

# Science Gateways and their Democratization and Acceleration of Science

Nancy Wilkins-Diehr  
wilkinsn@sdsc.edu

## Gateways:

### A natural result of the impact of the internet on worldwide communication and information retrieval

*Only 20 years since the release of Mosaic!*

- Implications on the conduct of science are still evolving
  - 1980's, Early gateways, National Center for Biotechnology Information BLAST server, search results sent by email, still a working portal today
  - 1989 World Wide Web developed at CERN
  - 1992 Mosaic web browser developed
  - 1995 “International Protein Data Bank Enhanced by Computer Browser”
  - 2004 TeraGrid project director Rick Stevens recognized growth in scientific portal development and proposed the Science Gateway Program
  - Today, Web 3.0 and programmatic exchange of data between web pages
- Simultaneous explosion of digital information
  - Growing analysis needs in many, many scientific areas
  - Sensors, telescopes, satellites, digital images, video, genome sequencers
  - #1 machine on Top500 today over 10,000x more powerful than *all combined* entries on the first list in 1993

# My experiences Science Gateways and high performance computing

- Interfaces to supercomputers haven't changed much in the last 20 years
- vt100 in the 1980s and a login window on the Ranger system at TACC today

```
File Edit View Tools Proxy Help
--> Example SGE batch job scripts are available in /share/doc/sgex
--> Ranger has 3 Lustre File Systems: $HOME, $WORK, and $SCRATCH. Users
    should run jobs out of $WORK or $SCRATCH (note that "cdw" and
    "cfs" aliases are provided to easily change between the file systems).
/usr/X11R6/bin/xauth: creating new authority file /share/home/00167/ux400782
It doesn't appear that you have set up your ssh key.
This process will make the files:
/share/home/00167/ux400782/.ssh/id_rsa.pub
/share/home/00167/ux400782/.ssh/id_rsa
/share/home/00167/ux400782/.ssh/authorized_keys
Generating public/private rsa key pair.
Created directory '/share/home/00167/ux400782/.ssh'.
Your identification has been saved in /share/home/00167/ux400782/.ssh/id_rsa
Your public key has been saved in /share/home/00167/ux400782/.ssh/id_rsa.pub
The key fingerprint is:
31:10:f0:0a:l4:c7:ce:d8:a4:78:90:7d:0b:f5:77:e9 ux400782@login3.ranger.tacc
----- Project balances for user ux400782 -----
| Name          Avail SUs   Expires |
| TG-STAO60014N 100000    2010-06-01 |
-----
| Disk          Usage (GB)  Limit  %Used  File Usage  Limit  %Us
| /share        0.0         6      0.00   15         100000 0.
| /work         0.0         350    0.00   1          2000000 0.
-----
login3% █
```

tg-login.ranger.tacc.teragrid.org:22	Unknown	Connected
--------------------------------------	---------	-----------

# Why are gateways worth the effort?

- Increasing range of expertise needed to tackle the most challenging scientific problems
  - How many details do you want each individual scientist to need to know?
    - PBS, RSL, Condor
    - Coupling multi-scale codes
    - Assembling data from multiple sources
    - Collaboration frameworks

```

=====
#!/bin/sh
#PBS -q dc
#PBS -l no
#PBS -l wa
#PBS -o pt
#PBS -e pt
#PBS -V
cd /users/w
../bin/mcell

# Full path to executable
executable=/users/wilkinsn/tutorial/bin/mcell

# Working directory, where
# Condor-G will write
# its output and error files on
# the local machine.
initialdir=/users/wilkinsn/tutorial/
exercise_3

+(&(re
login1.sd
pbs"))
# To set the working directory of
# the remote job, we
# specify it in this globus RSL,
# which will be appended
# to the RSL that Condor-G
# generates
globusrsl=(directory='/users/wilk
insn/tutorial/exercise_3')

(directory
se_3")

# Arguments to pass to
    
```

# Did you know?

- Supercomputers can be accessed through user-designed web interfaces as well as from the command line
- In 2011 40% of TeraGrid users came through the web

## 2.1. Categories of Research Activities

Within this broad scope, TeraGrid projects support various categories of research consortiums and services. Most often TeraGrid projects can be classified in one of the following categories:

1. Single Principal Investigator (PI): Most projects support a single PI and possibly a small research group working closely and co-authoring papers.
2. Multi-PI, Large Research Collaborations: Projects of this type are characterized by a single PI representing a large group of collaborating co-PIs who are working on subprojects within the overall collaboration. A single request is submitted, and a single project is allocated. The management of the allocated resources is left to the discretion of the principals on the request.
3. Large-scale Consortiums: Projects of this type are intended to support large-scale, funded projects that work through a consortium. Often in these cases, a mechanism already exists for allocating community or project resources (e.g., an instrument such as a telescope or detector), and that mechanism will also be used to make allocations. The time granted to the community project is allocated to the individual investigators. Requests for this type of project typically describe the internal processes for managing access of individual investigators within the consortium.
4. Gateways or Community Services: Projects of this type provide services to a large community of users who are typically not directly collaborating with the project PI. An example of such a project would be an application providing access to software and computer time to a community of biology researchers via a web-based interface. Requests to provide such a service must describe the details of the services provided, the methods used, the expected consumption of resources, and mechanisms for monitoring the users and usage of the service. Statistics of community usage should be reported quarterly and in renewal requests for resources, progress reports, and end-of-project reports. TeraGrid provides [How to Write a Winning Gateway Proposal](#) to assist in writing the requests.

