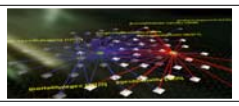
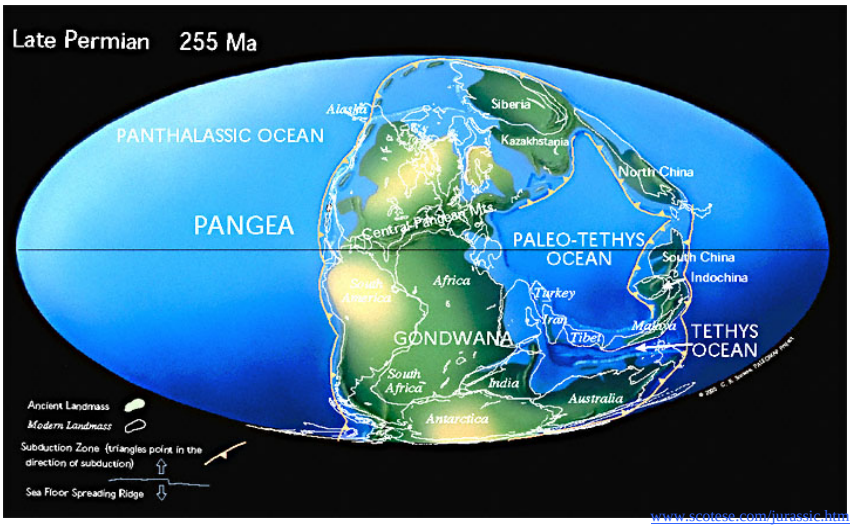
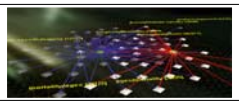
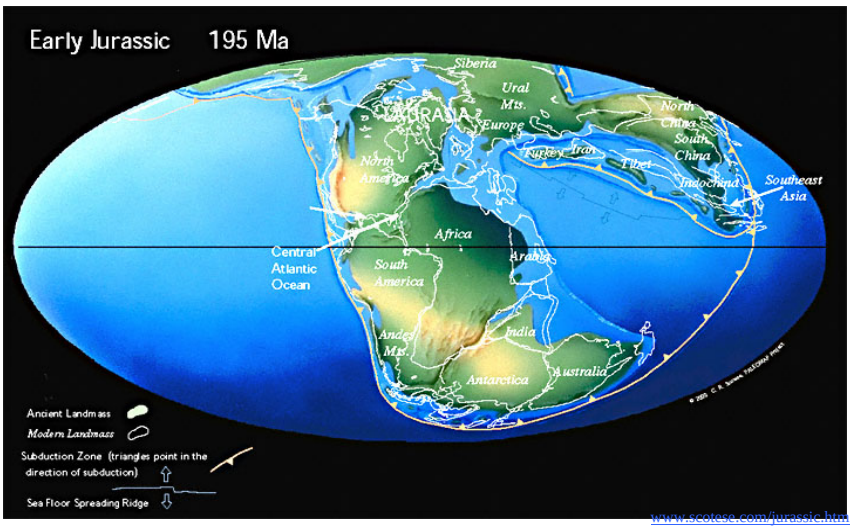




Katy Börner, Knowledge Domain Visualizations in Support of Scholarly Knowledge and Expertise Management, SRI International, Oct 21, 2004.





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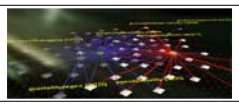

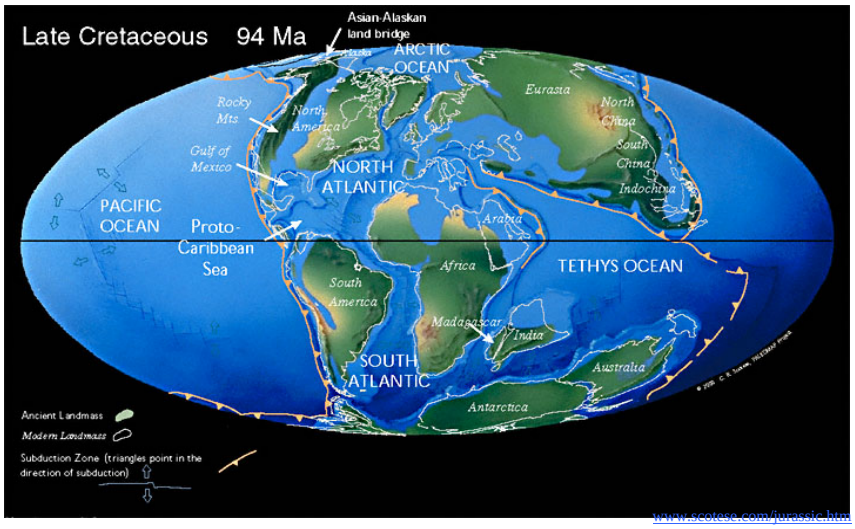

www.scotese.com/jurassic.htm

Session 4: Guidelines to Determine Specific Fields of S&E in SRS's Surveys

Knowledge Domain Visualizations in Support of Scholarly Knowledge and Expertise Management

Katy Börner
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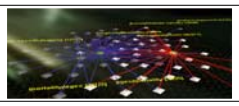
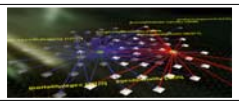
INDIANA UNIVERSITY
BLOOMINGTON
katy@indiana.edu

Panel Meeting on SRS's Evaluation of its Science and Engineering Taxonomies, NSF sponsored Workshop, SRI International, Arlington, VA, Oct 21st, 2004.



Overview

1. Motivation
2. Knowledge Domain Analysis and Visualization
3. Cyberinfrastructure for InfoVis/KDVis Research
4. Conclusions



1. Motivation

Facing the Information Flood:

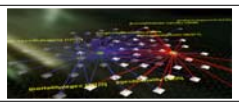
- Information available in electronic form doubles every 18 months.
- Human perception stays constant.
- Major means of accessing humanity's knowledge and expertise are search interfaces.

Opportunities & Challenges:

Apply advanced data mining and visualization techniques to study the structure and evolution of S&E development. Present results as visual maps to shift user's mental load from slow reading to faster perceptual processes such as visual pattern recognition.

Facilitated by:

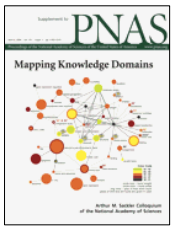
- CPU speed & hard disk sizes have increased by two orders of magnitude.
- Bandwidth: Since the invention of the web browser, international IP bandwidth deployments have more than doubled each year.
- Monitor resolution has increased by a factor of 4 (800x600 -> 1600x1200).



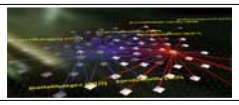
2. Analysis and Visualization of Knowledge Domains

Based on publication, patent, grant, etc. data to help answer questions such as:

- What are the major research areas, experts, institutions, regions, nations, grants, publications, journals in xx research?
- Which areas are most insular?
- What are the main connections for each area?
- What is the relative speed of areas?
- Which areas are the most dynamic/static?
- What new research areas are evolving?
- Impact of xx research on other fields?
- How does funding influence the number and quality of publications?

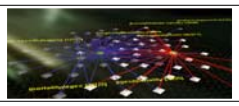


Answers are needed by funding agencies, companies, and researchers.



