Pittsburgh is a city of bridges: from its history in steel to its leadership in computer science and biotechnology, between diverse neighborhoods housing its many universities, and at PSC, from science-inspired national cyberinfrastructure to researchers’ breakthroughs.

*Bridges* is a new kind of converged HPC + Big Data system that will integrate advanced memory technologies to empower new communities, bring desktop convenience to HPC, connect to campuses, and intuitively express data-intensive workflows.
From HPC to Big Data

New Emphases

- Pan-STARRS telescope
  - http://pan-starrs.ifa.hawaii.edu/public/

- Genome sequencers
  - (Wikipedia Commons)

- NOAA climate modeling
  - http://www.ornl.gov/info/ornlreview/v42_3_09/article02.shtml

- Social networks and the Internet
- Video
- Wikipedia Commons

- Collections
  - Horniman museum: http://www.horniman.ac.uk/get_involved/blog/bioblitz-insects-reviewed

- Legacy documents
  - Wikipedia Commons

- Environmental sensors: Water temperature profiles from tagged hooded seals

- Library of Congress stacks
HPC → Big Data: Changing Algorithms

Structured Data
Statistics
Optimization (numerical)
Calculations on Data
Scientific Visualization

Unstructured Data
Machine Learning
Optimization (decision-making)
Natural Language Processing
Video
Image Analysis
Sound
Graph Analytics
Information Visualization

BRIDGES
A PITTSBURGH SUPERCOMPUTING CENTER RESOURCE
The $9.65M *Bridges* acquisition is made possible by National Science Foundation (NSF) award #ACI-1445606:

*Bridges: From Communities and Data to Workflows and Insight*

**Disclaimer:** The following presentation conveys the current plan for *Bridges*. Details are subject to change.
An Important Addition to the National Advanced Cyberinfrastructure Ecosystem

*Bridges* will be a new resource on XSEDE and will interoperate with other XSEDE resources, Advanced Cyberinfrastructure (ACI) projects, campuses, and instruments nationwide.

Examples:

- High-throughput genome sequencers
- Reconstructing brain circuits from high-resolution electron microscopy
- Social networks and the Internet
- Data Infrastructure Building Blocks (DIBBs)
  - Data Exacell (DXC)
  - Integrating Geospatial Capabilities into HUBzero
  - Building a Scalable Infrastructure for Data-Driven Discovery & Innovation in Education
  - Other DIBBs projects
  - Other ACI projects

Carnegie Mellon University’s Gates Center for Computer Science
Temple University’s new Science, Education, and Research Center
Motivating Use Cases (examples)

Data-intensive applications & workflows
Gateways – the power of HPC without the programming
Shared data collections & related analysis tools
Cross-domain analytics
Graph analytics, machine learning, genome sequence assembly, and other large-memory applications
Scaling research questions beyond the laptop
Scaling research from individuals to teams and collaborations
Very large in-memory databases
Optimization & parameter sweeps
Distributed & service-oriented architectures
Data assimilation from large instruments and Internet data
Leveraging an extensive collection of interoperating software
Potential Applications (Examples)

- Finding causal relationships in cancer genomics, lung disease, and brain dysfunction
- Analysis of financial markets and policies
- Improving the effectiveness of organ donation networks
- Assembling large genomes and metagenomes
- Recognizing events and enabling search for videos
- Understanding how the brain is connected from EM data
- Addressing societal issues from social media data
- Analyzing large corpora in the digital humanities
- Cross-observational analyses in astronomy & other sciences
- Data integration and fusion for history and related fields
Objectives and Approach

• Bring HPC to nontraditional users and research communities.

• Allow high-performance computing to be applied effectively to big data.

• Bridge to campuses to streamline access and provide cloud-like burst capability.

• Leveraging PSC’s expertise with shared memory, Bridges will feature 3 tiers of large, coherent shared-memory nodes: 12TB, 3TB, and 128GB.

• Bridges implements a uniquely flexible environment featuring interactivity, gateways, databases, distributed (web) services, high-productivity programming languages and frameworks, and virtualization, and campus bridging.
Interactivity

- **Interactivity is the feature most frequently requested by nontraditional HPC communities.**
- Interactivity provides immediate feedback for doing exploratory data analytics and testing hypotheses.
- *Bridges* will offer interactivity through a combination of virtualization for lighter-weight applications and dedicated nodes for more demanding ones.
Gateways and Tools for Building Them

Gateways provide easy-to-use access to Bridges’ HPC and data resources, allowing users to launch jobs, orchestrate complex workflows, and manage data from their browsers.

