Network Workbench

A Workbench for Network Scientists

Network Workbench Tool

For Network Analysis, Modeling, and Visualization

Four-Hour Workshop

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The Changing Scientific Landscape

Star Scientist -> Research Teams: In former times, science was driven by key scientists. Today, science is driven by effectively collaborating co-author teams often comprising expertise from multiple disciplines and several geospatial locations (Börner, Dall'Asta, Ke, & Vespignani, 2005; Shneiderman, 2008).

Users -> Contributors: Web 2.0 technologies empower anybody to contribute to Wikipedia and to exchange images and videos via Fickr and YouTube. WikiSpecies, WikiProfessionals, or WikiProteins combine wiki and semantic technology in support of real time community annotation of scientific datasets (Mons et al., 2008).

Cross-disciplinary: The best tools frequently borrow and synergistically combine methods and techniques from different disciplines of science and empower interdisciplinary and/or international teams of researchers, practitioners, or educators to fine-tune and interpret results collectively.

One Specimen -> Data Streams: Microscopes and telescopes were originally used to study one specimen at a time. Today, many researchers must make sense of massive streams of multiple types of data with different formats, dynamics, and origin.

Static Instrument -> Evolving Cyberinfrastructure (CI): The importance of hardware instruments that are rather static and expensive decreases relative to software infrastructures that are highly flexible and continuously evolving according to the needs of different sciences. Some of the most successful services and tools are decentralized increasing scalability and fault tolerance.

Modularity: The design of software modules with well defined functionality that can be flexibly combined helps reduce costs, makes it possible to have many contribute, and increases flexibility in tool development, augmentation, and customization.

Standardization: Adoption of standards speeds up development as existing code can be leveraged. It helps pool resources, supports interoperability, but also eases the migration from research code to production code and hence the transfer of research results into industry applications and products.

Open data and open code: Lets anybody check, improve, or repurpose code and eases the replication of scientific studies.

Desirable Features of Plug-and-Play Macroscopes

Division of Labor: Ideally, labor is divided in a way that the expertise and skills of computer scientists are utilized for the design of standardized, modular, easy to maintain and extend "core architecture". Dataset and algorithm plugins, i.e., the "filling", are initially provided by those that care and know most about the data and developed the algorithms: the domain experts.

Ease of Use: As most plugin contributions and usage will come from non-computer scientists it must be possible to contribute, share, and use new plugins without writing one line of code. Wizard-driven integration of new algorithms and data sets by domain experts, sharing via email or online sites, deploying plugins by adding them to the 'plugin' directory, and running them via a Menu driven user interfaces (as used in Word processing systems or Web browsers) seems to work well.

Plugin Content and Interfaces: Should a plugin represent one algorithm or an entire tool? What about data converters needed to make the output of one algorithm compatible with the input of the next? Should those be part of the algorithm plugin or should they be packaged separately?

Supported (Central) Data Models: Some tools use a central data model to which all algorithms conform, e.g., Cytoscape, see Related Work section. Other tools support many internal data models and provide an extensive set of data converters, e.g., Network Workbench, see below. The former often speeds up execution and visual rendering while the latter eases the integration of new algorithms. In addition, most tools support an extensive set of input and output formats.

Core vs. Plugins: As will be shown, the "core architecture" and the "plugin filling" can be implemented as sets of plugin bundles. Answers to questions such as: "Should the graphical user interface (GUI), interface menu, scheduler, or data manager be part of the core or its filling?" will depend on the type of tools and services to be delivered.

Supported Platforms: If the software is to be used via Web interfaces then Web services need to be implemented. If a majority of domain experts prefers a stand-alone tool running on a specific operating system then a different deployment is necessary.

NetworkWorkbench
A Workbench for Network Scientists

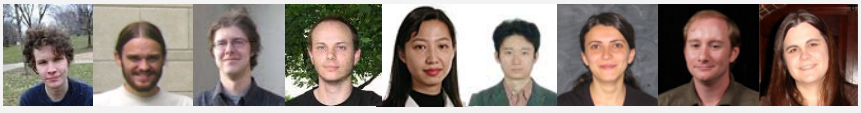
Project Details

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

Software Team: Lead: Micah Linnemeier

Members: Patrick Phillips, Russell Duhon, Tim Kelley & Ann McCranie

Previous Developers: Weixia (Bonnie) Huang, Bruce Herr, Heng Zhang, Duygu Balcan, Bryan Hook, Ben Markines, Santo Fortunato, Felix Terkhorn, Ramya Sabbineni, Vivek S. Thakre & Cesar Hidalgo



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

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

Duration: Sept. 2005 - Aug. 2009

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

Project Details (cont.)

NWB Advisory Board:

James Hendler (Semantic Web) http://www.cs.umd.edu/~hendler/
Jason Leigh (CI) http://www.evl.uic.edu/spiff/
Neo Martinez (Biology) http://online.sfsu.edu/~webhead/
Michael Macy, Cornell University (Sociology)
http://www.soc.cornell.edu/faculty/macy.shtml
Ulrik Brandes (Graph Theory) http://www.inf.uni-konstanz.de/~brandes/
Mark Gerstein, Yale University (Bioinformatics) http://bioinfo.mbb.yale.edu/
Stephen North (AT&T) http://public.research.att.com/viewPage.cfm?PageID=81
Tom Snijders, University of Groningen http://stat.gamma.rug.nl/snijders/
Noshir Contractor, Northwestern University http://www.spcomm.uiuc.edu/nosh/

Resources

Publications
- http://nwb.slis.indiana.edu/pub.html

Community Wiki, Tutorials, FAQ
- https://nwb.slis.indiana.edu/community
- http://nwb.slis.indiana.edu/doc.html
- GUESS Manual http://guess.wikispot.org/manual

Software
- http://cishell.org
- http://nwb.slis.indiana.edu/download.html

Developer Resources
- http://cns-trac.slis.indiana.edu/trac/nwb

Outline

1. Exemplary Network Science Research by NWB PIs
   - Computational Proteomics
   - Computational Economics
   - Computational Social Science
   - Computational Scientometrics
   - Computational Epidemics
2. NWB Tool Challenges and Opportunities
3. NWB Tool Overview
4. NWB Tool for Scientometrics Research
5. Discussion of Future Work

Computational Proteomics

What relationships exist between protein targets of all drugs and all disease-gene products in the human protein–protein interaction network?

Yildriim, Muhammed A., Kwan-Il Goh, Michael E. Cusick, Albert-László Barabási and Marc Vidal. (2007) Drug-target Network. Nature Biotechnology 25 no. 10: 1119-1126.

Figure 2 Drug–target network (DT network). The DT network is generated by using the known associations between FDA-approved drugs and their target proteins. Circles and rectangles correspond to drugs and target proteins, respectively. A link is placed between a drug node and a target node if the protein is a known target of that drug. The area of the drug (protein) node is proportional to the number of targets that the drug has (the number of drugs targeting the protein). Color codes are given in the legend. Drug nodes (circles) are colored according to their Anatomical Therapeutic Chemical Classification, and the target proteins (rectangular boxes) are colored according to their cellular component obtained from the Gene Ontology database.

Computational Economics

Does the type of product that a country exports matter for subsequent economic performance?

C. A. Hidalgo, B. Klinger, A.-L. Barabási, R. Hausmann (2007) The Product Space Conditions the Development of Nations. *Science* 317, 482 (2007).

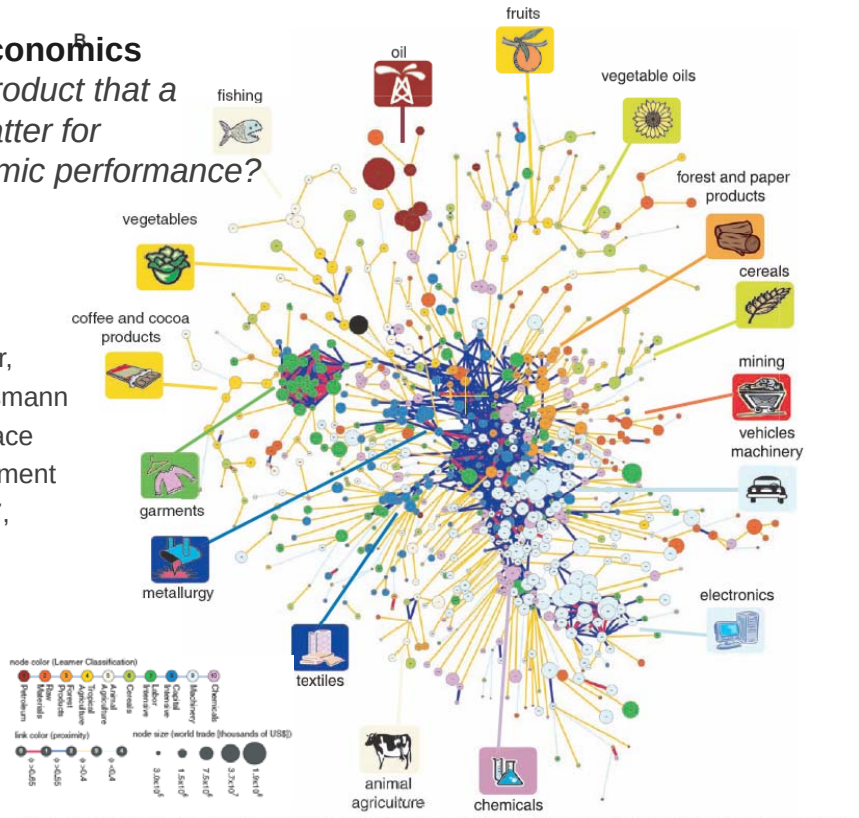


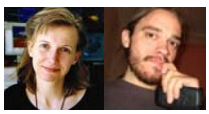
Fig. 1. The product space. **(A)** Hierarchically clustered proximity (φ) matrix representing the 775 SITC-4 product classes exported in the 1998–2000 period. **(B)** Network representation of the product space. Links are color coded with their proximity value. The sizes of the nodes are proportional to world trade, and their colors are chosen according to the classification introduced by Leamer.

Computational Social Science

Studying large scale social networks such as Wikipedia

Vizzards 2007 Entry

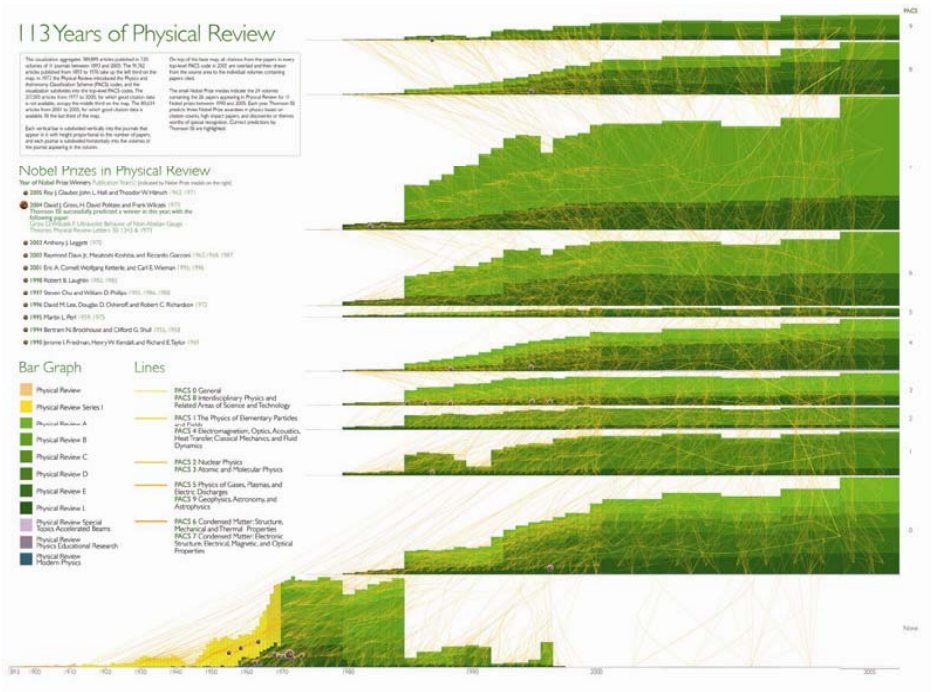
Second Sight: An Emergent Mosaic of Wikipedian Activity, The NewScientist, May 19, 2007

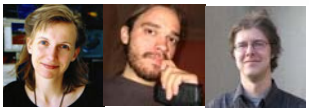


Computational Scientometrics

113 Years of Physical Review

Bruce W. Herr II and Russell Duhon (Data Mining & Visualization), Elisha F. Hardy (Graphic Design), Shashikant Penumarthy (Data Preparation) and Katy Börner (Concept)





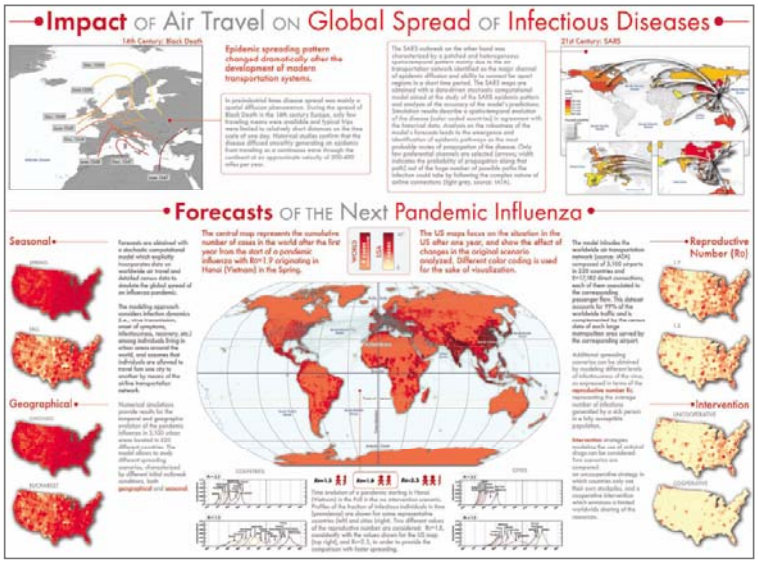
Computational Epidemics

Forecasting (and preventing the effects of) the next pandemic.

Epidemic Modeling in Complex realities, V. Colizza, A. Barrat, M. Barthelemy, A.Vespignani, Comptes Rendus Biologie, 330, 364-374 (2007).

Reaction-diffusion processes and metapopulation models in heterogeneous networks, V.Colizza, R. Pastor-Satorras, A.Vespignani, Nature Physics 3, 276-282 (2007).

Modeling the Worldwide Spread of Pandemic Influenza: Baseline Case and Containment Interventions, V. Colizza, A. Barrat, M. Barthelemy, A.-J. Valleron, A.Vespignani, PloS-Medicine 4, e13, 95-110 (2007).



Network Workbench (http://nwb.slis.indiana.edu).

2. NWB Challenges and Opportunities

- Data
  - Different data formats
  - Different data models
- Algorithms
  - Different research purposes (preprocessing, modeling, analysis, visualization, clustering)
  - Different implementations of the same algorithm
  - Different programming languages
  - Algorithm developers/users are not computer scientists
- Different tools (Pajek, UCINet, Guess, Cytoscape, R, …)
- Different communities, practices, cultures

NWB Deliverables

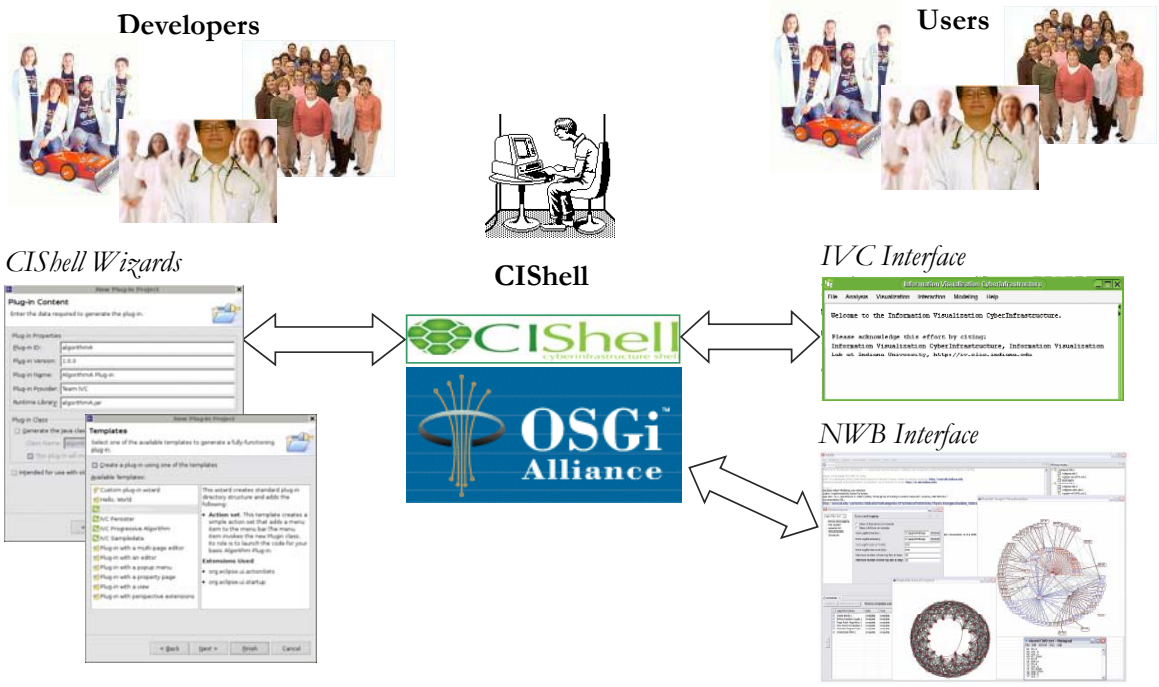
Network Workbench (NWB) Tool

- A network analysis, modeling, and visualization toolkit for physics, biomedical, and social science research.
- Install and run on multiple Operating Systems.
- Supports many file formats.
- Easy integration of new algorithms thanks to CIShell/OSGi.

Cyberinfrastructure Shell (CIShell)

- An open source, software framework for the integration and utilization of datasets, algorithms, tools, and computing resources.
- Extends OSGi industry standard.

CIShell – Serving Non-CS Algorithm Developers & Users



CIShell – Builds on OSGi Industry Standard

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 8 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.

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NWB Community Wiki

- A place for users of the NWB Tool, the Cyberinfrastructure Shell (CIShell), or any other CIShell-based program to request, obtain, contribute, and share algorithms and datasets.
- All algorithms and datasets that are available via the NWB Tool have been well documented in the Community Wiki.

Network Workbench Tool

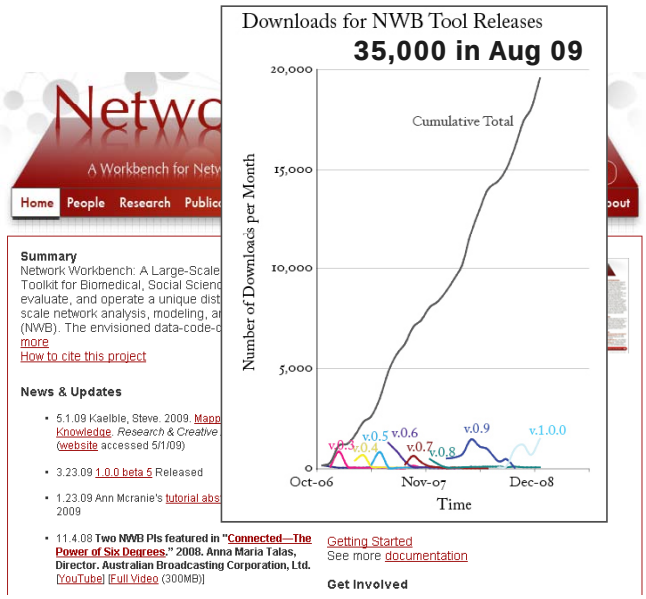
http://nwb.slis.indiana.edu

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

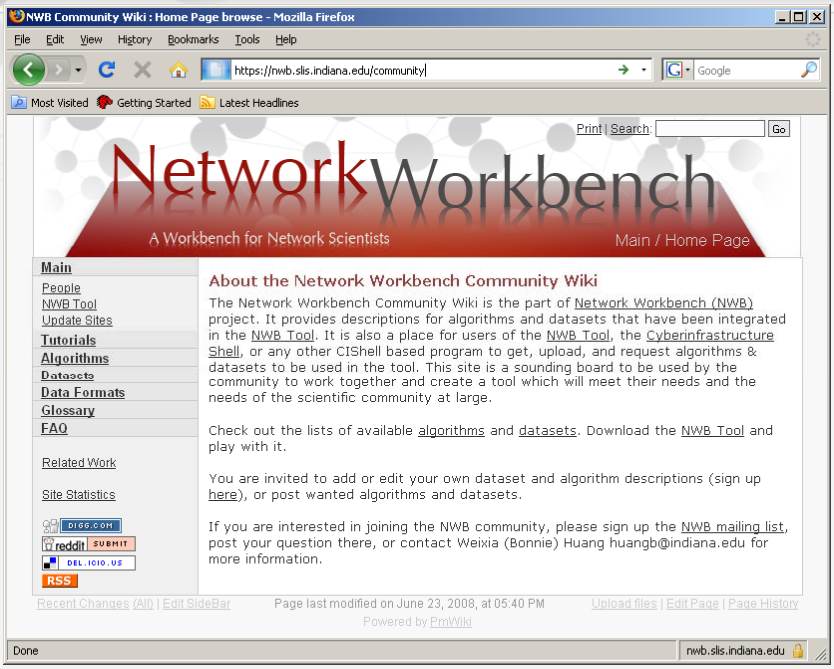
In Aug. 2009, the tool provides more 160 plugins that support the preprocessing, analysis, modeling, and visualization of networks.