## 2.2. PI Eligibility

The principal investigator (PI) of an allocated project is the person responsible for the accuracy of the resource request and the management of the ensuing allocation. This person must be a researcher or educator at a U.S. academic or non-profit institution. A PI may not be a high school or undergraduate student; a qualified advisor, for example, a high school teacher or faculty member, must serve in this capacity. In most cases, a graduate student may not be a PI; however, see [Section 2.1.2](#) for an exception for NSF Graduate Research Fellows and Honorable Mention awardees. A post-doctoral researcher is eligible to be a PI.

A U.S.-based scientist, engineer, or educator who has a joint appointment with a university or non-profit research institution may submit a request using that affiliation. The appointment may be adjunct, instructional, or any other official position.

# Today, there are approximately 35 gateways using XSEDE

**NBCR**

NATIONAL BIOMEDICAL COMPUTATION RESOURCE  
Conduct, catalyze and enable multiscale biomedical research

SC/EC

Earthworks

**UltraScan LIMS Portal**

UNIVERSITY OF MINNESOTA

for GEODYNAMICS

portal Facilities Outreach Resources Publications

**Asteroseismic Modeling Portal**

**CMMAP**

Reach for the sky

**COMAP**

isoscapes modeling, analysis and prediction

biodrugscre

**X-ray Crystallography**

Earth System Grid



DARK ENERGY Survey

Community Climate System Modeling Portal

**NEEShub**

George E. Brown, Jr. Network for Earthquake Engineering Simulation

**CIPRES** SCIENCE GATEWAY

CHEMBIOGRID

CyberInfrastructure for End-to-End Environmental Exploration

**HUB** 2012  
the HUBzero conference

**SDSC**  
SAN DIEGO SUPERCOMPUTER CENTER

**Science Gateways**

# Cyberinfrastructure for Phylogenetic Research (CIPRES)

- Most popular science gateway
  - ~25% of all XSEDE users
- In use on 6 continents
- Cited in major journals (Cell, Nature, PNAS)
- Used at major research institutions (Stanford, Harvard, Yale)
- Used by 57 researchers for curriculum delivery
- Used in 80% of EPSCoR states
- Recently used by a 15-year-old high school student who won the Massachusetts state science fair with no support from gateway staff

## The CIPRES Science Gateway V. 3.1

The CIPRES Science Gateway V. 3.1 is a public resource for inference of large trees designed to provide all researchers with access to large computational resources through a simple browser interface. The CIPRES Science Gateway provides new versions of RAxML (7.2.7) and MrBayes (3.1.2), as well as parallel GARLI (1.0) code to increase run times for submitted jobs. Through a collaboration with Alexandros Stamatakis, we offer the fastest hybrid versions of RAxML [[pdf](#)] and MrBayes [[pdf](#)] currently available.

 [Use the CIPRES Science Gateway](#)

**High Performance Parallel Codes for Large Tree Inference on TeraGrid:**

[RAxML \(7.2.7\)](#); [MrBayes \(3.1.2\)](#); [GARLI \(1.0\)](#)

**High Performance Parallel Codes for Sequence Alignment on TeraGrid:**

[MAFFT \(6.822\)](#)

**Serial Codes for Tree Inference:**

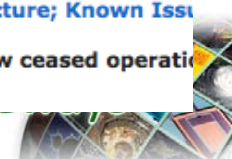
[PAUP\\*](#) (Parsimony); [Poy](#) (Simultaneous Sequence Alignment and Tree Inference)

**Serial Codes for Sequence Alignment:**

[ClustalW](#), [Contraalign](#), [FSA](#), [MUSCLE](#), [PROBCONS](#), [PROBALIGN](#).

Learn more about: [Requirements](#); [Limitations](#); [Architecture](#); [Known Issues](#)

CIPRES Portal V 1.15 and CIPRES Portal V 2.2 have now ceased operation.