- **Extensive leveraging of databases and polystore systems**
- **Great attention to HCI is needed to get these right**

Interactive pipeline creation in GenePattern (Broad Institute)

Col*Fusion portal for the systematic accumulation, integration, and utilization of historical data, from http://colfusion.exp.sis.pitt.edu/colfusion/

Download sites for MEGA-6 (Molecular Evolutionary Genetic Analysis), from www.megasoftware.net
Virtualization and Containers

- Virtual Machines (VMs) will enable flexibility, customization, security, reproducibility, ease of use, and interoperability with other services.

- Early user demand on PSC’s Data Exacell research pilot project has centered on VMs for custom database and web server installations to develop data-intensive, distributed applications and containers for reproducibility.

- Bridges leverages OpenStack to provision resources, between interactive, batch, Hadoop, and VM uses.
High-Productivity Programming

Supporting the languages that communities are already using is critical for successful application of HPC to their research questions.
Bridges’ large memory is great for Spark!

*Bridges* enables workflows that integrate Spark/Hadoop, HPC, and/or shared-memory components.
Campus Bridging

- Through a pilot project with Temple University, the Bridges project will explore new ways to transition data and computing seamlessly between campus and XSEDE resources.

- **Federated identity management** will allow users to use their local credentials for single sign-on to remote resources, facilitating data transfers between Bridges and Temple’s local storage systems.

- **Burst offload** will enable cloud-like offloading of jobs from Temple to Bridges and vice versa during periods of unusually heavy load.

[http://www.temple.edu/medicine/research/RESEARCH_TUSM/]
Custom PSC topology for data-intensive HPC

20 Storage Building Blocks, implementing the parallel Pylon filesystem (~10PB) using PSC's SLASH2 filesystem

6 “core” Intel OPA edge switches: fully interconnected, 2 links per switch

20 “leaf” Intel OPA edge switches

800 RSM (128GB) compute nodes, 48 with GPUs

32 RSM nodes with NVIDIA next-generation GPUs

16 RSM nodes with NVIDIA K80 GPUs

4 ESM (12TB) compute nodes

2 gateways per ESM

42 LSM (3TB) compute nodes

12 database nodes

6 web server nodes

20 MDS nodes

2 boot nodes

8 management nodes

Intel OPA cables

See a running Bridges prototype in the PSC Booth (#1041)
3 tiers of large, coherent shared memory nodes

<table>
<thead>
<tr>
<th>Memory per node</th>
<th>Number of nodes</th>
<th>Example applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 TB</td>
<td>4</td>
<td>Genomics, machine learning, graph analytics, other extreme-memory memory applications</td>
</tr>
<tr>
<td>HPE Integrity Superdome X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 TB</td>
<td>42</td>
<td>Virtualization and interactivity including large-scale visualization and analytics; mid-spectrum memory-intensive jobs</td>
</tr>
<tr>
<td>HPE ProLiant DL580</td>
<td></td>
<td></td>
</tr>
<tr>
<td>128 GB</td>
<td>800</td>
<td>Execution of most components of workflows, interactivity, Hadoop, and capacity computing</td>
</tr>
<tr>
<td>HPE ProLiant DL580</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NVIDIA® Tesla® dual-GPU accelerators
Database and Web Server Nodes

• Dedicated database nodes will power persistent relational and NoSQL databases HPE ProLiant DL380
  – Support data management and data-driven workflows
  – SSDs for high IOPs; RAIDed HDDs for high capacity

• Dedicated web server nodes HPE ProLiant DL360
  – Enable distributed, service-oriented architectures
  – High-bandwidth connections to XSEDE and the Internet

(examples)
Data Management

• *Pylon*: A large, central, high-performance filesystem
  – Visible to all nodes
  – Large datasets, community repositories (~10 PB usable)

• Distributed (node-local) storage
  – Enhance application portability
  – Improve overall system performance
  – Improve performance consistency to the shared filesystem

• Acceleration for Hadoop-based applications
Supporting a Vast Number of Accelerated Applications and Tools

- Deep Learning
- Genomics
- Neuroscience
- Python
- Speech
- Video Analytics
- MATLAB
- Chemistry
- Graph Analytics
- Image Analytics
- Rendering
- Engineering
- Materials Science
- Physics
- Databases

...
Getting Started on *Bridges*

- **Starter Allocation**  
  - Can request *anytime*... including *now!*
  - Can request XSEDE ECSS (Extended Collaborative Support Service)

- **Research Allocation (XRAC)**  
  - Appropriate for larger requests; can request ECSS
  - Quarterly submission windows; *Next: Dec. 15, 2015–Jan. 15, 2016*

- **Early User Period**
  - Users with starter or research proposals may be eligible for *Bridges’* Early User Period (starting late 2015)

- **Questions?**
  - See [http://psc.edu/bridges](http://psc.edu/bridges)  
  or email Nick Nystrom at nystrom@psc.edu