. Compute nodes maximize GPU density, with up to eight GPUs in a single node. Service nodes are designed with room for multiple expansion cards and are restricted to a maximum of two GPUs per node.

Compute nodes and service nodes are available with Intel Xeon E5 2600 v3 host processors.
Cray CS-Storm 2826X8 Compute Node

This hybrid compute server offers up to eight NVIDIA® Tesla® accelerators and two Intel® Xeon® E5 family processors, delivering exceptional high-density computing, memory bandwidth and compute power efficiency in a small footprint for GPU-compute-intensive applications.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>2626X8</th>
<th>2826X8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motherboard</td>
<td>1 per chassis, 2 Xeon host processors in a 2-way SMP</td>
<td></td>
</tr>
<tr>
<td>Processor</td>
<td>Intel Xeon E5-2600 v3 family processors (up to 145W)</td>
<td></td>
</tr>
<tr>
<td>Memory Capacity</td>
<td>Up to 1.024 GB DDR4</td>
<td></td>
</tr>
<tr>
<td>Accelerators</td>
<td>Up to 8 NVIDIA Tesla GPU accelerators (K40 or K80); supports up to 300W parts</td>
<td></td>
</tr>
<tr>
<td>Drive Bays</td>
<td>Up to 6 enterprise-grade SSD drives</td>
<td></td>
</tr>
<tr>
<td>Expansion Slots</td>
<td>1 riser card slot: x8 PCIe 3.0</td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>6 80 mm x 80 mm x 38 mm fans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Provides ample air flow for optimal GPU operation</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>Dual 1,630W redundant power supplies; 80 PLUS Gold Efficiency (optional N+1)</td>
<td></td>
</tr>
<tr>
<td>Power Input</td>
<td>200-277 VAC, 10A max</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>Up to 93 lbs.</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>3.38”H x 23.98”W x 32.33”D</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>Operating: 10°C–30°C</td>
<td></td>
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<tr>
<td></td>
<td>Storage: -40°C–70°C</td>
<td></td>
</tr>
<tr>
<td>Server Management</td>
<td>Integrated BMC with IPMI 2.0 support</td>
<td></td>
</tr>
</tbody>
</table>
Cray CS-Storm 2826X2 Service Node

This hybrid service node offers up to two NVIDIA® Tesla® accelerators and two Intel® Xeon® E5 family processors per motherboard along with flexible I/O options, making them well suited for management or login node functions in conjunction with 2826X8 hybrid compute servers.

<table>
<thead>
<tr>
<th>Model Number</th>
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<th>2826X2</th>
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<tr>
<td>Motherboard</td>
<td>1 per chassis, 2 Xeon host processors in a 2-way SMP</td>
<td>Intel Xeon E5-2600 v3 family processors (up to 145W)</td>
</tr>
<tr>
<td>Processor</td>
<td>Up to 1,024 GB DDR4</td>
<td>Up to 2 NVIDIA® Tesla® GPU accelerators (K40); supports up to 300W parts</td>
</tr>
<tr>
<td>Memory Capacity</td>
<td>Up to 6 enterprise-grade SSD drives</td>
<td>Dual-port gigabit Ethernet (optional on-board single-port ConnectX®-3 QDR/FDR InfiniBand with QSFP)</td>
</tr>
<tr>
<td>Network Interface</td>
<td>DB-15 VGA, 2 RJ-45 LAN ports, 1 stacked two-port USB 2.0 compliant connector</td>
<td>DB-15 VGA, 2 RJ-45 LAN ports, 1 stacked two-port USB 2.0 compliant connector</td>
</tr>
<tr>
<td>Expansion Slots</td>
<td>1 riser card slot: x8 PCIe3 (external)</td>
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<td>Coolingle</td>
<td>6 80 mm x 80 mm x 38 mm fans</td>
<td>Provides ample air flow for optimal GPU operation</td>
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<td>Storage: -40°C–70°C</td>
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<td>Server Management</td>
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