Introducing Bridges-2

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PI & Project Director, Bridges-2
Acquisition and operation of *Bridges*, *Bridges-AI*, and *Bridges-2* are made possible by the National Science Foundation:

NSF Award OAC-1928147 ($12.0M awarded to date):

*Bridges-2: Scalable Converged Computing, Data, and Analytics for Rapidly Evolving Science and Engineering Research*

Hewlett Packard Enterprise is delivering *Bridges-2*

*Bridges-2* will be deployed in Q4 2020.
The following information is subject to change.
To Learn More and Participate

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Driving Rapidly Evolving Science and Engineering

- **HPC & HTC**
  - Simulation and Modeling
  - Ease of use, familiar software, interactivity, productivity

- **HPAI and AI-enhanced simulation and modeling**

- **Community Data, Big Data as a Service**

- **HPC + AI + data, workflows, heterogeneous, cloud**
An Ecosystem for Rapidly Evolving, Data-Intensive Science & Engineering

Connecting new communities to advanced research computing.

Converged computation and data ecosystem to empower users to explore new ways of doing computing.

- 2,100 projects
- 16,000 users
- 800 institutions
- 122 fields of study
- 130 education allocations

For more information: https://www.psc.edu/bridges

Pioneered HPC+AI+Big Data
Bridges-AI expansion
Intel OPA first installation
Has become an ecosystem

BRIDGES-2
Converged HPC, AI, and Big Data

Provides transformative capability for rapidly evolving, computation-intensive and data-intensive research, creating opportunities for collaboration and convergence research.

Coming Q4 2020

More Science:
- Approximately 3x larger than Bridges

Faster Computing:
- Latest AMD EPYC processors

Faster Storage:
- Fast flash array and tiered data management

Smarter Science:
- Designed for Full System AI and data-centric computing

Scalable:
- Interoperability with cloud and campus resources

Award OAC-1445606
Award OAC-1928147

NSF
Hewlett Packard Enterprise
Intel
NVIDIA

For more information: https://www.psc.edu/bridges-2

Carnegie Mellon University
PSC
University of Pittsburgh
Application Areas: Examples

**Gene Expression**


**Advancing Digital Pathology with AI**


**Mapping the Human Body at Cellular Resolution**


**Developing Smart Cities**


**Workflows for CMS @ HL-LHC**


**Improving Severe Storm Prediction**


**Understanding Immunity**

C. M. Quine et al., *Dynamic regulation of HIV-1 capsid interaction with the restriction factor TRIM5α identified by magico-angle spinning NMR and molecular dynamics simulations*, *PNAS*, 2018. DOI: 10.1073/pnas.1800796115.

**New Materials**

M. Amrani et al., *CuBare, A Quasi Two-Dimensional Copper-Brmuth Nanosheet*, *Chem. Mater.*, 2017. DOI: 10.1021/acs.chemmater.7b03597
High-Level Architecture

- **Web Server Nodes**: (6) 6× AMD EPYC 7742 CPUs, 256GB RAM
- **Database Nodes**: (12) 12× AMD EPYC 7742 CPUs, 512GB RAM
- **Data Transfer Nodes**: (2) 2× Intel Xeon Platinum 8160M CPUs, 4TB RAM
- **Login Nodes**: (2) 2× Intel Xeon Gold 6248, 256GB HBM2, 512GB RAM
- **RM Nodes**: (488) 488× AMD EPYC 7742 CPUs, 256GB RAM
- **LM Nodes**: (16) 16× AMD EPYC 7742 CPUs, 512GB RAM
- **EM Nodes**: (4) 4× Intel Xeon Platinum 8160M CPUs, 4TB RAM
- **GPU Nodes**: (24) 24× NVIDIA V100-32 SXM-2, 2× Intel Xeon Gold 6248, 256GB HBM2, 512GB RAM

**Interconnect**

**Tape Backup and Archive** ~8.6PB usable

**Parallel File System** 15PB usable, 129GB/s R, 142GB/s W

**Flash Array** 100TB, 9M IOPs, 100GB/s

**HPE DMF**

**Interconnect Management Nodes**: (12)

**Users, XSEDE, campuses, instruments**
Building on the Flexible Architecture of *Bridges*
Introducing Innovations to Scale AI and High-Performance Data Analytics

*Bridges-2* provides transformative capability for rapidly-evolving, computationally-intensive and data-intensive research, supporting new and existing opportunities for collaboration and convergence research.