More than 40 of these plugins can be applied or were specifically designed for S&T studies.

It has been downloaded more than 35,000 times since Dec. 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.



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

NWB Tool: Supported Data Formats

Personal Bibliographies

- Bibtex (.bib)
- Endnote Export Format (.enw)

Data Providers

- Web of Science by Thomson Scientific/Reuters (.isi)
- Scopus by Elsevier (.scopus)
- Google Scholar (access via *Publish or Perish* save as CSV, Bibtex, EndNote)
- Awards Search by National Science Foundation (.nsf)

Scholarly Database (all text files are saved as .csv)

- Medline publications by National Library of Medicine
- NIH funding awards by the National Institutes of Health (NIH)
- NSF funding awards by the National Science Foundation (NSF)
- U.S. patents by the United States Patent and Trademark Office (USPTO)
- Medline papers – NIH Funding

Network Formats

- NWB (.nwb)
- Pajek (.net)
- GraphML (.xml or .graphml)
- XGMML (.xml)

Burst Analysis Format

- Burst (.burst)

Other Formats

- CSV (.csv)
- Edgelist (.edge)
- Pajek (.mat)
- TreeML (.xml)

NWB Tool: Algorithms (July 1st, 2008)

See https://nwb.slis.indiana.edu/community and handout for details.

Preprocessing Edit

- **Remove Nodes**
  - Extract Top Nodes
  - Extract Nodes Above or Below Val
  - Delete High Degree Nodes
  - Delete Random Nodes
  - Delete Isolates
- **Remove Edges**
  - Extract Top Edges
  - Extract Edges Above or Below Val
  - Remove Self Loops
  - Trim By Degree[2]
  - Pathfinder Network Scaling
- **Sampling**
  - Snowball Sampling (n nodes)
  - Node Sampling
  - Edge Sampling
- **Transformations**
  - Symmetrize
  - Dichotomize
  - Multipartite Joining

Modeling Edit

- **General**
  - Random Graph
  - Watts-Strogatz Small World
  - Barabási-Albert Scale-Free
- **Structured**
  - CAN
  - Chord
- **Unstructured**
  - Hypergrid
  - PRU
- **Other**
  - TARL
  - Discrete Network Dynamics

Analysis Edit

- **General Purpose**
  - Network Analysis Toolkit[2]
- **Unweighted & Undirected**
  - **Based on degree/**
    - Node Degree
    - Node Distribution
  - **Based on clustering**
    - k-Nearest Neighbor
    - Watts Strogatz Clustering Coefficient
    - Watts Strogatz Clustering Coefficient Over k
  - **Based on path**
    - Diameter
    - Average Shortest Path
    - Shortest Path Distribution
    - Node Betweenness Centrality
  - **Based on components**
    - Connected Components
    - Weak Component Clustering
  - **K-Core**
    - Extract K-Core[2]
    - Annotate K-Coreness[2]
- **Unweighted & Directed**
  - **Based on degree**
    - Node Indegree
    - Node Outdegree
    - Indegree Distribution
    - Outdegree Distribution
  - **Based on local graph structure**
    - k-Nearest Neighbor
    - Single Node In-Out Degree Correlations[2]
  - **Unnamed Category?**
    - Page Rank
  - **Based on local graph structure #2**
    - Dyad Reciprocity[2]
    - Arc Reciprocity[2]

tion Edit

- **Tools**
  - GUESS
  - GnuPlot[2]
- **Predefined Positions Layout**
  - DrL (VxOrd)
  - Pre-defined Positions (prefuse beta)[2]
- **Move**
  - Circular
- **Tree Layouts**
  - Radial Tree (prefuse alpha)
  - Radial Tree with Annotations (prefuse beta)[2]
  - Tree Map
  - Tree View
  - Balloon Graph (prefuse alpha)[2]
- **Network Layouts**
  - Force Directed with Annotation (prefuse beta)
  - Kamada-Kawai (JUNG)
  - Fruchterman-Reingold (JUNG)
  - Fruchterman-Reingold with Annotation (prefuse beta)
  - Spring (JUNG)
  - Small World (prefuse alpha)
- **Other Layouts**
  - Parallel Coordinates (demo)[2]
  - LaNet (k-Core Decomposition)

etrics Edit

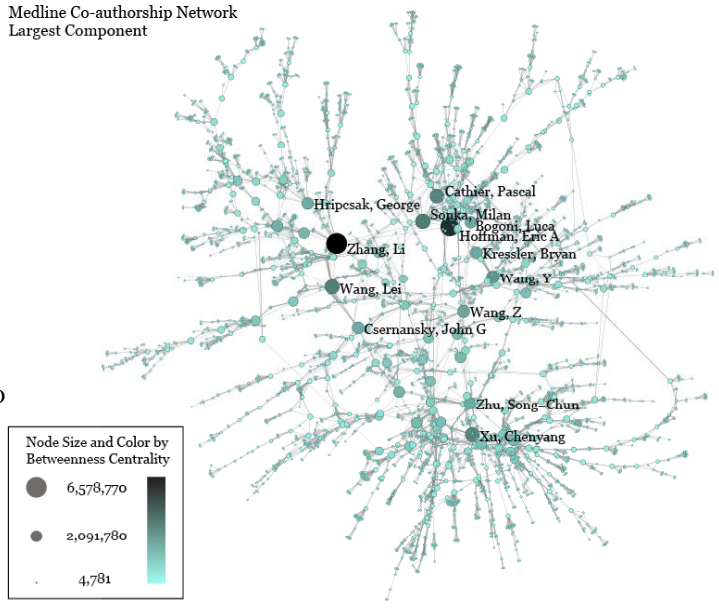
- **Extract Network From Table**
  - Extract Co-Authorship Network
  - Extract Co-Occurrence Network From Table[2]
  - Extract Directed Network From Table[2]
- **Extract Network From Another Network**
  - Extract Bibliographic Coupling Similarity Network
  - Extract Co-Citation Similarity Network[2]
- **Cleaning**
  - Remove ISI Duplicate Records

NWB Tool: Output Formats

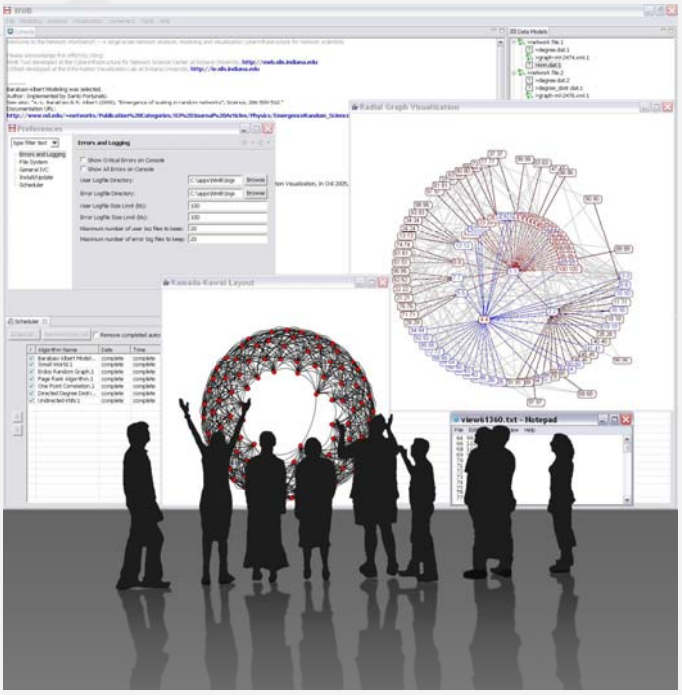
- NWB tool can be used for data conversion. Supported output formats comprise:
- CSV (.csv)
- NWB (.nwb)
- Pajek (.net)
- Pajek (.mat)
- GraphML (.xml or .graphml)
- XGMML (.xml)

- GUESS
  Supports export of images into common image file formats.

- Horizontal Bar Graphs
- saves out raster and ps files.



Demo



NWB Tool Overview

1. **Download, install, and run.**
2. **Load, view, convert, save data.**
3. **Read and visualize a directory hierarchy.**
4. **Load a network, compute its basic properties, and explore it in GUESS.**

NWB Tool Overview

1. **Download, install, and run.**
2. Load, view, convert, save data.
3. Read and visualize a directory hierarchy.
4. Load a network, compute its basic properties, and explore it in GUESS.

Download, install, and run

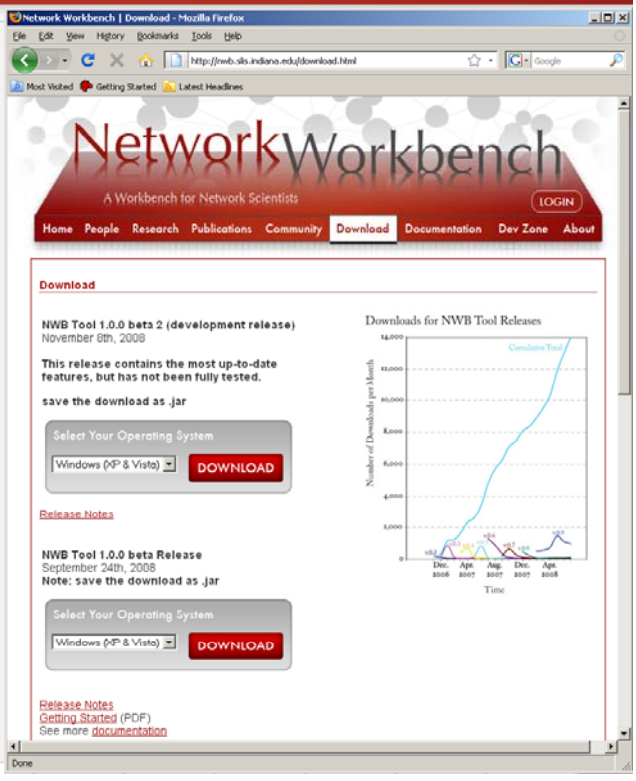
Goto http://nwb.slis.indiana.edu

NWB Tool 1.0.0
Select your operating system from the pull down menu.

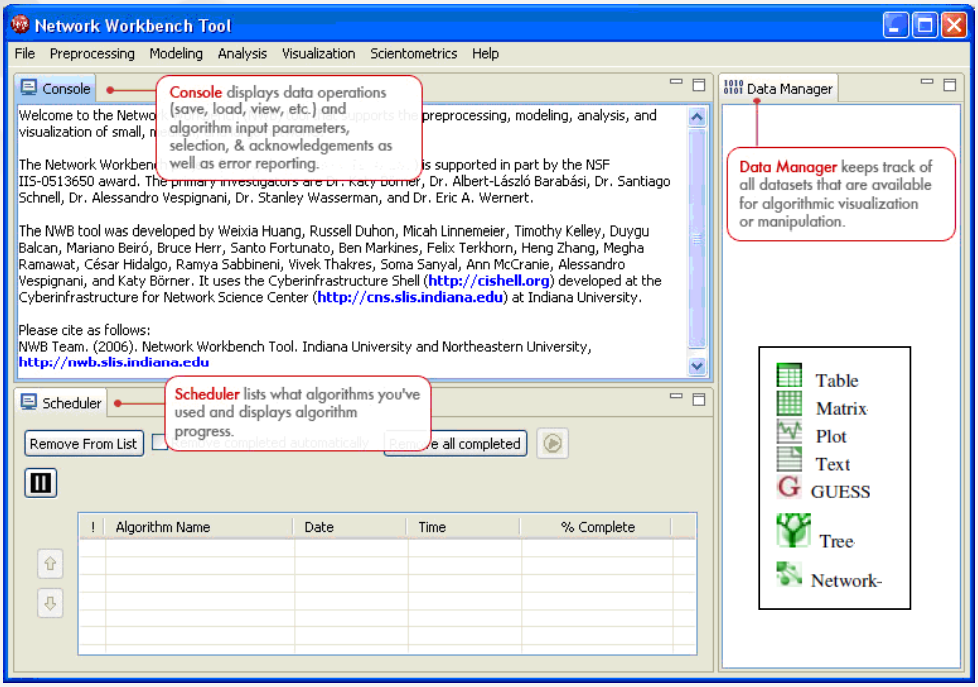
Save as *.jar file.

Install and run.

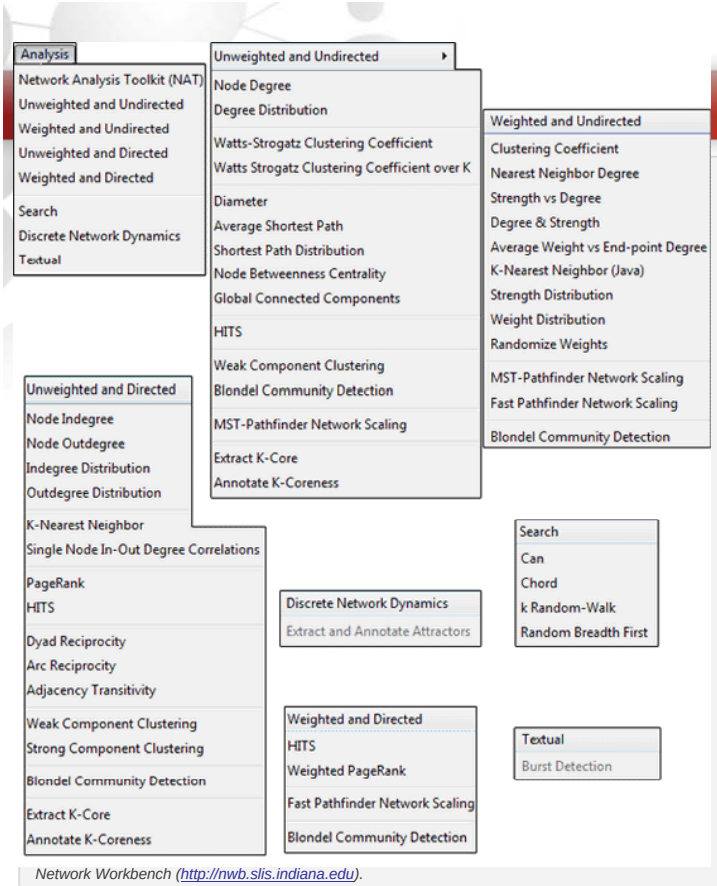
Session log files are stored in '**yournwbdirectory*/logs*' directory.



NWB Tool Interface Components



File, Preprocessing, Modeling, and Visualization Menus



Analysis Menu and Submenus

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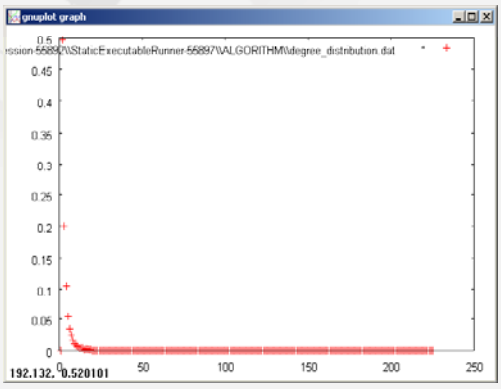
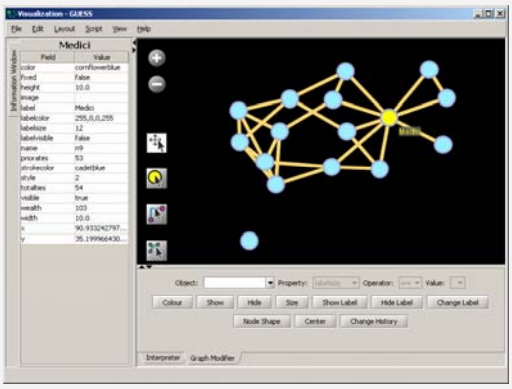
Integrated Tools



Gnuplot

portable command-line driven interactive data and function plotting utility http://www.gnuplot.info/.



GUESS

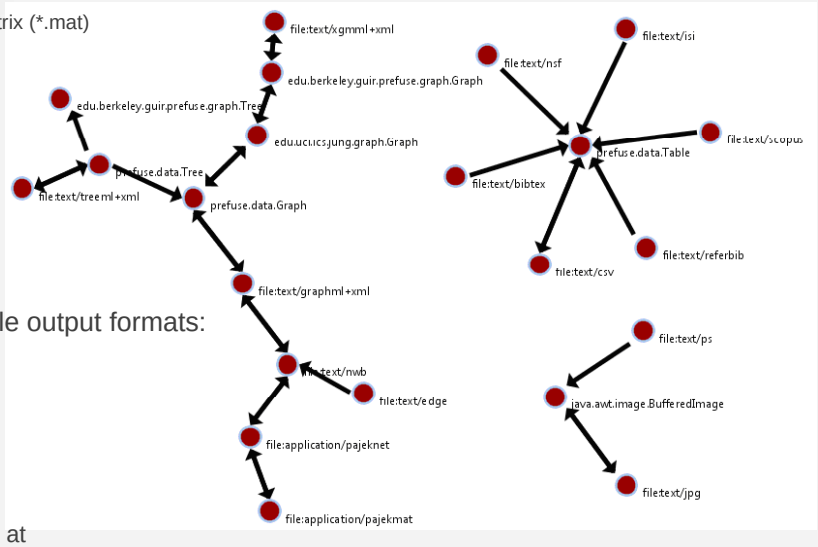
exploratory data analysis and visualization tool for graphs and networks.

https://nwb.slis.indiana.edu/community/?n=VisualizeData.GUESS.

Supported Data Formats

In November 2008, the NWB tool supports loading the following input file formats:

- GraphML (*.xml or *.graphml)
- XGMML (*.xml)
- Pajek .NET (*.net) & Pajek .Matrix (*.mat)
- NWB (*.nwb)
- TreeML (*.xml)
- Edge list (*.edge)
- CSV (*.csv)
- ISI (*.isi)
- Scopus (*.scopus)
- NSF (*.nsf)
- Bibtex (*.bib)
- Endnote (*.enw)



and the following network file output formats:

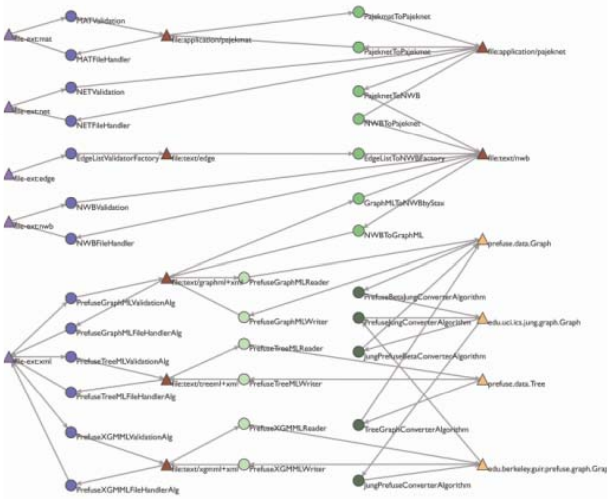
- GraphML (*.xml or *.graphml)
- Pajek .MAT (*.mat)
- Pajek .NET (*.net)
- NWB (*.nwb)
- XGMML (*.xml)
- CSV (*.csv)

These formats are documented at https://nwb.slis.indiana.edu/community/?n=DataFormats.HomePage.