## Locations of the last 1000 users of the CIPRES Science Gateway

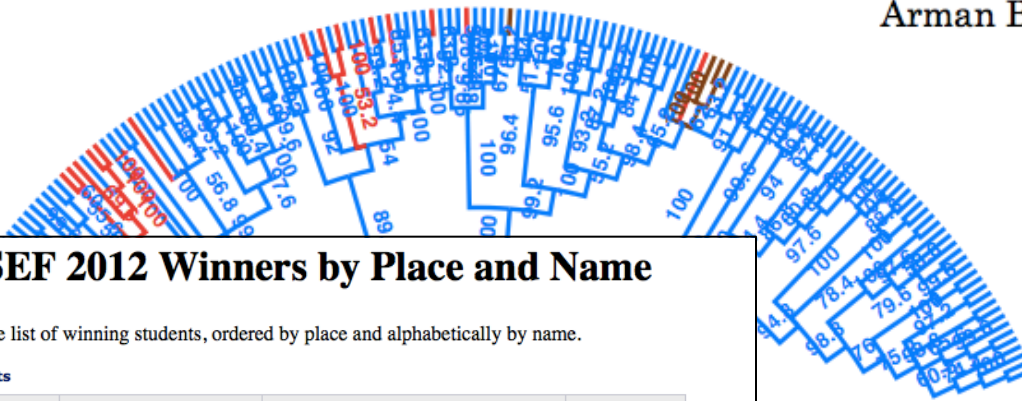




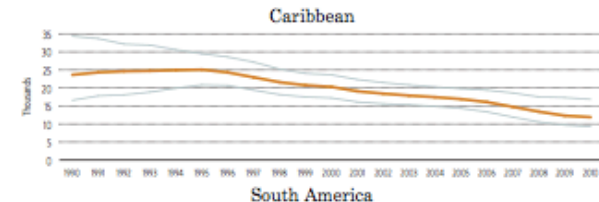
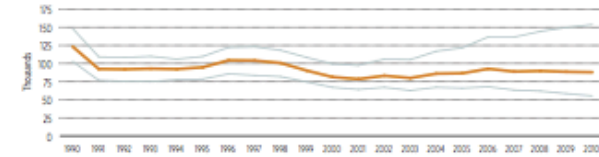
# Arman Bilge, Lexington High School wins MA state science fair using CIPRES

## The Origin & Spread of HIV-1 Subtype B in the Americas

Arman Bilge



### Number of New HIV Infections North America & West Europe



### MSSEF 2012 Winners by Place and Name

This is the list of winning students, ordered by place and alphabetically by name.

#### 160 Results

Exhibitor	School	Title	Place
Ackell, Ryan	Falmouth Academy	Effects of Nicotine and Vicodin on Memory Formation in <i>Hermissenda</i>	Team 1st Place
Athalye, Anish	Mass. Academy of Math & Science	Cooling without Electricity: Engineering a New Refrigerator	1st Place
Bhupatiraju, Surya	Lexington High School	Investigating the Spread of the Influenza A Virus: A Phylogenetic Anal	Team 1st Place
Bilge, Arman	Lexington High School	The Origin & Spread of HIV-1 Subtype B in the Americas	1st Place
Dodd, Oliver	Needham High School	Cancer Growth Regulators	1st Place
Fleron, Addie	Westfield High School	The Adverse Effects of Consumer and Pharmaceutical Goods on Plant Life	Team 1st Place

Miller, M. A., Pfeiffer, W., & Schwartz, T. (2010). Creating the CIPRES Science Gateway for inference of large phylogenetic trees. Gateway Computing Environments Workshop, 1-8. Retrieved from <http://www.phylo.org/>

### References

Ayres, D. L., Darling, A., Zwickl, D. J., Bieri, P., Holder, M. T., Lewis, P. O., ... Suckard, M. A. (2011). BEAGLE: An application programming interface and high-performance computing library for statistical phylogenetics. *Systematic Biology*, 60(10), 1097-1110. doi:10.1093/sysbio/tyt10

Bacon, D. A., & Olfelt, S. (2004). Phylogenetic tree thinking. *The American Biology Teacher*, 70(5), 229-239. doi:10.1892/0002-7688(2004)070[0229:PTT]2.0.CO;2

Baldwin, F., Banchard, A., Suckard, M. A., & Ho, S. Y. W. (2012). SPREAD: Spatial phylogenetic reconstruction of evolutionary dynamics. *Bioinformatics*, 28(10), 1260-1268. doi:10.1093/bioinformatics/bts484

Donnell, A. J., & Banchard, A. (2007). BEAST: Bayesian evolutionary analysis by sampling trees. *BMC Evolutionary Biology*, 7(21), 1-12. doi:10.1186/1471-2148-7-214

Donnell, A. J., Nkolle, G. N., Bouchard, A. G., & Schuman, W. (2002). Estimating mutation parameters, population history and prevalence simultaneously from temporally spaced sequence data. *Genetics*, 162(2), 1207-1220. Retrieved from <http://www.genetics.org/content/162/2/1207>

Donnell, A. J., Banchard, A., Shapiro, H., & Pyba, O. G. (2005). Bayesian reconstruction of past population dynamics from molecular sequences. *Molecular Biology and Evolution*, 22(10), 1186-1192. doi:10.1093/molbev/msi123

Donnell, A. J., Ho, S. Y. W., Phillips, M. J., & Banchard, A. (2006). Robust phylogenetic inference. *PLoS Biology*, 4(1), pii=004098

Hollan, E. C. (2006). *Map to a better job: Nature Reviews Ge*, 4(10), 520-522

Miller, M. A., Pfeiffer, W., & Schwartz, T. (2010). Creating the CIPRES Science Gateway for inference of large phylogenetic trees. Gateway Computing Environments Workshop, 1-8. Retrieved from <http://www.phylo.org/>

Miller, M. A., Pfeiffer, W., & Schwartz, T. (2010). Creating the CIPRES Science Gateway for inference of large phylogenetic trees. Gateway Computing Environments Workshop, 1-8. Retrieved from <http://www.phylo.org/>

Parsons, G., Crandall, C., & Faurt, A. R. (1993). The demographic history of human immunodeficiency virus infection. *The New England Journal of Medicine*, 329(1), 977-983. doi:10.1056/NEJM199302053290119

Ponsio, D. (2008). Modified Phylogenetic root averaging. *Molecular Biology and Evolution*, 25(7), 1263-1266. doi:10.1093/molbev/etn083

Ross, D., & Crandall, K. A. (2001). Selecting models of nucleotide substitution: An application to human immunodeficiency virus 1 (HIV-1). *Molecular Biology and Evolution*, 18(6), 807-806. Retrieved from <http://www.infodiv.unmc.edu/content/18/6/807>

Bandman, A. (2006). FigTree (Version 1.3.1) [Computer software]. Retrieved from <http://www.bio.ed.ac.uk/software/figtree/>

Bandman, A. (2006). TreeK (Version 1.4) [Computer software]. Retrieved from <http://www.bio.ed.ac.uk/software/treek/>

Swaidan, D. L. (2002). PAUP\* [Phylogenetic analysis using parsimony (\*and other methods)] (Version 4) [Computer software]. Sunderland, Massachusetts: Sinauer Associates.