User Groups

- **Students** can gain an overview of a particular knowledge domain, identify major research areas, experts, institutions, grants, publications, patents, citations, and journals as well as their interconnections, or see the influence of certain theories.
- **Researchers** can monitor and access research results, relevant funding opportunities, potential collaborators inside and outside the fields of inquiry, the dynamics (speed of growth, diversification) of scientific fields, and complementary capabilities.
- **Grant agencies/R&D managers** could use the maps to select reviewers or expert panels, to augment peer-review, to monitor (long-term) money flow and research developments, evaluate funding strategies for different programs, decisions on project durations, and funding patterns, but also to identify the impact of strategic and applied research funding programs.
- **Industry** can use the maps to access scientific results and knowledge carriers, to detect research frontiers, etc. Information on needed technologies could be incorporated into the maps, facilitating industry pulls for specific directions of research.
- **Data providers** benefit as the maps provide unique visual interfaces to digital libraries.
- Last but not least, the availability of dynamically evolving maps of science (as ubiquitous as daily weather forecast maps) would dramatically improve the communication of scientific results to the **general public**.



Process of Mapping Knowledge Domains

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, **Topics**
- Pathfinder networks (PFNet)
- Self-organizing maps (SOM) includes SOM, ET-maps, etc.

CLUSTER ANALYSIS

SCALAR
- Triangulation
- Force-directed placement (FDP)

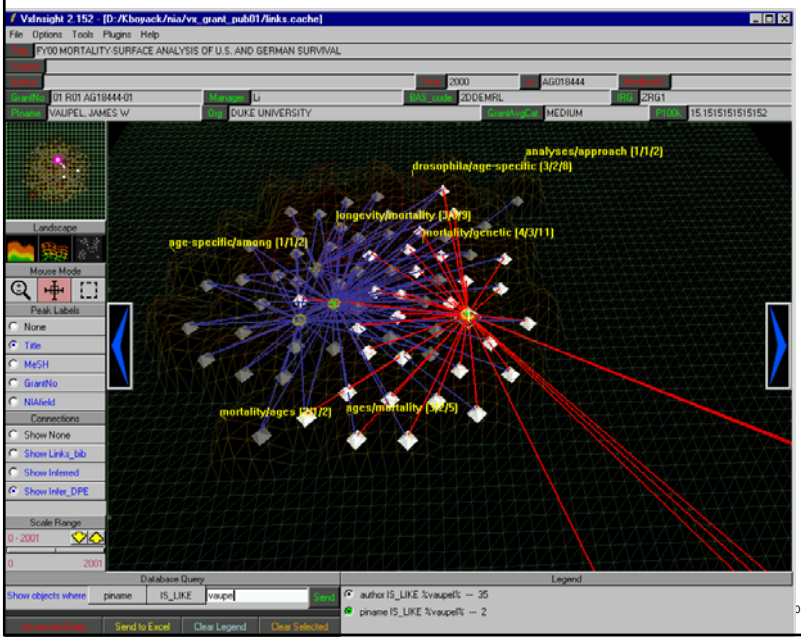
INTERACTION
- Browse
- Pan
- Zoom
- Filter
- Query
- Detail on demand

ANALYSIS

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.

Indicator-Assisted Evaluation and Funding of Research

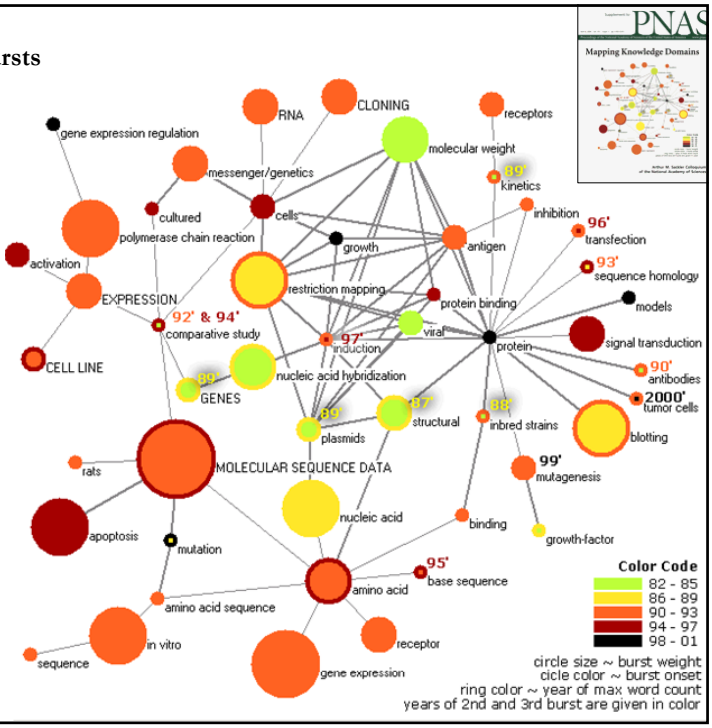
Visualizing the influence of grants on the number and citation counts of research papers (Boyack & Börner, 2003)

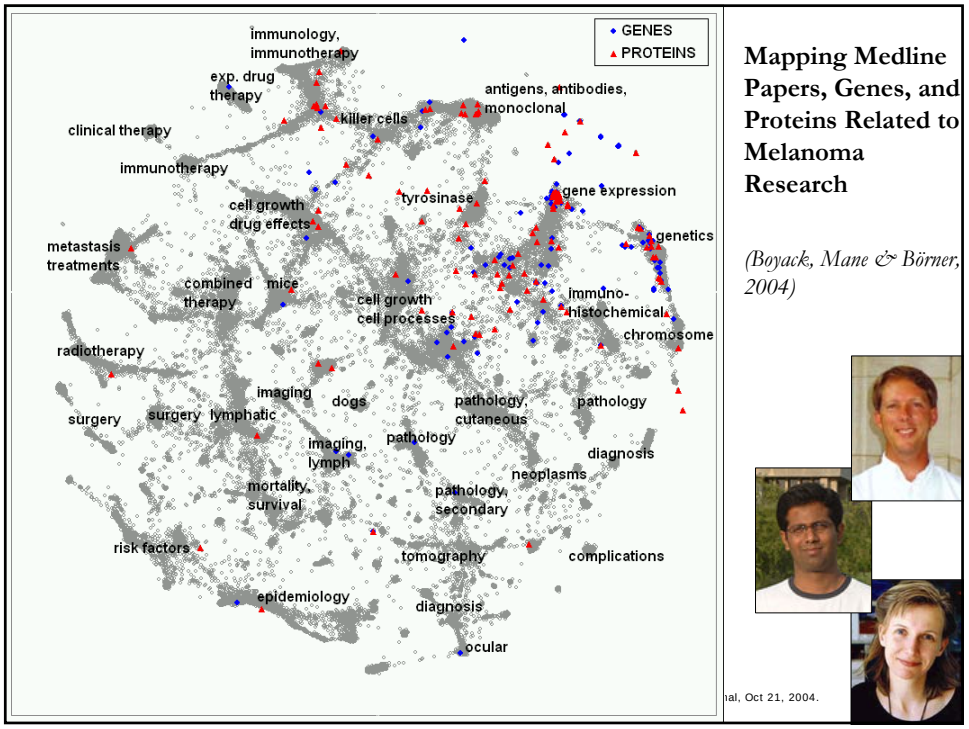


Mapping Topic Bursts

(Mane & Börner, 2004)

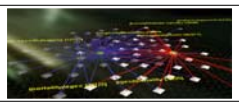
Co-word space of the top 50 highly frequent and bursty words used in the top 10% most highly cited PNAS publications in 1982-2001.