*Bridges-2* supports traditional and nontraditional research communities and applications, integrate new technologies for converged, scalable HPC, AI, and data; prioritize researcher productivity and ease of use; and provide an extensible architecture for interoperation with complementary data-intensive projects, campuses, and clouds.

**Bridges-2 core concepts:**
- Converged HPC + AI + Data
- Custom fat tree Clos topology optimized for data-centric HPC, AI, and HPDA
- Heterogeneous node types for different aspects of workflows
- CPUs and AI-targeted GPUs
- 3 tiers of per-node RAM (256GB, 512GB, 4TB)
- Extremely flexible software environment
- Community data collections & Big Data as a Service

**Innovations beyond Bridges:**
- AMD EPYC 7742 CPUs: 64-core, 2.25–3.4 GHz
- AI scaling to 192 V100-32GB SXM2 GPUs
- 100TB, 9M IOPs flash array accelerates deep learning training, genomics, and other applications
- Mellanox HDR-200 InfiniBand doubles bandwidth & supports in-network MPI-Direct, RDMA, GPUTDirect, SR-IOV, and data encryption
- Cray ClusterStor E1000 Storage System
- HPE DMF single namespace across disk and tape for data security and expandable archiving
Prioritizing Flexibility and Ease of Use

- Interactivity
- Popular languages and frameworks: Python, Anaconda, R, MATLAB, Java, Spark, Hadoop
- AI frameworks: TensorFlow, Caffe2, PyTorch, etc.
- Containers and virtual machines (VMs)
- Databases
- Gateways and distributed (web) services
- Large collection of applications and libraries
“Regular-Memory” (RM) and “Large-Memory” (LM) Nodes

Bridges-2 RM and LM nodes provide extremely powerful general-purpose computing and AI inferencing, with 128 cores per node and great memory bandwidth.

Each Bridges-2 RM node contains:

• 2× AMD EPYC “Rome” 7742 CPUs:
  • 64 cores, 128 threads, 2.25–3.40GHz, 256MB L3, 8 memory channels
• 488 RM nodes with 256GB of RAM
  16 LM nodes with 512GB of RAM
• DDR4-3200 memory
• 3.84TB NVMe SSD
• Mellanox ConnectX-6 HDR InfiniBand 200Gb/s Adapter.
“Extreme-Memory” (EM) Nodes

*Bridges*-2 EM nodes provide additional memory for applications such as genome sequence assembly and graph analytics.

- Each *Bridges*-2 EM node contains:
  - 4× Intel Xeon Platinum 8260M “Cascade Lake” CPUs:
    - 24 cores, 48 threads, 2.40–3.90GHz, 35.75MB LLC, 6 memory channels
  - 4TB of RAM: DDR4-2933
  - 7.68TB NVMe SSD
  - Mellanox ConnectX-6 HDR InfiniBand 200Gb/s Adapter.
GPU Nodes

*BRIDGES-2*

*Bridges*-2 GPU nodes provide exceptional performance and scalability for deep learning and accelerated computing.

Each *Bridges*-2 GPU node contains:

- 8× NVIDIA Tesla V100-32GB SXM2 GPUs:
  - 40,960 CUDA cores and 5,120 tensor cores;
  - 1 Pf/s tensor, 125 Tf/s 32b, 64 Tf/s 64b

- 2× Intel Xeon Gold 6248 “Cascade Lake” CPUs:
  - 20 cores, 40 threads, 2.50–3.90GHz,
  - 27.5MB LLC, 6 memory channels

- 512GB of RAM: DDR4-2933

- 7.68TB NVMe SSD

- 2× Mellanox ConnectX-6 HDR InfiniBand 200Gb/s Adapter.
Bridges-2 GPU Infrastructure

12 Mellanox HDR Quantum Spine Switches

All links in Bridges-2 are HDR-200

12 × HPE Apollo 6500 Gen10 Server
Each: 1Pf/s tensor, 125 Tf/s fp32, 64 Tf/s fp64

12 × HPE Apollo 6500 Gen10 Server
Each: 1Pf/s tensor, 125 Tf/s fp32, 64 Tf/s fp64
Bridges-2 filesystem (b2fs): Managed by HPE Data Management Framework (DMF) to provide a single namespace and user-friendly, rule-based migration.