Tanner, S. (1986). Some probabilistic and statistical problems in the analysis of DNA sequences. *Lectures on Mathematics in the Life Sciences*, 17, 37-66. Retrieved from <http://www.csb.cmc.edu/~tanner/papers/L86/Tanner.pdf/7386.pdf>

The origin of AIDS and HIV and the first cases of AIDS. Retrieved 27 January 2012 from <http://www.aids.gov/>

Thompson, R. C. (2009). PhyML: A simple GNU/Linux distribution for phylogenetic and phylogenetic. *Evolutionary Bioinformatics*, 5, 91-95. Retrieved from <http://www.ebi.ac.uk/ena/ENA/xhtml/PhyML.pdf>

UNAIDS. (2011). Global HIV/AIDS response: Epidemic update and strategic vision progress to work Universal Access. Joint United Nations Programme on HIV/AIDS. Retrieved from <http://www.unaids.org/>

Worley, M., Gussler, M., Treese, D. E., Hoshino, T., Kuznetsov, K., Shure, M., ... Williams, S. M. (2008). Direct evidence of extensive diversity of HIV-1 in Kinshasa by 1980. *Nature*, 455(7213), 661-664. doi:10.1038/nature07290

Worley, M., Telfer, P., Sussman, S., Hatten, M. P. A. (2010). Island biogeography reveals the global history of HIV-1. *Science*, 329(5950), 1487-1491. doi:10.1126/science.1193060

# CIPRES on NSF's front page today!

The image shows a screenshot of the National Science Foundation (NSF) website. At the top left is the NSF logo with the tagline "National Science Foundation WHERE DISCOVERIES BEGIN". A search bar is located at the top right. Below the header is a navigation menu with links for HOME, FUNDING, AWARDS, DISCOVERIES, NEWS, PUBLICATIONS, STATISTICS, ABOUT NSF, and FASTLANE. The main content area features a large banner image of the White House with a fountain in the foreground. Overlaid on the right side of the banner is a dark box with the text "White House Visit for PAEMST Winners" and a "FULL STORY" button. Below the banner is a secondary navigation bar with three tabs: "Advancing the Sciences", "Funding & Supporting", and "Inspiring & Educating", followed by a "HIDE" button. The main content area is a grid of six news items, each with a small image, a title, and a date:

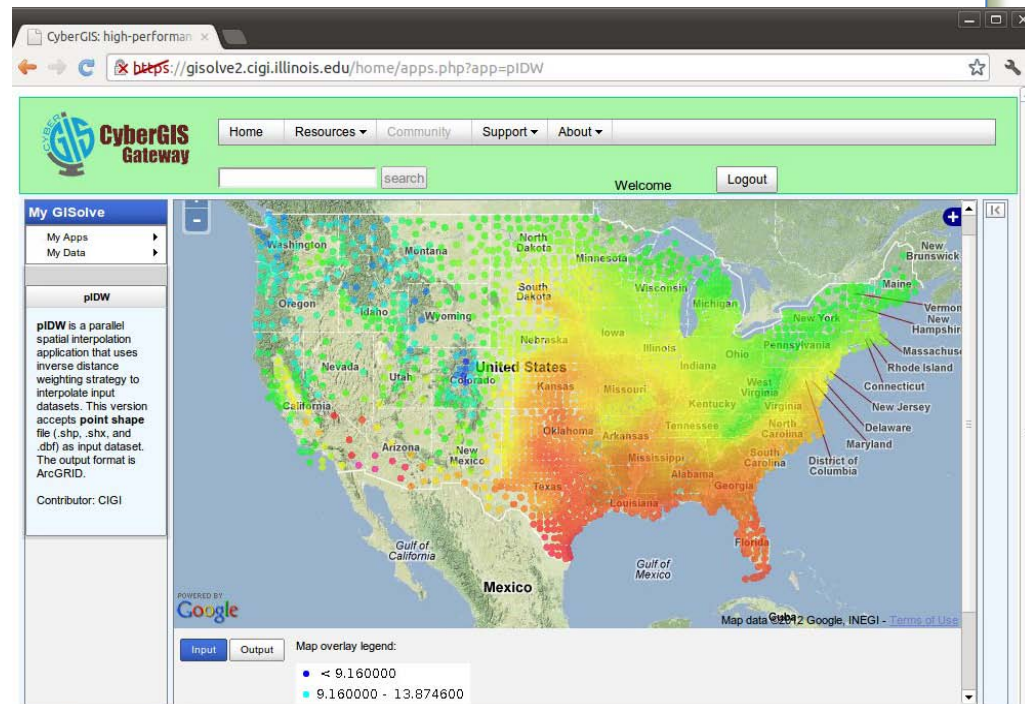
- NSF Research Dollars Fortify America's Science and Engineering Infrastructure** (July 13, 2012)
- Robot Vision: Muscle-like Action Allows Camera to Mimic Human Eye Movement** (July 5, 2012)
- CIPRES Science Gateway Clarifies Branches in Evolution's "Tree of Life"** (July 3, 2012)
- New Coral Reef Crustacean Described and Named After Late Reggae Performer Bob Marley** (July 9, 2012)
- Microscope Probe-sharpening Technique Improves Resolution, Durability** (July 5, 2012)
- NSF Charters Icebreaker to Support U.S. Research Stations in Antarctica** (July 3, 2012)



