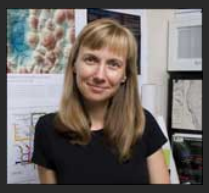
Towards Scholarly Marketplaces



Dr. Katy Börner
Cyberinfrastructure for Network Science Center, Director
Information Visualization Laboratory, Director
School of Library and Information Science
Indiana University, Bloomington, IN
katy@indiana.edu

Talk at the New Network Theory International Conference
2007.06.29

Global Brain Pressures

15th Century: One person can make major contributions to **many areas of science**

Mankind's Knowledge

use

contribute

Human Brain

Amount of knowledge on brain can mange

Leonardo Da Vinci (1452-1519)

20th Century: One person can make major contributions to **a few areas of science**

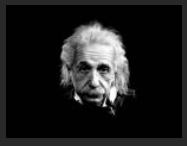
Mankind's Knowledge

use

contribute

Human Brain

Amount of knowledge on brain can mange



Albert Einstein (1879-1955)

21th Century: One person can make major contributions to **a specific area of science**

Mankind's Knowledge

use

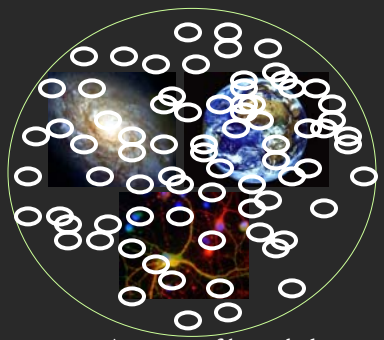
contribute

Human Brain

Amount of knowledge
on brain can mange

21th Century: One person can make major contributions to **a specific area of science**

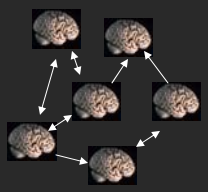
Mankind's Knowledge



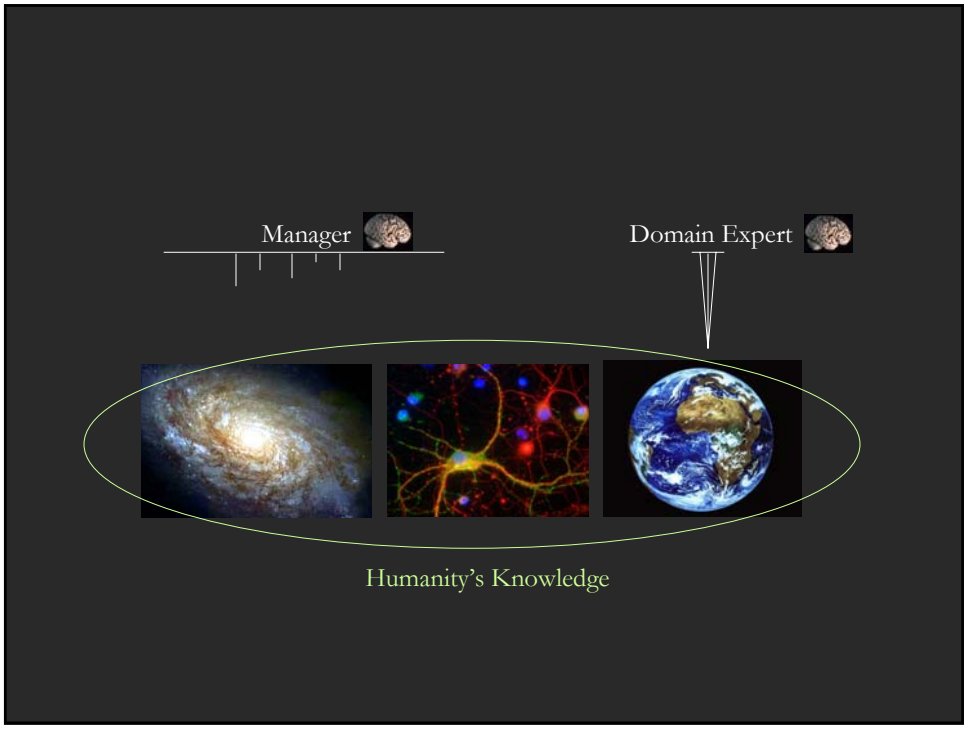
use

contribute

Human Brains



Amount of knowledge
on brain can mange

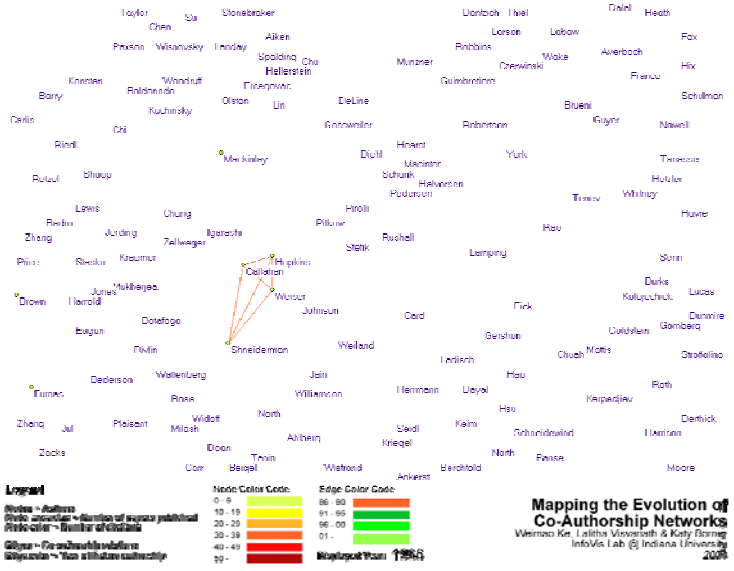


The Great Wave Off Kanagawa (Katsushika Hokusai, 1760-1849)

