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 a 1:1 configuration 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 is often nothing more than a conduit carrying data into the accelerator, where it is 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 reams of raw data into actionable information.

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 rackmount CS-Storm server nodes. Each of these servers integrates eight accelerators and two Intel® Xeon® processors, delivering double-precision compute performance of up to 329 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 and/or OpenMP 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, cluster and storage management capabilities with easy system administration and maintenance for scale-out environments.

1Source: NVIDIA analysis of GPU-accelerated codes

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

The ability to turn pioneering hardware and software technologies into world-renowned supercomputing solutions is the work of decades. And no one has more experience than Cray. It's why leading users across industries and disciplines repeatedly choose us. 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.
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 teraflops
- With K80 accelerators, double-precision performance of up to 15 teraflops
- 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 room
- Multiple interconnect topology options, including 3D Torus/fat tree, single/dual rail, QDR/FDR IB
- Cray Programming Environment on Cluster Systems (Cray PE on CS)
- 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 connection to any open-source or commercial resource manager or job scheduler

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

**Intel® Xeon® Host Processor**
The Cray CS-Storm cluster supercomputer is available with Intel Xeon E5 2600 v2 (up to 130 watts) or 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 DDR5 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 DDR5 memory to deliver up to 1.87 TF double precision performance. GPU Boost uses available power headroom to deliver additional performance as a user-controlled performance boost. 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's HPC Cluster Software Stack

The CS-Storm accelerator-optimized cluster is available with a comprehensive HPC software stack including tools that are customizable to work with most open-source and commercial compilers, schedulers and libraries, such as the optional Cray Programming Environment on Cluster Systems (Cray PE on CS), which includes the Cray Compiling Environment, Cray Scientific and Math Libraries and Performance Measurement and Analysis Tools. Cray LibSci_ACC provides accelerated BLAS and LAPACK routines that generate and execute auto-tuned kernels on GPUs.

Cray's Advanced Cluster Engine (ACE) management software is included in the HPC cluster software stack. ACE provides network, server, cluster and storage management capabilities for easy system administration and maintenance. The software stack works seamlessly with any open-source or commercial resource manager or job scheduler in an ACE-managed cluster under Linux.
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 HPC Cluster Software Stack
OS, Drivers, Management, File Systems, Schedulers, Programming Tools

Advanced Cluster Engine – Cluster Management Software
Turns Cray clusters into functional, usable, reliable and available computing systems

Cluster Management
- Hierarchical management infrastructure
- Hierarchical cached root file system
- Divides the cluster into multiple logical partitions, each with unique OS personality
- Revision system with rollback
- Redundancy and failover
- Remote management and remote power control

Compute
- Automatic discovery
- Scalable, fast, diskless booting - inherits partition personality

Network
- Automatic discovery
- Redundant paths
- Load balancing
- Failover

Storage
- High bandwidth to storage

GUI AND CLI
- View/change/control
- Monitor health
- Plugin interface

Applications

Cluster Management | Compute | Network | Storage
---|---|---|---

ACE ADVANCED CLUSTER ENGINE

GUI AND CLI
- View/change/control
- Monitor health
- Plugin interface
### 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 memory per K40/K80 GPU

#### 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 or 3D Torus

#### 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 Grid Engine

#### Reliable, Available, Serviceable (RAS)
- Optional redundant networks for interconnect and management (InfiniBand, GbE and 10GbE) with failover

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

#### System Storage
- Full line of FC-attached disk arrays with support for FC, SATA disk drives and SSDs

#### 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, Perftcr, 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 a choice of 208 V or 277 V 3-phase power supplies

#### Cooling Features
- Airflow: front intake, back exhaust; up to 7,000 CFM depending on configuration
- Optional passive or active chilled cooling rear-door heat exchangers

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

#### Cabinet Weight (Empty)
- Without optional rear door heat exchanger:
  - 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 2.5 inch SATA/SAS or 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.

Both compute nodes and service nodes are available with the Intel Xeon E5 2600 v2 or v3 host processors, allowing nodes to be configured for optimum price/performance based on application requirements.
Cray CS-Storm 2626X8 and 2826X8 Compute Nodes
These hybrid compute servers offer 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 V2 family processors (up to 130W)</td>
<td>Intel Xeon E5-2600 V3 family processors (up to 145W)</td>
</tr>
<tr>
<td>Memory Capacity</td>
<td>512 GB DDR3</td>
<td>1,024 GB DDR4</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 2.5&quot; SSD or SATA/SAS 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>Provides ample air flow for optimal GPU operation</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>10 A at 277 VAC</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>Up to 93 lbs.</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>3.38&quot;H x 23.98&quot;W x 32.33&quot;D</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>Operating: 10°C–30°C</td>
<td>Storage: -40°C–70°C</td>
</tr>
<tr>
<td>Server Management</td>
<td>Integrated BMC with IPMI 2.0 support</td>
<td></td>
</tr>
</tbody>
</table>
# Cray CS-Storm 2626X2 and 2826X2 Service Nodes

These hybrid service nodes offer 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 2626X8 hybrid compute servers.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>2626X2</th>
<th>2826X2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motherboard</td>
<td>1 per chassis, 2 Xeon host processors in a 2-way SMP</td>
<td>Intel Xeon E5-2600 V2 family processors (up to 130W)</td>
</tr>
<tr>
<td>Processor</td>
<td>Intel Xeon E5-2600 V2 family processors (up to 130W)</td>
<td>Intel Xeon E5-2600 V3 family processors (up to 145W)</td>
</tr>
<tr>
<td>Memory Capacity</td>
<td>512 GB DDR3</td>
<td>1,024 GB DDR4</td>
</tr>
<tr>
<td>Accelerators</td>
<td>Up to 2 NVIDIA® Tesla® GPU accelerators (K40); supports up to 300W parts</td>
<td>Up to 6 2.5” SSD or SATA/SAS drives</td>
</tr>
<tr>
<td>Drive Bays</td>
<td>Dual-port gigabit Ethernet (optional on-board single-port ConnectX®-3 QDR/FDR InfiniBand with QSFP)</td>
<td>Up to 6 2.5” SSD or SATA/SAS drives</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>Dual-port gigabit Ethernet (optional on-board single-port ConnectX®-3 QDR/FDR InfiniBand with QSFP)</td>
</tr>
<tr>
<td>Expansion Slots</td>
<td>1 riser card slot: x8 PCIe3 (external)</td>
<td>1 riser card slot: x16 PCIe3 (external)</td>
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<td>Cooling</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>Power Supply</td>
<td>Dual 1,630W redundant power supplies; 80 PLUS Gold Efficiency (optional N+1)</td>
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<td>Power Input</td>
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<td>Weight</td>
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<td>Dimensions</td>
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