Cyberinfrastructure and Datasets for Science of Team Science Research

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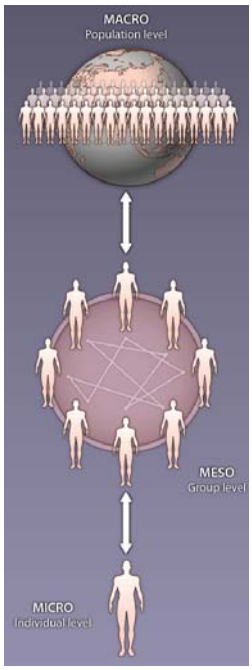

TEAM SCIENCE

A Multi-Level Systems Perspective for the Science of Team Science

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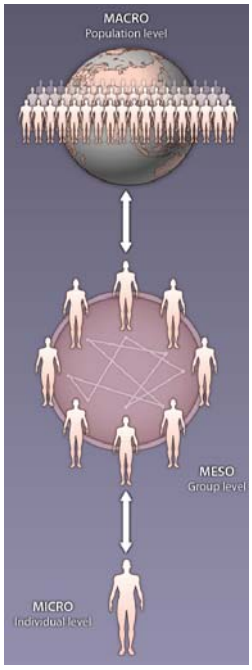
This Commentary describes recent research progress and professional developments in the study of scientific teamwork, an area of inquiry termed the "science of team science" (SciTS, pronounced "sahyts"). It proposes a systems perspective that incorporates a mixed-methods approach to SciTS that is commensurate with the conceptual, methodological, and translational complexities addressed within the SciTS field. The theoretically grounded and practically useful framework is intended to integrate existing and future lines of SciTS research to facilitate the field's evolution as it addresses key challenges spanning macro, meso, and micro levels of analysis.

SciTS research and practice require an interdisciplinary, multi-level, mixed-methods approach. Expertise, theories, methods, data, and tools from diverse research fields need to be applied and advanced to arrive at a holistic understanding of the science system.



Mixed-methods, multi-level SciTS needs:

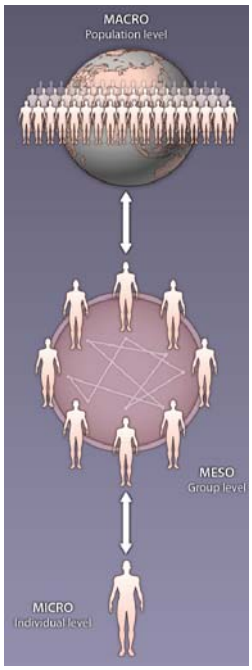
Expertise – identify and access it at the perfect moment using, e.g., Facebook, LinkedIn, Academia, VIVO, Harvard Profiles, Elsevier's Collexis, Loki, Stanford's CAP, or other systems.

Theories and Methods – find, understand, apply, advance them, e.g., using http://scienceofteamscience.northwestern.edu/team-science-resources.

Data – find, interlink, unify, merge, reformat, share them, e.g., using web sites analogous to http://www.diggingintodata.org/Repositories/tabid/167/Default.aspx, SDB, or LOD.

Tools – identify, learn, advance, share code, e.g., via Plug-and-Play Macroscopes, to arrive at a holistic understanding of the science system.

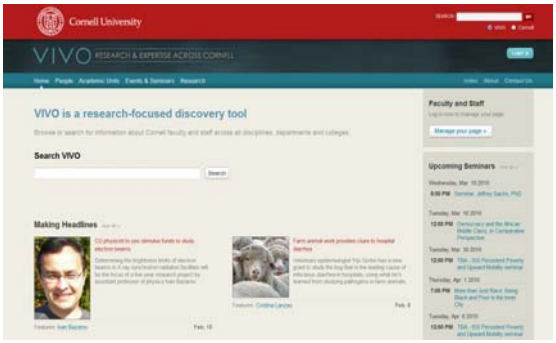
Note that the evolution of all of the above could be an extremely interesting and valuable SciTS study object.



Expertise – identify and access it at the perfect moment using, e.g., Facebook, LinkedIn, Academia, VIVO, Harvard Profiles, Elsevier's Collexis, Loki, Stanford's CAP, or other systems.

VIVO: A Semantic Approach to Creating a National Network of Researchers (http://vivoweb.org)

- Semantic web application and ontology editor originally developed at Cornell U.
- Integrates research and scholarship info from systems of record across institution(s).
- Facilitates research discovery and cross-disciplinary collaboration.
- Simplify reporting tasks, e.g., generate biosketch, department report.



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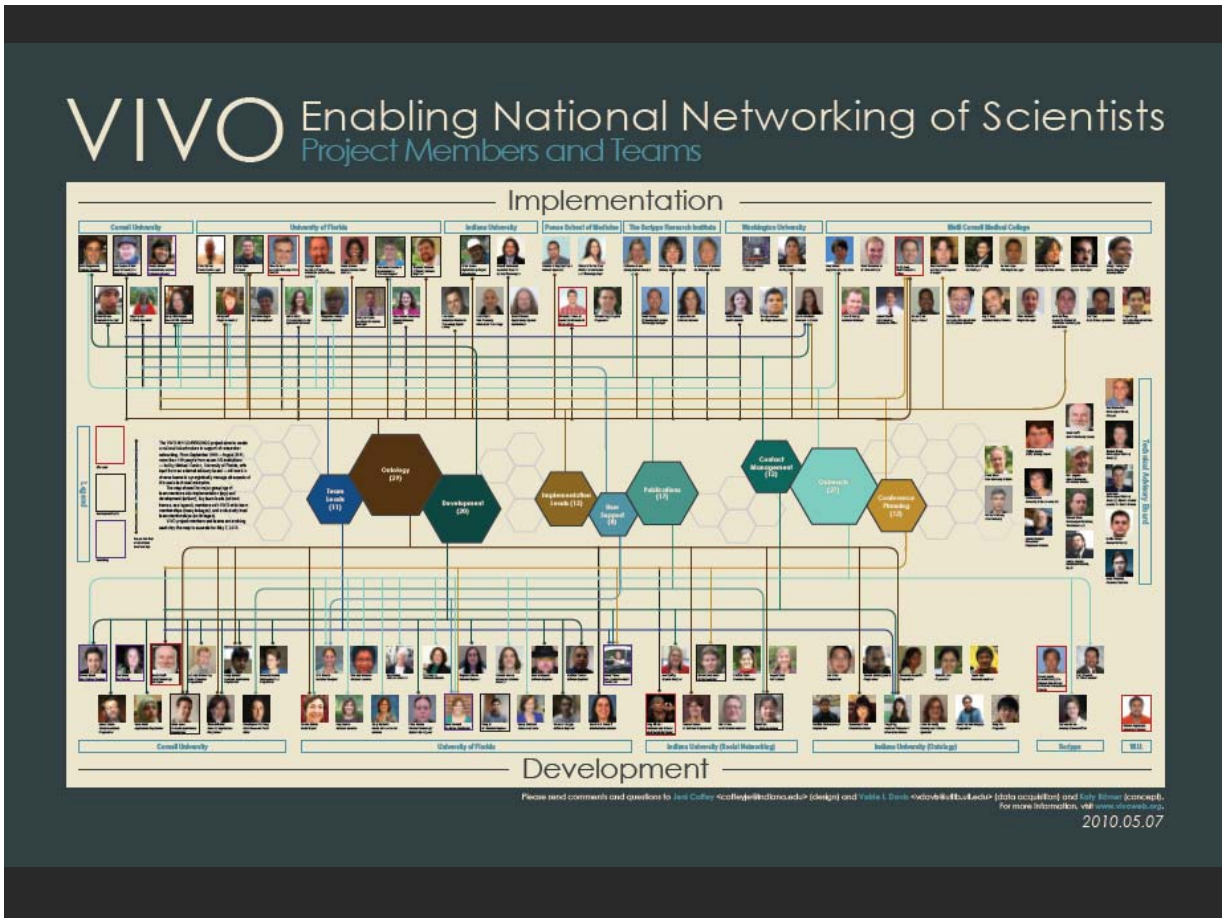
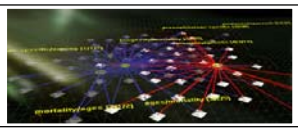
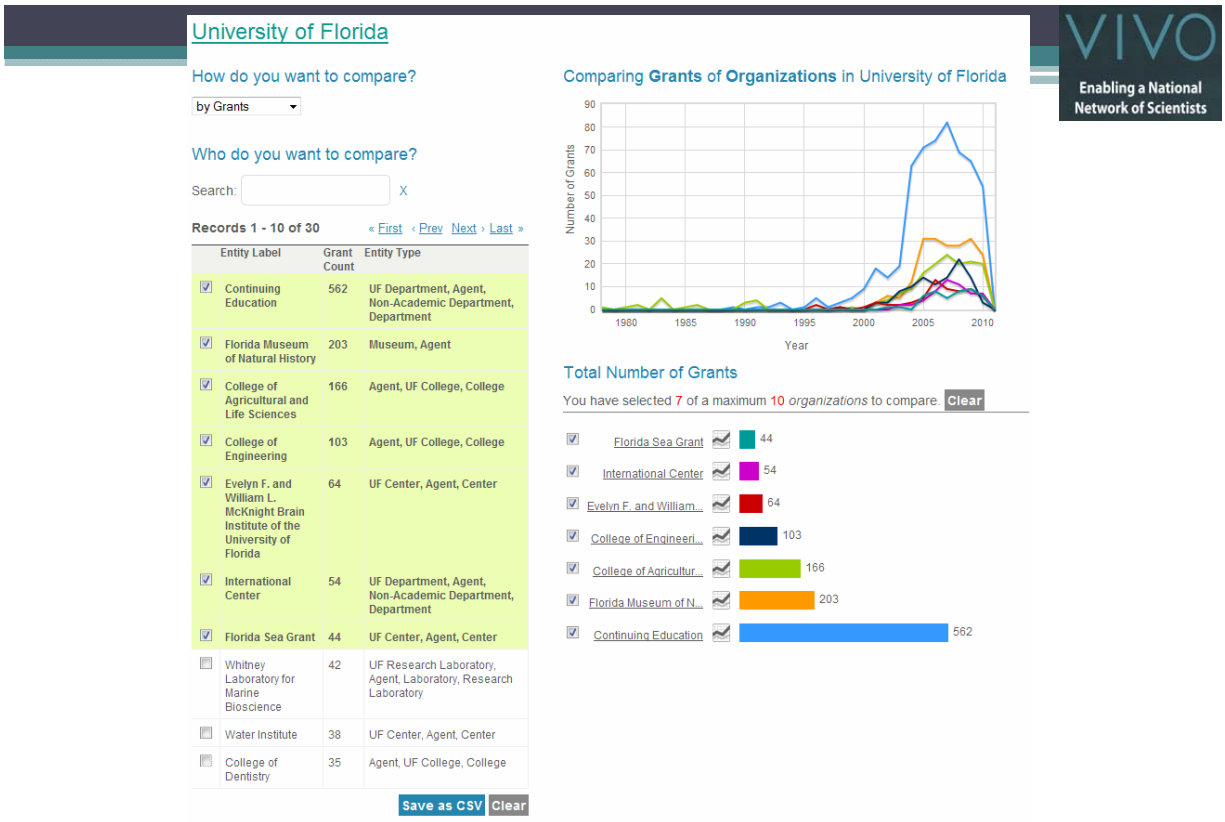