# CyberGIS

## Software Integration for Sustained Geospatial Innovation

- Application of high-end cyberinfrastructure to GIS
- Influence on multiple domains
- Improved decision support
- Spatial joins, layers of multiple datasets at different resolutions
- Goal is core set of composable, interoperable, manageable, and reusable software elements
- Collaborative geospatial problem solving environment



# Analytical Ultracentrifugation: Emerging computational tool for the study of proteins

- Samples from researchers all over the world
  - Some (Germany, Australia) have their own ultracentrifuges and use only the analysis capabilities, others send samples to UT to spin
- Spin the samples at high speeds, learn about macromolecule properties
- Monte Carlo simulations
- Observations are electronically digitized and stored for further mathematical analysis

## UltraScan 9.0

The Center for Analytical Ultracentrifugation of  
Macromolecular Assemblies, UT Health Sciences,  
Borries Demeler, PI



# Ultrascan provides a comprehensive data analysis environment

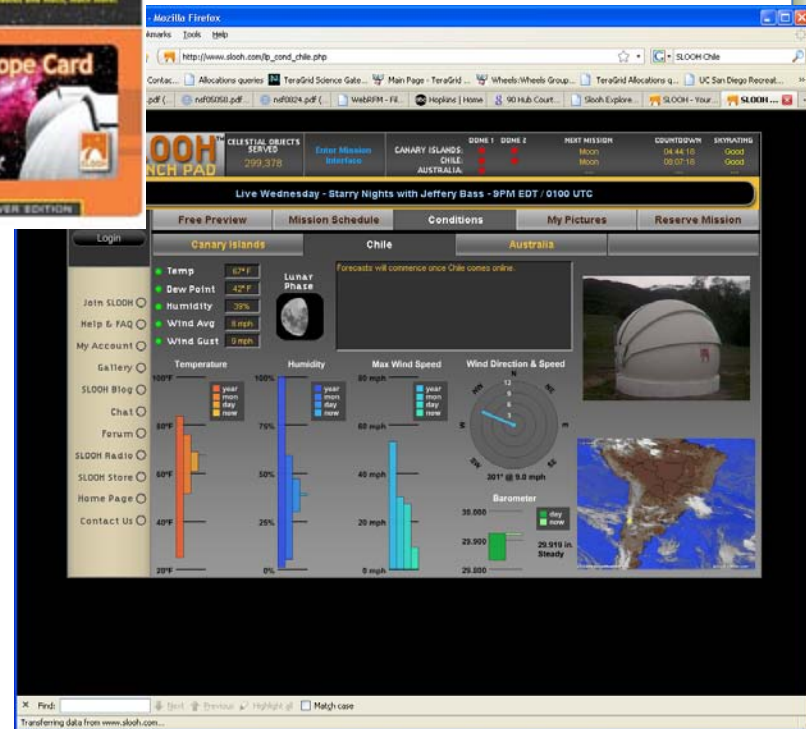
- Management of analytical ultracentrifugation data for single users or entire facilities
- Support for storage, editing, sharing and analysis of data
  - HPC facilities used for 2-D spectrum analysis and genetic algorithm analysis
    - XSEDE
    - Technische University of Munich
    - Juelich Supercomputing Center
- Portable graphical user interface
- MySQL database backend for data management
- Over 30 active institutions

Source: Suresh Marru, IU

# Gateways in the marketplace

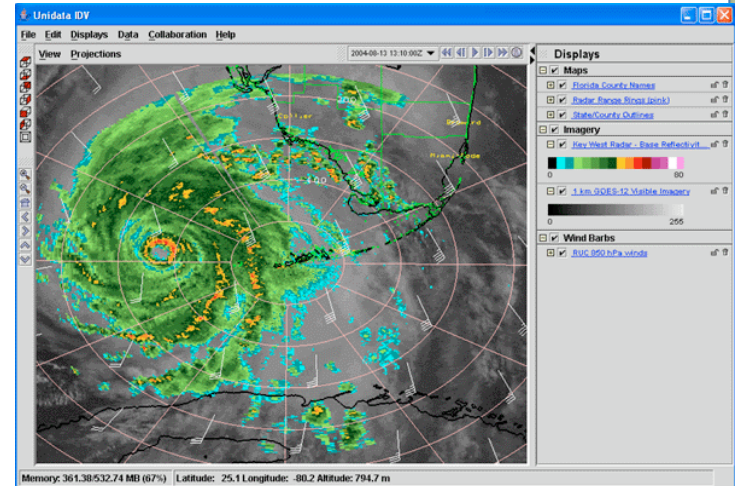
## Kids control telescopes and share images

- “In seconds my computer screen was transformed into a live telescopic view”
  - “Slooh's users include newbies and professional astronomers in 70 countries”
- Observatories in the Canary Islands and Chile, Australia coming soon
- 5000 images/month since 2003
- Increases public support for investment in these facilities



# Linked Environments for Atmospheric Discovery LEAD

- Providing tools that are needed to make accurate predictions of tornados and hurricanes
- Data exploration and Grid workflow



Welcome to the **LEAD PORTAL** Linked Environments for Atmospheric Discovery  
Sponsored by the National Science Foundation

Portal Home | Geo GUI | Education and Outreach | Weather | Links | About LEAD | Help

Home

To view a local radar, select area of interest and click on the image below.