NWB Ecology of Data Formats and Converters

*Not shown are **15** sample datasets, **45** data preprocessing, analysis, modeling and visualization algorithms, **9** services.*

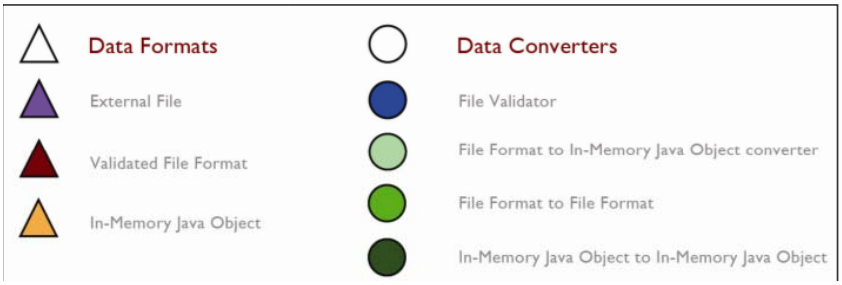
13
Supported data formats



6
Output formats for diverse visualization algorithms

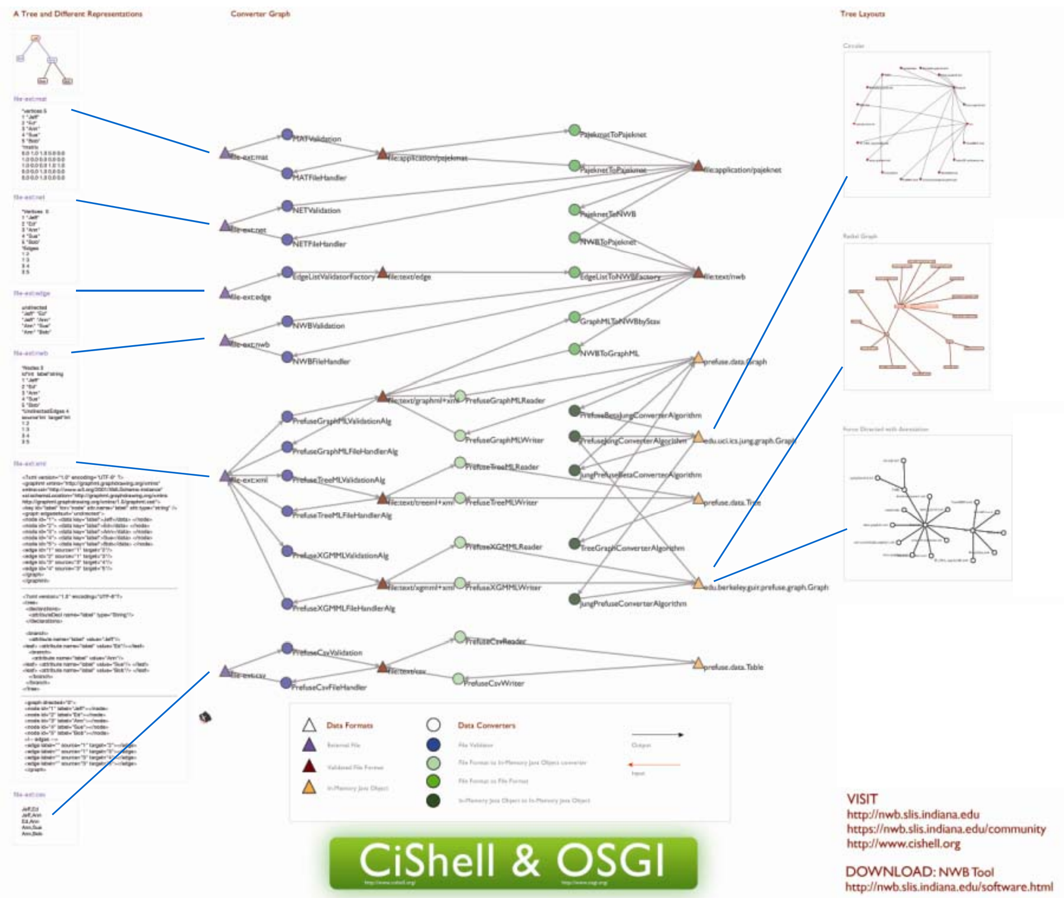
8
Intermediate data formats

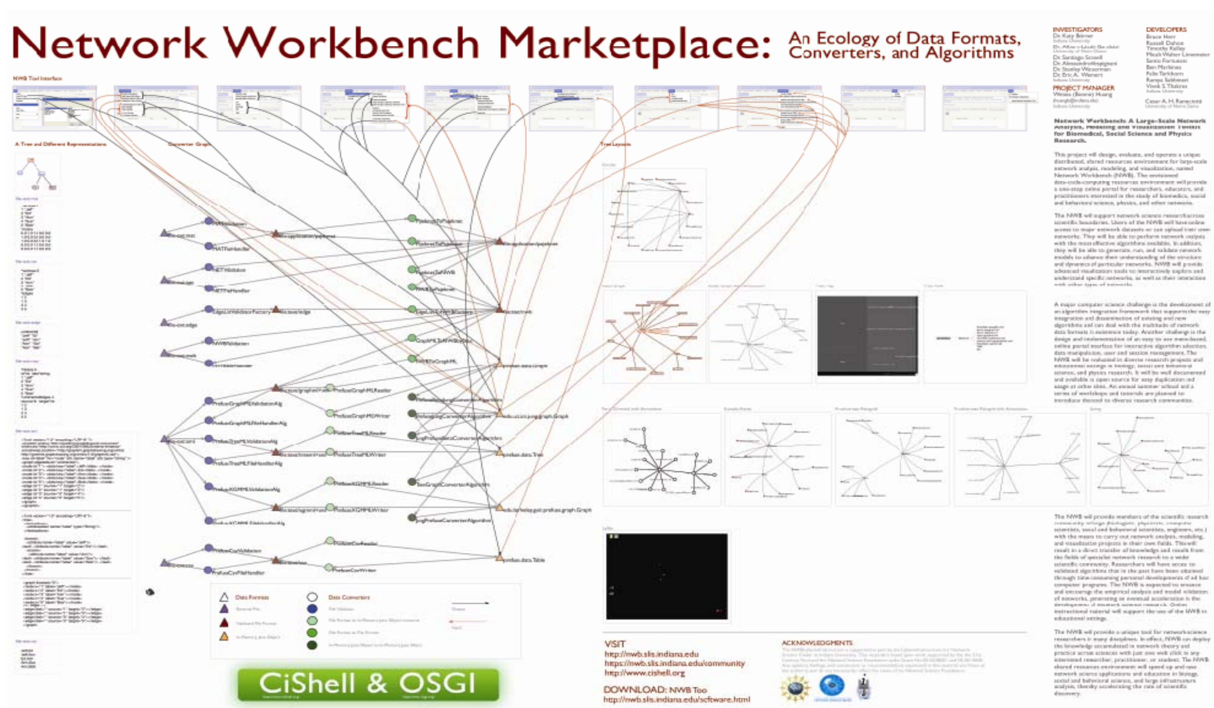
Supported by
35
data converters.



VISIT
http://nwb.slis.indiana.edu
https://nwb.slis.indiana.edu/community
http://www.cishell.org

DOWNLOAD: NWB Tool
http://nwb.slis.indiana.edu/software.html


A Tree and Different Representations
Converter Graph
Tree Layouts
Circular
Radial Graph
Force Directed with Annotation
file-ext:mat
file-ext:net
file-ext:edge
file-ext:nwb
file-ext:xml
file-ext:csv
MATValidation
MATFileHandler
file:application/pajekmat
PajekmatToPajeknet
PajeknetToPajekmat
file:application/pajeknet
NETValidation
NETFileHandler
PajeknetToNWB
NWBToPajeknet
EdgeListValidatorFactory
file:text/edge
EdgeListToNWBFactory
file:text/nwb
NWBValidation
NWBFileHandler
GraphMLToNWBbyStax
NWBToGraphML
prefuse.data.Graph
file:text/graphml+xml
PrefuseGraphMLReader
PrefuseGraphMLWriter
PrefuseGraphMLValidationAlg
PrefuseGraphMLFileHandlerAlg
PrefuseBetaJungConverterAlgorithm
PrefuseJungConverterAlgorithm
edu.uci.ics.jung.graph.Graph
JungPrefuseBetaConverterAlgorithm
PrefuseTreeMLValidationAlg
PrefuseTreeMLFileHandlerAlg
file:text/treeml+xml
PrefuseTreeMLReader
PrefuseTreeMLWriter
prefuse.data.Tree
PrefuseXGMMLValidationAlg
PrefuseXGMMLFileHandlerAlg
file:text/xgmml+xml
PrefuseXGMMLReader
PrefuseXGMMLWriter
TreeGraphConverterAlgorithm
JungPrefuseConverterAlgorithm
edu.berkeley.guir.prefuse.graph.Graph
PrefuseCsvValidation
PrefuseCsvFileHandler
file:text/csv
PrefuseCsvReader
PrefuseCsvWriter
prefuse.data.Table
Data Formats
Data Converters
VISIT
http://nwb.slis.indiana.edu
https://nwb.slis.indiana.edu/community
http://www.cishell.org
DOWNLOAD: NWB Tool
http://nwb.slis.indiana.edu/software.html
CiShell & OSGI


Network Workbench Marketplace: An Ecology of Data Formats, Converters, and Algorithms
NWB Tool Interface
A Tree and Different Representations
Converter Graph
Tree Layouts
INVESTIGATORS
DEVELOPERS
PROJECT MANAGER
VISIT
http://nwb.slis.indiana.edu
https://nwb.slis.indiana.edu/community
http://www.cishell.org
DOWNLOAD: NWB Tool
http://nwb.slis.indiana.edu/software.html
ACKNOWLEDGMENTS
CiShell & OSGI

Sample Datasets

The '**yournwbdirectory*/sampledata'* directory provides sample datasets from the biology, network, scientometics, and social science research domains:

/biology
/network
/scientometrics
/scientometrics/bibtex
/scientometrics/csv
/scientometrics/endnote
/scientometrics/isi
- FourNetSciResearchers.isi

/scientometrics/nsf
- Cornell.nsf
- Indiana.nsf
- Michigan.nsf

/scientometrics/scopus
/socialscience
- florentine.nwb

The blue ones are used in this tutorial.

Property Files and Python Scripts

The '**yournwbdirectory*/*" directory also contains

/sampledata/scientometrics/properties // Used to extract networks and merge data
- bibtexCoAuthorship.properties
- endnoteCoAuthorship.properties
- isiCoAuthorship.properties
- isiCoCitation.properties
- isiPaperCitation.properties
- mergeBibtexAuthors.properties
- mergeEndnoteAuthors.properties
- mergeIsiAuthors.properties
- mergeNsfPIs.properties
- mergeScopusAuthors.properties
- nsfCoPI.properties
- scopusCoAuthorship.properties

/sampledata/scripts/GUESS // Used to do color/size/shape code networks
- co-author-nw.py
- co-PI-nw.py
- paper-citation-nw.py
- reference-co-occurrence-nw.py

NWB Tool Overview

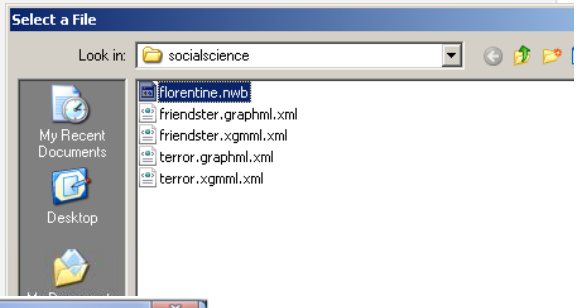
1. Download, install, and run.
2. **Load, view, convert, save data.**
3. Read and visualize a directory hierarchy.
4. Load a network, compute its basic properties, and explore it in GUESS.

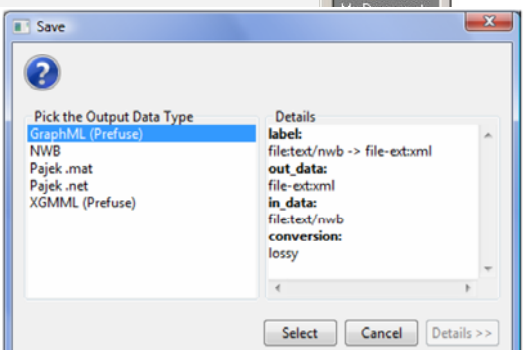
Load, View and Save (Convert) Data

Use *'File > Load File'* to load *florentine.nwb* in sample datasets in '**yournwbdirectory*/sampledata/socialscience'*.

The loaded file will appear in the Data Manager window.

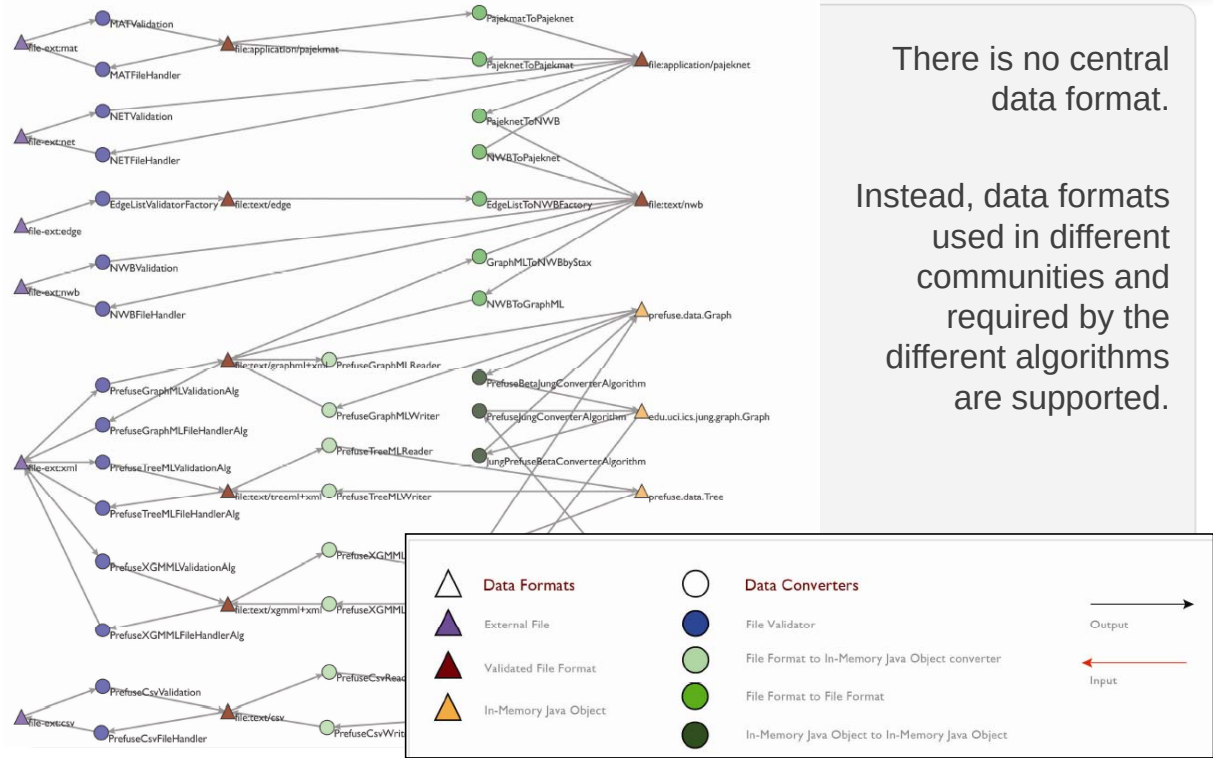
Right click loaded file to save, view, rename, or discard.





NetworkWorkbench
A Workbench for Network Scientists

Data Converter Graph



There is no central data format.

Instead, data formats used in different communities and required by the different algorithms are supported.

NetworkWorkbench
A Workbench for Network Scientists

NWB Tool Overview

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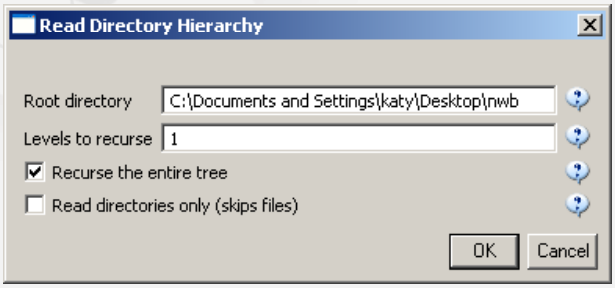
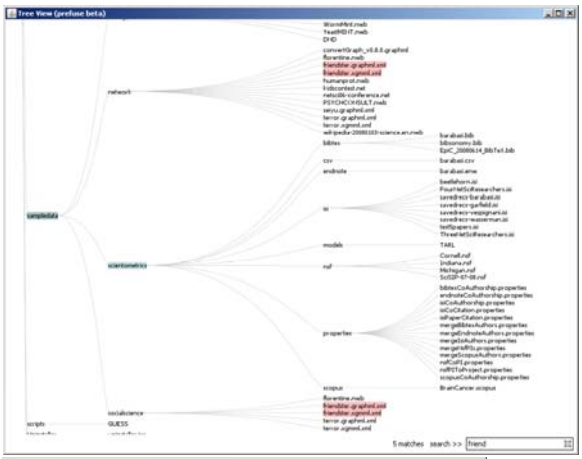
Reading and Visualizing a Directory Hierarchy

Use *'File > Read Directory Hierarchy'* with parameters



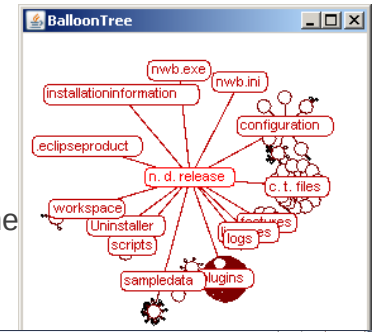
Visualize resulting *'Directory Tree - Prefuse (Beta) Graph'* using

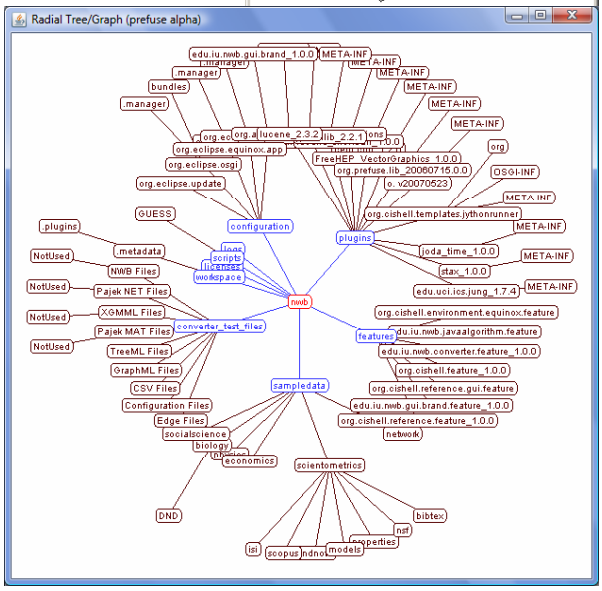
- *'Visualization > Tree View (prefuse beta)'*
- *'Visualization > Tree Map (prefuse beta)'*
- *'Visualization > Balloon Graph (prefuse alpha)'*
- *'Visualization > Radial Tree/Graph (prefuse alpha)'*



Different views of the /nwb directory hierarchy.

Note the size of the /plugin directory.





NWB Tool Overview

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2. Load, view, convert, save data.
3. Read and visualize a directory hierarchy.
4. **Load a network, compute its basic properties, and explore it in GUESS.**

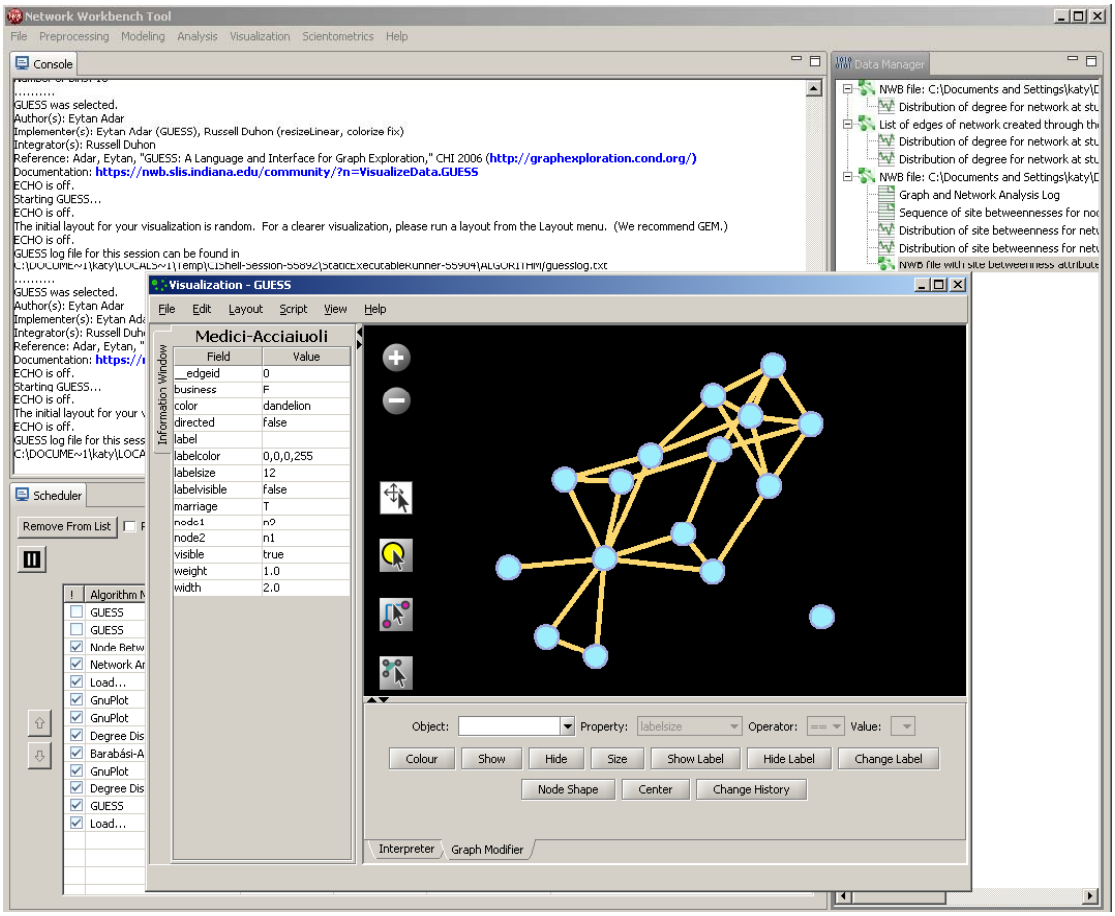
Compute Basic NW Properties & View in GUESS

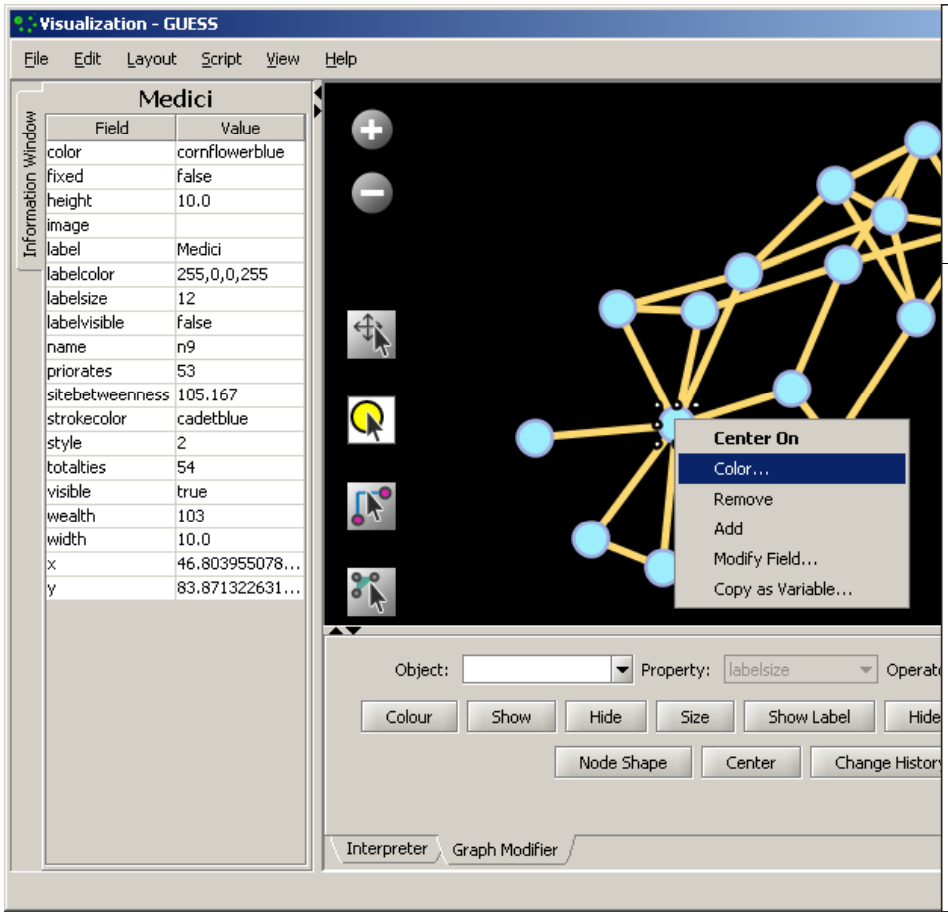
Select *florentine.nwb* in Data Manager.