UF Clinical and Translational Science Institute
UNIVERSITY of FLORIDA

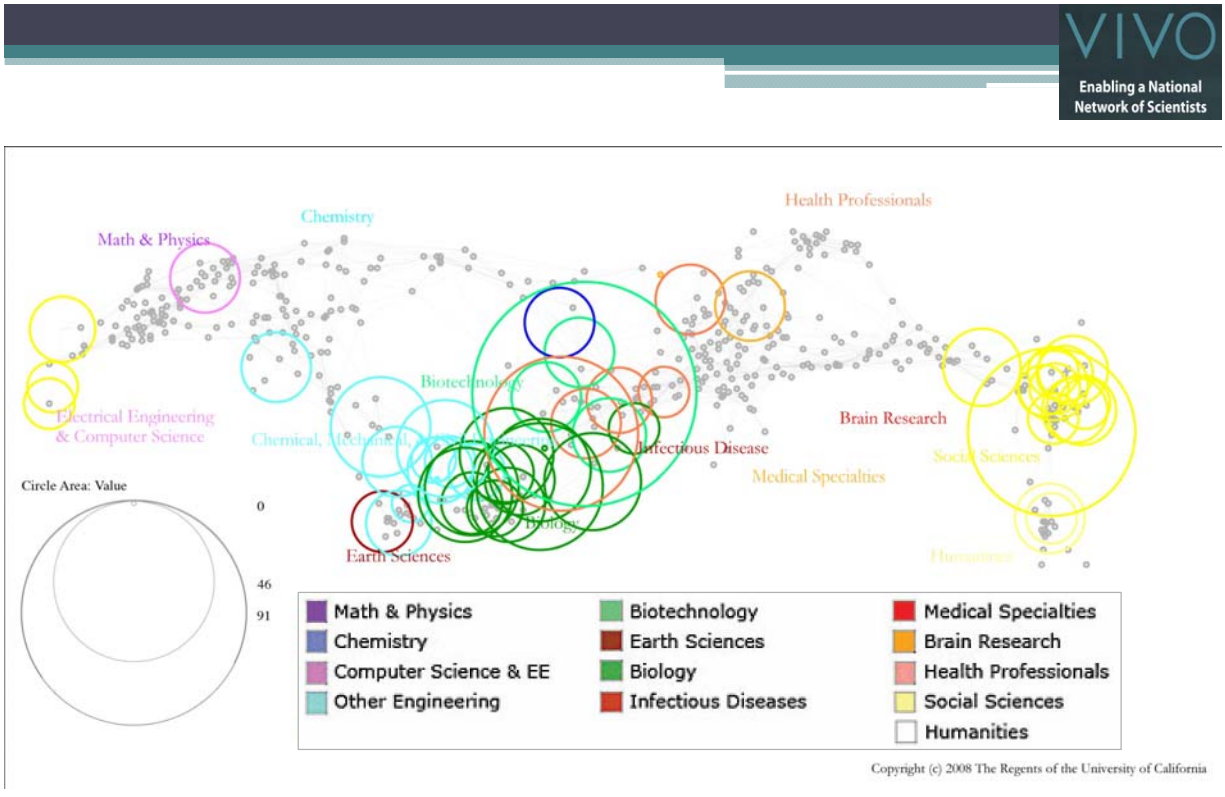


Type of Analysis vs. Level of Analysis

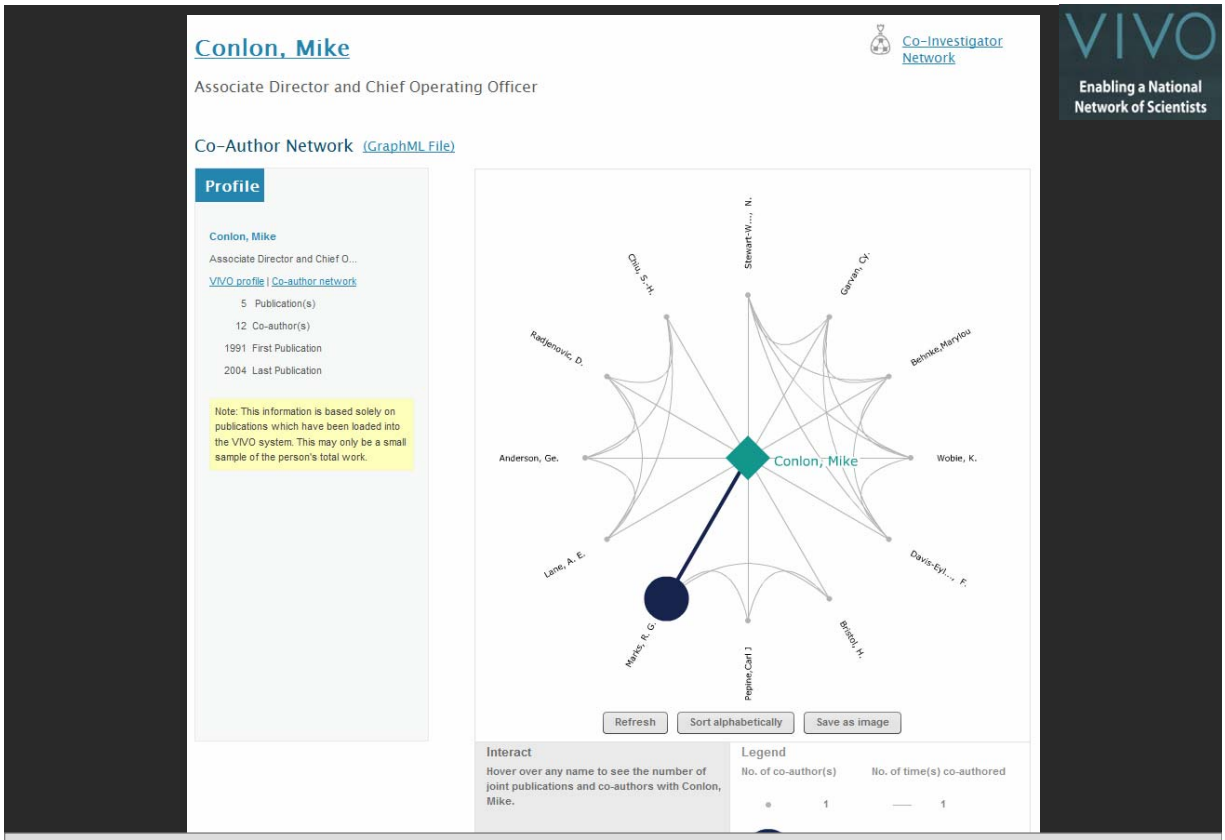
	Micro/Individual (1-100 records)	*Meso/Local (101–10,000 records)*	*Macro/Global (10,000 < records)*
Statistical Analysis/Profiling	Individual person and their expertise profiles	Larger labs, centers, universities, research domains, or states	All of NS SA, all of sci
Temporal Analysis (When)	Funding portfolio of one individual	ic bursts f PNAS	113 Years of P Research
Geospatial Analysis (Where)	Career trajectory of one individual	Mapping a s intellectual la	PNAS
Topical Analysis (What)	s.	flows in research	VxOrd/Topic n NIH funding
Network Analysis (With Whom?)	NSF work of one	k	NIH's cy



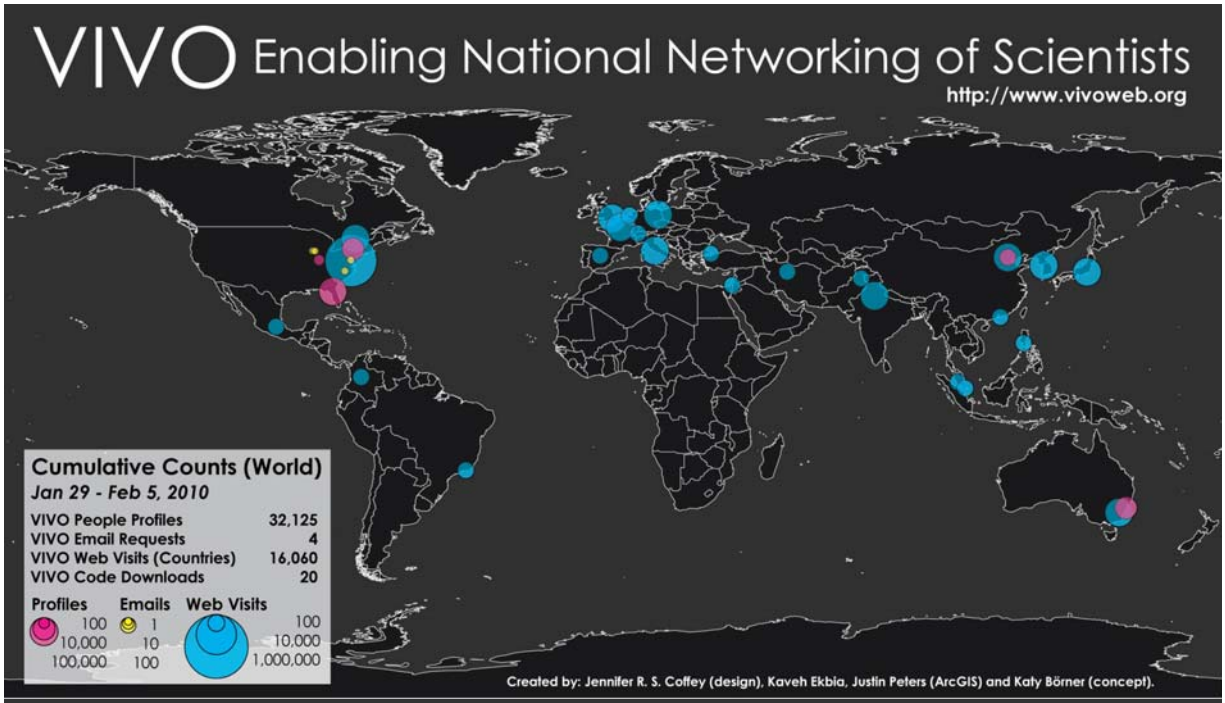
Temporal Analysis (When) Temporal visualizations of the number of papers/funding award at the institution, school, department, and people level



Topical Analysis (What) Science map overlays will show where a person, department, or university publishes most in the world of science. (soon)

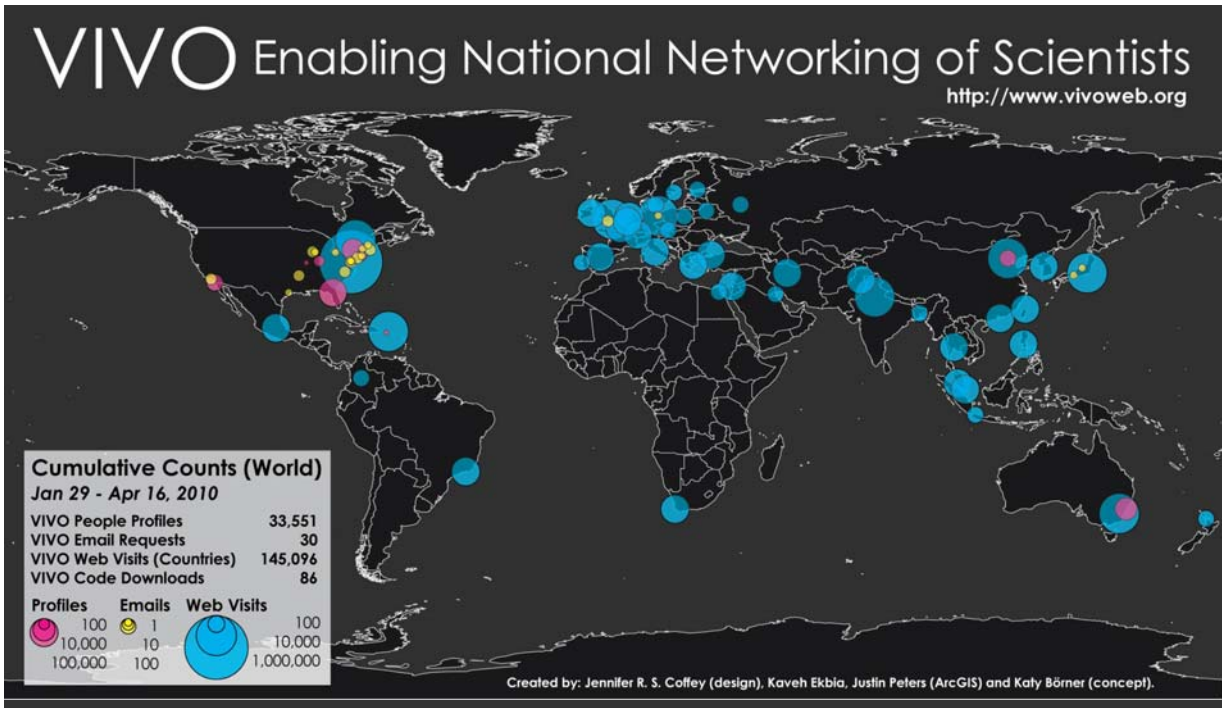


Network Analysis (With Whom?) Who is co-authoring, co-investigating, co-inventing with whom? What teams are most productive in what projects?