Mapping, Managing and Utilizing Our Collective Scholarly Knowledge

Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner, (2004) Won 1st price at the IEEE InfoVis Contest.



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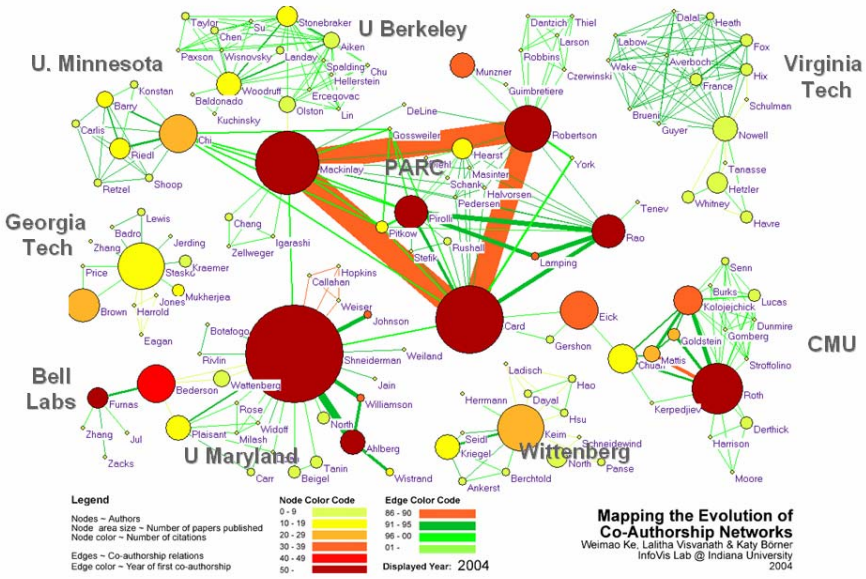
Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner, (2004) Won 1st price at the IEEE InfoVis Contest



11

Studying the Emerging Global Brain: Analyzing and Visualizing the Impact of Co-Authorship Teams

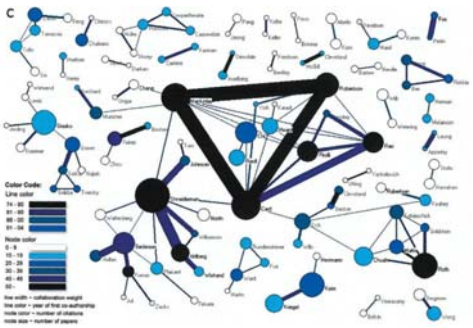
Börner, Dall'Asta, Ke & Vespignani (2005) Complexity, 10(4):58-67.

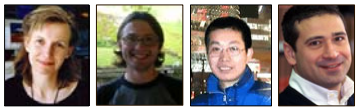
Research question:

- Is science driven by prolific single experts or by high-impact co-authorship teams?

Contributions:

- New approach to allocate citational credit.
- Novel weighted graph representation.
- Visualization of the growth of weighted co-author network.
- Centrality measures to identify author impact.
- Global statistical analysis of paper production and citations in correlation with co-authorship team size over time.
- Local, author-centered entropy measure.



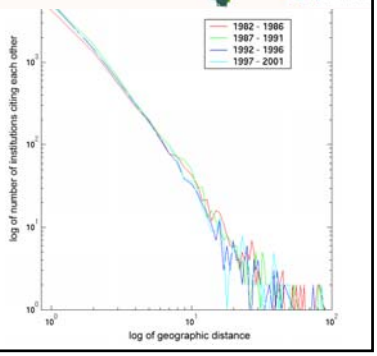


Spatio-Temporal Information Production and Consumption of Major U.S. Research Institutions

Börner, Katy, Penumarthy, Shashikant, Meiss, Mark and Ke, Weimao. (2006) Mapping the Diffusion of Scholarly Knowledge Among Major U.S. Research Institutions. Scientometrics. 68(3), pp. 415-426.

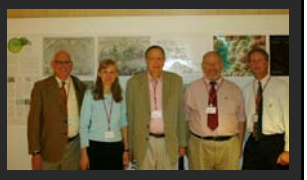
Research questions:

1. Does space still matter in the Internet age?
2. Does one still have to study and work at major research institutions in order to have access to high quality data and expertise and to produce high quality research?
3. Does the Internet lead to more global citation patterns, i.e., more citation links between papers produced at geographically distant research instructions?



