**Facilities**

**Institute for CyberScience-Advanced Cyber Infrastructure**

Penn State’s Institute for CyberScience (ICS) operates the Advanced Cyber Infrastructure (ICS-ACI), the university’s state-of-the-art high-performance research cloud.

### Data Center Facilities

ICS-ACI equipment is located at the newly-constructed Tower Road Data Center at Penn State’s University Park Campus. The Data Center is a 49,500 square-foot, two-story building with 12,000 square feet of raised floor, or “white space.” The white space is raised 4 feet above the substrate, providing extensive plenum space for cool air return.

Two main feeds provide 2.15 MW of critical power to the data center. The main feeds are backed up by a static uninterruptible power supply in a 2N configuration, two 2 MW generators with 48 hours of fuel storage capacity, and a 25 KW life safety generator. The building is powered efficiently, with a PUE of 1.21.

The Data Center features five indirect evaporative cooling units with DX trim on the rooftop. The cooling units are in an N+1 configuration, such that necessary cooling can be achieved even if any one unit fails. 85% of the year, the Data Center only needs to use outdoor ambient air for cooling. Heat is routed to the cooling units from the white space via hot-aisle containment systems. All racks exhaust from the rear into the hot-aisle containment systems. A select quantity of racks are fitted with rear-door heat exchangers to accommodate the highest rack power densities. The building uses a ducted supply and ceiling plenum return.

The building has various systems for control and monitoring, including a building automation system for mechanical system controls, an electrical power monitoring system, and a data center infrastructure management system. The networks can be monitored from an operations center featuring a Christie Phoenix visual wall display.

For fire protection, the building has fire alarms and a Very Early Warning Smoke Detection Apparatus (VESDA). The white space is protected by a pre-action (dry pipe) sprinkler system, while office and administrative space is protected by a wet pipe sprinkler system.

To protect the facilities, equipment, and data, the white space is locked at all times with electronic locks on all doors and is monitored by camera 24x7. Only those with authorized ID-card swipe access can enter the white space. The building itself is secured by a single-rotary entrance featuring a “man-trap” to prevent multiple people for entering at one time (i.e., tail-gating). Visitors must check in at the operations center to receive a visitor badge. All people within the data center must display an authorized Penn State ID or a visitor badge at all times.

**Equipment**

**ICS-ACI Equipment**

The ICS-ACI high-performance research cloud is composed of hardware that is interconnected over high-speed network fabrics, and includes various software offerings and services.

### Hardware

ICS-ACI currently maintains 23,000 computational cores. ICS-ACI offers four different core configurations: high-memory cores (1TB RAM per server), standard-memory cores (256 GB RAM per server), and basic-memory cores (128 GB RAM per server), and GPU cores (using NVidia Tesla K80 GPU accelerators). The standard-memory and basic-memory compute cores are housed within high density Dell M1000E Blade server enclosures, while the high-memory and GPU accelerator cores are in conventional 4U and 2U rack mount configurations, respectively.

ICS-ACI also maintains 20 PB of data storage capacity. The storage is comprised of 8 PB of active storage pools that provide immediate data access and retrieval, and 12 PB of near-line storage for long-term and archival purposes. The active storage operates on DDN 12KX40 and GS7K flash storage array systems, while near-line storage utilizes Oracle’s FS1 flash storage appliance and a SL8500 Tape Library.

The compute and storage hardware is interconnected using Ethernet and Infiniband network fabrics. The Ethernet network utilizes Brocade VCS fabric technology and is currently comprised of 1) four aggregate and two core layer Brocade VDX 8770-8 Enterprise-level switches that provide 10, 40, and 100 Gbps link capacity, 2) four Brocade VDX 6740 switches that provide 10 Gbps link capacity, and 3) one Brocade N2024 switch per rack for host iDRAC (integrated DELL Remote Access Controller) remote management over Gbps line rate. The Infiniband network consists of 15 Mellanox SX6025 switches and two Mellanox SX6536 648 port non-blocking SDN switch systems, all operating on 56 Gbps (FDR) line rate.

### Software

ICS-ACI maintains and regularly updates an expansive software stack. The stack currently contains 240 applications, with more added at regularly-scheduled intervals. The applications include security monitoring software (e.g., OSSEC), batch schedulers (e.g., MOAB, Torque), compilers, file transfer programs, and communication libraries (e.g., MPI, OpenMP). The stack also contains software applications commonly used by researchers, such as MATLAB, COMSOL, R, and Python, as well as programs for performing specialized tasks, such as Abaqus, Quantumwise, and TopHat.

**Other Resources**

**ICS-ACI Support**

ICS-ACI is maintained by the ICS staff, who provide network monitoring, backup services, software updates, code optimization, and service-desk support. ICS uses Solarwinds network monitoring software to monitor the health and status of the network, hardware, and storage. ICS-ACI is actively monitored during normal business hours (9:00 AM – 5:00 PM) Monday through Friday. ICS-ACI also hosts OSSEC, an open-source host-based intrusion detection system, which is used to control the system by monitoring available logs, alerting administrators of unauthorized system modifications, and providing a mechanism to enforce security requirements. The team uses NESSUS Professional to scan the system for potential vulnerabilities such as hacking and Denial of Service (DoS) attacks.

The ICS website offers documentation to help users resolve technical issues they may encounter. This support is supplemented by the i-ASK Center, a service desk which supplies expert technical assistance for user problems. In the event of more complex issues, the engineers of the ICS Technical Support Team provide advanced in-person support to users to ensure that problems are resolved in a timely and professional manner.