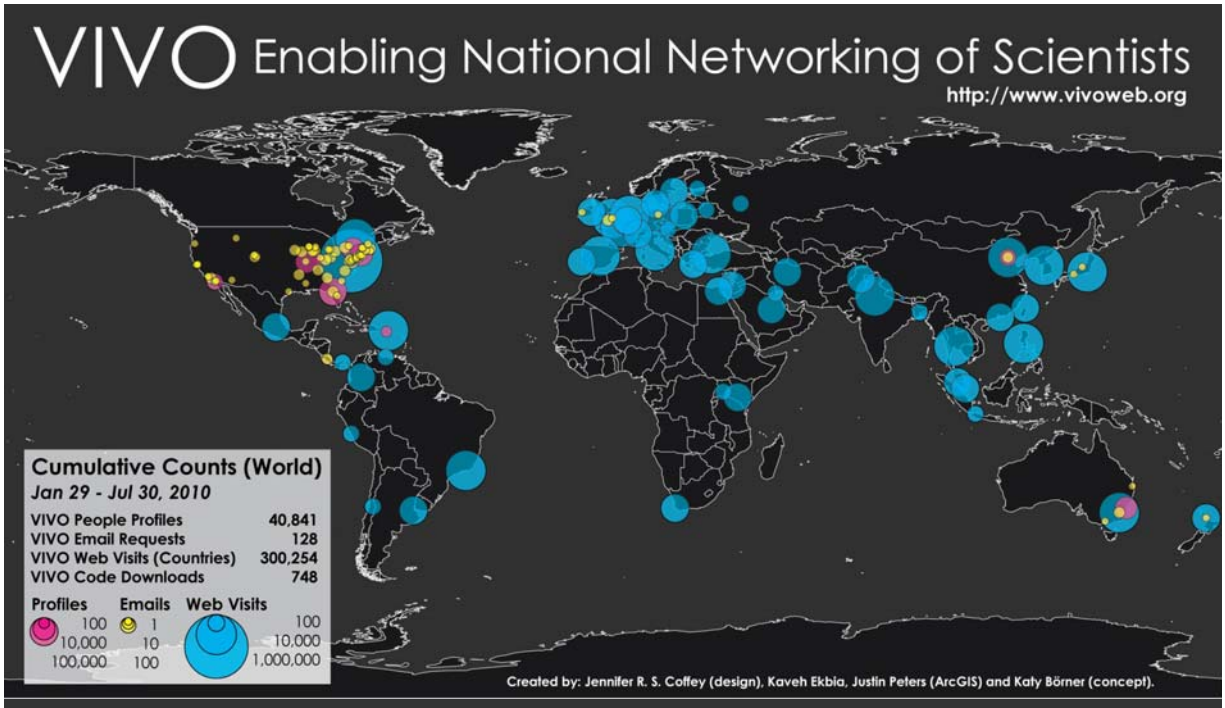
Science is global. World view of VIVO activity.
Web site visits are aggregated at the country level.

Geospatial Analysis (Where) Where is what science performed by whom? Science is global and needs to be studied globally. (in work)



Shown are the
- Number of people profiles in the 7 different VIVO installation sites plus CAS and U Melbourne.
- Email contacts by data and service providers as well as institutions interested to adopt VIVO.
- The number of visitors on http://vivoweb.org

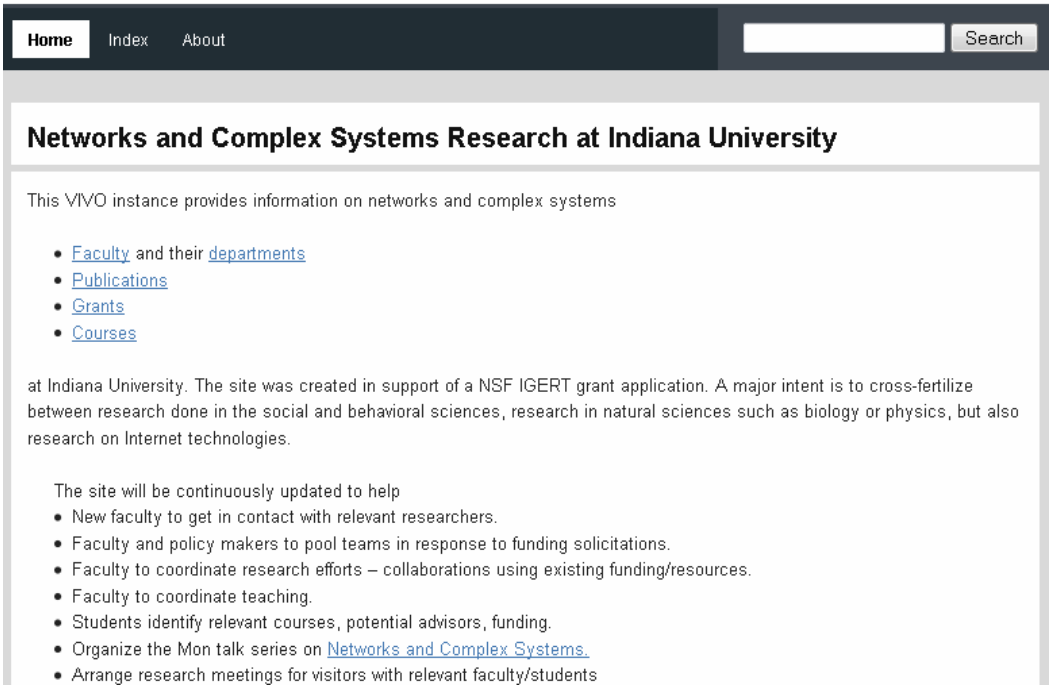
Circles are area size coded using a logarithmic scale.



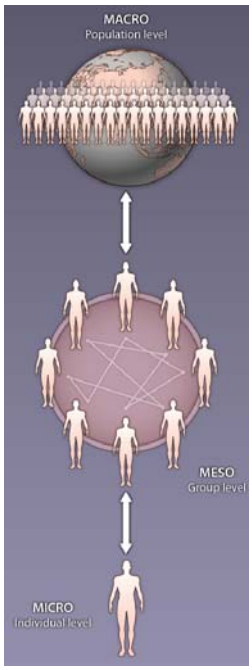
VIVO 1.0 source code was publicly released on April 14, 2010
87 downloads by June 11, 2010.
The more institutions adopt VIVO, the more high quality data will be available to understand, navigate, manage, utilize, and communicate progress in science and technology.

VIVO enabling national networking of scientists

VIVO Enabling a National Network of Scientists



http://vivo-netsci.cns.iu.edu



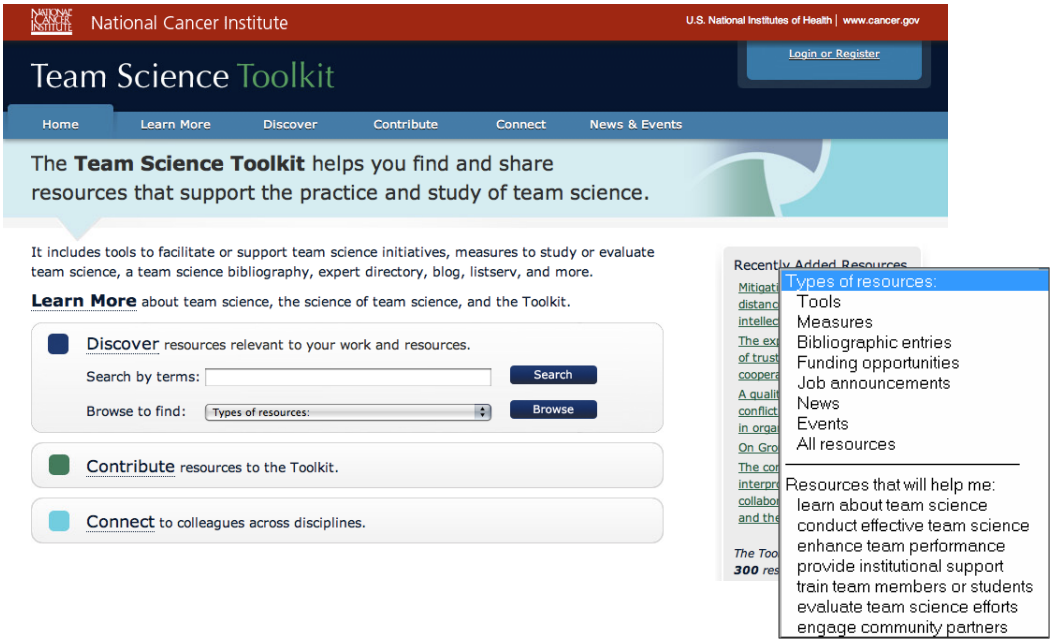
Theories and Methods

– find, understand, apply, advance them.

Also available are listings of

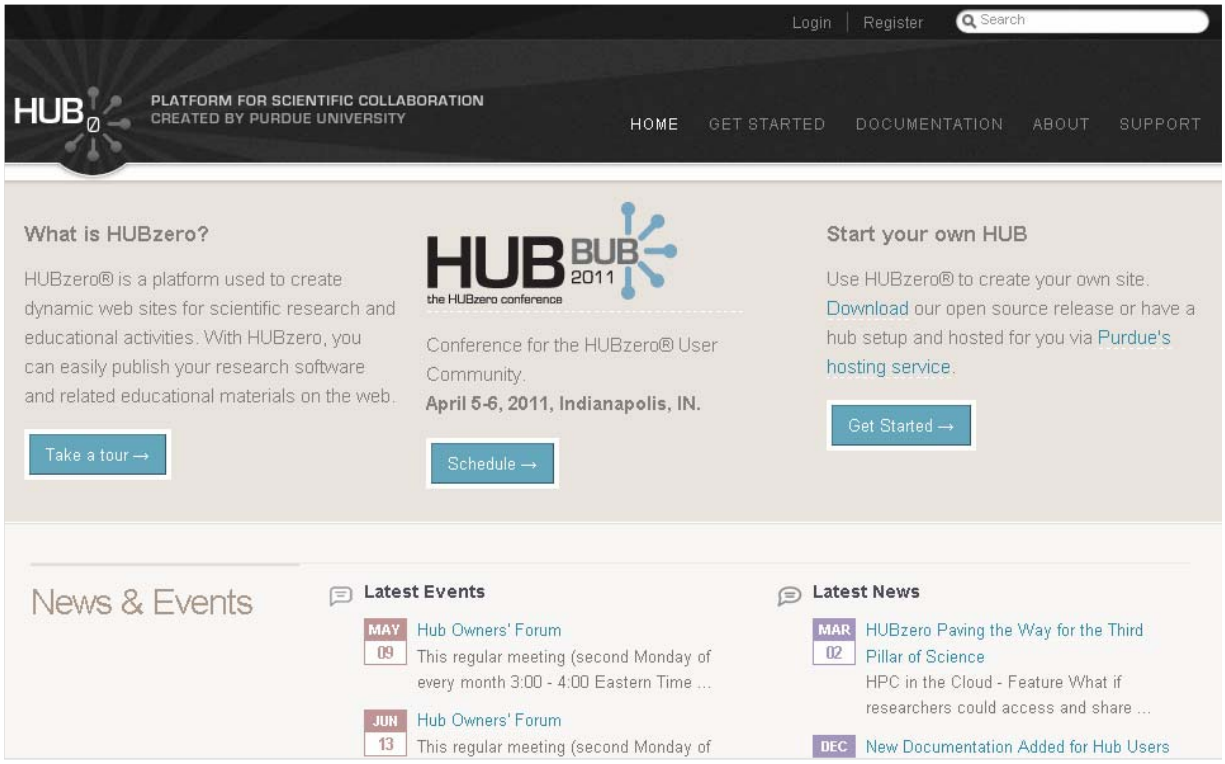
- **Upcoming conference and workshops:**
- **Past Conferences and Workshops:**
- **Selected References:**
- **Team Science Training:**
- **Team Science Tools:**
- **Interdisciplinary Research and Team Science Resources:**
- **Professional Organizations:**
- **Team Science Blog and Twitter:**
- **Science of Team Science Publishing Venues:**