Mapping Medline Papers, Genes, and Proteins Related to Melanoma Research

(Boyack, Mane & Börner, 2004)



Co-PI Map of Current IDM Awardees

(Ke & Börner, 2004)


Legend

Node size: # awarded grants

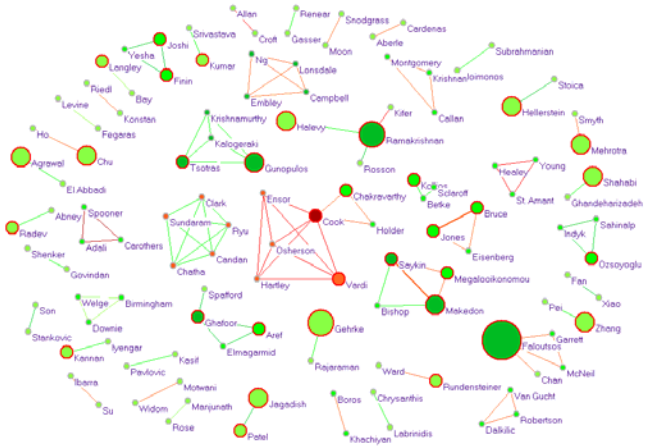
Node Inner Color: # unique Co-PIs (0 white; 1 YellowGreen; 2 Green; 3 PineGreen; 4 Orange; 5 Red; 6 Maroon)

Node Border Color: Grant Source (Career "Yellow"; Pecase "Blue"; ITR "Green"; SGER "Pink"; other "White"; Multi-Grants "Red")

Edge Width: # times people Co-PI'd

Edge Color: First year of Co-PIship (1999 Maroon; 2000 Red; 2001 Orange; 2002 PineGreen; 2003 Green; 2004 YellowGreen)

Career awardees are not showing except they have other IDM grant support as well.



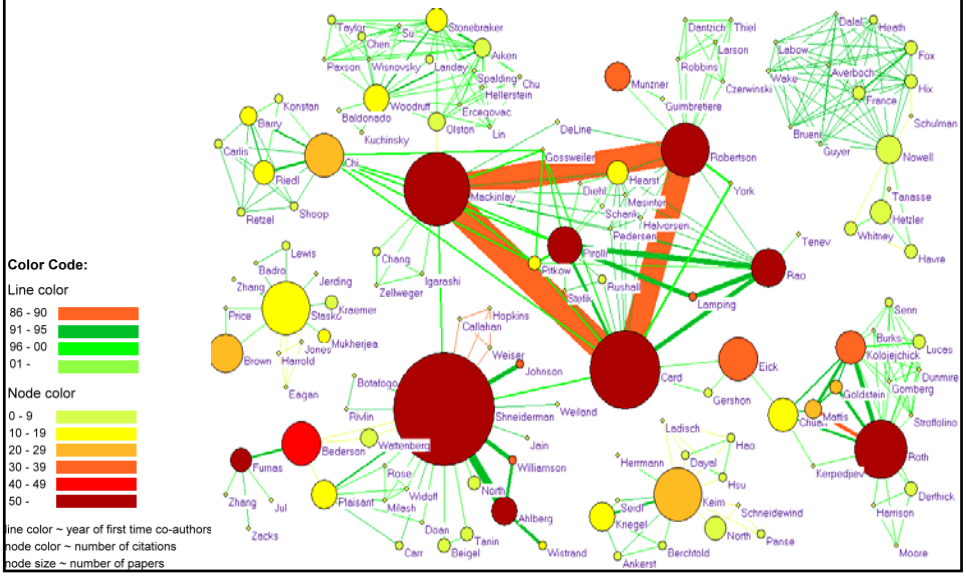
Katy Börner, Knowledge Domain Visualizations in Support of Scholarly Knowledge and Expertise Management, SRI International, Oct 21, 2004.

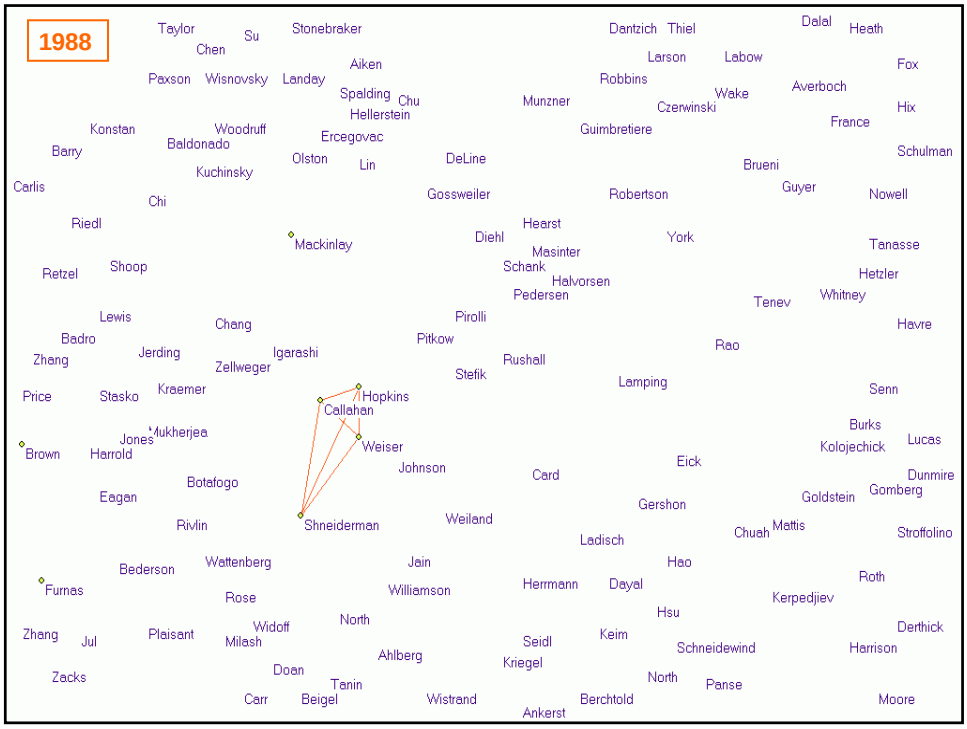
Mapping the Evolution of Co-Authorship Networks

Won 1st price at the IEEE InfoVis Contest

(Ke, Visvanath & Börner, 2004)