- Run *'Analysis > Network Analysis Toolkit (NAT)'* to get basic properties.

```
This graph claims to be undirected.

Nodes: 16
Isolated nodes: 1
Node attributes present: label, wealth, totalties, priorates

Edges: 27
No self loops were discovered.
No parallel edges were discovered.
Edge attributes:
  Nonnumeric attributes:
                        Example value
        marriag...      T
        busines...      F

  Did not detect any numeric attributes
  This network does not seem to be a valued network.

Average degree: 3.375
This graph is not weakly connected.
There are 2 weakly connected components. (1 isolates)
The largest connected component consists of 15 nodes.
Did not calculate strong connectedness because this graph was not directed.


Density (disregarding weights): 0.225
```

- Optional: Run 'Analysis -> Unweighted & Undirected -> Node Betweenness Centrality' with default parameters.
- Select network and run *'Visualization > GUESS'* to open GUESS with file loaded.
- Apply 'Layout -> GEM'.



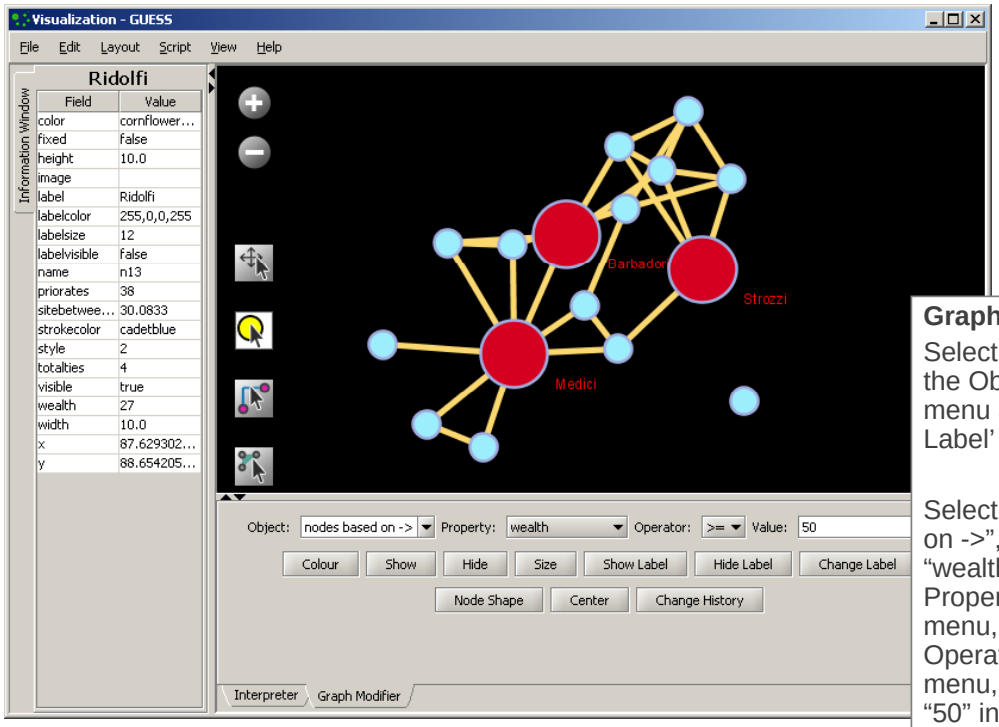


Pan:
"grab" the background by holding left-click and moving your mouse.

Zoom:
Using scroll wheel, press the "+" and "-" buttons in the upper-left hand corner, or right-click and move the mouse left or right. Center graph by selecting 'View -> Center'.

Select to select/move single nodes. Hold down 'Shift' to select multiple.

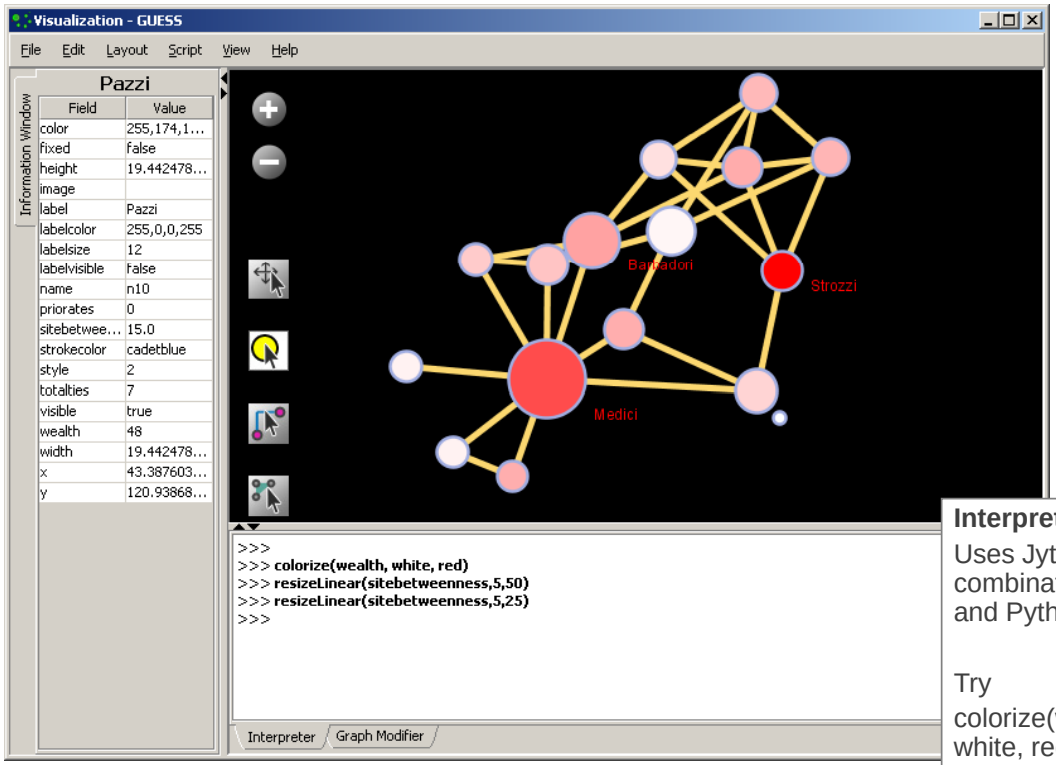
Right click to modify Color, etc.



Graph Modifier:

Select “all nodes” in the Object drop-down menu and click ‘Show Label’ button.

Select “nodes based on ->”, then select “wealth” from the Property drop-down menu, “>=” from the Operator drop-down menu, and finally type “50” into the Value box. Then a color/size/ shape code.



Interpreter:

Uses Jython a combination of Java and Python.

Try colorize(wealth, white, red)

resizeLinear(sitebetweenness, 5, 25)

Workflow Design Primer

Modularity at data preprocessing/analysis/modeling level.

Modularity at visualization level:

- 'Data Layers' are used in GIS systems to support the visual layering and coordination of different datasets, e.g., water pipes, streets, electricity lines, etc.
- 'Design Layers' supported by graphic design software such as Photoshop or Dreamweaver enable the separate design and modular composition of design elements.
- 'Visualization Layers' define distinct parts with very specific functionality that collectively define a visualization.

BREAK

Exemplary Analyses and Visualizations

Individual Level

A. Loading ISI files of major network science researchers, extracting, analyzing and visualizing paper-citation networks and co-author networks.

B. Loading NSF datasets with currently active NSF funding for 3 researchers at Indiana U

Institution Level

C. Indiana U, Cornell U, and Michigan U, extracting, and comparing Co-PI networks.

Scientific Field Level

D. Extracting co-author networks, patent-citation networks, and detecting bursts in SDB data.

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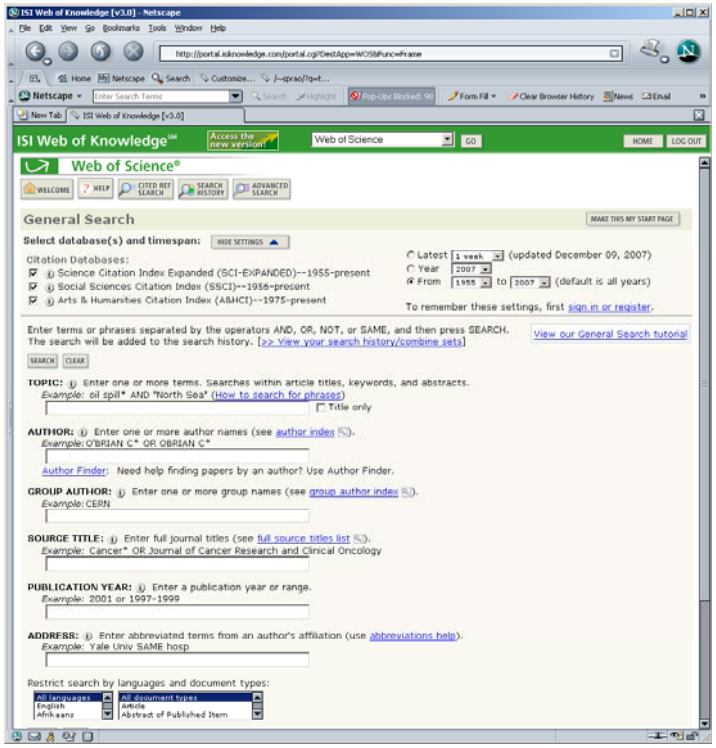
Data Acquisition from Web of Science

Download all papers by

- Eugene Garfield
- Stanley Wasserman
- Alessandro Vespignani
- Albert-László Barabási

from

- Science Citation Index Expanded (SCI-EXPANDED) --1955-present
- Social Sciences Citation Index (SSCI)--1956-present
- Arts & Humanities Citation Index (A&HCI)--1975-present



Comparison of Counts

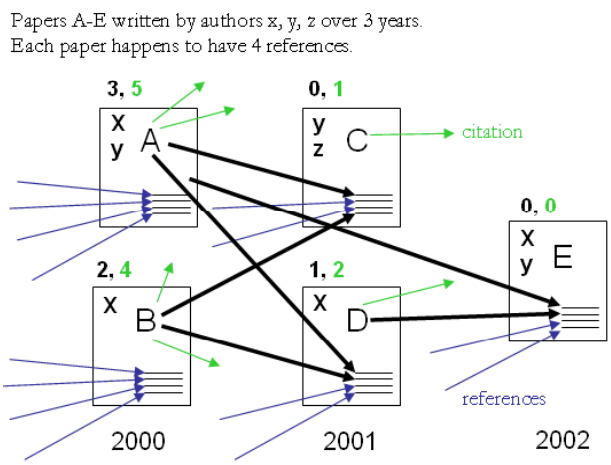
No books and other non-WoS publications are covered.

	Age	Total # Cites	Total # Papers	H-Index	
Eugene Garfield	82	1,525	672	31	
Stanley Wasserman		122	35	17	
Alessandro Vespignani	42	451	101	33	
Albert-László Barabási	40	2,218	126	47	*(Dec 2007)*
	41	16,920	159	52	*(Dec 2008)*

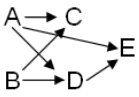
Network Extraction

Sample paper network (left) and
four different network types derived from it (right)

From ISI files, about 30 different networks can be extracted.



Paper-Paper Citation Network
Papers are connected via direct citation links.
Arrows represent information flow from older papers to younger papers.



Author-Author (Co-Author) Network
x and y co-author papers A and E together
y and z co-author papers A and E

Document Co-Citation (DCA) Network
A and B are co-cited by C and D
A and D are co-cited by E

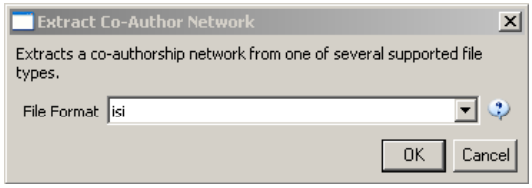
Reference Co-Occurrence (Bibliographic Coupling) Network
C and D are bibliographically coupled as they both cite/reference A and B.

Local citation counts (within this dataset) are given in **black** and global citation counts (ISI times cited) are given in green above each paper.

Extract Co-Author Network

Load *'yournwbdirectory*/sampledata/scientometrics/isi/FourNetSciResearchers.isi'* using *'File > Load and Clean ISI File'*.

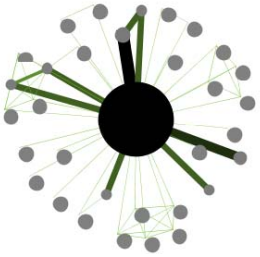
To extract the co-author network, select the *'361 Unique ISI Records'* table and run *'Scientometrics > Extract Co-Author Network'* using isi file format:



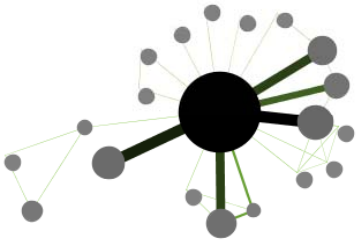
The result is an undirected network of co-authors in the Data Manager. It has 247 nodes and 891 edges.

To view the complete network, select the network and run *'Visualization > GUESS > GEM'*. Run *Script > Run Script… . And select Script folder > GUESS > co-author-nw.py*.

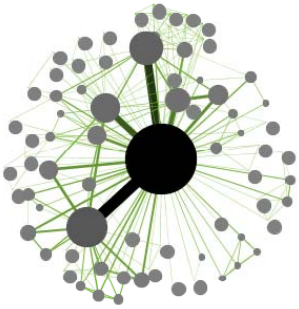
Comparison of Co-Author Networks



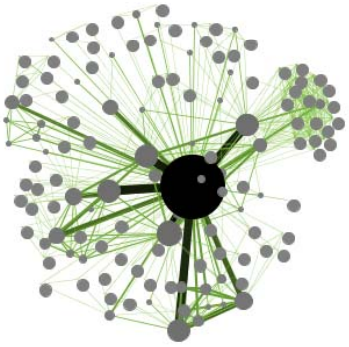
Eugene Garfield



Stanley Wasserman

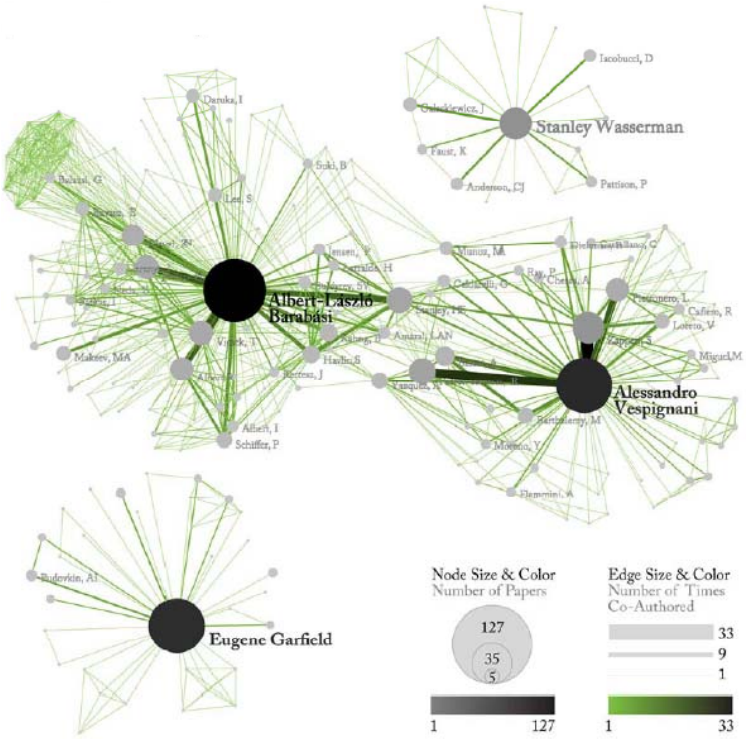


Alessandro Vespignani



Albert-László Barabási

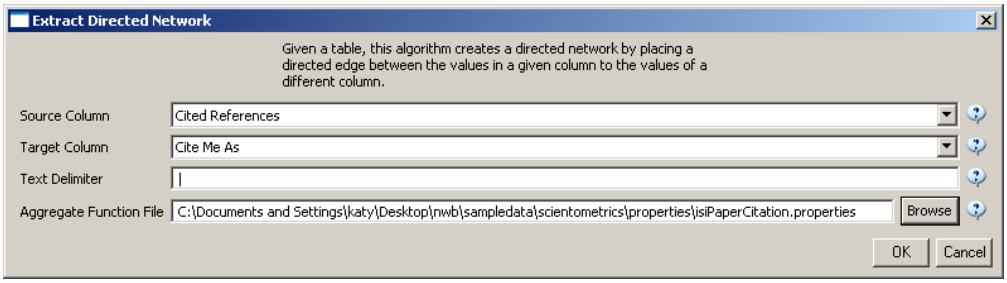
Joint Co-Author Network of all Four NetsSci Researchers



Paper-Citation Network Layout

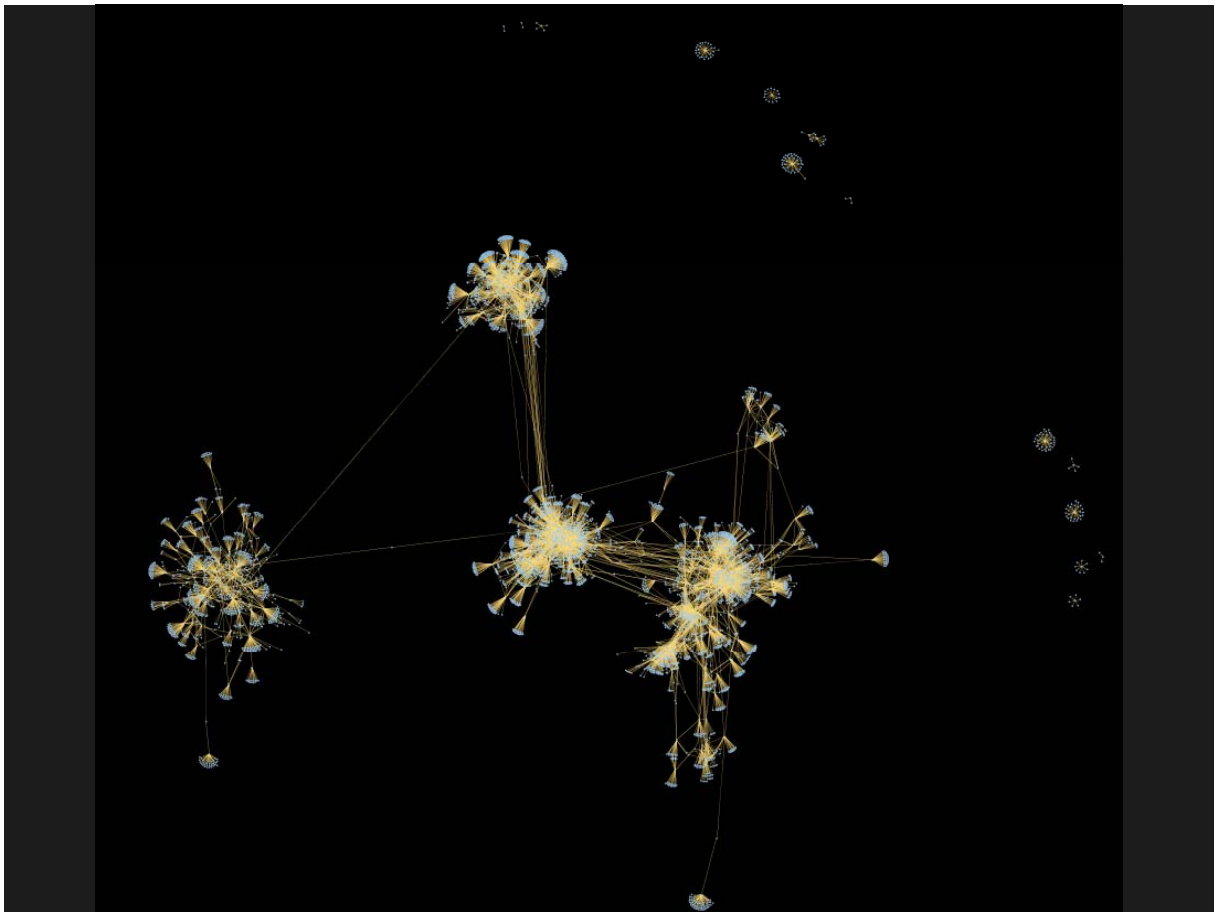
Load *'*yournwbdirectory*/sampledata/scientometrics/isi/FourNetSciResearchers.isi'* using *'File > Load and Clean ISI File'*.