http://scienceofteamscience.northwestern.edu/team-science-resources



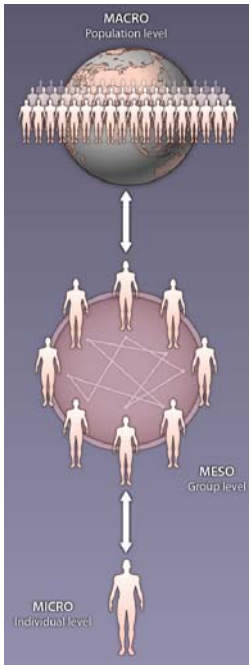
- Facilitates information and knowledge exchange, via a wiki-based platform
- Users can freely upload/download publicly available team science resources
- Will help reduce replication of resources, accelerate advances in the field

www.teamsciencetoolkit.cancer.gov



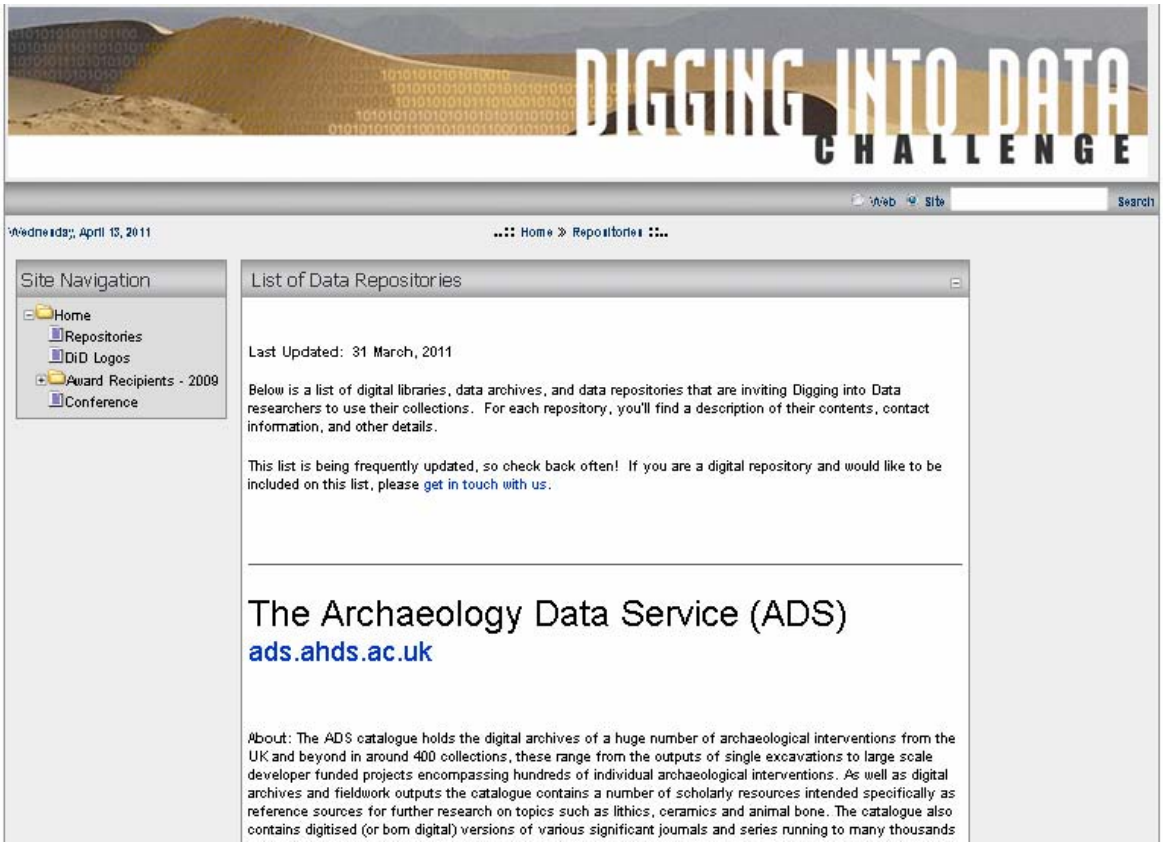
http://hubzero.org

http://hubzero.org



Data – find, access, interlink, unify,

merge, reformat, share them, e.g., using web sites analogous to http://www.diggingintodata.org/Repositories/tabid/167/Default.aspx, SDB, or LOD.

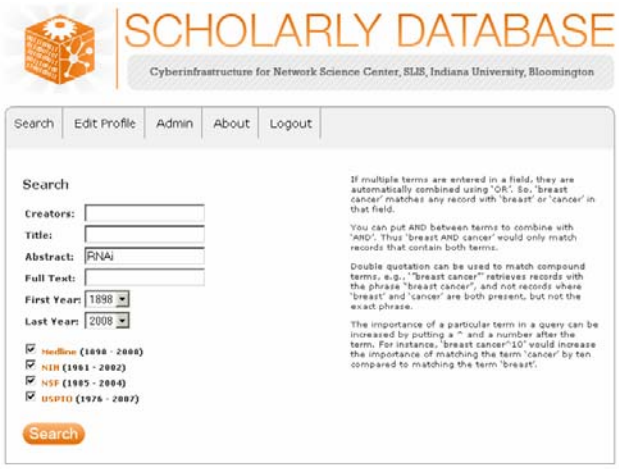


http://www.diggingintodata.org/Repositories/tabid/167/Default.aspx

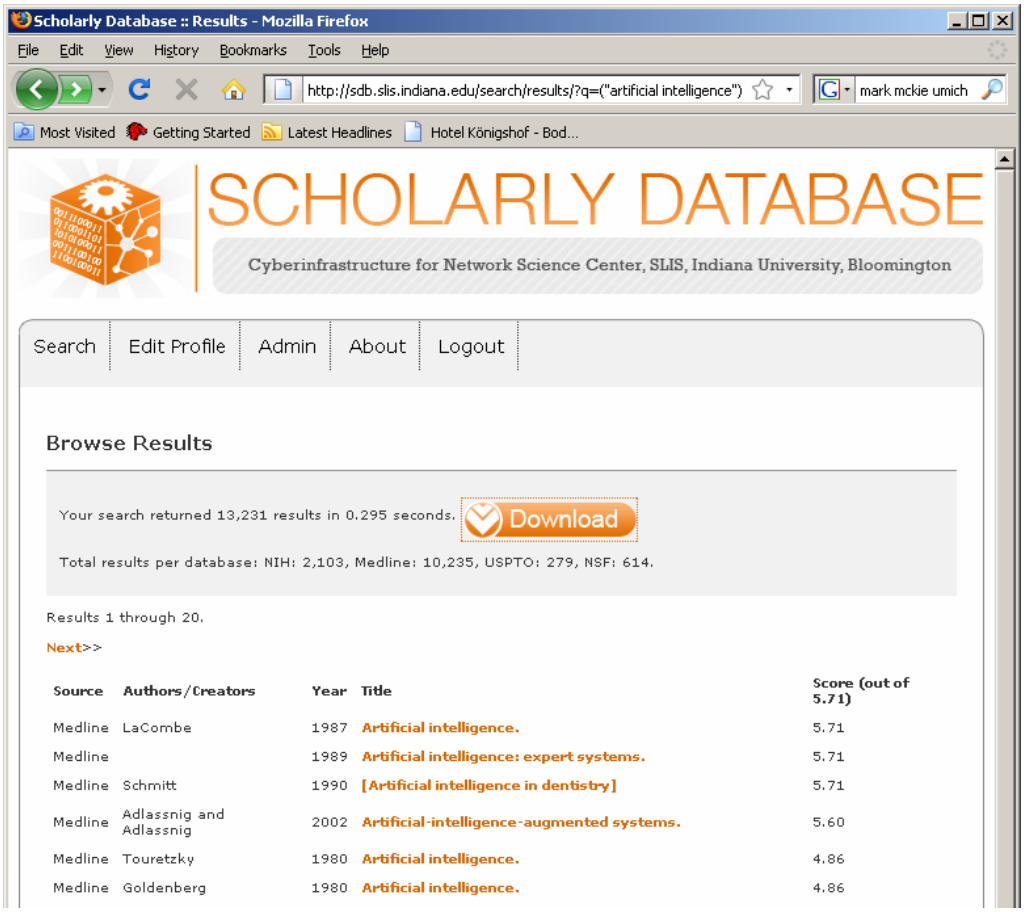
Scholarly Database at Indiana University

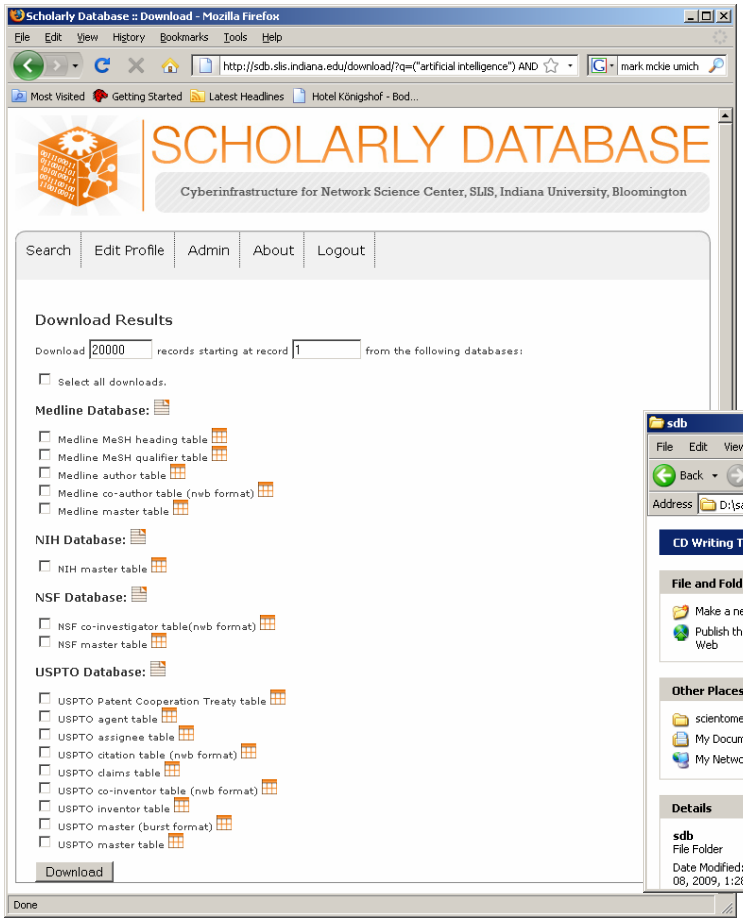
http://sdb.wiki.cns.iu.edu

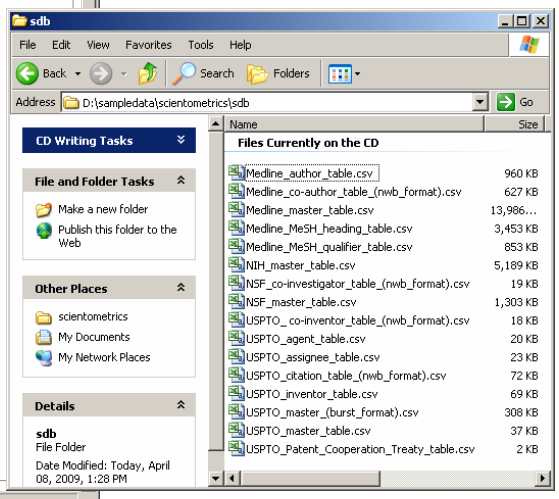
Supports federated search of 25 million publication, patent, grant records.
Results can be downloaded as data dump and (evolving) co-author, paper-citation networks.