**RADAR REFLECTIVITY FROM RADAR CODED MESSAGES  
NATIONAL WEATHER SERVICE  
AUTOMATED EDITING APPLIED  
SEP 24, 2005 21:49 UTC**

MSG  
55 DBZ  
50 DBZ  
45 DBZ  
40 DBZ  
30 DBZ  
15 DBZ

Data provided by NOAA's National Weather Service

User Name:   
Password:   
 Remember my login

[Create new account](#)  
[Forgot your password?](#)

**LEAD Grid Testbed Status**

Testbed	Grid Auth	GRAM	Grid
IU [chinkapin]	✓	✓	✓
NCSA [copper]	✓	✓	✓
OU [aquaman]	✓	✓	✓
UAH [frozone]	✓	✓	✓
UNC [dante0]	✗	✗	✗
Unidata [lead1]	✓	✓	✓

Last updated: Sat Sep 24 17:00:00 2005 Indiana 1

LEAD Home | FAQ | Privacy | Terms of use | Contact us

the HUBzero conference

**SAN DIEGO SUPERCOMPUTING CENTER**

**Workflow Composer**

Workflow MyLead Component Monitor

Add Node Remove Node Connect/Disconnect

Component List

- System Components
- http://whitney.extreme.indiana.edu
- http://www.extreme.indiana.edu
- Adder
- Multiplier
- Divider
- decoder
- threads
- arps-trn
- arps-sfc
- ext2arps-ibc

Composer

Component Information

**Service: decoder**

**Description:**  
A service for decoding raw eta data to netcdf format

**Operation: Run**

Port Information | Notification |

Selected Output Port

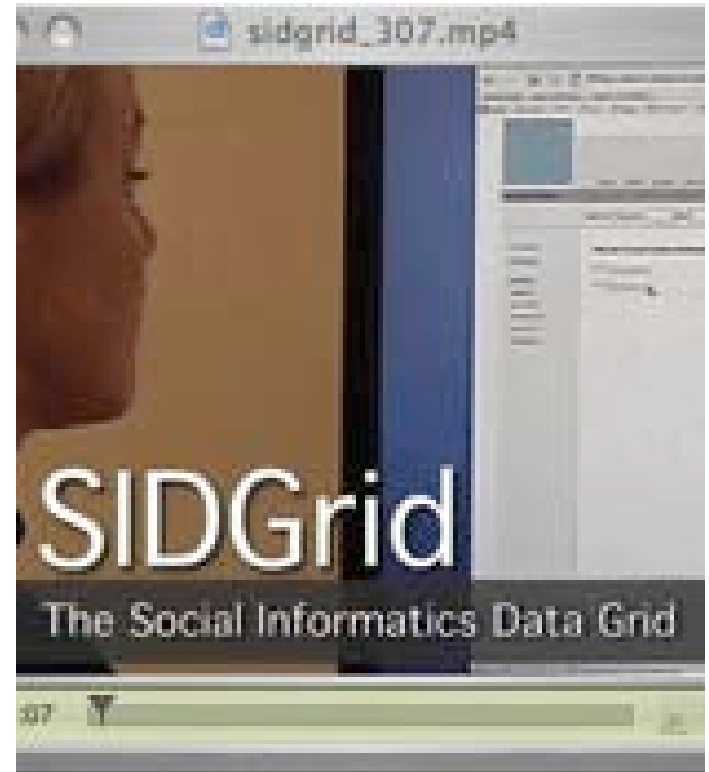
Selected Input Port

**Component: Output\_URL**  
**Port: Parameter**  
**Type: Any**  
**Description:** This port can be connected to any type.

# Social Informatics Data Grid

## Collaborative access to large, complex datasets

- SIDGrid is unique among social science data archive projects
  - Streaming data which change over time
    - Voice, video, images (e.g. fMRI), text, numerical (e.g. heart rate, eye movement)
  - Investigate multiple datasets, collected at different time scales, simultaneously
    - Large data requirements
    - Sophisticated analysis tools
- Especially valuable for multi-disciplinary course
  - Computer science, linguistics, psychology