To extract the paper-citation network, select the *'361 Unique ISI Records'* table and run *'Scientometrics > Extract Directed Network'* using the parameters:



The result is a directed network of paper citations in the Data Manager. It has 5,335 nodes and 9,595 edges.

To view the complete network, select the network and run *'Visualization > GUESS'*. Run '*Script > Run Script …' and select 'yournwbdirectory*/script/GUESS/paper-citation-nw.py'*.



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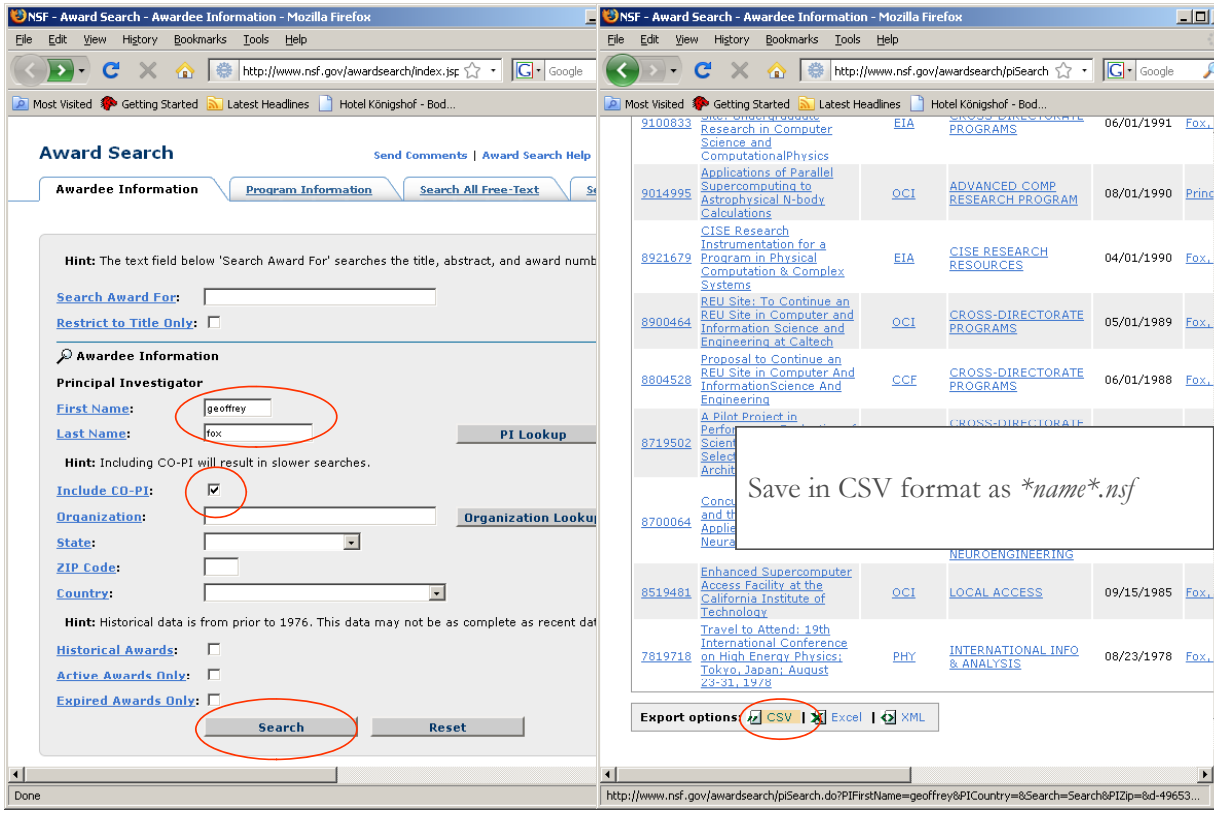
NSF Awards Search via http://www.nsf.gov/awardsearch



NSF Awards Search Results

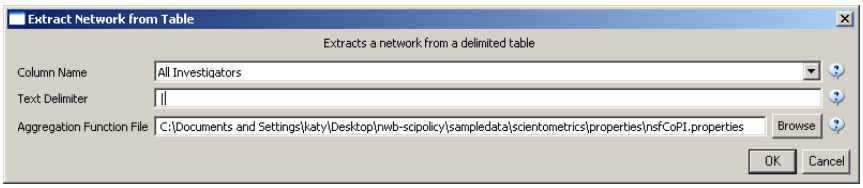
Name	# Awards	First A. Starts	Total Amount to Date
Geoffrey Fox	27	Aug 1978	12,196,260
Michael McRobbie	8	July 1997	19,611,178
Beth Plale	10	Aug 2005	7,224,522

Disclaimer:

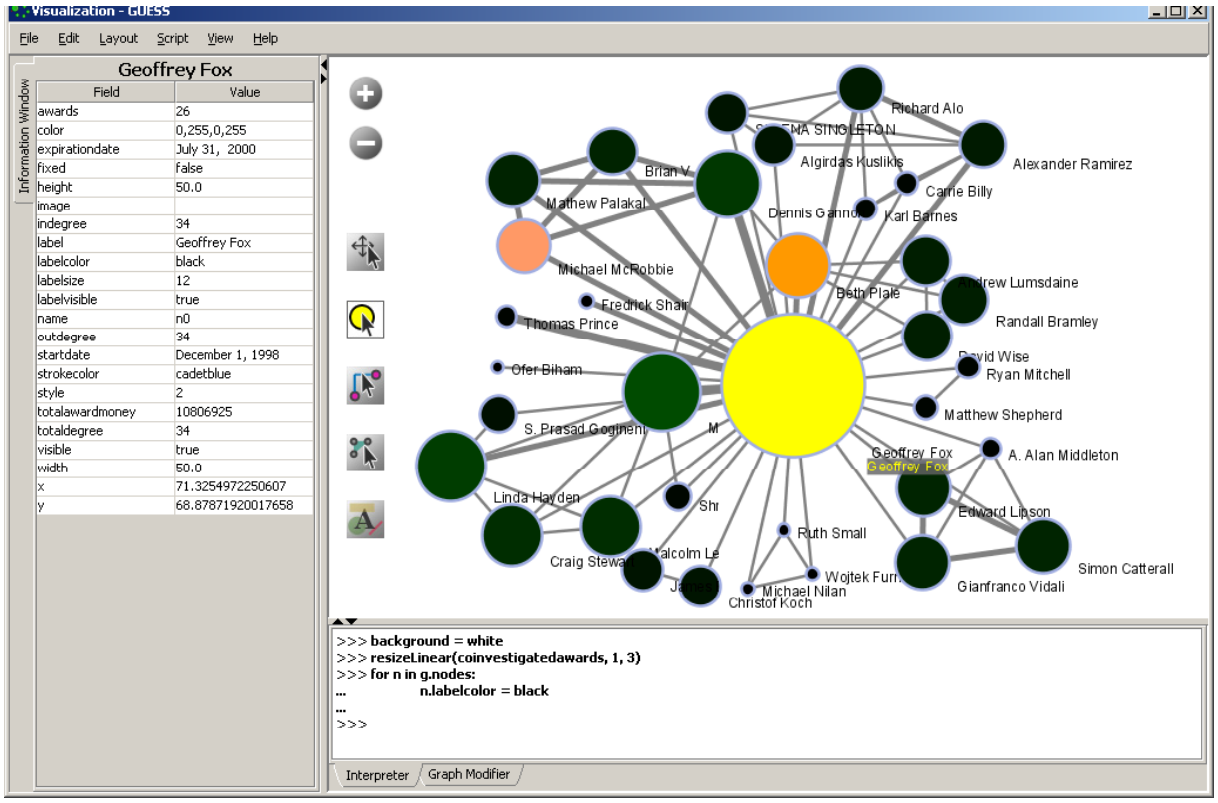
Only NSF funding, no funding in which they were senior personnel, only as good as NSF's internal record keeping and unique person ID. If there are 'collaborative' awards then only their portion of the project (award) will be included.

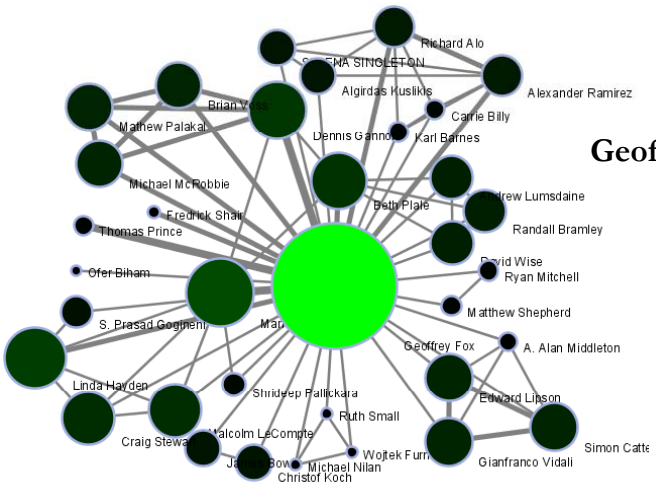
Using NWB to Extract Co-PI Networks

- Load into NWB, open file to count records, compute total award amount.
- Run '*Scientometrics* > *Extract Co-Occurrence Network*' using parameters:

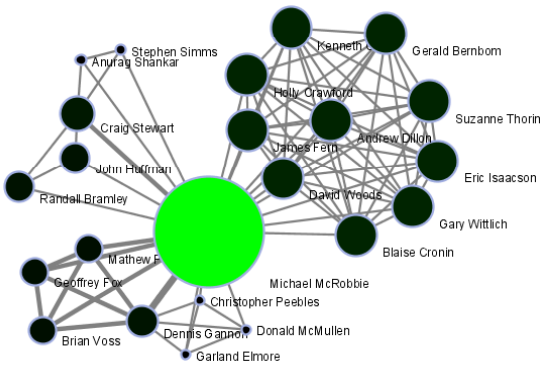


- Select *"Extracted Network .."* and run *'Analysis* > *Network Analysis Toolkit (NAT)'*
- Remove unconnected nodes via *'Preprocessing* > *Delete Isolates'*.
- *'Visualization* > *GUESS'*, layout with GEM
- Run 'co-PI-nw.py' GUESS script to color/size code.

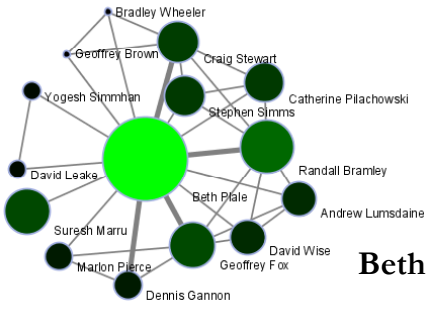




Geoffrey Fox



Michael McRobbie



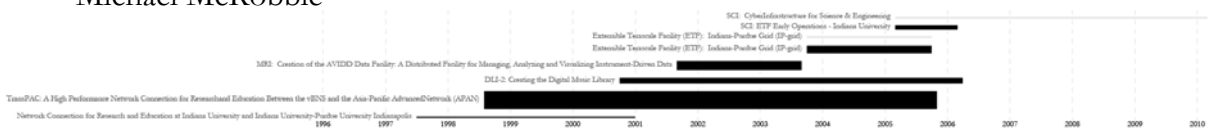
Beth Plale

Geoffrey Fox

Last Expiration date

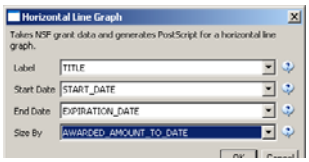
July 10

Michael McRobbie



Feb 10

Beth Plale



Sept 09

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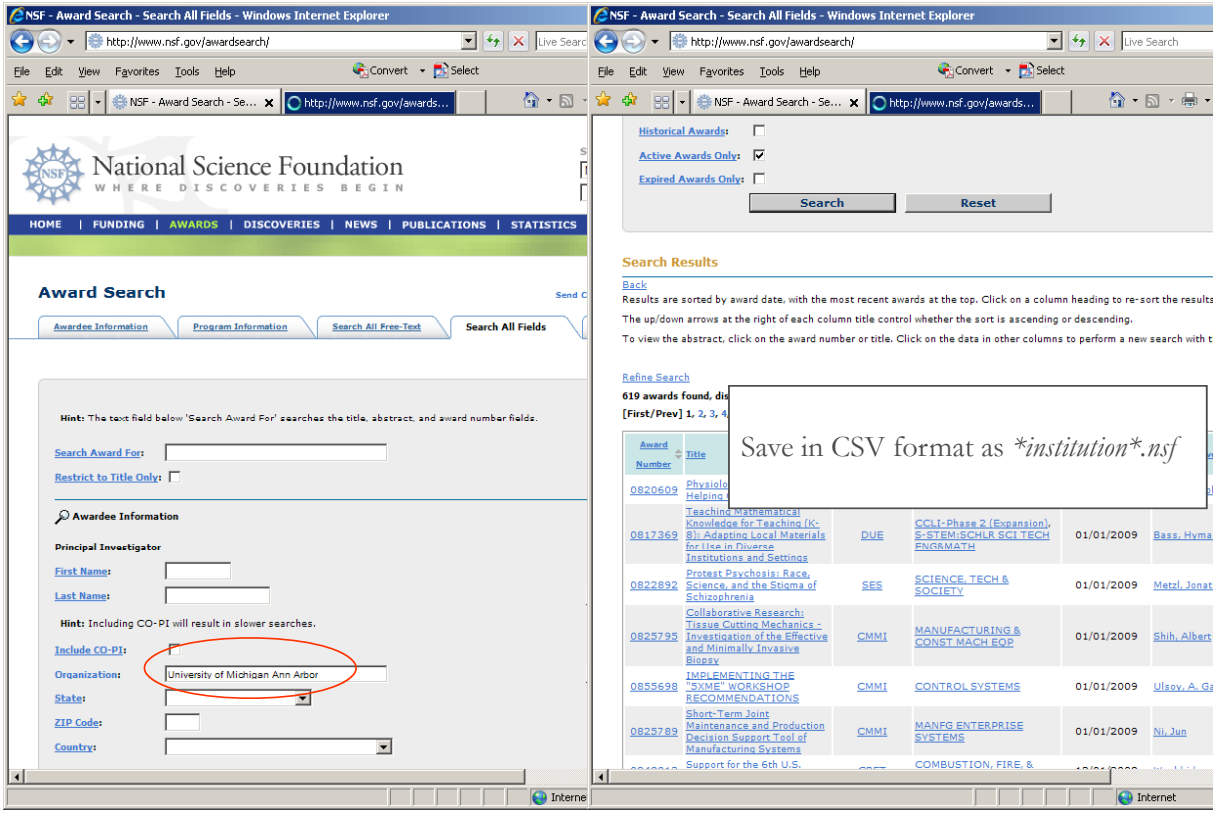


Active NSF Awards on 11/07/2008:

- Indiana University 257

  (there is also Indiana University at South Bend Indiana University Foundation, Indiana University Northwest, Indiana University-Purdue University at Fort Wayne, Indiana University-Purdue University at Indianapolis, Indiana University-Purdue University School of Medicine)

- Cornell University 501

  (there is also Cornell University – State, Joan and Sanford I. Weill Medical College of Cornell University)

- University of Michigan Ann Arbor 619

  (there is also University of Michigan Central Office, University of Michigan Dearborn, University of Michigan Flint, University of Michigan Medical School)

Active NSF Awards on 09/10/2009:

- Stanford University 429

Save files as csv but rename into .nsf.

Or simply use the files saved in *'*yournwbdirectory*/sampledata/scientometrics/nsf/'*.

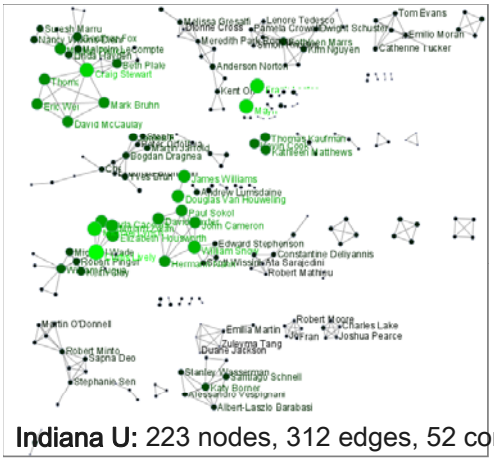
Extracting Co-PI Networks

Load NSF data, selecting the loaded dataset in the Data Manager window, run *'Scientometrics > Extract Co-Occurrence Network'* using parameters:

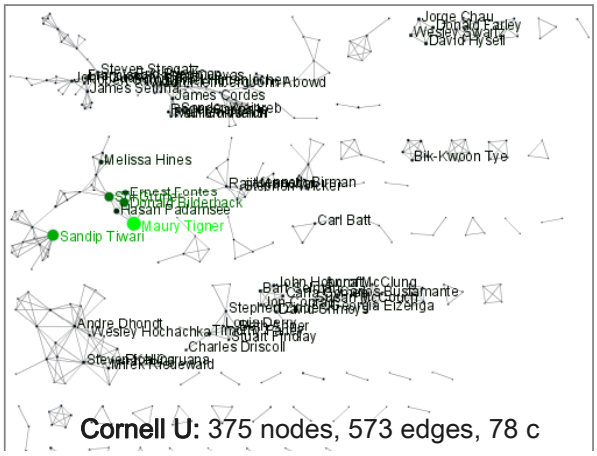
Two derived files will appear in the Data Manager window: the co-PI network and a merge table. In the network, nodes represent investigators and edges denote their co-PI relationships. The merge table can be used to further clean PI names.

Running the *'Analysis > Network Analysis Toolkit (NAT)'* reveals that the number of nodes and edges but also of isolate nodes that can be removed running *'Preprocessing > Delete Isolates'*.

Select *'Visualization > GUESS'* to visualize. Run 'co-PI-nw.py' script.



Indiana U: 223 nodes, 312 edges, 52 components

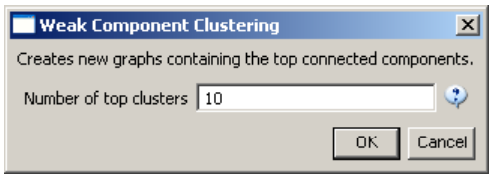


Cornell U: 375 nodes, 573 edges, 78 c

U of Michigan: 497 nodes, 672 edges, 117 c

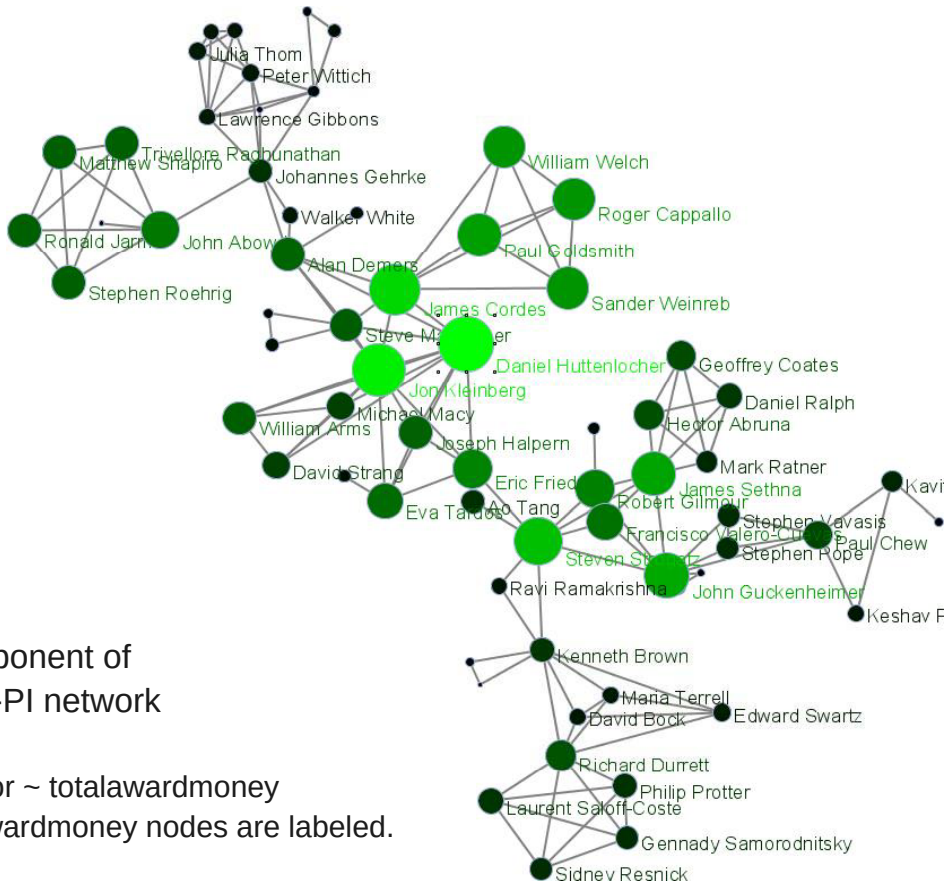
Extract Giant Component

Select network after removing isolates and run *'Analysis > Unweighted and Undirected > Weak Component Clustering' with parameter*



Indiana's largest component has 19 nodes, Cornell's has 67 nodes, Michigan's has 55 nodes.