Register for free access at http://sdb.cns.iu.edu

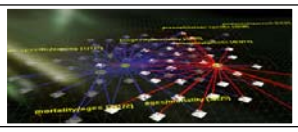






Since March 2009:
Users can download networks:
- Co-author
- Co-investigator
- Co-inventor
- Patent citation

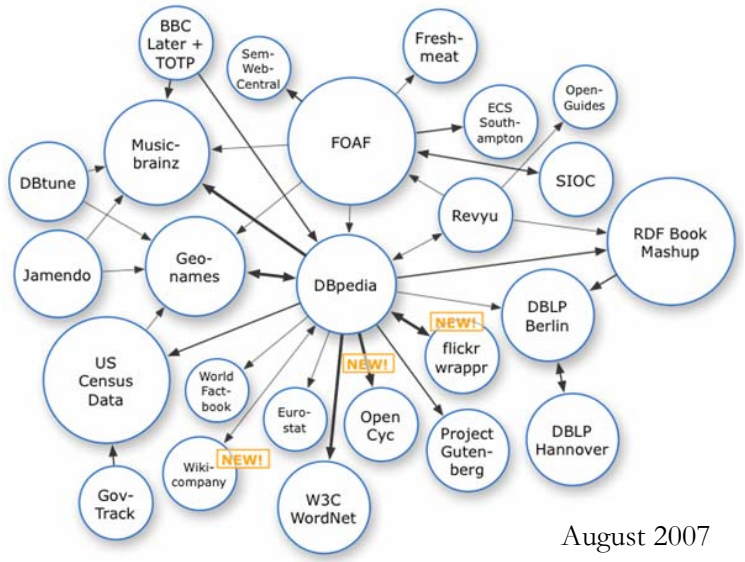
and tables for
burst analysis in NWB.



Semantic Web: Linked Open Data

- Interlinking existing data silos and
- Exposing them as structured data
- Adding new high quality data relevant for S&T studies

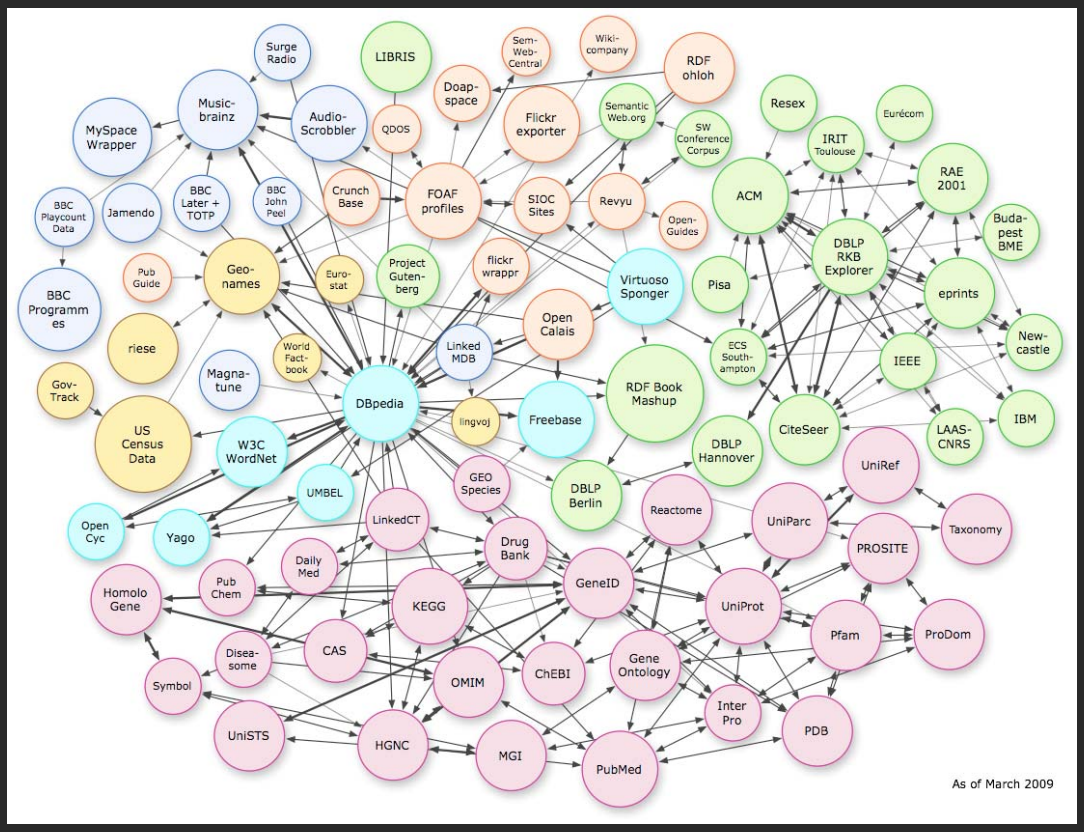
http://linkeddata.org



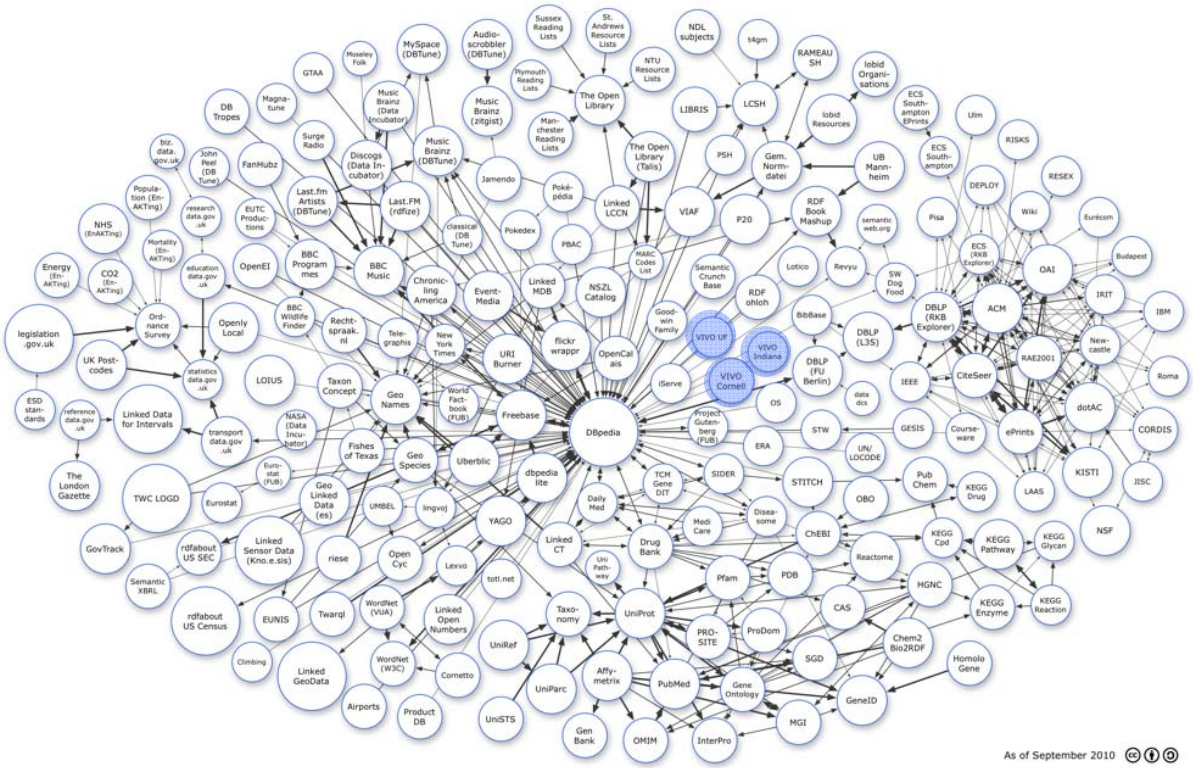
August 2007

Save Data.gov, sign the petition at
http://om.ly/BRPRE

Twitter
#savethedata

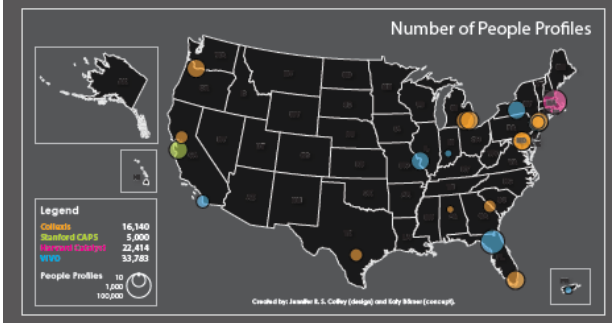


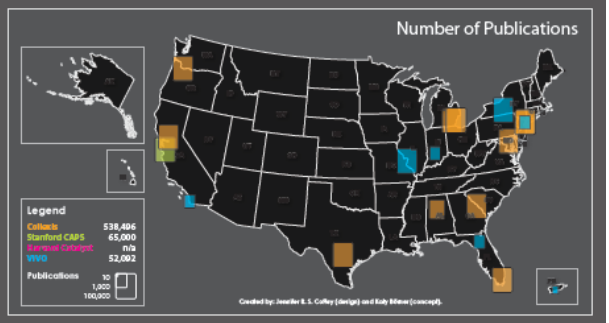
http://www4.wiwiss.fu-berlin.de/bizer/pub/lod-datasets_2009-03-05_colored.png

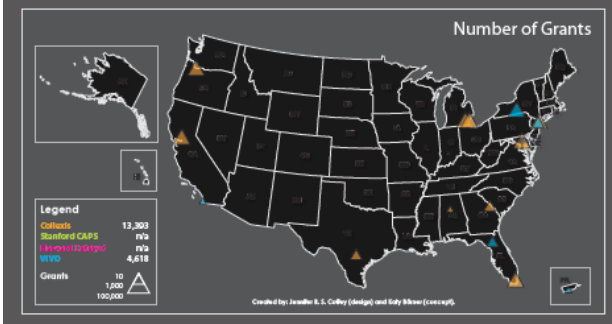


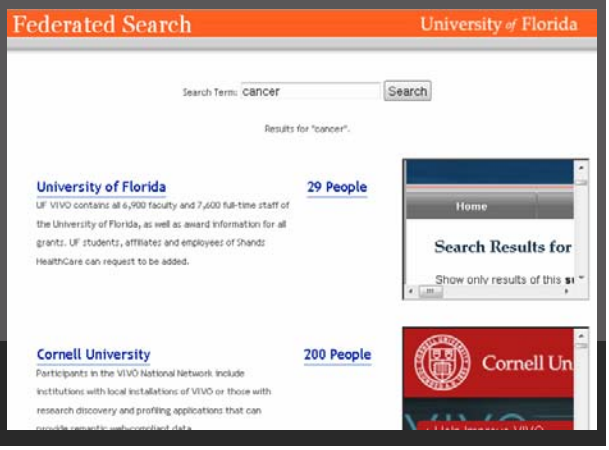
National Research Networking (NRN) Activity Visualization