Contributions:

- Answer to Qs 1 + 2 is YES.
- Answer to Qs 3 is NO.
- Novel approach to analyzing the dual role of institutions as information producers and consumers and to study and visualize the diffusion of information among them.



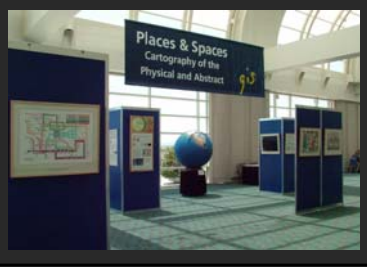
Places & Spaces: Mapping Science

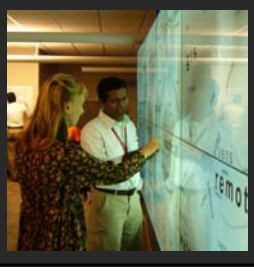
a science exhibit that introduces people to maps of sciences, their makers and users.

http://scimaps.org

Exhibit Curators:

Dr. Katy Börner &
Julie Smith, Indiana University





Places & Spaces: Mapping Science *exhibit, see also* [*http://scimaps.org*](http://scimaps.org)*.*

Illuminated Diagram Display

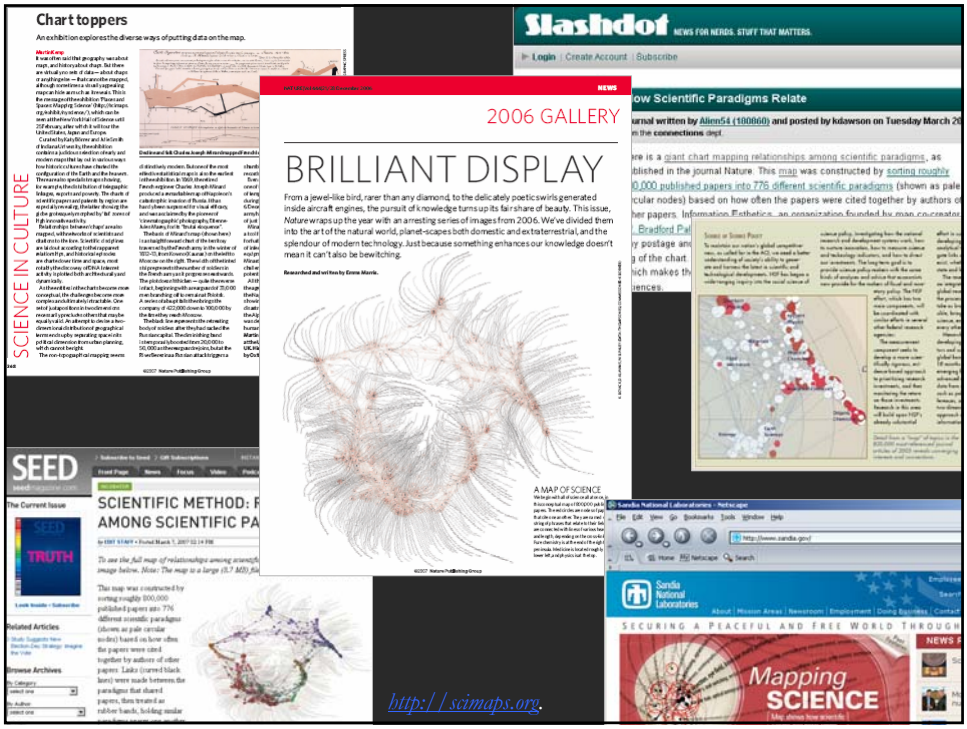


Chart toppers
An exhibition explores the diverse ways of putting data on the map.
SCIENCE IN CULTURE
Slashdot
NEWS FOR NERDS. STUFF THAT MATTERS.
Login | Create Account | Subscribe
2006 GALLERY
BRILLIANT DISPLAY
From a jewel-like bird, rarer than any diamond, to the delicately poetic swirls generated inside aircraft engines, the pursuit of knowledge turns up its fair share of beauty. This issue, Nature wraps up the year with an arresting series of images from 2006. We've divided them into the art of the natural world, planet-scapes both domestic and extraterrestrial, and the splendor of modern technology. Just because something enhances our knowledge doesn't mean it can't also be bewitching.
Researched and written by Emma Marris.
A MAP OF SCIENCE
SEED
SCIENTIFIC METHOD:
AMONG SCIENTIFIC PA
Sandia National Laboratories
SECURING A PEACEFUL AND FREE WORLD THROUGH
Mapping
SCIENCE
http://scimaps.org.

54
SOCCER

Science Puzzle Map for Kids by Fileve Palmer, Julie Smith, Elisha Hardy and Katy Börner, Indiana University, 2006
(Base map taken from Illuminated Diagram display by Kevin Boyack, Richard Klavans, and W. Bradford Paley.)