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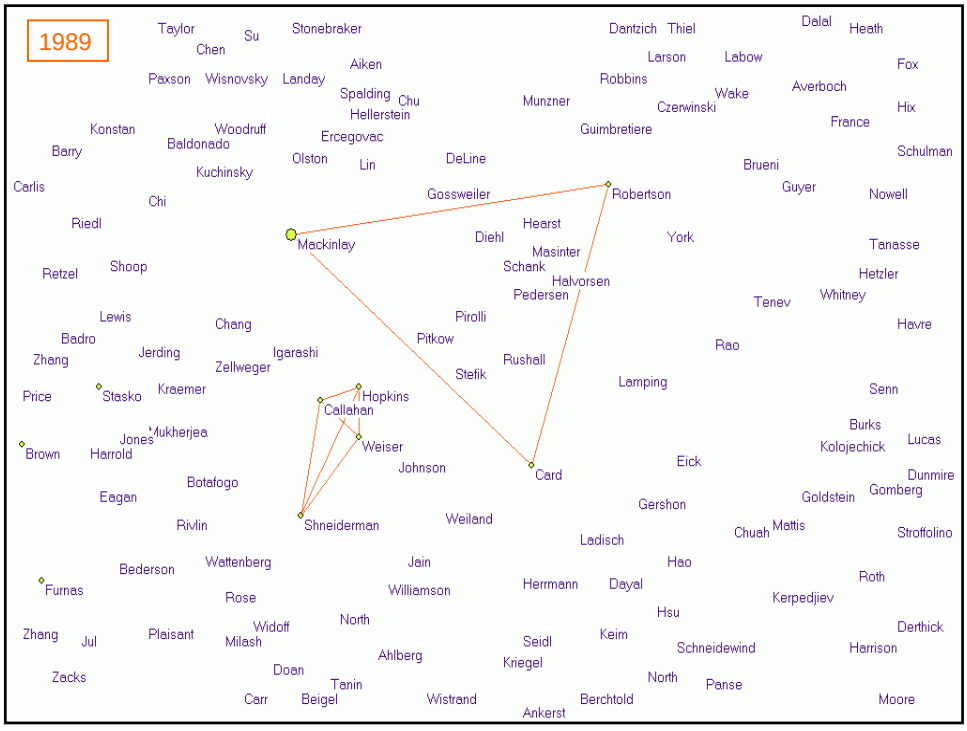
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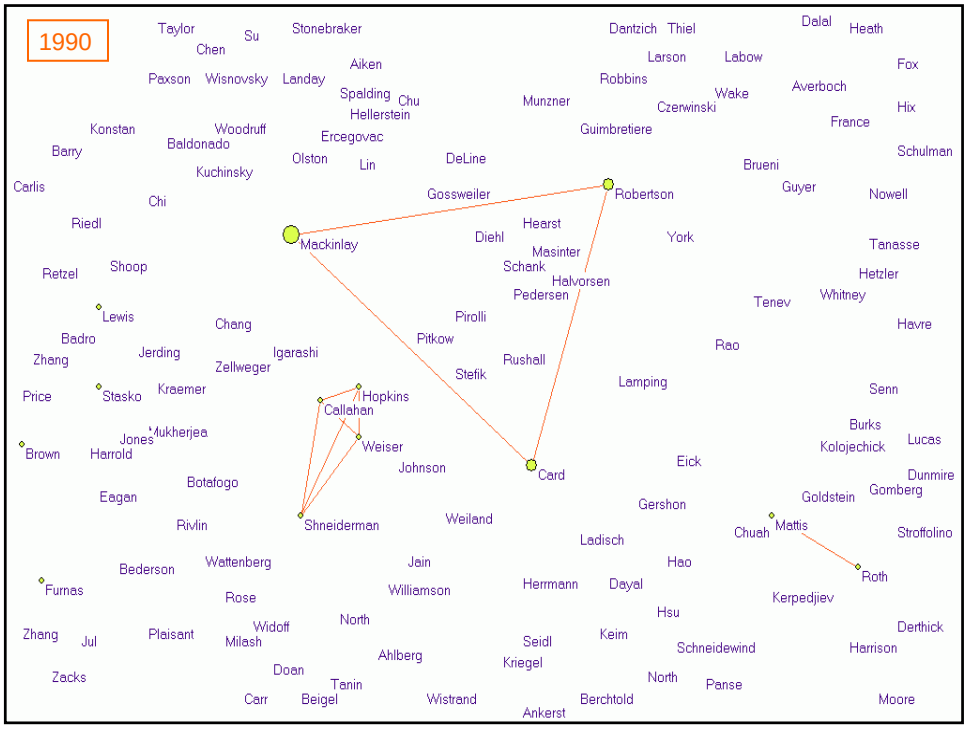
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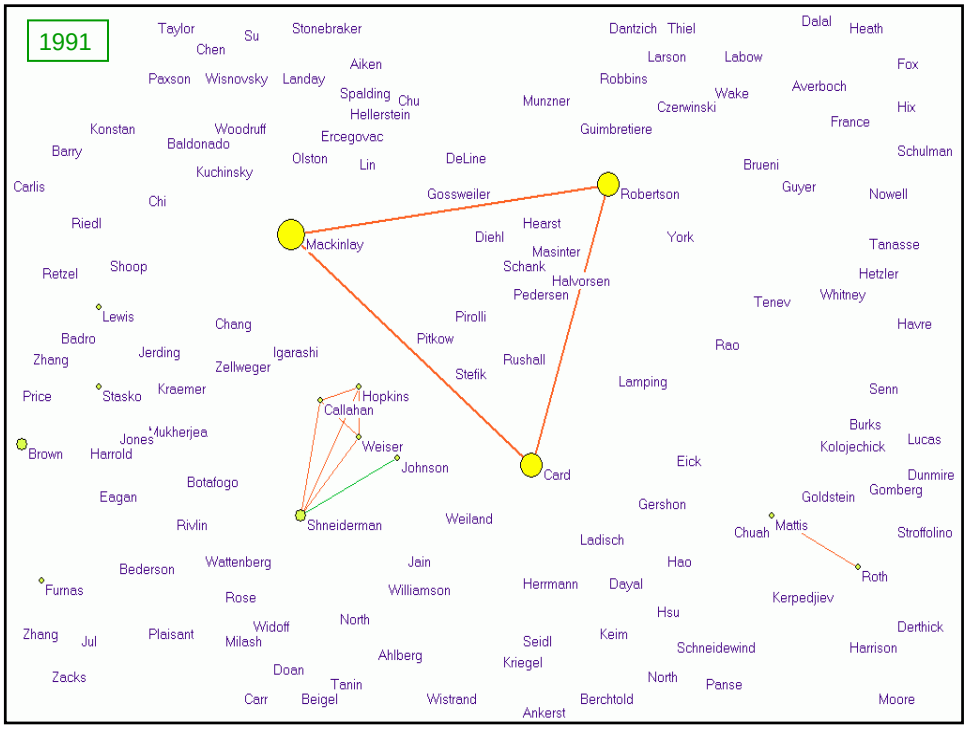