VIVO
Enabling a National Network of Scientists

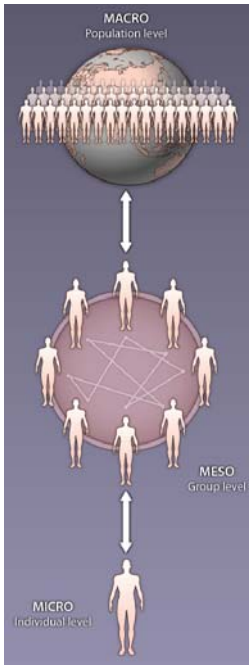




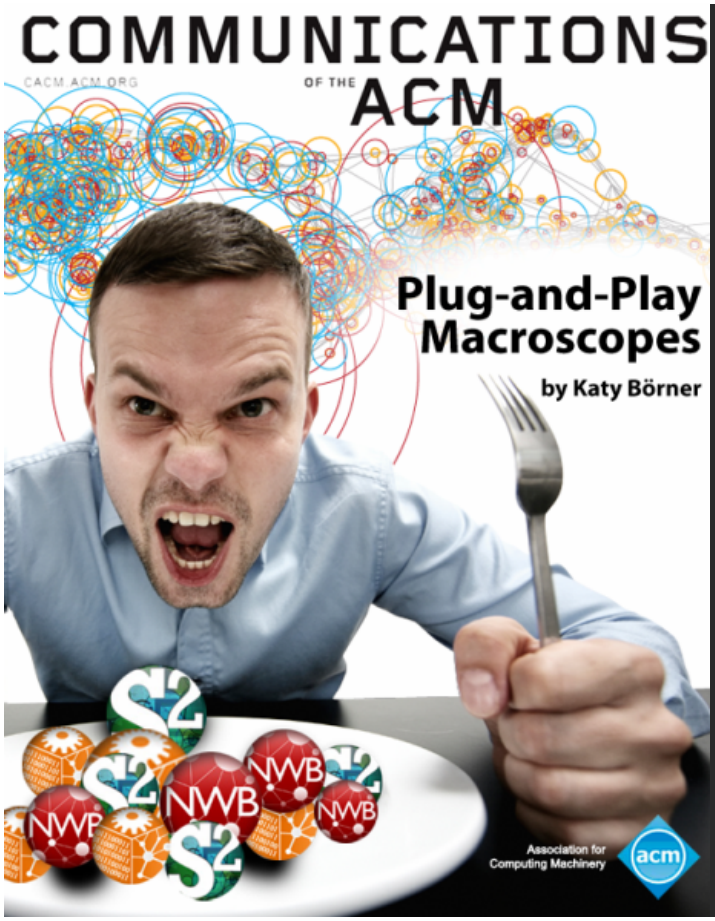




http://vivoexperts.ctsi.ufl.edu



Tools – **continuously identify, learn, advance, share code, e.g., via Plug-and-Play Macroscopes**



Börner, Katy. (March 2011). Plug-and-Play Macroscopes. *Communications of the ACM, 54(3), 60-69.*

Video and paper are at
http://www.scivee.tv/node/27704

Designing "Dream Tools"

Many of the best micro-, tele-, and macroscopes are designed by **scientists keen to observe and comprehend what no one has seen or understood before.** Galileo Galilei (1564–1642) recognized the potential of a spyglass for the study of the heavens, ground and polished his own lenses, and used the improved optical instruments to make discoveries like the moons of Jupiter, providing quantitative evidence for the Copernican theory.

Today, scientists **repurpose, extend, and invent new hardware and software** to create **"macroscopes"** that may solve both local and global challenges.

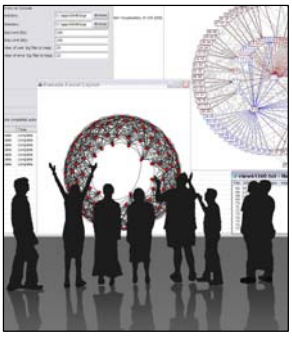
Plug-and-play macroscopes **empower** me, my students, colleagues, and 100,000 others that downloaded them.

Macroscopes

Decision making in science, industry, and politics, as well as in daily life, requires that we make sense of data sets representing the structure and dynamics of complex systems. Analysis, navigation, and management of these continuously evolving data sets require a new kind of data-analysis and visualization tool we call a macroscope (from the Greek macros, or "great," and skopein, or "to observe") inspired by de Rosnay's futurist science writings. Macroscopes provide a "vision of the whole," helping us "synthesize" the related elements and enabling us to detect patterns, trends, and outliers while granting access to myriad details. Rather than make things larger or smaller, **macroscopes let us observe what is at once too great, slow, or complex for the human eye and mind to notice and comprehend.**

Microscopes

Telescopes



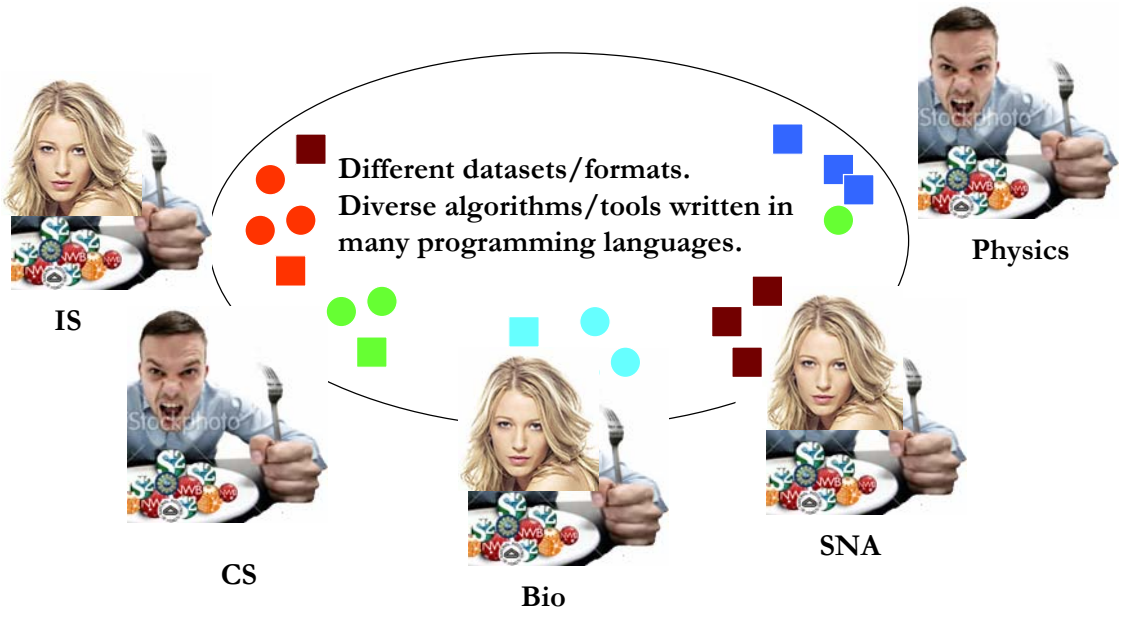
Macroscopes

Macroscopes cont.

While microscopes and telescopes are physical instruments, **macroscopes resemble continuously changing bundles of software plug-ins.** Macroscopes make it easy to select and combine algorithm and tool plug-ins but also interface plug-ins, workflow support, logging, scheduling, and other plug-ins needed for scientifically rigorous yet effective work.

They make it easy to share plug-ins via email, flash drives, or online. To use new plugins, simply copy the files into the plug-in directory, and they appear in the tool menu ready for use. No restart of the tool is necessary. **Sharing algorithm components, tools, or novel interfaces becomes as easy as sharing images on Flickr or videos on YouTube. Assembling custom tools is as quick as compiling your custom music collection.**

Macroscopes Serve the Changing Scientific Landscape



Changing Scientific Landscape—General Observations

Science becomes more data driven and computational but also collaborative and interdisciplinary. There is increased demand for tools that are easy to extend, share, and customize:

- *Star scientist —> Research teams.* Traditionally, science was driven by key scientists. Today, science is driven by collaborating co-author teams, often comprising experts from multiple disciplines and geospatial locations.
- *Users —> Contributors.* Web 2.0 technologies empower users to contribute to Wikipedia and exchange images, videos, and code via Fickr, YouTube, and SourceForge.net.
- *Disciplinary —> Cross-disciplinary.* The best tools frequently borrow and synergistically combine methods and techniques from different disciplines of science, empowering interdisciplinary and/or international teams to collectively fine-tune and interpret results;
- *Single specimen —> Data streams.* Microscopes and telescopes were originally used to study a single specimen at a time. Today, many researchers must make sense of massive data streams comprising multiple data types and formats from different origins; and
- *Static instrument —> Evolving cyberinfrastructure.* The importance of hardware instruments that are static and expensive tends to decrease relative to software tools and services that are highly flexible and evolving to meet the needs of different sciences. Some of the most successful tools and services are decentralized, increasing scalability and fault tolerance.

Related Work

Google Code and SourceForge.net provide special means for developing and distributing software

- In August 2009, SourceForge.net hosted more than 230,000 software projects by two million registered users (285,957 in January 2011);
- In August 2009 ProgrammableWeb.com hosted 1,366 application programming interfaces (APIs) and 4,092 mashups (2,699 APIs and 5,493 mashups in January 2011)

Cyberinfrastructures serving large biomedical communities

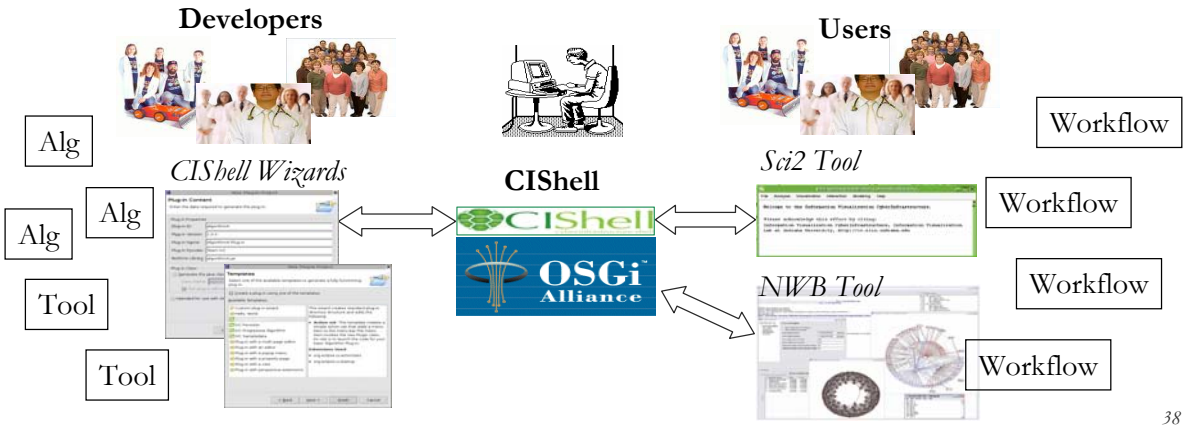
- Cancer Biomedical Informatics Grid (caBIG) (http://cabig.nci.nih.gov)
- Biomedical Informatics Research Network (BIRN) (http://nbirn.net)
- Informatics for Integrating Biology and the Bedside (i2b2) (https://www.i2b2.org)
- HUBzero (http://hubzero.org) platform for scientific collaboration uses
- myExperiment (http://myexperiment.org) supports the sharing of scientific workflows and other research objects.