How to Map Science

DATA EXTRACTION	UNIT OF ANALYSIS	MEASURES	LAYOUT (often one code does both similarity and ordination steps)		DISPLAY
			SIMILARITY	ORDINATION	

SEARCHES
- ISI
- INSPEC
- Eng Index
- Medline
- ResearchIndex
- Patents
- etc.

BROADENING
- By citation
- By terms

COMMON CHOICES
- Journal
- Document
- Author
- Term

COUNTS/FREQUENCIES
- Attributes (e.g. terms)
- Author citations
- Co-citations
- By year

THRESHOLDS
- By counts

SCALAR (unit by unit matrix)
- Direct citation
- Co-citation
- Combined linkage
- Co-word / co-term
- Co-classification

VECTOR (unit by attribute matrix)
- Vector space model (words/terms)
- Latent Semantic Analysis (words/terms) incl. Singular Value Decomp (SVD)

CORRELATION (if desired)
- Pearson's R on any of above

DIMENSIONALITY REDUCTION
- Eigenvector/ Eigenvalue solutions
- Factor Analysis (FA) and Principal Components Analysis (PCA)
- Multi-dimensional scaling (MDS)
- LSA
- Pathfinder networks (PFNet)
- Self-organizing maps (SOM) includes SOM_ET-maps, etc.

CLUSTER ANALYSIS

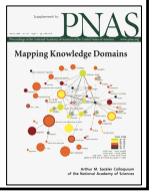
SCALAR
- Triangulation
- Force-directed placement (FDP)

INTERACTION
- Browse
- Pan
- Zoom
- Filter
- Query
- Detail on demand

ANALYSIS

Shiffrin, Richard M. and Börner, Katy (Eds.) (2004). Mapping Knowledge Domains. Proceedings of the National Academy of Sciences of the United States of America, 101(Suppl_1).

Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003). Visualizing Knowledge Domains. In Blaise Cronin (Ed.), Annual Review of Information Science & Technology, Volume 37, Medford, NJ: Information Today, Inc./American Society for Information Science and Technology, chapter 5, pp. 179-255.



Towards Scholarly Marketplaces

Building Market Places not Cathedrals

- Requires the design & implementation of 'software glue' that can interlink datasets and algorithms written in different languages using different data formats.
- The smaller the glue or 'CI Shell', the more likely it can be maintained.
- Dataset and algorithm 'plugins' are provided by application holders/ community.
- Applications resemble custom 'fillings'.

Cyberinfrastructure Shell (CIShell)

http://cishell.org

CIShell is an 'empty shell' that supports

- Easy integration of new datasets and algorithms by algorithm developers and
- Easy usage of algorithms by algorithm users.

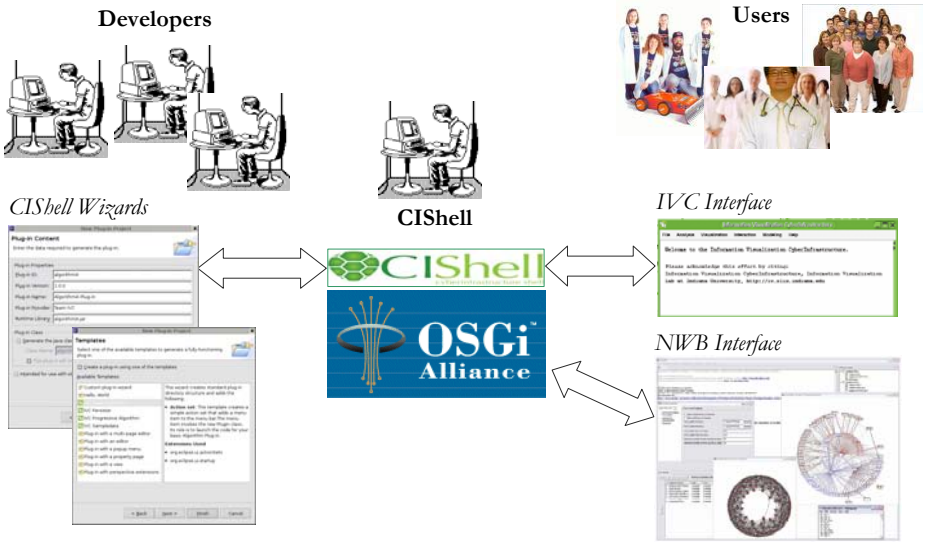
Its plug-and-play architecture supports the integration and utilization of diverse

- Datasets, e.g., stored in files, databases, steaming data.
- Algorithms, e.g., data processing, analysis, modeling, visualization.
- Interfaces, e.g., remote services, scripting engines, peer-to-peer clients.
- Services, e.g., workflow support, scheduler.