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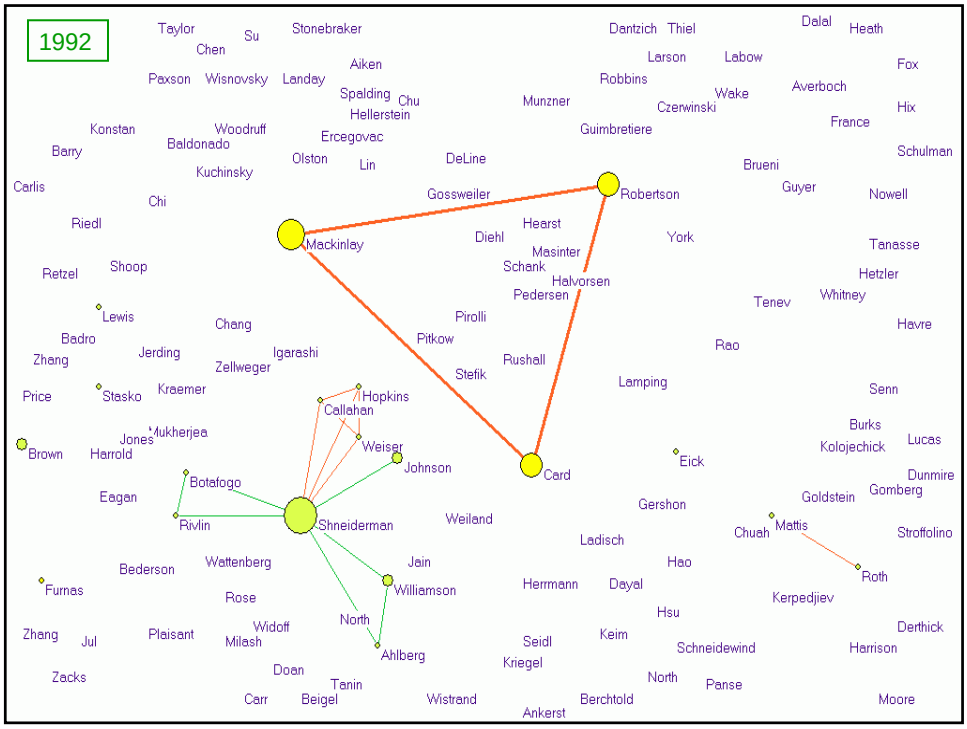
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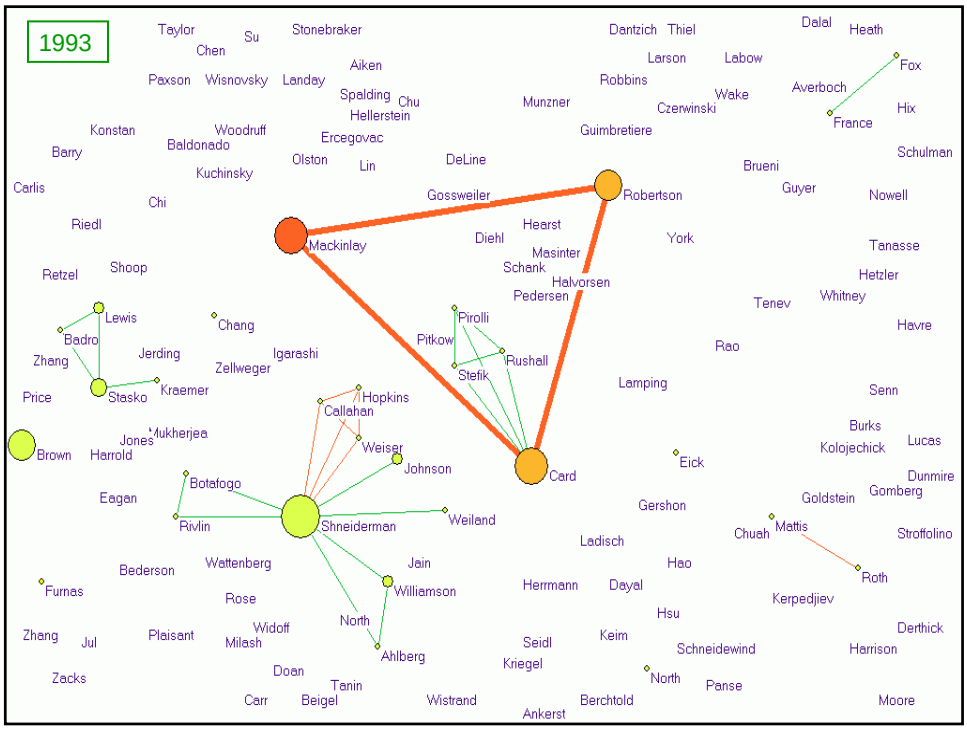
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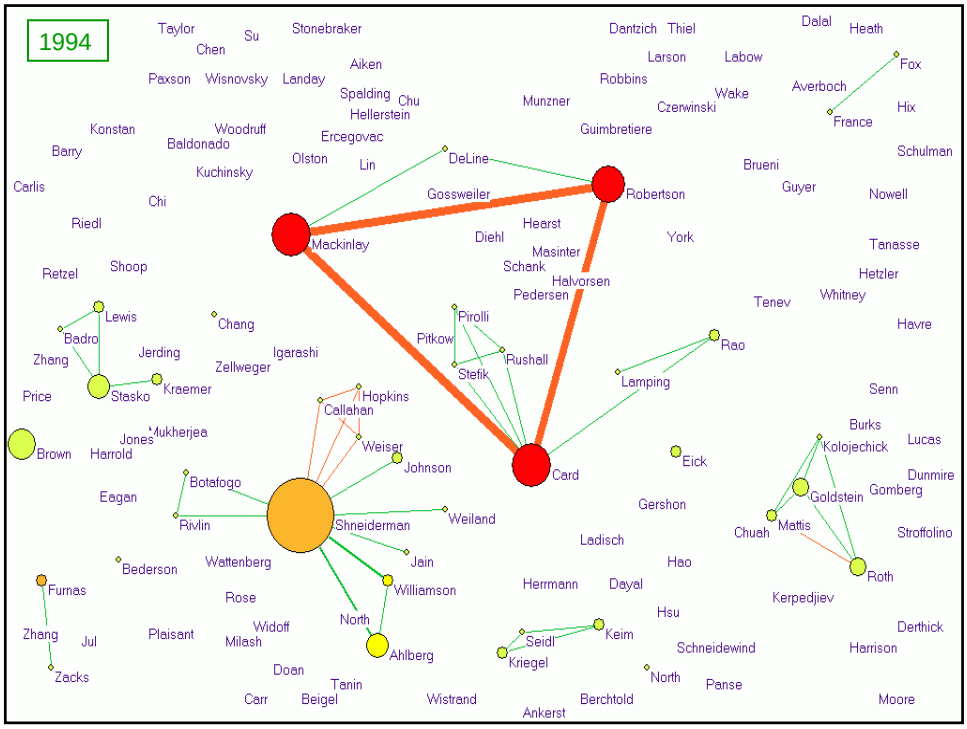
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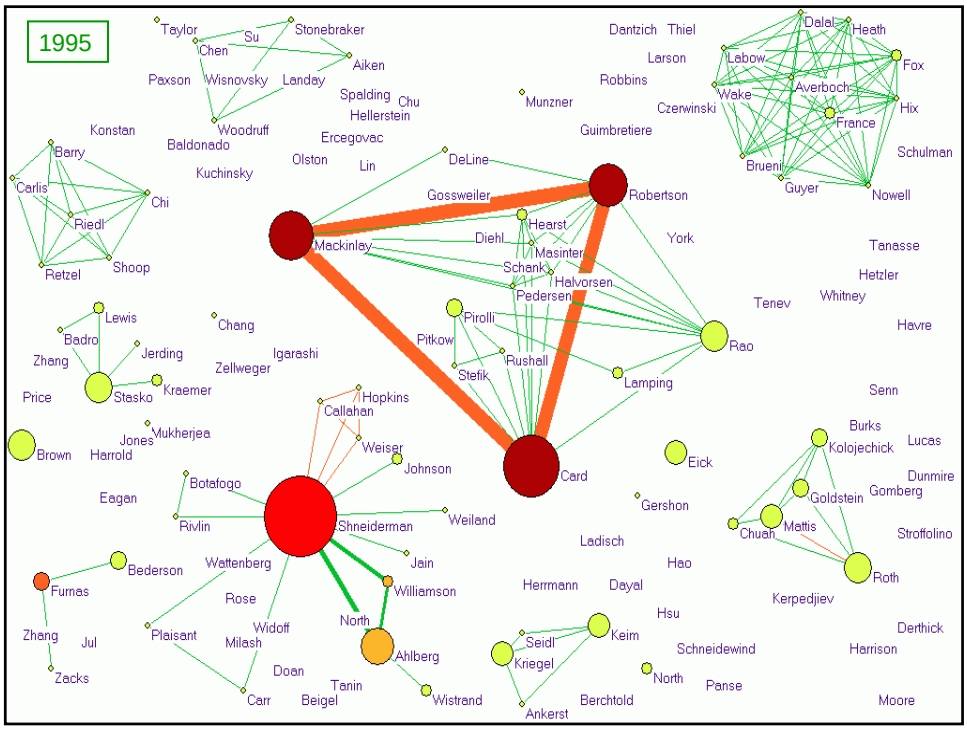