ClusterStor E1000

- Lustre filesystem
  - 15 PB usable, 21 PB raw
  - 129 GB/s read, 142 GB/s write
  - RAIDZ2
  - 10 data server pairs, each serving 2.1 PB (raw)
  - To be allocated through XSEDE

- Flash Array
  - >100 TB usable, 9M IOPs
  - Use cases: training on large data, genomics, databases

HPE StoreEver MSL6480 Tape Library

- 5 modules (scalable to 7); 80 LTO-8 Type M tape slots per module
- 7.2 PB uncompressed, ~8.6 PB compressed
- 50 TB/hour
- Use cases: archiving, disaster recovery
- To be implemented as a resource to be allocated through XSEDE
- Option for external groups to fund project-specific expansion
“Prior to 2012, AI results closely tracked Moore’s Law, with compute doubling every two years. Post-2012, compute has been doubling every 3.4 months.”

### Convolutional Neural Networks (CNNs)

![Image of CNNs]

**Figure from S. Bianco, R. Cadene, L. Celona, and P. Napoletano, Benchmark Analysis of Representative Deep Neural Network Architectures, IEEE Access, vol. 6, pp. 64270–64277, 2018. arXiv:1810.00736v2.**

### Some Recent Transformer-type Networks

<table>
<thead>
<tr>
<th>Network</th>
<th>Published</th>
<th>Parameters</th>
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<tr>
<td>BERT Large</td>
<td>October 11, 2018</td>
<td>340M</td>
</tr>
<tr>
<td>PEGASUS Large</td>
<td>December 18, 2019</td>
<td>568M</td>
</tr>
<tr>
<td>GPT-2 (48 layers)</td>
<td>February 2019</td>
<td>1.5B</td>
</tr>
<tr>
<td>Megatron-LM</td>
<td>August 13, 2019</td>
<td>8.3B</td>
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### Sources of Additional Complexity

- Generative Adversarial Networks (GANs)
- Domain Adaptation
- Reinforcement Learning (RL)
AI and Data @ Bridges-2

Productivity

Usability

Interoperability
AI and Data @ Bridges-2

Productivity

Usability

Interoperability

AI @ Scale

Training
Support
Monitoring
AI and Data @ *Bridges*-2

**Productivity**

**Usability**

**Interoperability**

Diagram showing various tools and technologies related to AI and Data, including NVIDIA DIGITS, Caffe, PyTorch, Chainer, TensorFlow, Theano, mlflow, Jupyter, Spark, Anaconda, and more.
AI and Data @ *Bridges-2*

**Productivity**  
**Usability**  
**Interoperability**
Early User Program (EUP)

- Port, tune and optimize your application early and at no charge (There is also no charge for XSEDE allocations.)

- Achieve scientific progress early and at no charge

- User guide, frontline support and advanced support from Day 1

- Software and datasets most frequently used on Bridges will be pre-installed and ready from Day 1

- Please tell us about your specific software and dataset needs:  
  https://psc.edu/bridges-2/software-request  
  https://psc.edu/bridges-2/dataset-request

- For news updates, including on the opportunity to apply for access, please sign up at  
  https://psc.edu/bridges-2/eup-apply
EUP Process and Feedback

• Access will be granted based on lightweight proposals submitted via XRAS (see next slides):
  • Supplements to active XSEDE grants
  • Startups for those with no active XSEDE grant

• We will provide a feedback collection widget on every page of the user guide. Please use it whenever you have an issue, question or comment on any aspect of your EUP experience.

• We will check in to ask you about your experience and progress once a week. Please share your insights as to how we can further improve Bridges-2.

• You will be asked to complete a short survey after 4 weeks of the EUP.

• Ideally, EUP activities will result in scientific progress.
Target Timeline

October 1, 2019  Award start date; preparatory activities begin
• System and user environment, documentation, content, dissemination, etc.
• Broadly invite researchers for the Early User Program

March 2020  XRAC proposals awarded for Bridges/Bridges-AI, extending into Bridges-2

June-July 2020  Accept initial round of XRAC proposals

Fall 2020  Delivery, installation, initial testing

Fall-Winter 2020  Early User Program, conclusion of Acceptance Testing

Q1 2021  Start of Bridges-2 Production Operations

Q1 2021  Transition from Bridges to Bridges-2
Summary

• *Bridges* pioneered AI, HPC, and Big Data, and through its heterogeneous, very flexible architecture, created a large community of nontraditional users and interoperating cyberinfrastructure.

• *Bridges*-2 will greatly extend these proven concepts with full-system HPAI, HDR-200 communications, a new all-flash array fast data, tiered data management, and enhanced cloud interoperability.

• Innovative User Support, including substantial development during Early Operations.

• Join us for the *Bridges*-2 Early User Program!
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