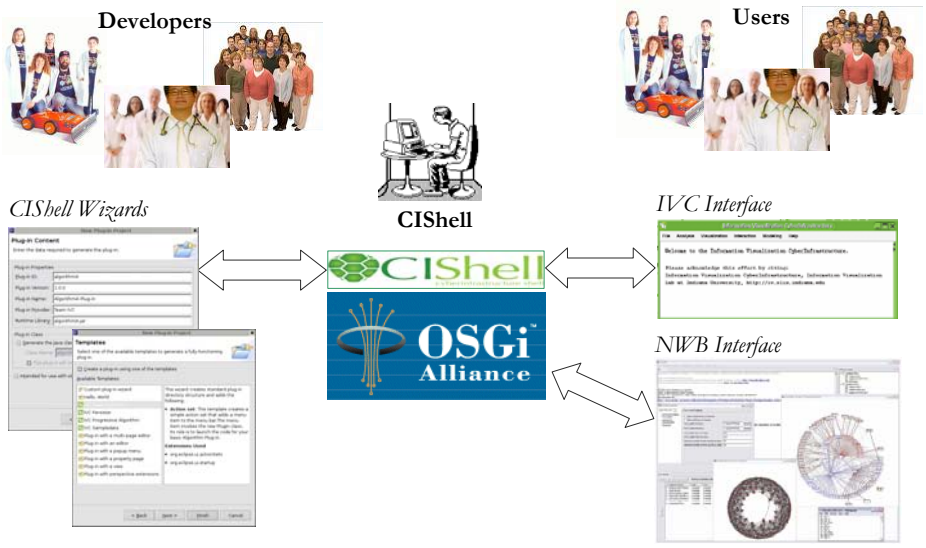
Hence, it can be used for custom UI/Toolkit development.

Network Workbench: A Large-Scale Network Analysis, Modeling and Visualization Toolkit for Biomedical, Social Science and Physics Research. NSF IIS-0513650 award (Katy Börner, Albert-Laszlo Barabasi, Santiago Schnell, Alessandro Vespignani & Stanley Wasserman, Eric Wernert (Senior Personnel), $1,120,926) Sept. 05 - Aug. 08.
http://nwb.slis.indiana.edu

CIShell – Needs of Algorithm Developers & Users



CIShell – Needs of Algorithm Developers & Users



CIShell – Technical Details

CIShell is built upon the Open Services Gateway Initiative (OSGi) Framework.

OSGi (http://www.osgi.org) is

- A standardized, component oriented, computing environment for networked services.
- Successfully used in the industry from high-end servers to embedded mobile devices since 7 years.
- Alliance members include IBM (Eclipse), Sun, Intel, Oracle, Motorola, NEC and many others.
- Widely adopted in open source realm, especially since Eclipse 3.0 that uses OSGi R4 for its plugin model.

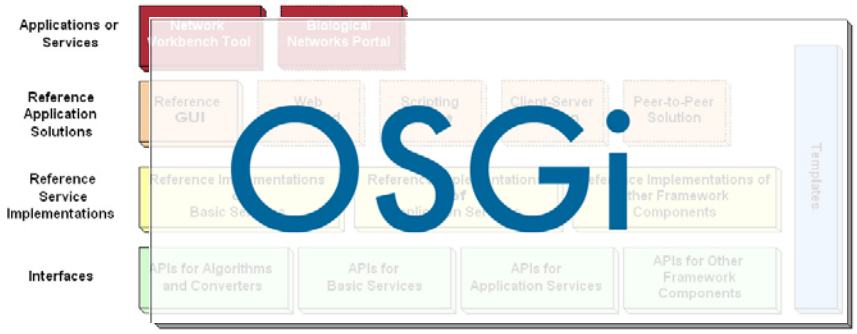
Advantages of Using OSGi

- Any CIShell algorithm is a service that can be used in any OSGi-framework based system.
- Using OSGi, running CIShells/tools can connected via RPC/RMI supporting peer-to-peer sharing of data, algorithms, and computing power.

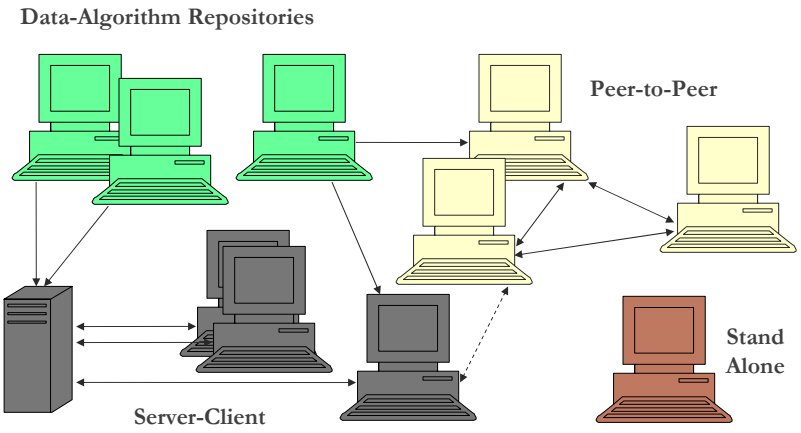
Ideally, CIShell becomes a standard for creating OSGi Services for algorithms. Developed Tools/CI, e.g., IVC & NWB, provide a reference GUI for underlying services.