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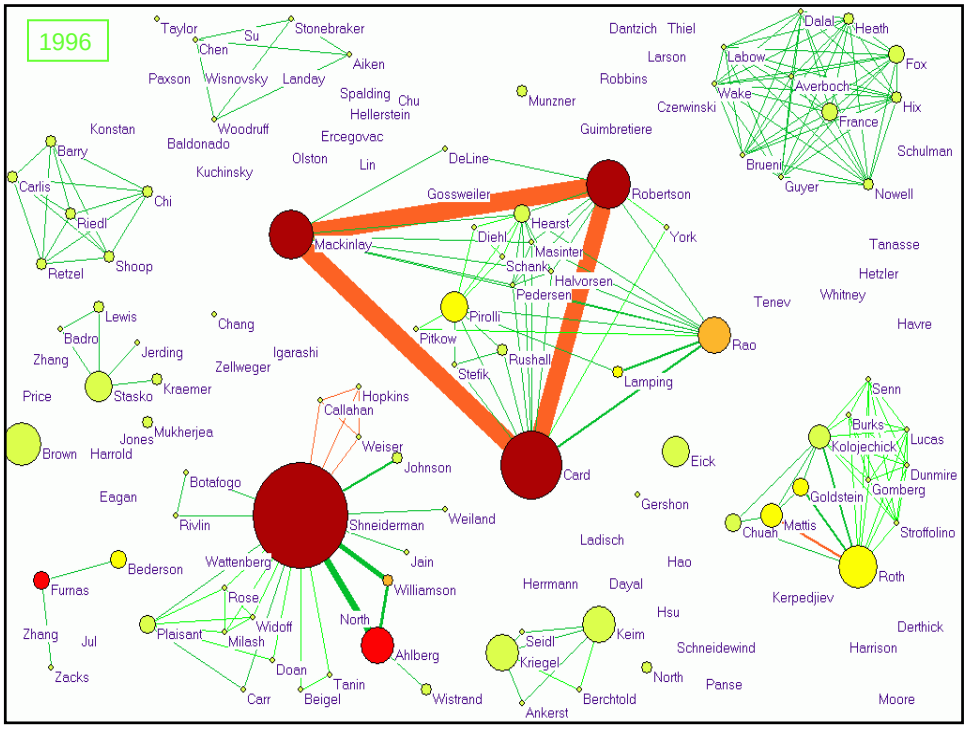
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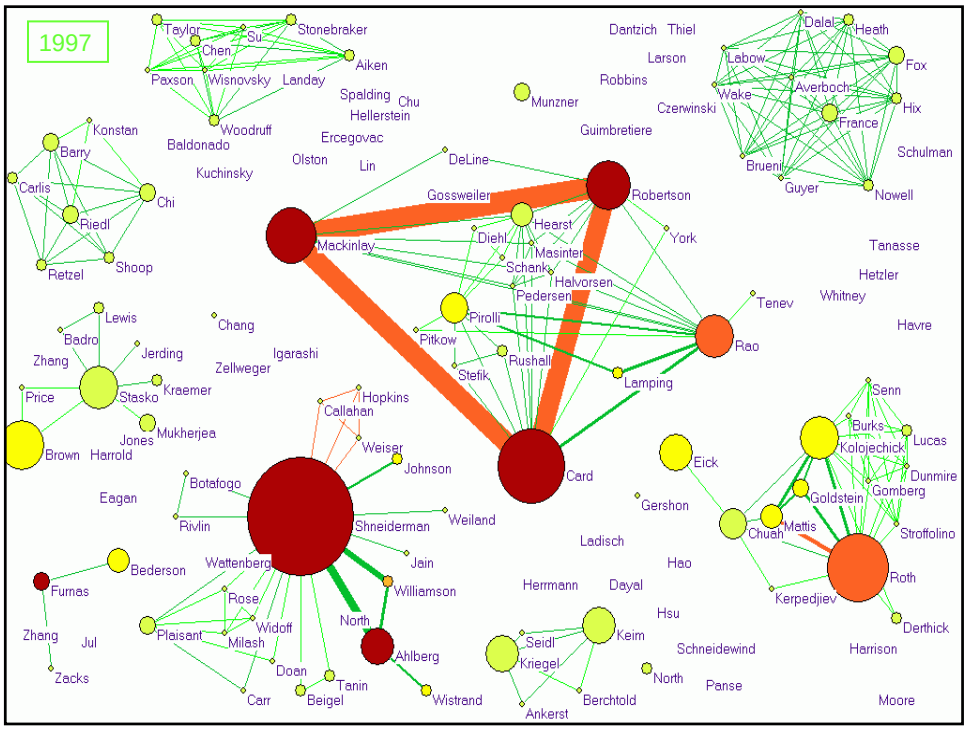
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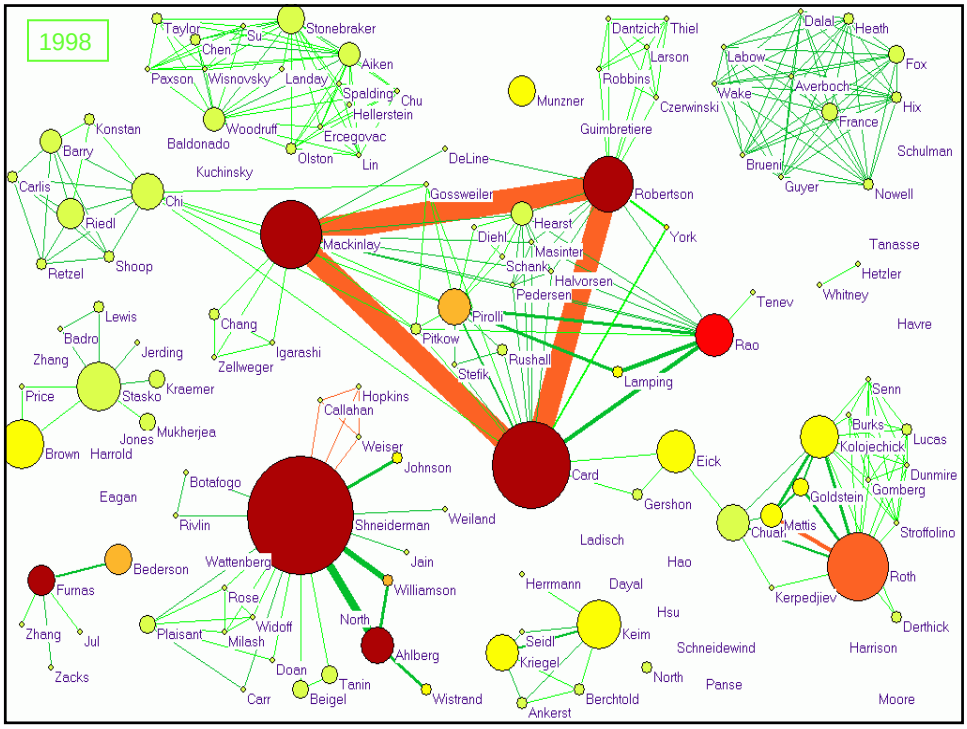