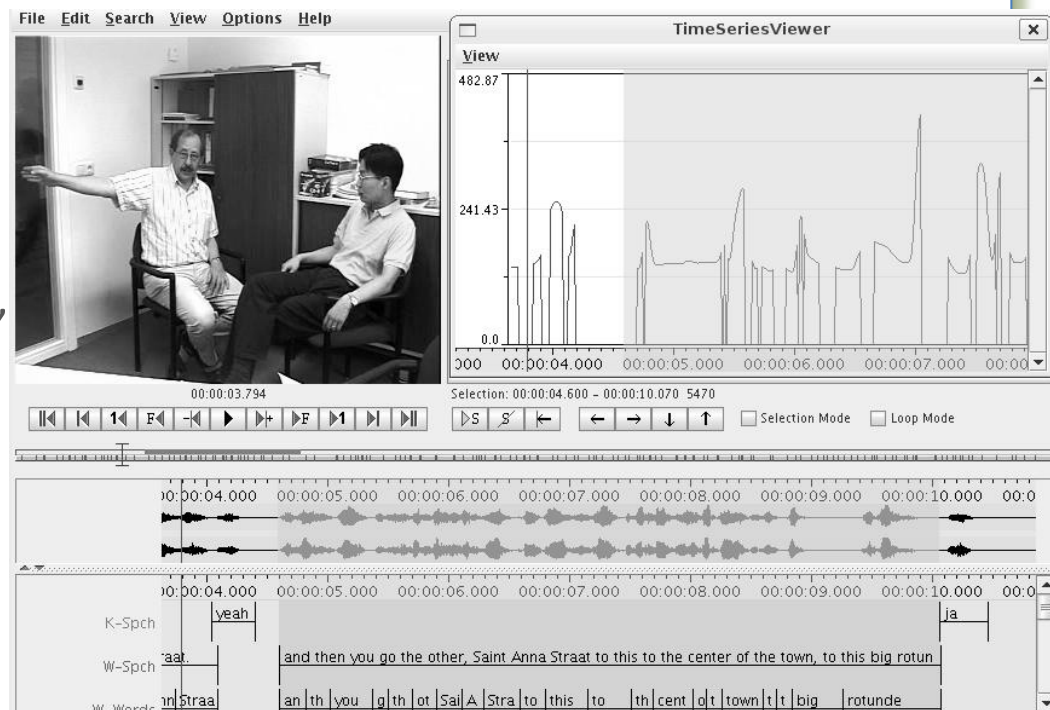


<http://www.ci.uchicago.edu/research/files/sidgrid.mov>



# Viewing multimodal data like a symphony conductor

- “Music-score” display and synchronized playback of video and audio files
  - Pitch tracks
  - Text
  - Head nods, pause, gesture references
- Central archive of multi-modal data, annotations, and analyses
  - Distributed annotation efforts by multiple researchers working on a common data set
    - History of updates
- Computational tools
  - Distributed acoustic analysis using Praat
  - Statistical analysis using R
  - Matrix computations using Matlab and Octave



Source: Studying Discourse and Dialog with SIDGrid, Levow, 2008

# Gateways democratize access to high end resources

- Almost anyone can investigate scientific questions using high end resources
  - Not just those in high profile research groups
- Gateways allow anyone with a web browser to explore
- Foster new ideas, cross-disciplinary approaches
  - Encourage students to experiment
- But used in production, too
  - Significant number of papers resulting from gateways, including GridChem, nanoHUB
  - Scientists can focus on challenging science problems rather than challenging infrastructure problems

# Gateway Sustainability Study

With Dr. Katherine Lawrence, U Michigan School of Information

- Characteristics of short funding cycles
  - Build exciting prototypes with input from scientists
  - Work with early adopters to extend capabilities
  - Tools are publicized, more scientists interested
  - Funding ends
  - Scientists who invested their time to use new tools are disillusioned
    - Less likely to try something new again
  - Start again on new short-term project
- Need to break this cycle
- Small grant to look at characteristics of successful gateways and domain areas where a gateway could have a big impact

**Opening Science Gateways to Future Success**  
A study funded by the National Science Foundation's Office of Cyberinfrastructure

Exploring ways to deliver more effective tools to researchers from the worlds of science and engineering

About the Study    Participant Information    References    Contact Us

© 2009 Science Gateway Model Study | Terms of Use | Privacy Policy      This project is supported by the National Science Foundation under Award # OCI-0940476

4 focus group meetings over 2 years

First 2 held June, 2010

Final 3 held June, 2011

After reading stacks of reports, we wanted to capture our findings in a memorable way



# These findings lead nicely into NSF's Scientific Software Innovation Institutes (S2I2) program

- Cyberinfrastructure Framework for the 21<sup>st</sup> Century Science and Engineering (CIF21) vision
- Software as integral enabler of computation, experiment and theory
- NSF expects that software investment will result in robust, reliable, usable, sustainable software infrastructure
- **S2I2 institutes are viewed as long-term hubs of excellence that serve communities of substantial size and disciplinary breadth**

# Science Gateway Institute

- One of several 1-year conceptualization grants awarded this past summer
- Collaboration involves
  - SDSC, Elizabeth City State, Indiana, Purdue, U Michigan, U Texas
- Gathering community feedback on Institute offerings this year
  - Incubator service
  - Extended support services
  - Gateway forum
  - Gateway framework
  - Workforce development
  - Community engagement

# Incubator Service

## Assist with the entire lifecycle of a gateway:

- Business plan development and review
- Development environment, consulting, documentation and software recommendations
- Software repositories
- Software engineering facilities
- Software assessment services
  - like Open Source Software Advisory Service, Apache assessment service, Software Sustainability Institute (UK)
- Build-and-test facilities
- Hosting service
- Offering gateways expertise in the following areas:
  - Usability assessment
  - Licensing
  - Sustainability
  - Project management
  - Security

# Extended Support

- Peer-reviewed request process open to all
- Institute staff assigned to a project for months, up to a year
  - Assist with gateway development
  - Teach research teams what it takes to build, enhance, operate, and maintain gateways after support ends