Visualize Cornell network in GUESS using same .py script and save via *'File > Export Image'* as jpg.



Largest component of
Cornell U co-PI network

Node size/color ~ totalawardmoney
Top-50 totalawardmoney nodes are labeled.

Top-10 Investigators by Total Award Money

```
for i in range(0, 10):
    print str(nodesbytotalawardmoney[i].label) + ": " +
    str(nodesbytotalawardmoney[i].totalawardmoney)
```

Indiana University

Curtis Lively:	7,436,828
Frank Lester:	6,402,330
Maynard Thompson:	6,402,330
Michael Lynch:	6,361,796
Craig Stewart:	6,216,352
William Snow:	5,434,796
Douglas V. Houweling:	5,068,122
James Williams:	5,068,122
Miriam Zolan:	5,000,627
Carla Caceres:	5,000,627

Cornell University

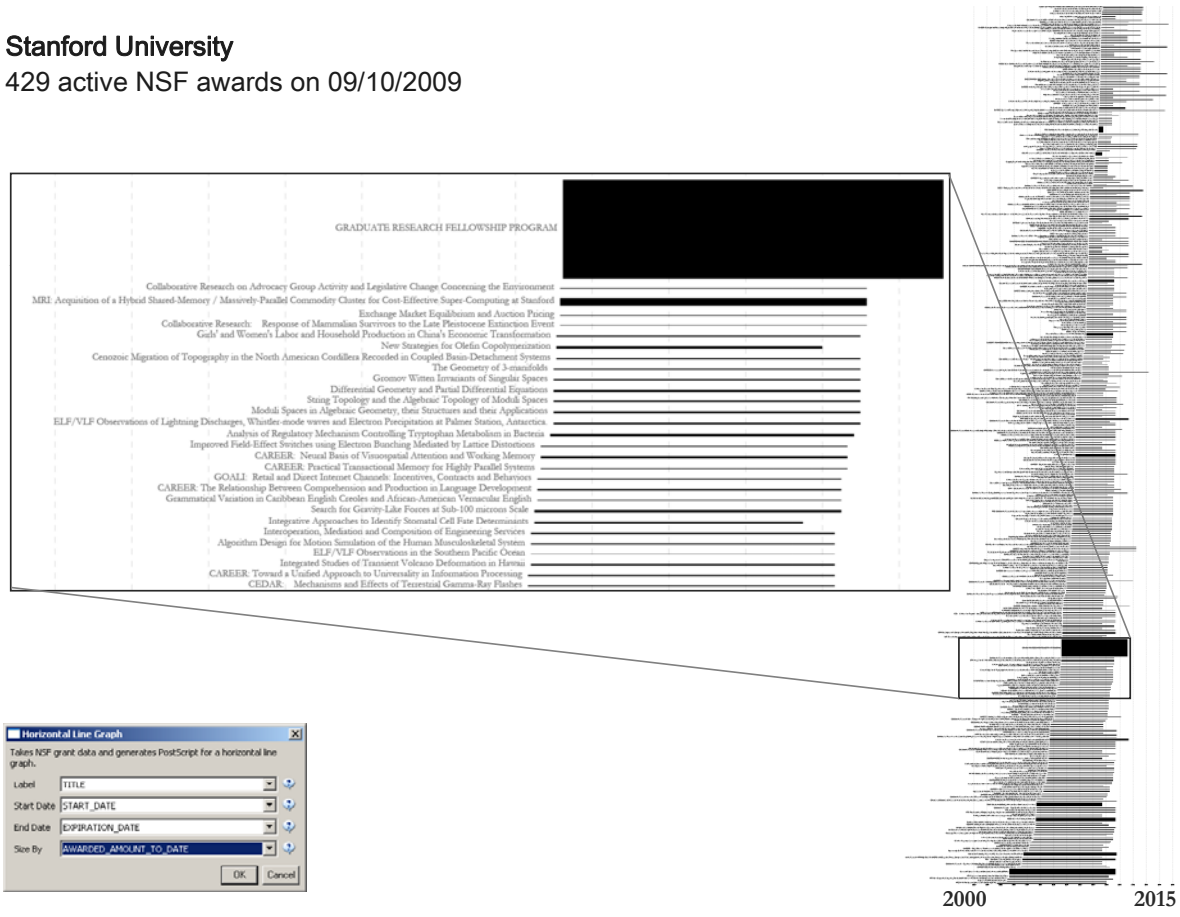
Maury Tigner:	107,216,976
Sandip Tiwari:	72,094,578
Sol Gruner:	48,469,991
Donald Bilderback:	47,360,053
Ernest Fontes:	29,380,053
Hasan Padamsee:	18,292,000
Melissa Hines:	13,099,545
Daniel Huttenlocher:	7,614,326
Timothy Fahey:	7,223,112
Jon Kleinberg:	7,165,507

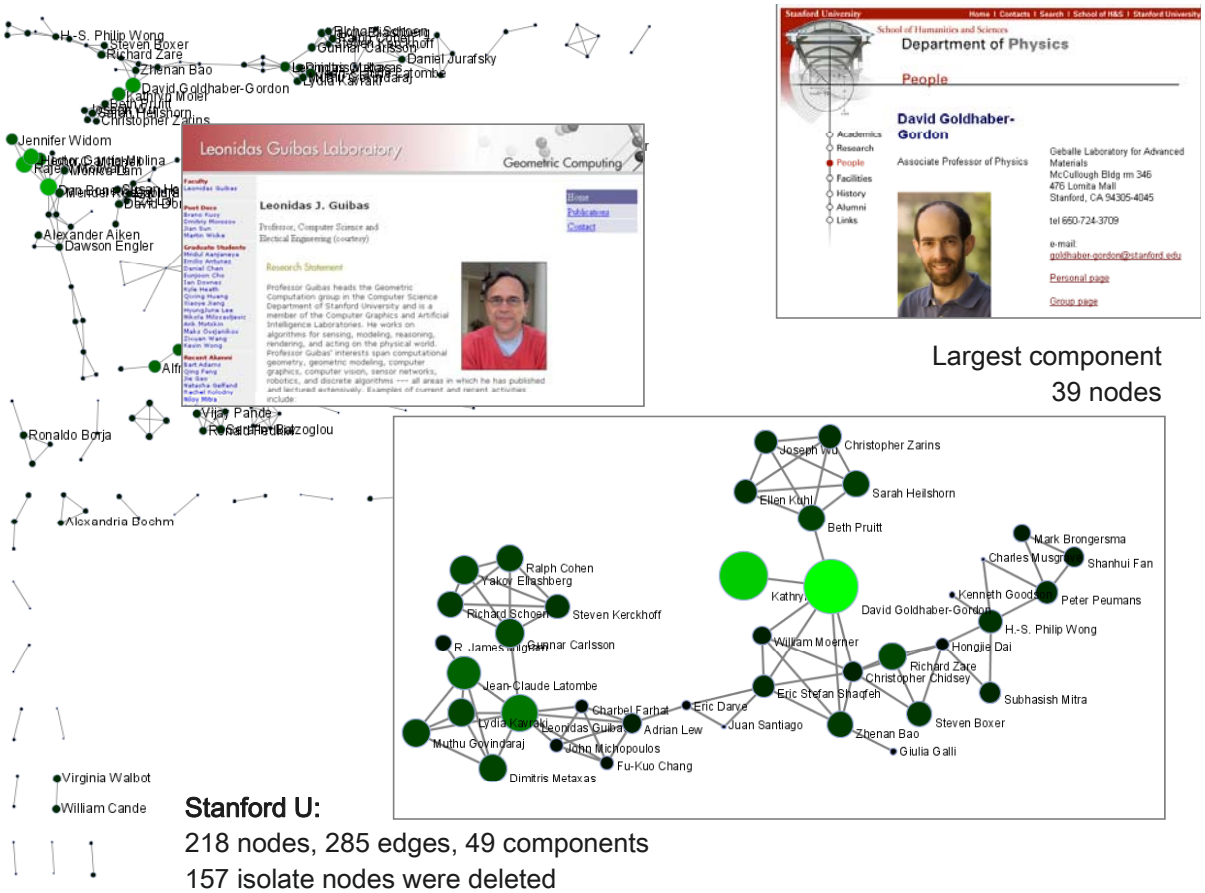
Michigan University

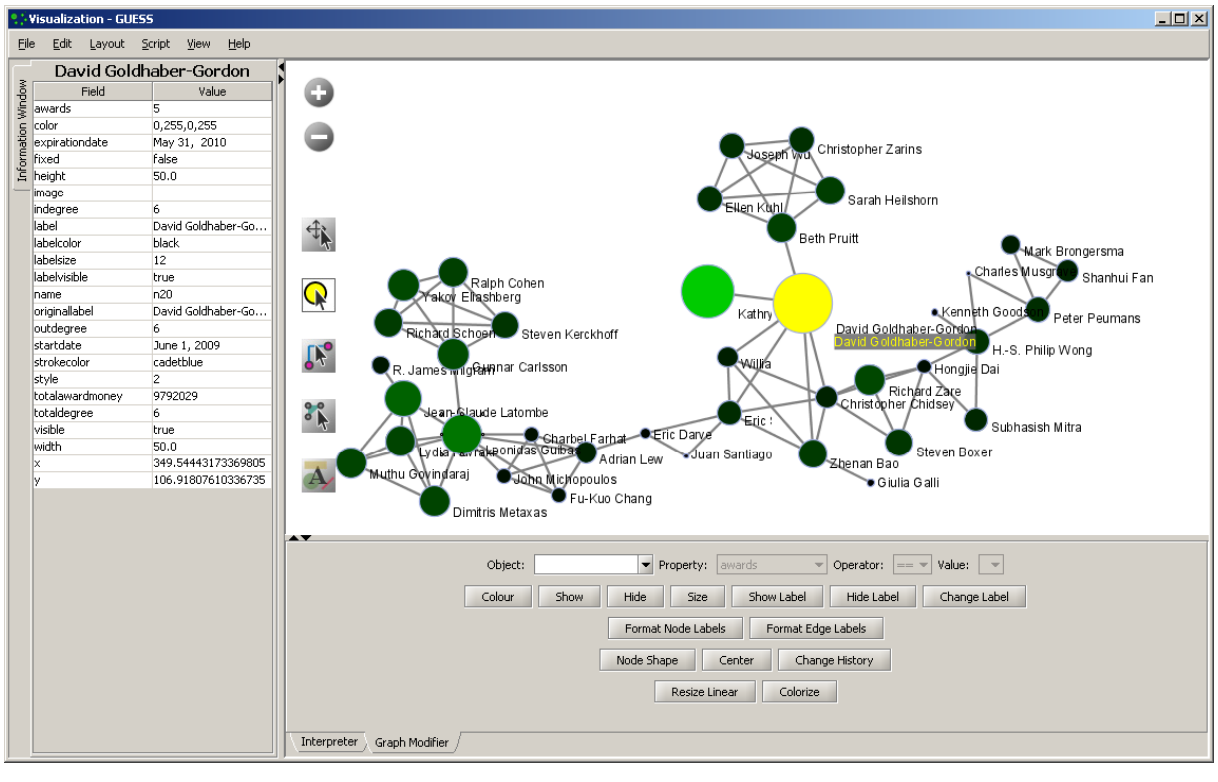
Khalil Najafi:	32,541,158
Kensall Wise:	32,164,404
Jacquelynne Eccles:	25,890,711
Georg Raithel:	23,832,421
Roseanne Sension:	23,812,921
Theodore Norris:	23,35,0921
Paul Berman:	23,350,921
Roberto Merlin:	23,350,921
Robert Schoeni:	21,991,140
Wei-Jun Jean Yeung:	21,991,140

Stanford University

429 active NSF awards on 09/10/2009

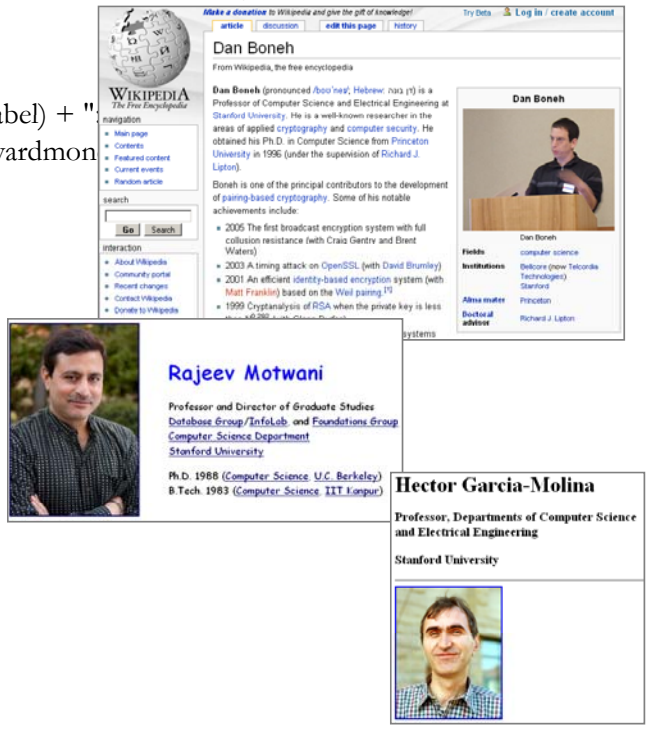



Leonidas Guibas Laboratory
Geometric Computing
Leonidas J. Guibas
Department of Physics
People
David Goldhaber-Gordon
Associate Professor of Physics
Largest component
39 nodes
Stanford U:
218 nodes, 285 edges, 49 components
157 isolate nodes were deleted


Visualization - GUESS
File Edit Layout Script View Help
David Goldhaber-Gordon
Information Window
Field Value
awards 5
color 0,255,0,255
expirationdate May 31, 2010
fixed false
height 50.0
image
indegree 6
label David Goldhaber-Go...
labelcolor black
labelsize 12
labelvisible true
name n20
originallabel David Goldhaber-Go...
outdegree 6
startdate June 1, 2009
strokecolor cadetblue
style 2
totalawardmoney 9792029
totaldegree 6
visible true
width 50.0
x 349.54443173369805
y 106.91807610336735
Object: Property: awards Operator: == Value:
Colour Show Hide Size Show Label Hide Label Change Label
Format Node Labels Format Edge Labels
Node Shape Center Change History
Resize Linear Colorize
Interpreter Graph Modifier

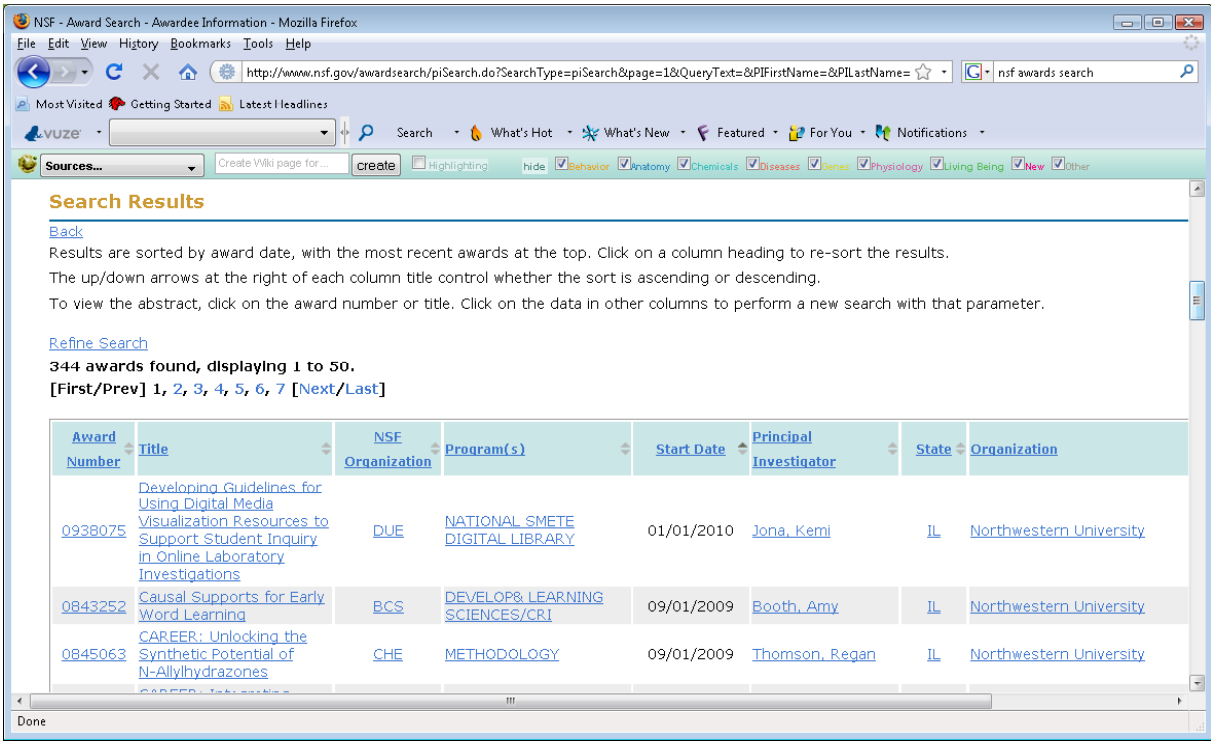
Top-10 Investigators by Total Award Money

```
for i in range(0, 10):
    print str(nodesbytotalawardmoney[i].label) + "
    str(nodesbytotalawardmoney[i].totalawardmon
```

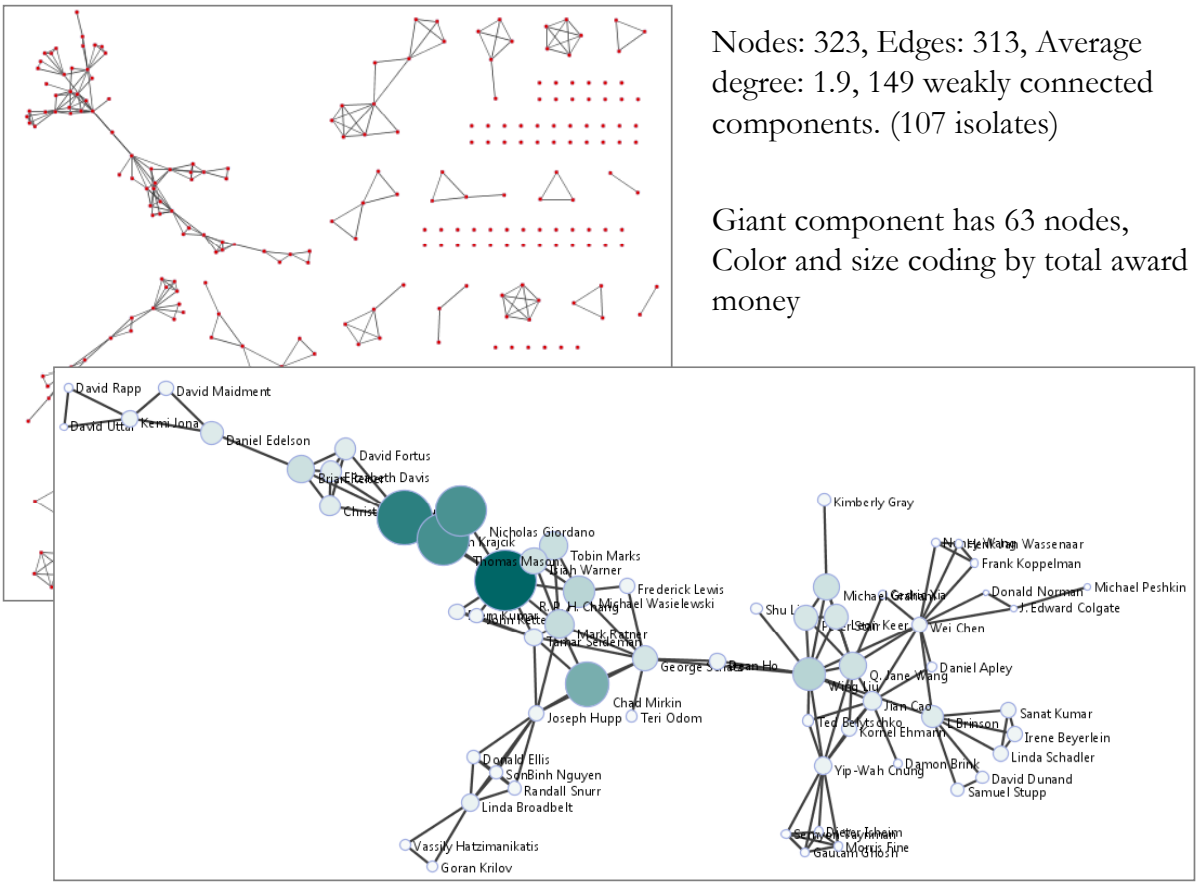


Stanford University

Dan Boneh:	11,837,800
Rajeev Motwani:	11,232,154
Hector Garcia-Molina:	10,577,906
David Goldhaber-Gordon:	9,792,029
Kathryn Moler:	7,870,029
John C. Mitchell:	7,290,668
Alfred Spormann:	6,803,000
Gordon Brown:	6,158,000
Jennifer Widom:	5,661,311



Search for all active NSF awards by Northwestern University on 9/2/2009 via http://www.nsf.gov/awardsearch



Nodes: 323, Edges: 313, Average degree: 1.9, 149 weakly connected components. (107 isolates)

Giant component has 63 nodes, Color and size coding by total award money

3. Exemplary Analyses and Visualizations

Individual Level

A. Loading ISI files of major network science researchers, extracting, analyzing and visualizing paper-citation networks and co-author networks.