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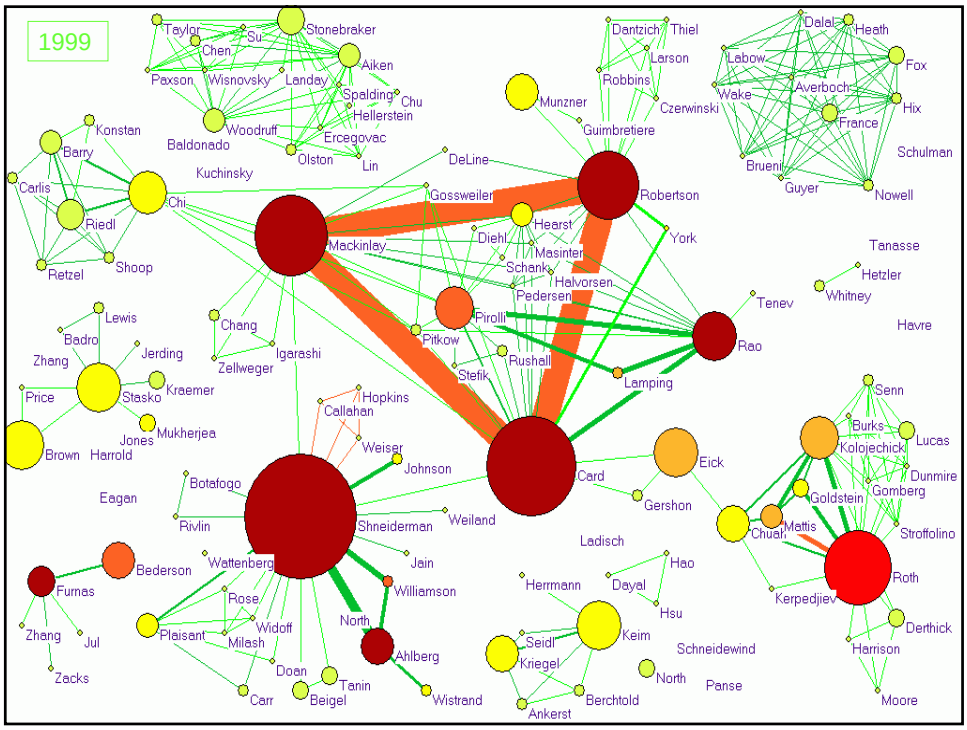
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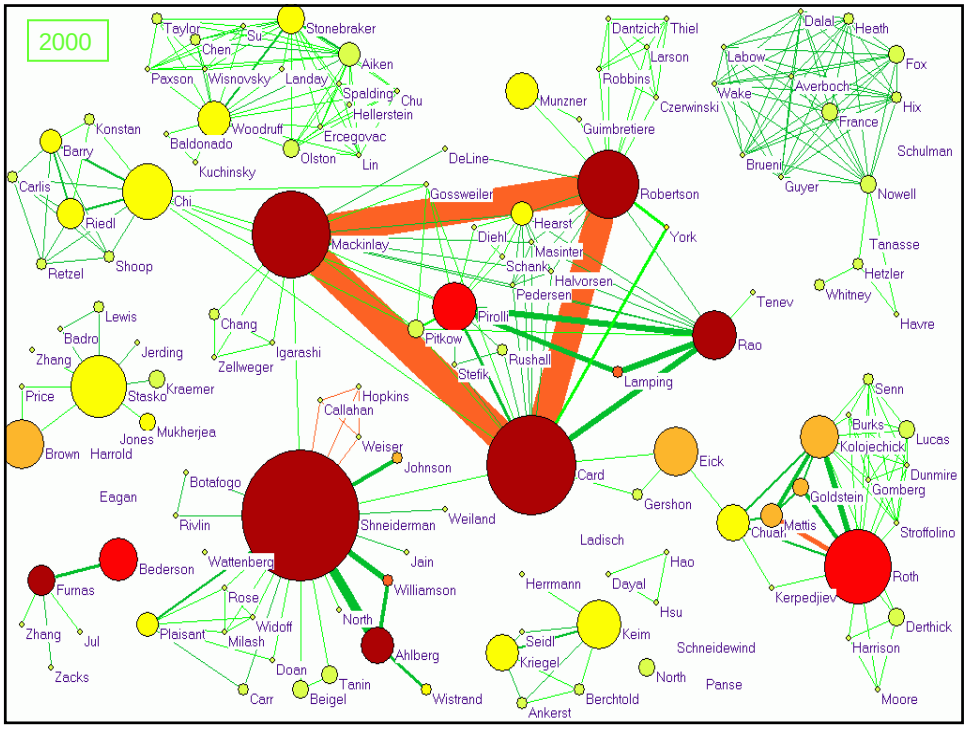
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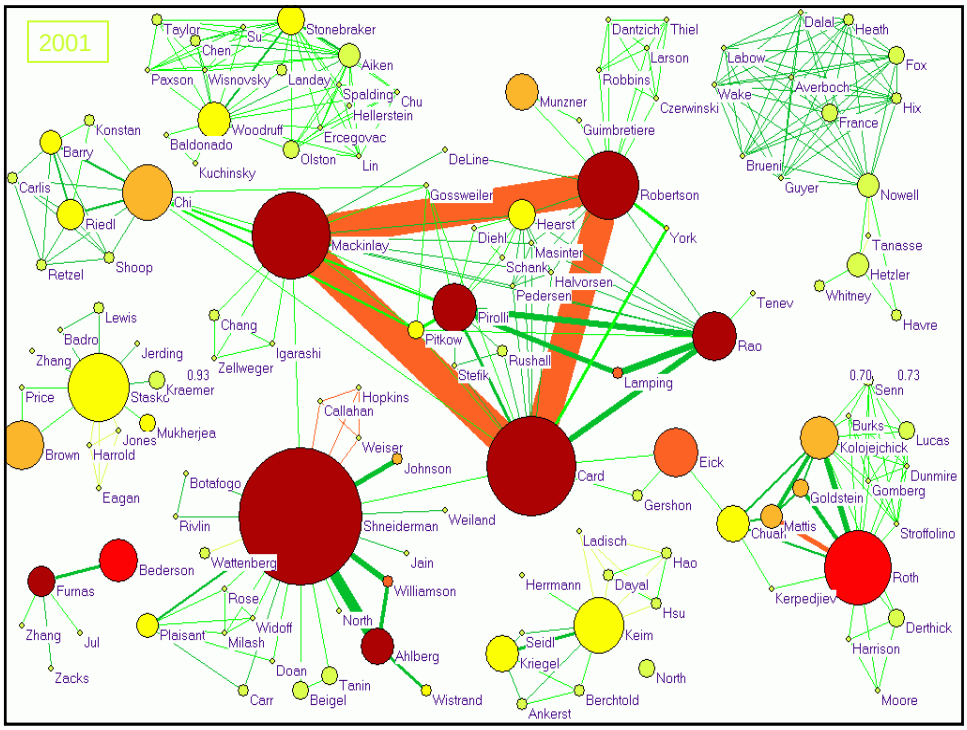