CIShell – Technical Details

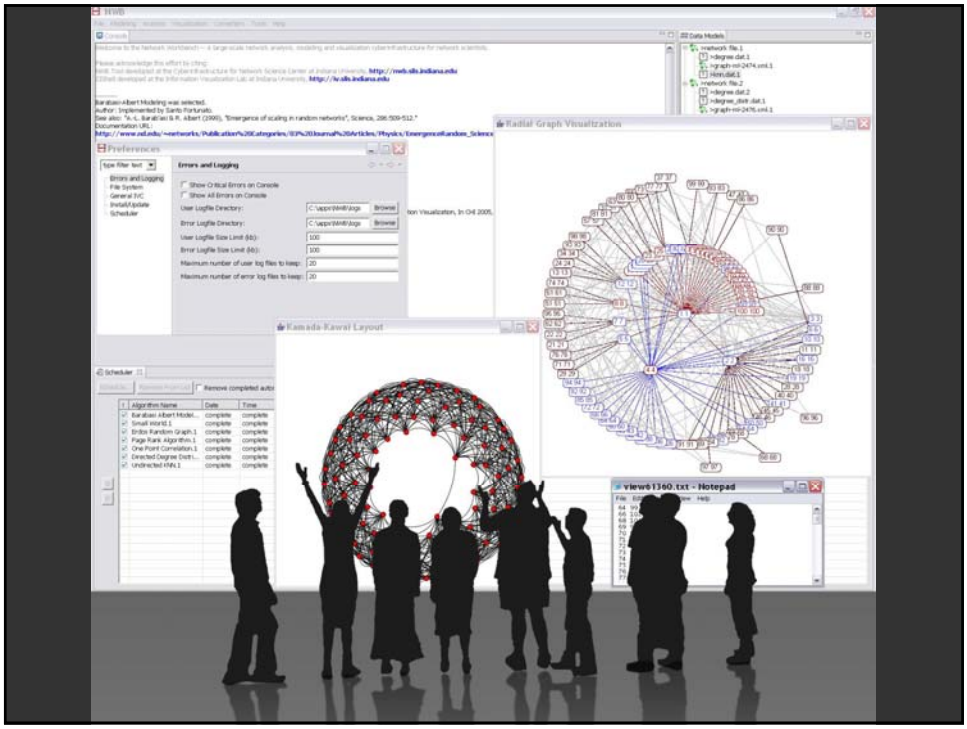
CIShell layer cake.



CIShell – Deployment



CIShell applications can be deployed as distributed data and algorithm repositories, stand alone applications, peer-to-peer architectures, and server-client architectures.



Network Workbench (NWB)

Investigators: Katy Börner, Albert-Laszlo Barabasi, Santiago Schnell, Alessandro Vespignani & Stanley Wasserman, Eric Wernert

Software Team: Lead: Weixia (Bonnie) Huang

Developers: Bruce Herr, Ben Markines, Santo Fortunato, Cesar Hidalgo, Ramya Sabbineni, Vivek S. Thakre, & Russell Duhon

Goal: Develop a large-scale network analysis, modeling and visualization toolkit for biomedical, social science and physics research.

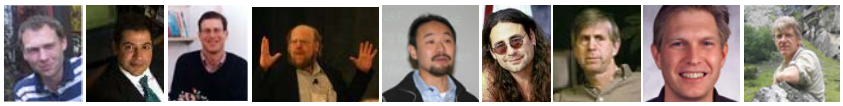
Amount: $1,120,926 NSF IIS-0513650 award.

Duration: Sept. 2005 - Aug. 2008

Website: http://nwb.slis.indiana.edu

NWB Advisory Board

- Ulrik Brandes, University of Konstanz, Germany (Graph Theory)
- Noshier Contractor, Northwestern University (Communication Theory)
- Mark Gerstein, Yale University (Bioinformatics)
- James Hendler, Rensselaer Polytechnic Institute (Semantic Web)
- Jason Leigh, Electronic Visualization Laboratory, University of Illinois at Chicago (Visualization & CI)
- Neo Martinez, Pacific Ecoinformatics and Computational Ecology Lab (Biology)
- Michael Macy, Cornell University (Sociology)
- Stephen North, AT&T (Graph Visualization)
- Tom Snijders, University of Groningen (Social Network Analysis)



NWB CI Deliverables

Glue:

- CIShell — Core programmer team lead by Bonnie Huang

Tools, Services & Portals:

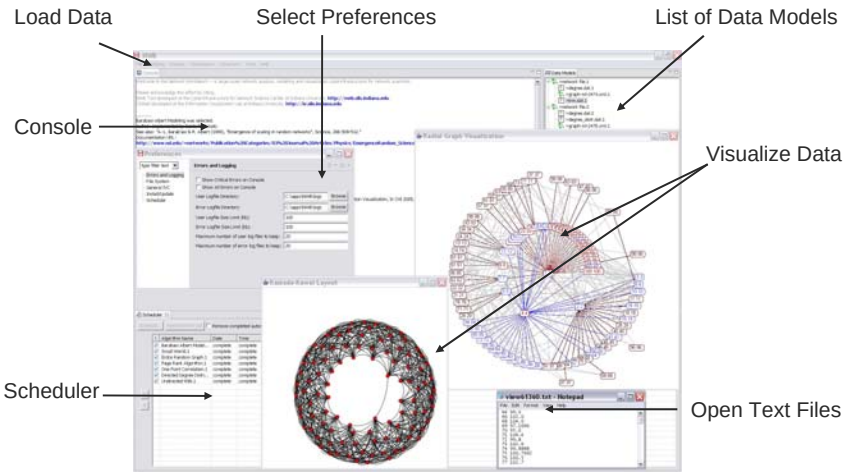
- NWB Tool — Lead by Alex Vespignani with input from other PIs
- SciMaps Service Online — Lead by Katy Borner
- Bio Tool — Lead by Laszlo Barabasi & Santiago Schnell