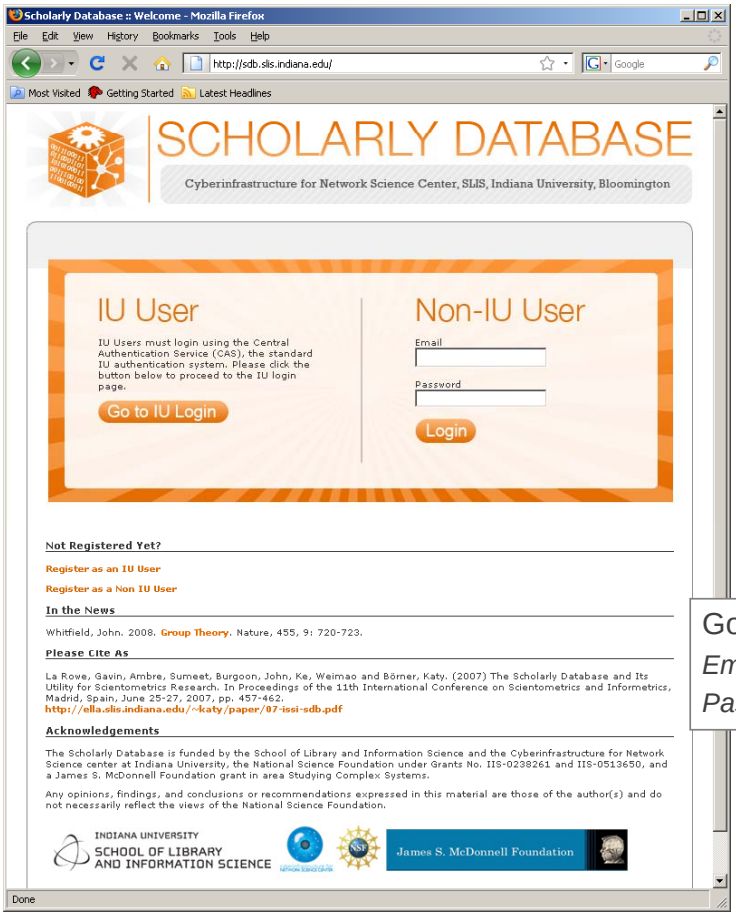
B. Loading NSF datasets with currently active NSF funding for 3 researchers at Indiana U

Institution Level

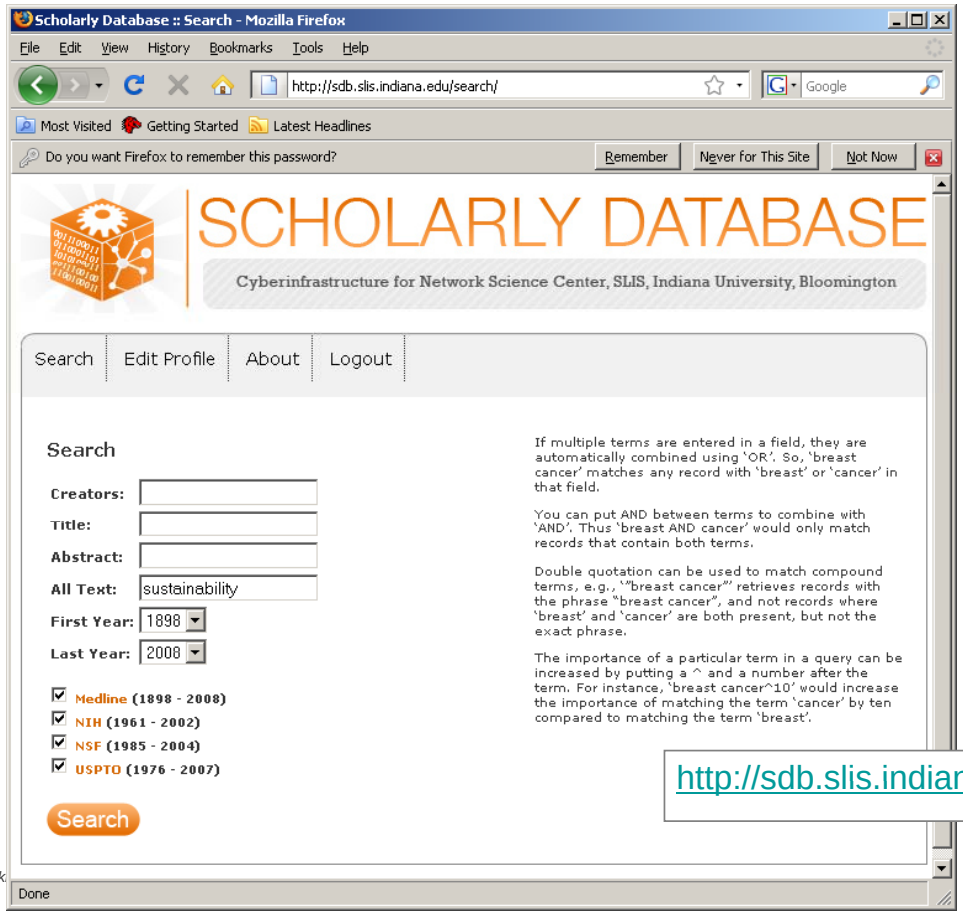
C. Indiana U, Cornell U, and Michigan U, extracting, and comparing Co-PI networks.

Scientific Field Level

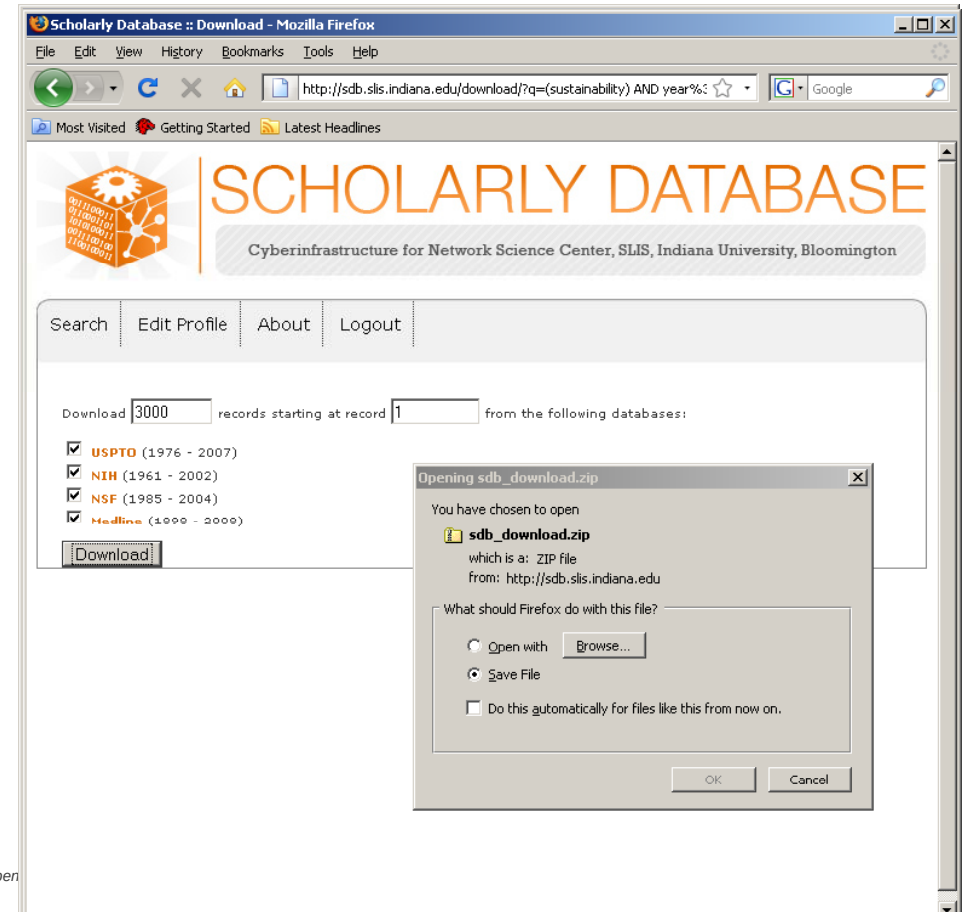
D. Extracting co-author networks, patent-citation networks, and detecting bursts in SDB data.



Goto: http://sdb.slis.indiana.edu
Email: nwb@indiana.edu
Password: nwb



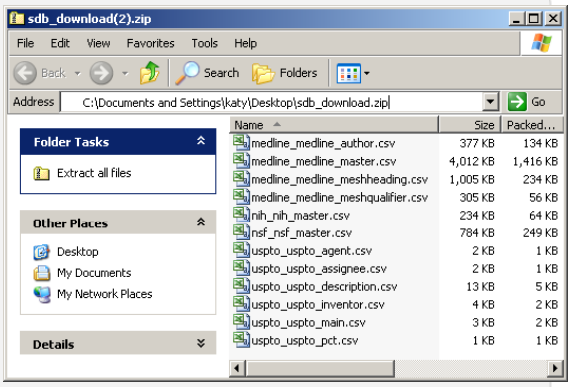
http://sdb.slis.indiana.edu

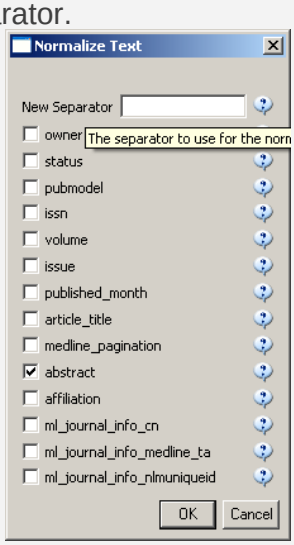


Open and Preprocess SDB zip file

Load medline_medline_master.csv to NWB.

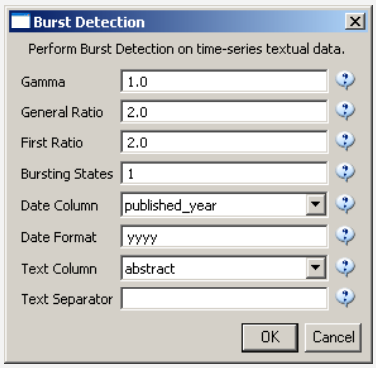
Run *'Preprocessing > Normalize Text'* with a space as New Separator.





Burst Analysis

Run ‘Analysis > Textual > Burst Detection’ with parameters:
and space as a separator.

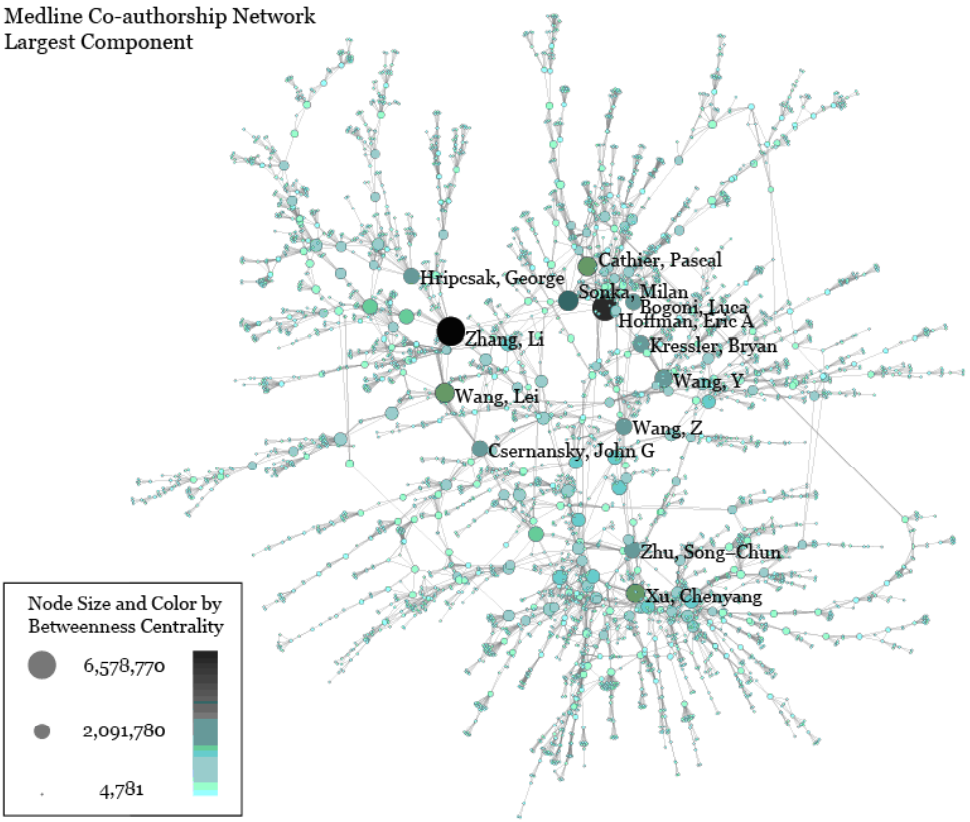


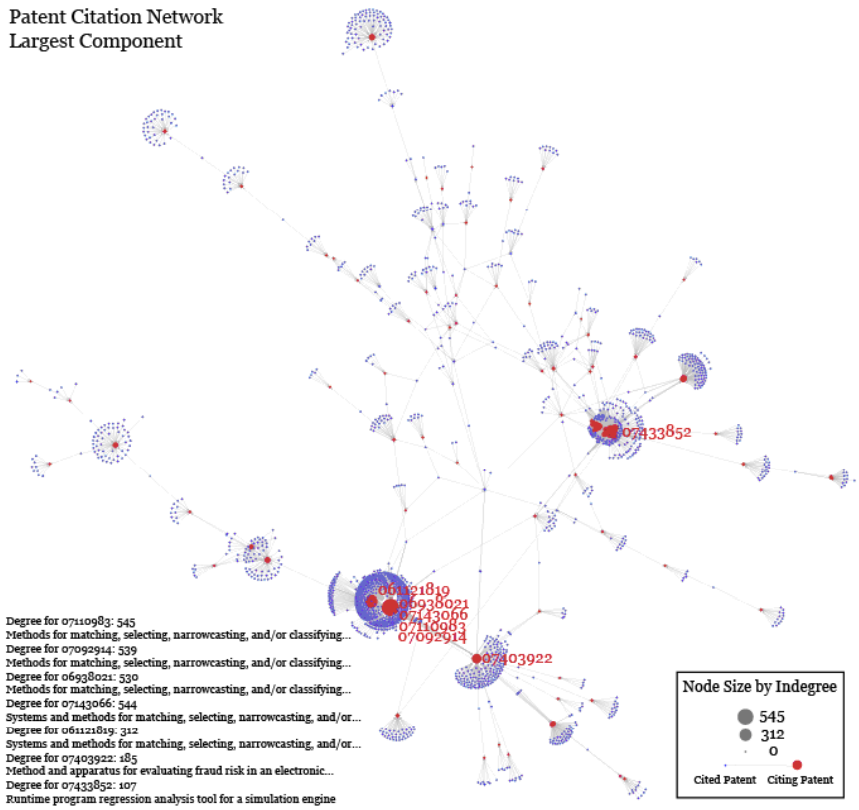
Sort result by burst weight

||

V

Word	Length	Weight	Strength	Start	End
care	1	Infinity	Infinity	1988	1988
water	1	29.8883	29.8883	2002	2002
countri	10	27.03612	27.03612	1990	1999
protect	1	26.88557	26.88557	2002	2002
farm	1	23.32114	23.32114	2005	2005
villag	2	23.273	40.65081	2008	
crop	2	22.33649	30.42535	2008	
educ	2	22.14556	26.98588	1995	1996
blood	5	22.12166	22.12166	1996	2000





Top-10 burst terms from abstracts of the AI search results.

Medline				
Word	**Length**	**Weight**	**Start**	**End**
medical	17	299.7924	1983	1999
knowledge	5	293.9375	1991	1995
knowledge	6	215.2407	1997	2002
expert	13	171.0443	1985	1997
systems	15	170.3306	1985	1999
intelligence	21	123.9794	1981	2001
patient	21	123.9297	1982	2002
care	12	106.5522	1990	2001
registration	5	104.8139	2005	
knowledge-based	16	98.83778	1987	2002

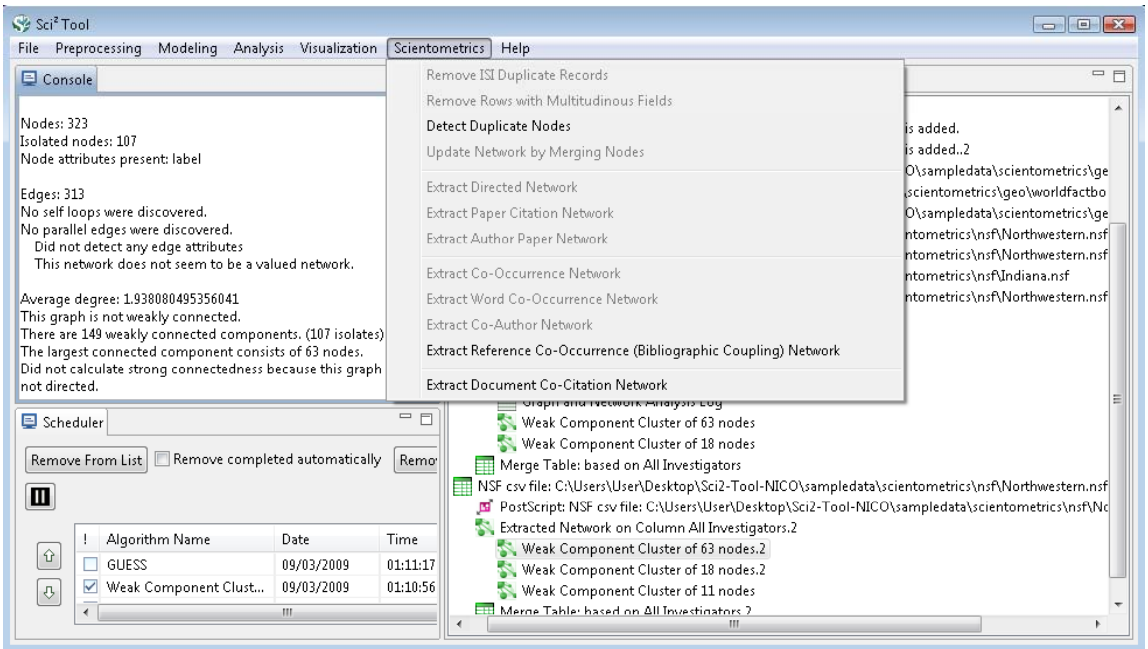
NIH				
Word	**Length**	**Weight**	**Start**	**End**
Phase	8	117.2205	1993	2000
commercial	9	87.57158	1995	
proposed	9	87.57158	1995	
mass	3	83.36952	1978	1980
protein	1	72.15788	1988	1988
networks	4	71.252	1993	1996
patterns	3	66.44826	1977	1979
being	8	66.29254	1971	1978
reasoning	2	65.68178	1984	1985
expert	4	60.49935	1987	1990