Missing so far is a **common standard** for

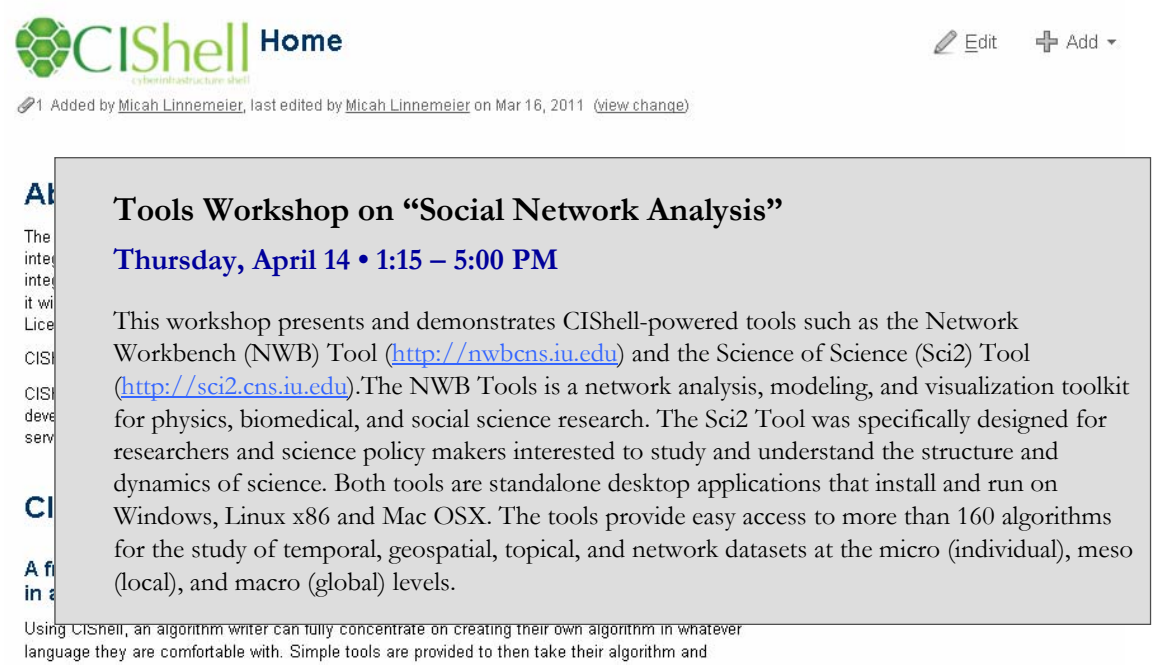
- the design of **modular, compatible algorithm and tool plug-ins** (also called "modules" or "components")
- that can be **easily combined into scientific workflows** ("pipeline" or "composition"),
- and packaged as **custom tools.**

OSGi & CIShell

- CIShell (http://cishell.org) is an open source software specification for the integration and utilization of datasets, algorithms, and tools.
- It extends the Open Services Gateway Initiative (OSGi) (http://osgi.org), a standardized, component oriented, computing environment for networked services widely used in industry since more than 10 years.
- Specifically, CIShell provides "sockets" into which existing and new datasets, algorithms, and tools can be plugged using a wizard-driven process.



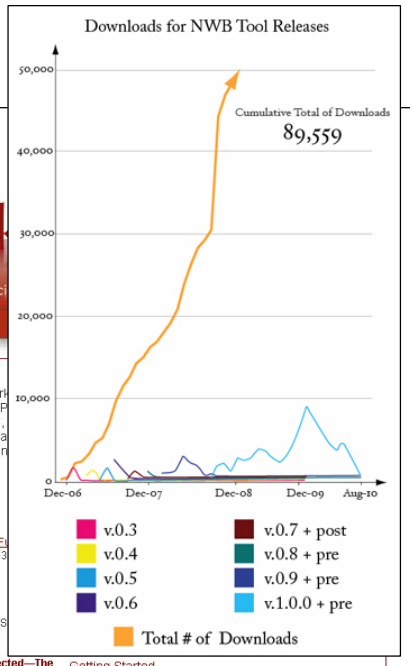
CIShell Developer Guide
(*http://cishell.wiki.cns.iu.edu*)



CIShell Portal (http://cishell.org)

Network Workbench Tool

http://nwb.slis.indiana.edu



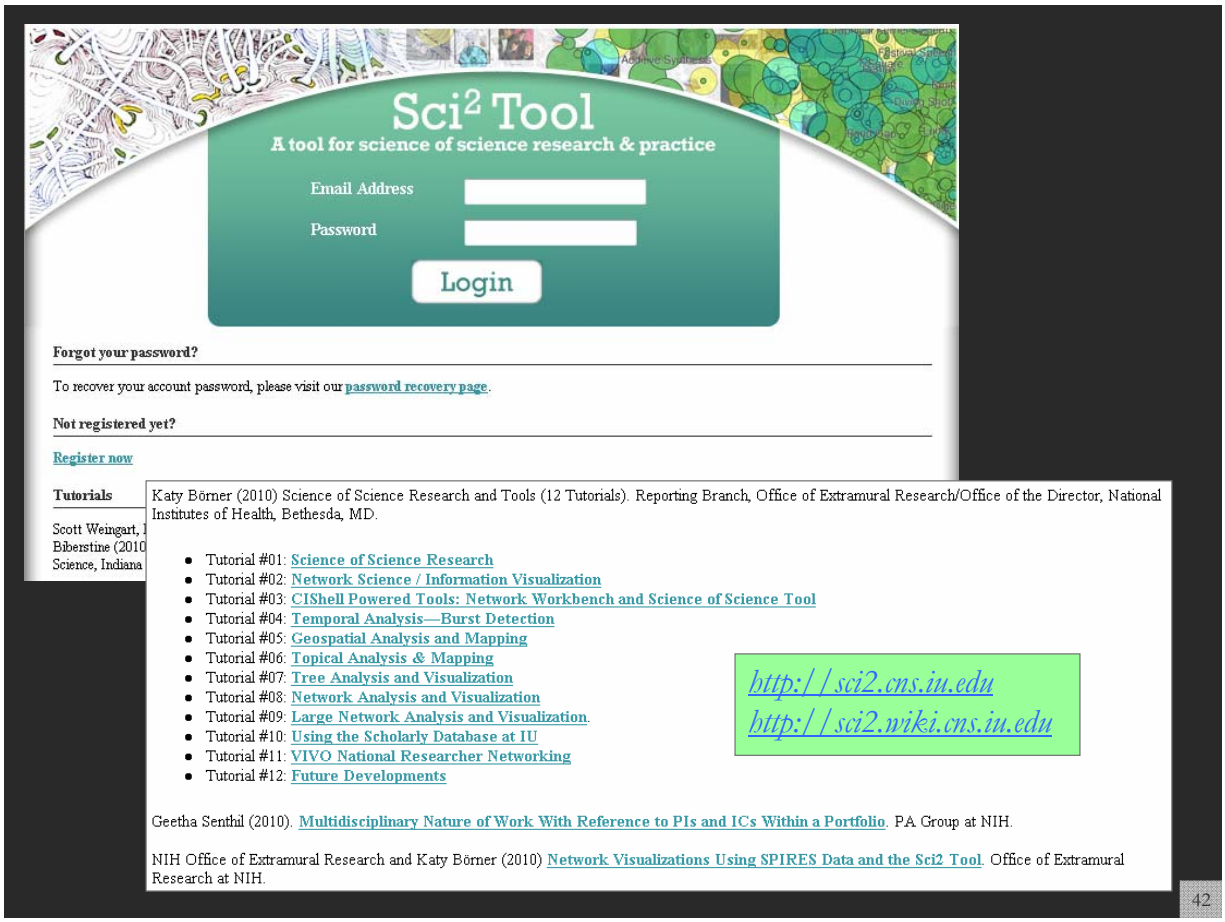
The Network Workbench (NWB) tool supports researchers, educators, and practitioners interested in the study of biomedical, social and behavioral science, physics, and other networks.

In February 2009, the tool provides more 169 plugins that support the preprocessing, analysis, modeling, and visualization of networks.

More than 50 of these plugins can be applied or were specifically designed for S&T studies.

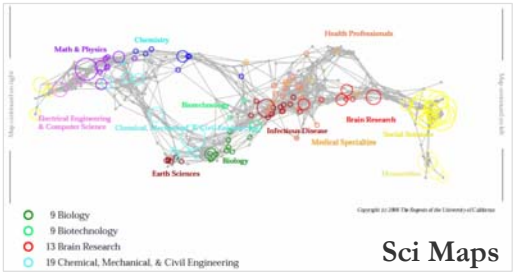
It has been downloaded more than 65,000 times since December 2006.

Herr II, Bruce W., Huang, Weixia (Bonnie), Penumarthy, Shashikant & Börner, Katy. (2007). Designing Highly Flexible and Usable Cyberinfrastructures for Convergence. In Bainbridge, William S. & Roco, Mihail C. (Eds.), Progress in Convergence - Technologies for Human Wellbeing (Vol. 1093, pp. 161-179), Annals of the New York Academy of Sciences, Boston, MA.

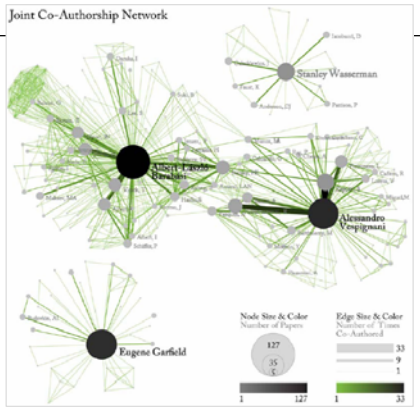


Sci² Tool – "Open Code for S&T Assessment"

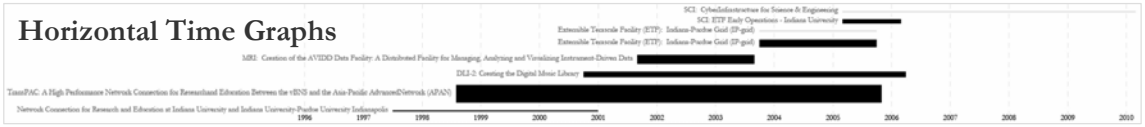
OSGi/CIShell powered tool with NWB plugins and many new scientometrics and visualizations plugins.



Sci Maps

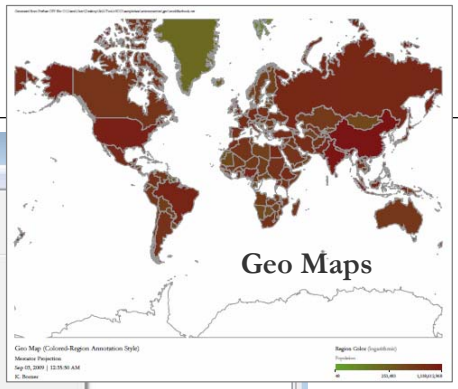


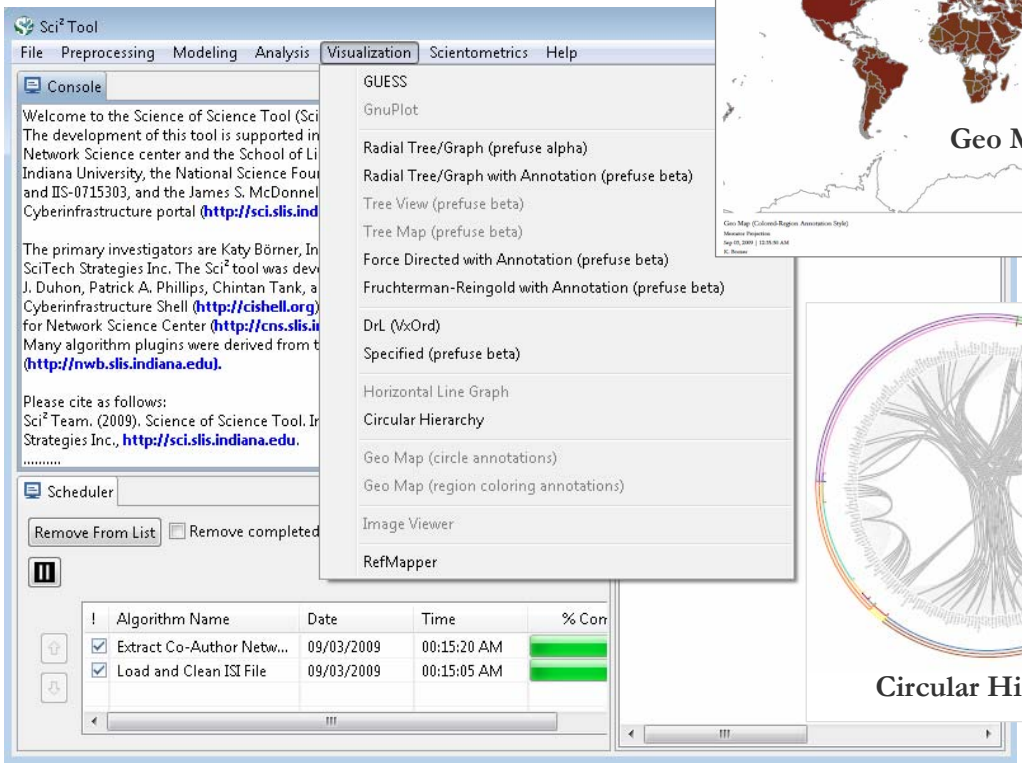
GUESS Network Vis



Börner, Katy, Huang, Weixia (Bonnie), Linnemeier, Micah, Duhon, Russell Jackson, Phillips, Patrick, Ma, Nianli, Zoss, Angela, Guo, Hanning & Price, Mark. (2009). Rete-Netzwerk-Red: Analyzing and Visualizing Scholarly Networks Using the Scholarly Database and the Network Workbench Tool. Proceedings of ISSI 2009: 12th International Conference on Scientometrics and Informetrics, Rio de Janeiro, Brazil, July 14-17 . Vol. 2, pp. 619-630.