# Gateway Forum

- Gathering place for scientific web developers across NSF directorates, agencies, and international boundaries
- Social forums, white papers, blogs, testimonials and user stories
- Annual conference
- Broad and engaging symposium series
- Gateway training program
  - Synchronous and asynchronous, video tutorials
  - Best practices, case studies
- Showcase of successful projects
- Environment that enables continuous community feedback

# Gateway Framework

- Modular, layered approach
  - Supports community contributions
  - Grocery store approach allows developers to pick and choose the components they need
- 4 levels of architecture
  - Value-added services such as a publication channel for delivering content to a wider audience, information repositories for good design practices, and information/code samples for best practices in user-interface and user-experience design
  - Core web framework which includes hosted site creation and content management
  - Platform API to provide a cohesive set of RESTful web services upon which the previous two layers rely
  - Systems layer where the hardware and low-level middleware reside
    - Clouds and cloud services, HPC systems, grid middleware, data warehouses, databases, instrumentation, and distributed data stores

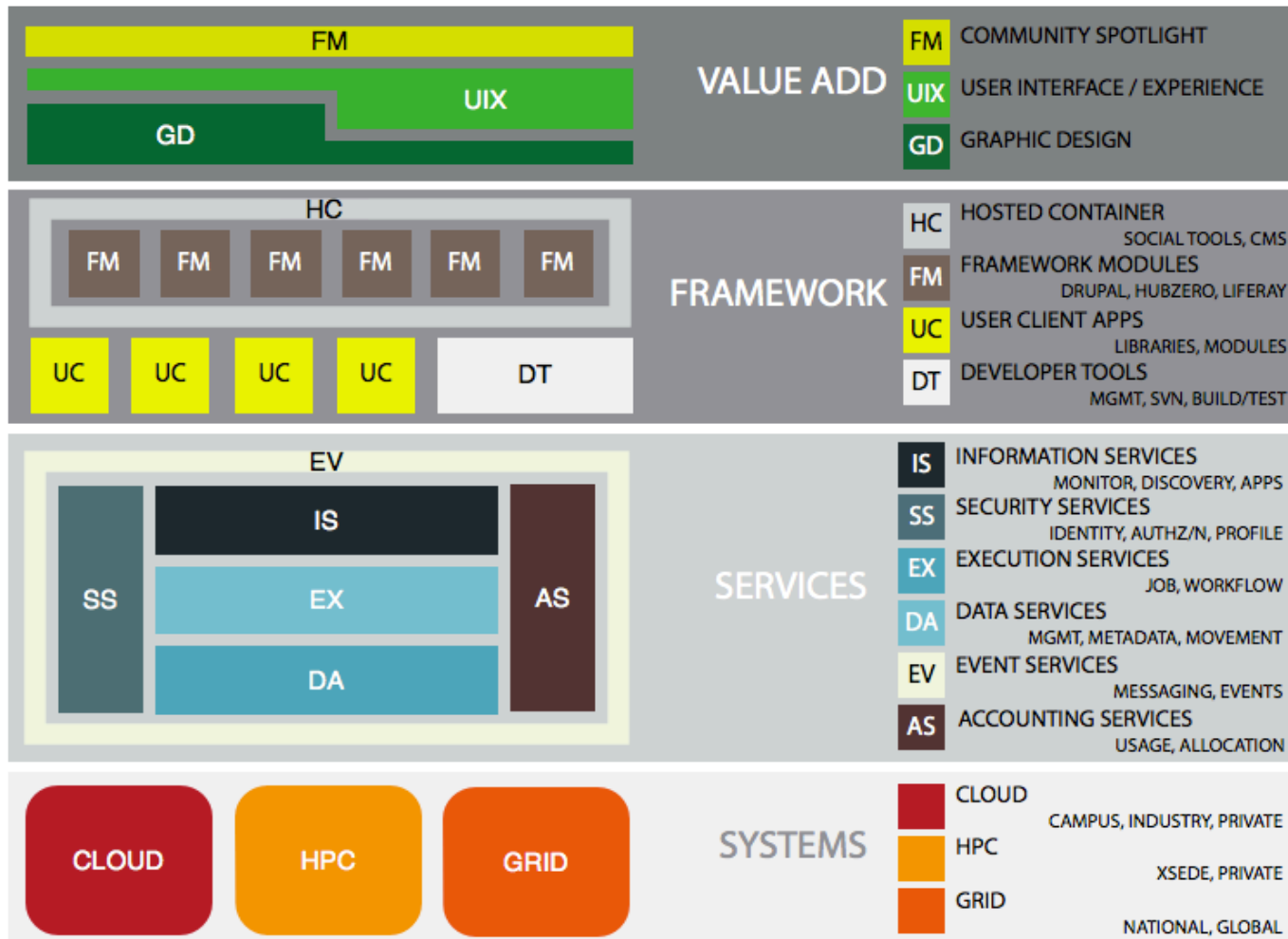


Figure 1. High-level architecture of software offerings and value-added services provided by the institute.

# First community input session this afternoon!

- Lightning talks highlighting gateways from 1:30-4, 5-5:30
- Live polling and interactive session on what would be of value in an institute from 4-5
- Hope to see some of you this afternoon
  
- **Thank you for your attention**