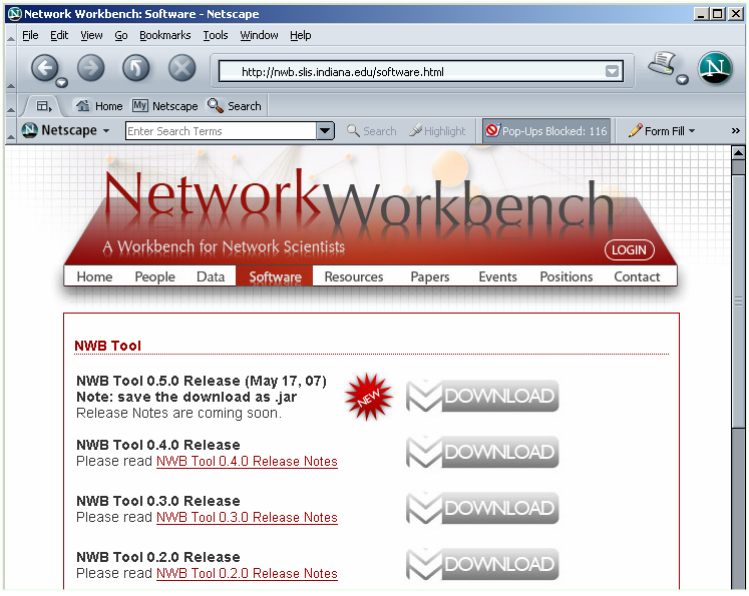
All three are prototypical instantiations of CIShell serving as reference implementations.

Documentation/Registry/Market Place:

- NWB Community Wiki — Lead by Katy Borner

NWB Tool: Interface Elements



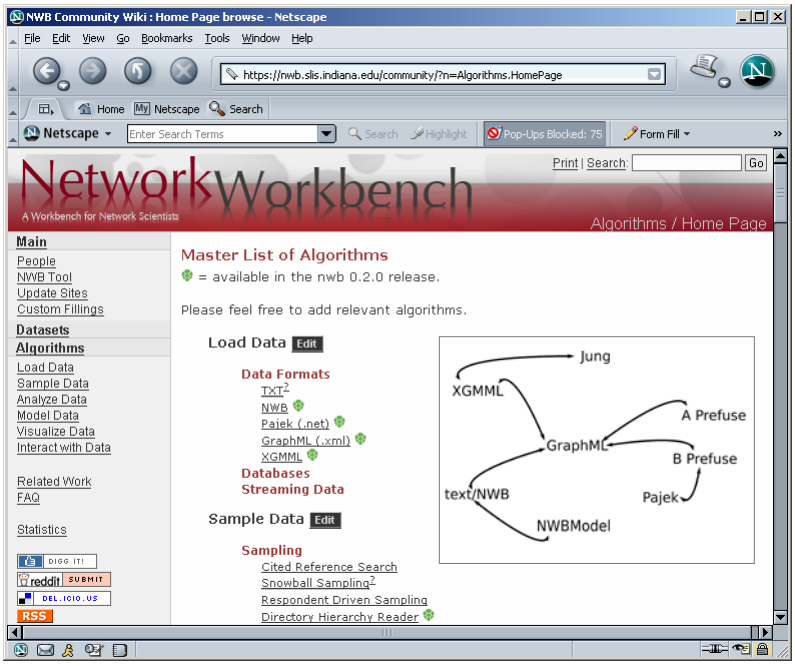


http://nwb.slis.indiana.edu/software.html

NWB Tool 0.2.0: List of Algorithms

Category	*Algorithm*	*Language*
Preprocessing	Directory Hierarchy Reader	JAVA
Modeling	Erdös-Rényi Random	FORTRAN
	Barabási-Albert Scale-Free	FORTRAN
	Watts-Strogatz Small World	FORTRAN
	Chord	JAVA
	CAN	JAVA
	Hypergrid	JAVA
	PRU	JAVA
Visualization	Tree Map	JAVA
	Tree Viz	JAVA
	Radial Tree / Graph	JAVA
	Kamada-Kawai	JAVA
	Force Directed	JAVA
	Spring	JAVA
	Fruchterman-Reingold	JAVA
	Circular	JAVA
	Parallel Coordinates (demo)	JAVA
Tool	XMGrace	