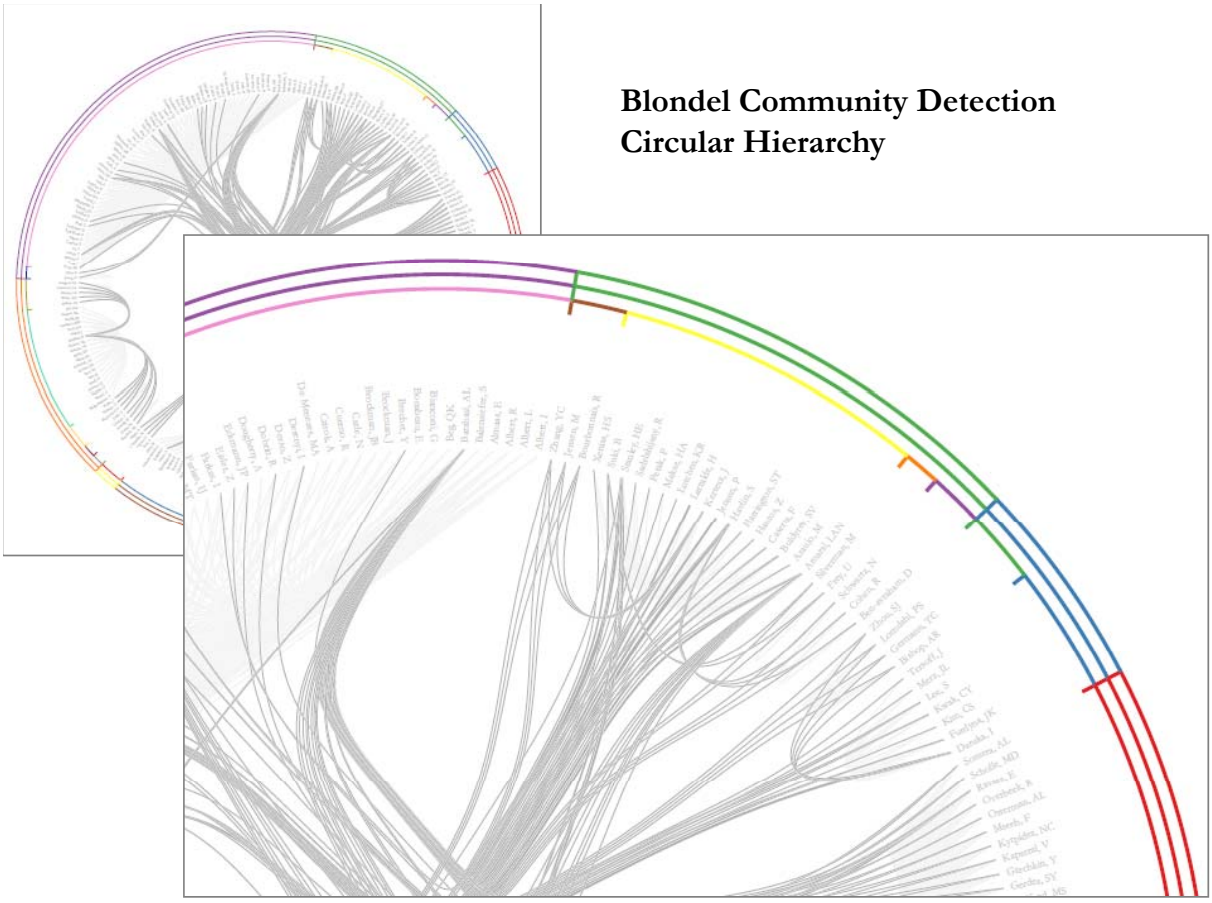
NSF				
Word	**Length**	**Weight**	**Start**	**End**
their	6	47.05097	1999	
gray	2	28.19808	2000	2001
learning	2	27.40728	1997	1998
human	5	25.4525	2000	
control	2	24.07877	1992	1993
knowledge	1	21.48756	1998	1998
students	1	21.07674	1997	1997
problems	2	20.77133	1998	1999
more	2	19.96109	2000	2001
use	1	19.38503	2001	2001

USPTO				
Word	**Length**	**Weight**	**Start**	**End**
human	3	19.03937321	2004	2006
video	3	15.32736425	1998	2000
disclosed	2	14.06694671	1999	2000
neural	3	13.30105906	2004	2006
"correct"	2	12.4336047	1999	2000
unit	2	12.35745838	2002	2003
material	1	12.08487035	2000	2000
feedback	1	12.07730195	2000	2000
rule	1	12.07730195	2000	2000
elevator	4	11.83351857	1991	1994

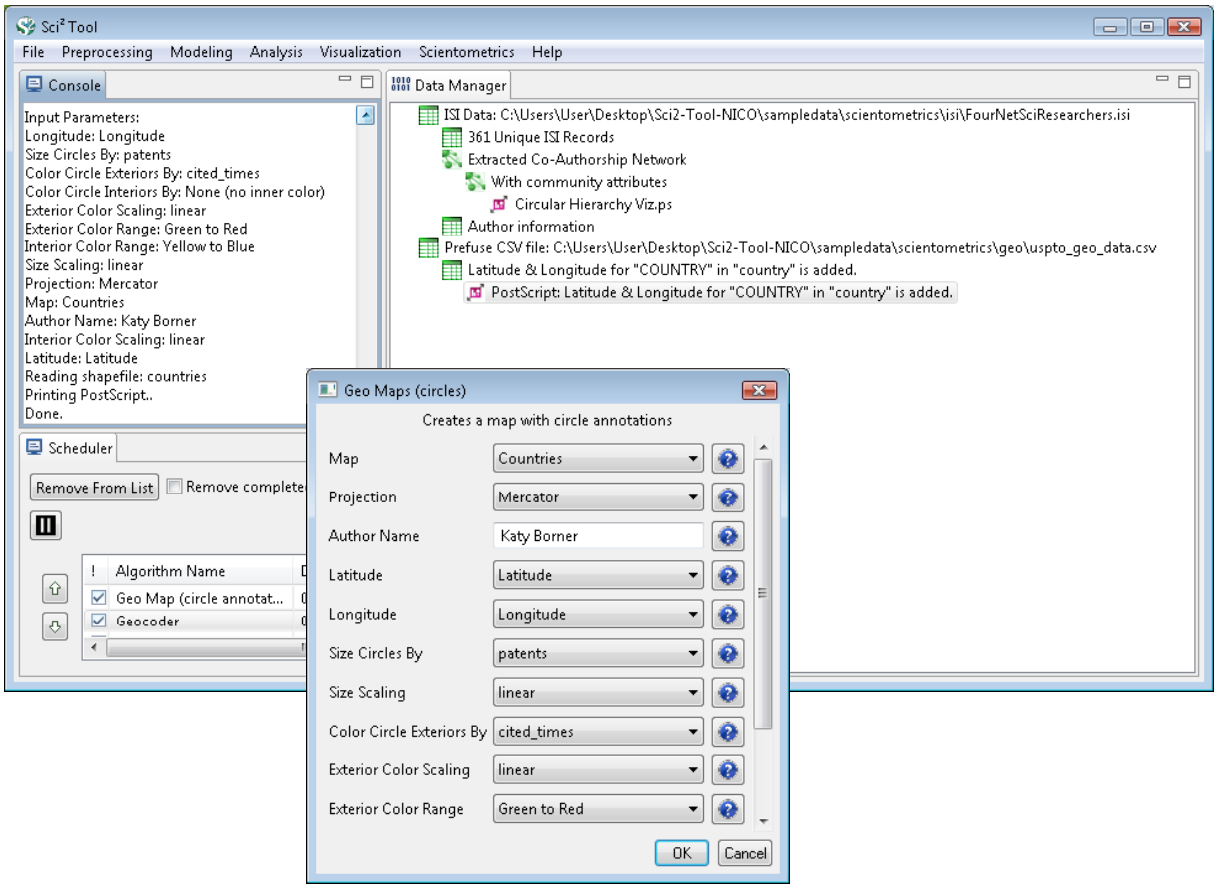
Bonus: Sci² Tool

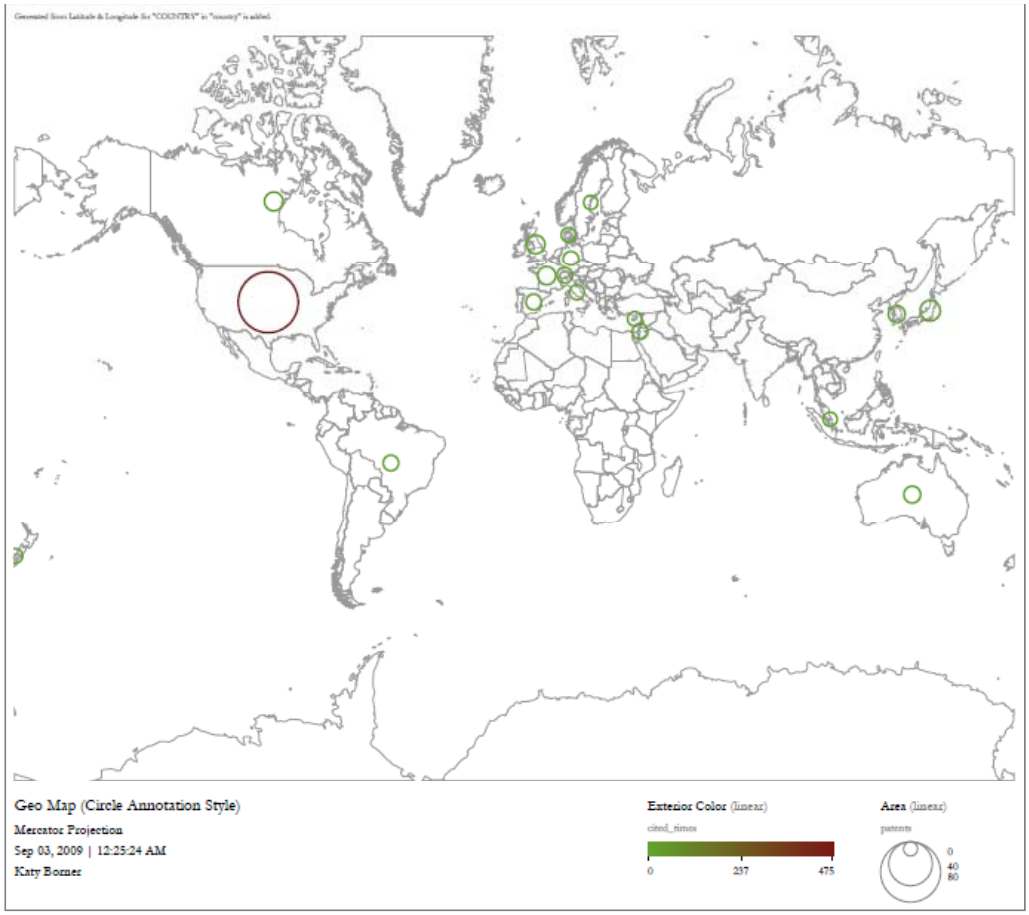
Sci² Tool

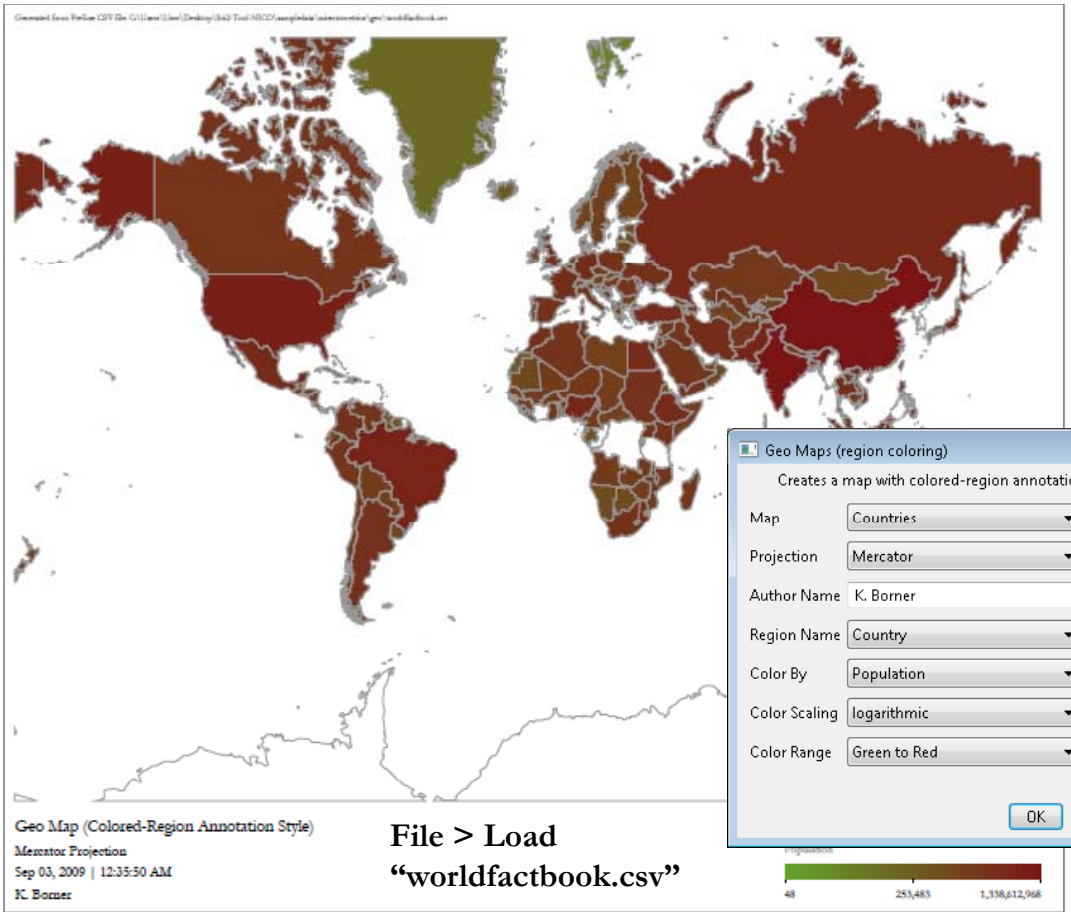




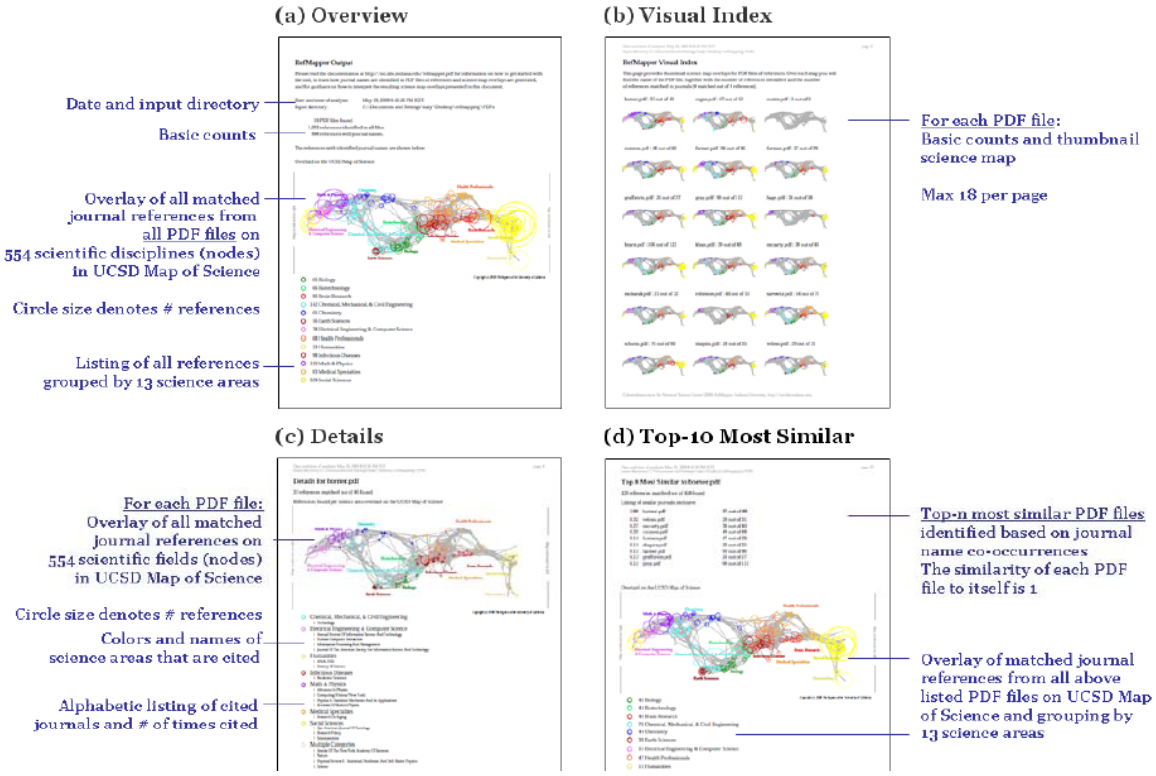
Blondel Community Detection
Circular Hierarchy







File > Load "worldfactbook.csv"



RefMapper Output

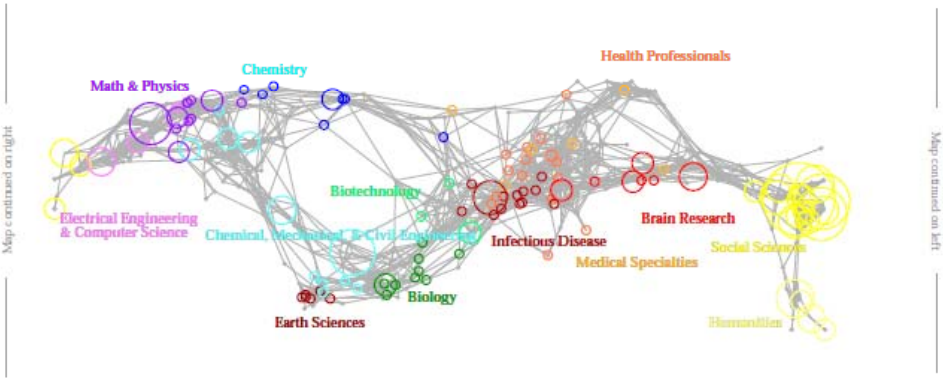
Please read the documentation at http://sci.slis.indiana.edu/refmapper.pdf for information on how to get started with the tool, to learn how journal names are identified in PDF files of references and science map overlays are generated, and for guidance on how to interpret the resulting science map overlays presented in this document.

Date and time of analysis: June 5, 2009 10:16:47 AM EDT
Input directory: C:\Users\User\Desktop\RefMapper\Data\Scisip-2008\Implementing_science_policy

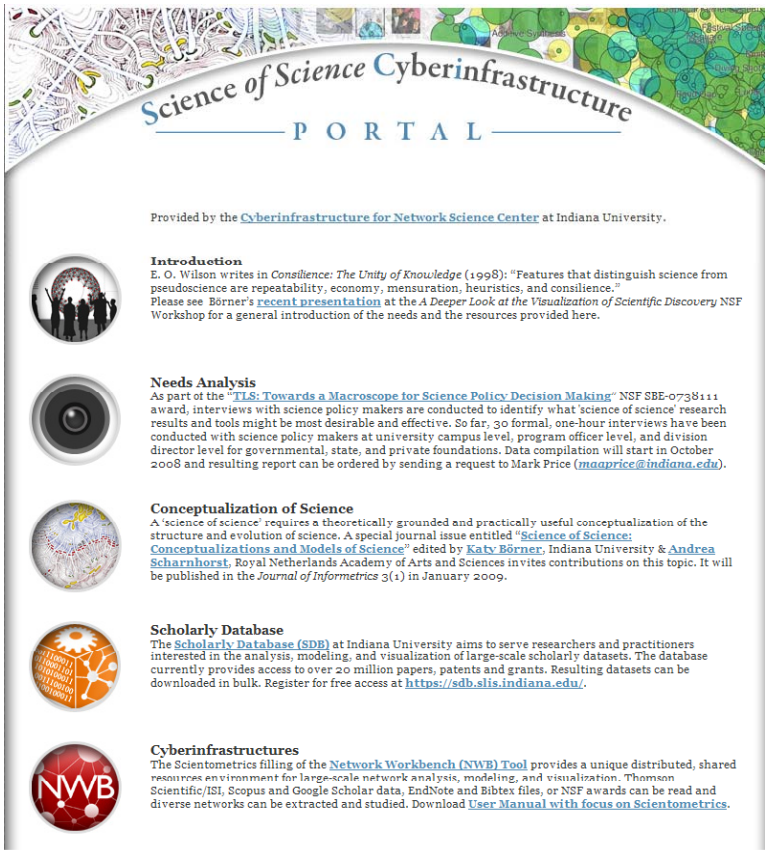
6 PDF files found.
112 references identified in all files.
107 references with journal names.

The references with identified journal names are shown below:

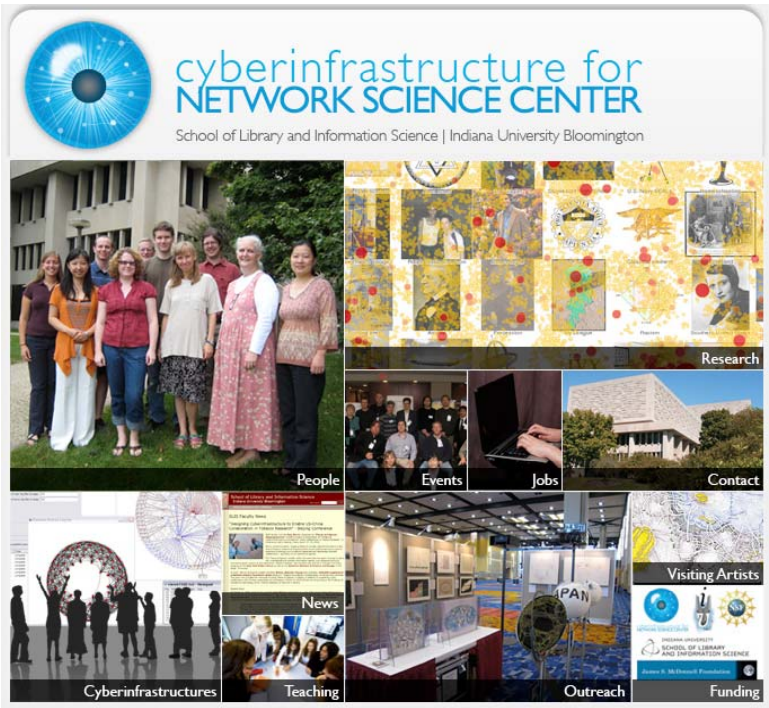
Overlaid on the UCSD Map of Science



9 Biology
9 Biotechnology
13 Brain Research



http://sci.slis.indiana.edu



All papers, maps, cyberinfrastructures, talks, press are linked from http://cns.slis.indiana.edu