Sci² Tool





Circular Hierarchy

OSGi/CIShell Adoption

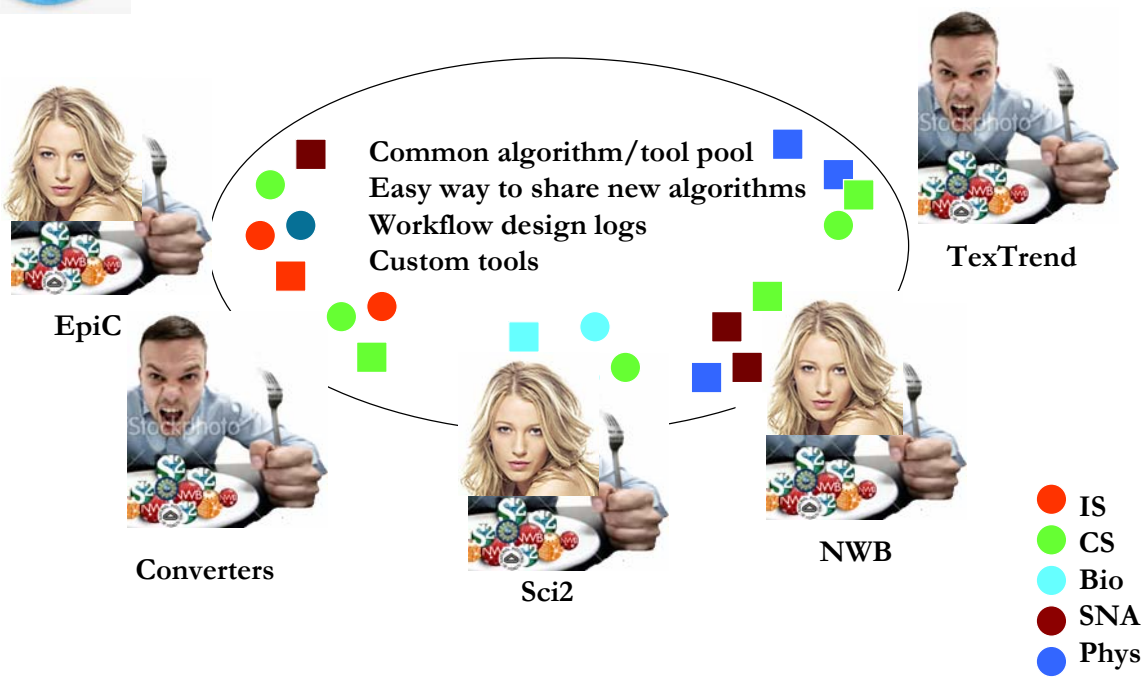
A number of other projects recently adopted OSGi and/or CIShell:

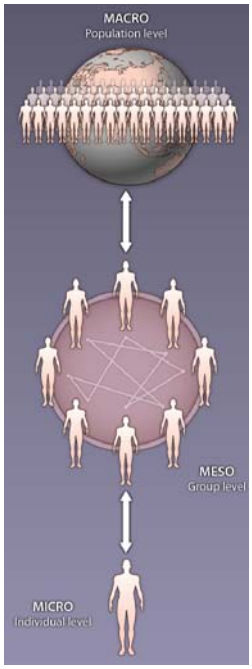
Cytoscape (http://cytoscape.org) Led by Trey Ideker at the University of California, San Diegois an open source bioinformatics software platform for visualizing molecular interaction networks and integrating these interactions with gene expression profiles and other state data (Shannon et al., 2002).

- *Taverna Workbench (http://taverna.org.uk)* Developed by the myGrid team (http://mygrid.org.uk) led by Carol Goble at the University of Manchester, U.K. is a free software tool for designing and executing workflows (Hull et al., 2006). Taverna allows users to integrate many different software tools, including over 30,000 web services.
- *MAEviz (https://wiki.ncsa.uiuc.edu/display/MAE/Home)* Managed by Jong Lee at NCSA is an open-source, extensible software platform which supports seismic risk assessment based on the Mid-America Earthquake (MAE) Center research.
- *TEXTrend (http://textrend.org)* Led by George Kampis at Eötvös Loránd University, Budapest, Hungary supports natural language processing (NLP), classification/mining, and graph algorithms for the analysis of business and governmental text corpuses with an inherently temporal component.
- *DynaNets (http://www.dynanets.org)* Coordinated by Peter M.A. Sloot at the University of Amsterdam, The Netherlands develops algorithms to study evolving networks.

As the functionality of OSGi-based software frameworks improves and the number and diversity of dataset and algorithm plugins increases, the capabilities of custom tools will expand.

Embrace the Changing Scientific Landscape





Mixed-methods, multi-level SciTS needs:

Expertise – identify and access it at the perfect moment using, e.g., Facebook, LinkedIn, Academia, VIVO, Harvard Profiles, Elsevier's Collexis, Loki, Stanford's CAP, or other systems.

Theories and Methods – find, understand, apply, advance them, e.g., using http://scienceofteamscience.northwestern. edu/team-science-resources.

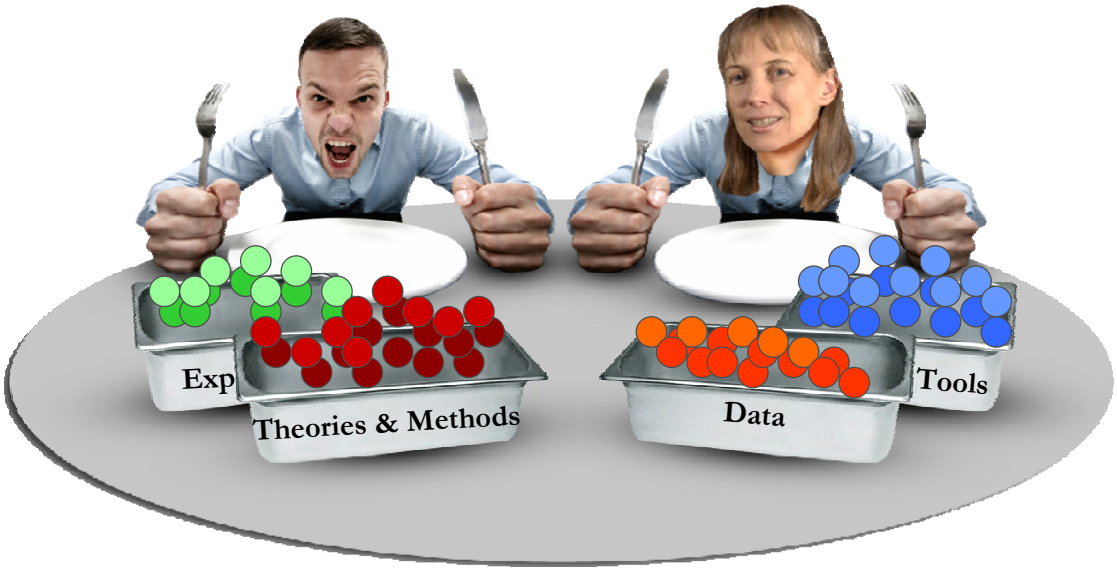
Data – find, interlink, unify, merge, reformat, share them, e.g., using web sites analogous to http://www.diggingintodata.org/Repositories/tabid/167/Default.aspx, SDB, or LOD.

Tools – identify, learn, advance, share code, e.g., via Plug-and-Play Macroscopes, to arrive at a holistic understanding of the science system.

Note that the evolution of all of the above could be an extremely interesting and valuable SciTS study object.

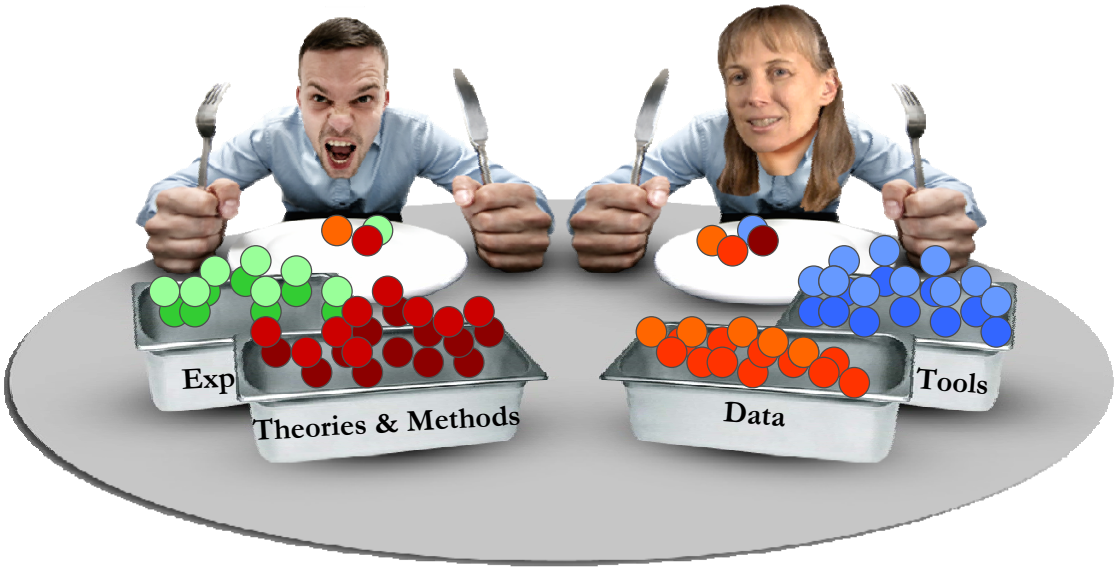
Different levels and types of analysis will require access to very different

Expertise, Theories and Methods, Data, and Tools.



Ideally, a future SciTS CI can provide easy access to the best, highest quality

Expertise, Theories and Methods, Data, and Tools.



So that researchers, practitioners, and students can fully benefit and advance

Expertise, Theories and Methods, Data, and Tools.

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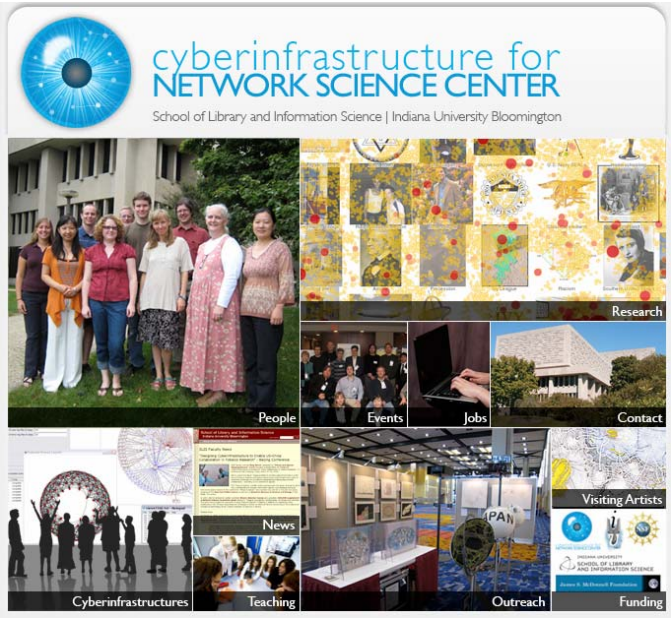

All papers, maps, tools, talks, press are linked from http://cns.iu.edu

CNS Facebook: http://www.facebook.com/pages/Cyberinfrastructure-for-Network-Science-Center/144339535612571

Maping Science Exhibit Facebook: http://www.facebook.com/mappingscience