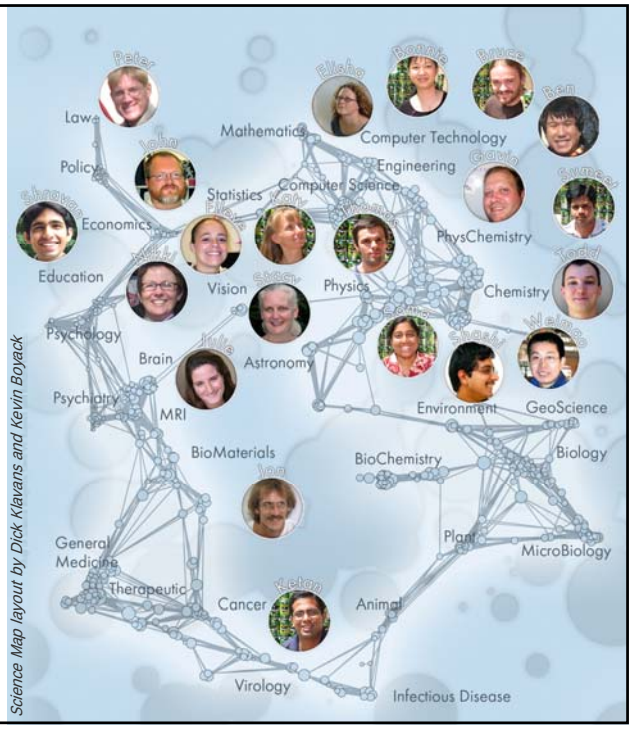
Analysis Algorithm	*Language*
Attack Tolerance	JAVA
Error Tolerance	JAVA
Betweenness Centrality	JAVA
Site Betweenness	FORTRAN
Average Shortest Path	FORTRAN
Connected Components	FORTRAN
Diameter	FORTRAN
Page Rank	FORTRAN
Shortest Path Distribution	FORTRAN
Watts-Strogatz Clustering Coefficient	FORTRAN
Watts-Strogatz Clustering Coefficient Versus Degree	FORTRAN
Directed k-Nearest Neighbor	FORTRAN
Undirected k-Nearest Neighbor	FORTRAN
Indegree Distribution	FORTRAN
Outdegree Distribution	FORTRAN
Node Indegree	FORTRAN
Node Outdegree	FORTRAN
One-point Degree Correlations	FORTRAN
Undirected Degree Distribution	FORTRAN
Node Degree	FORTRAN
k Random-Walk Search	JAVA
Random Breadth First Search	JAVA
CAN Search	JAVA



https://nwb.slis.indiana.edu/community

I would like to thank all my colleagues and collaborators.

If not otherwise indicated, this work was conducted at the Information Visualization Laboratory and the Cyberinfrastructure for Network Science Center at Indiana University.



Our Sponsors

- I-IKM: "Visualizing Network Dynamics" Competition at the International Conference on Network Science 2007. NSF IIS-0724282 award (Katy Börner) April 07 - March. 08.
- Creative Metaphors to Stimulate New Approaches to Visualizing, Understanding, and Rethinking Large Repositories of Scholarly Data. NSF award (Katy Börner) June 07 - May 09.
- Mapping Science Exhibit at the 233rd National Meeting & Exposition of the American Chemical Society in Chicago, IL. NSF award (Katy Börner, March 15, 07- March 14, 08)
- Collaborative Research: Social Networking Tools to Enable Collaboration in the Tobacco Surveillance, Epidemiology, and Evaluation Network (TSEEN). Collaborative Systems NSF IIS-0534909 award (Katy Börner, March 15, 06 - Feb 28, 09). Collaborative proposal with Noshir S. Contractor, NCSA, Tom Finholt, University of Michigan, and Gary Giovino, University at Buffalo.
- Modeling the Structure and Evolution of Scholarly Knowledge. James S. McDonnell Foundation grant in area Studying Complex Systems (Katy Börner & Robert L. Goldstone) Jan. 06 - Dec. 08.
- SEI: NetWorkBench: A Large-Scale Network Analysis, Modeling and Visualization Toolkit for Biomedical, Social Science and Physics Research. NSF IIS-0513650 award (Katy Börner, Albert-Laszlo Barabasi, Santiago Schnell, Alessandro Vespignani & Stanley Wasserman, Eric Wernert (Senior Personnel)) Sept. 05 - Aug. 08.
- Center of Excellence for Computational Diagnostics. 21st Century Grant (Susanne Ragg, David Clemmer, Sven Rahmann, and Ilka Ott, Terry Vik, R Clement McDonald, Nunroe Pecock, Zina Ben Miled & Katy Börner) Sept. 04 - Aug. 07.
- Quest Atlantis: Advancing a Socially-Responsive Meta-Game for Learning. NSF Role-0411846 award (Sasha Barab & Susan Herring, Daniel Hickey, William Blanton, Katy Börner (Senior Personnel)) Sept. 04 - Aug. 07.
- CAREER: Visualizing Knowledge Domains. NSF IIS-0238261 award (Katy Börner) Sept. 03-Aug. 08.

The End.