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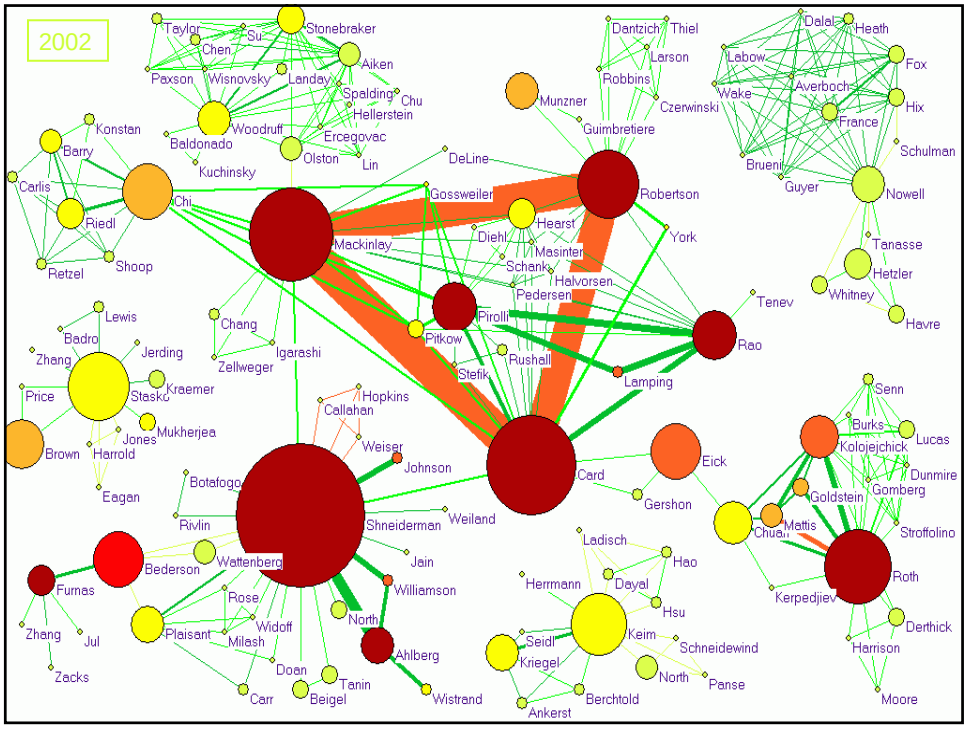
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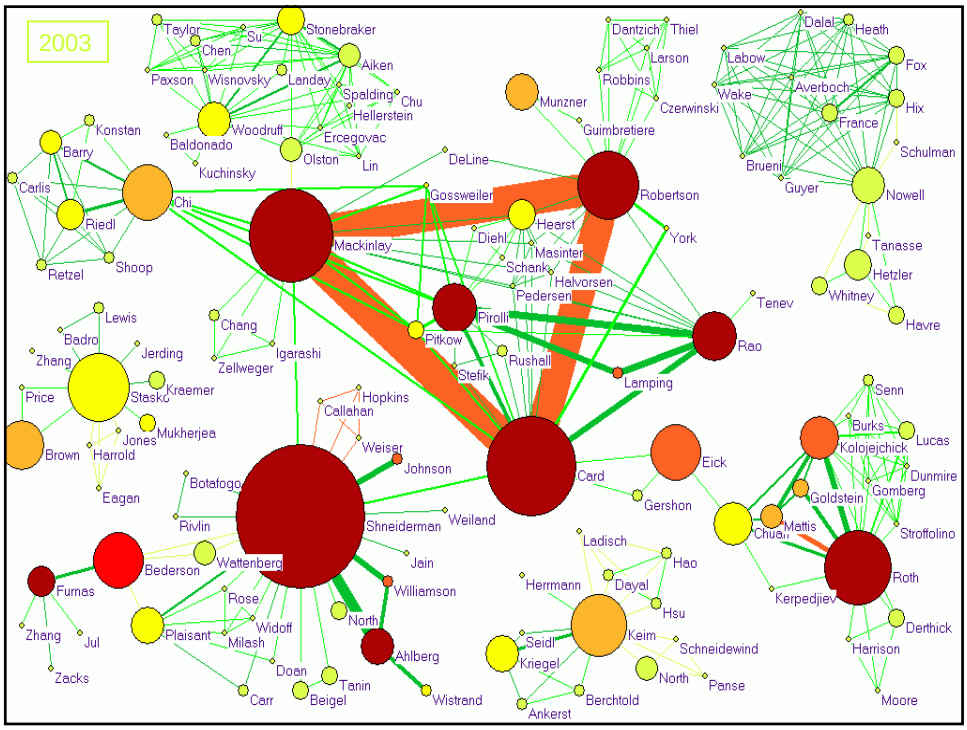
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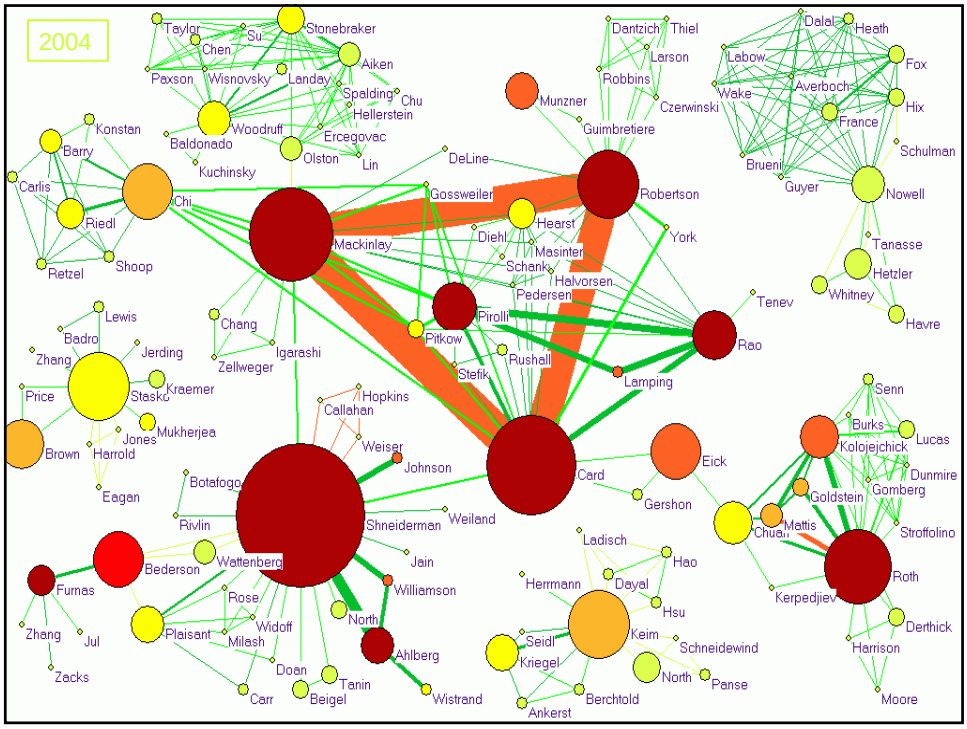
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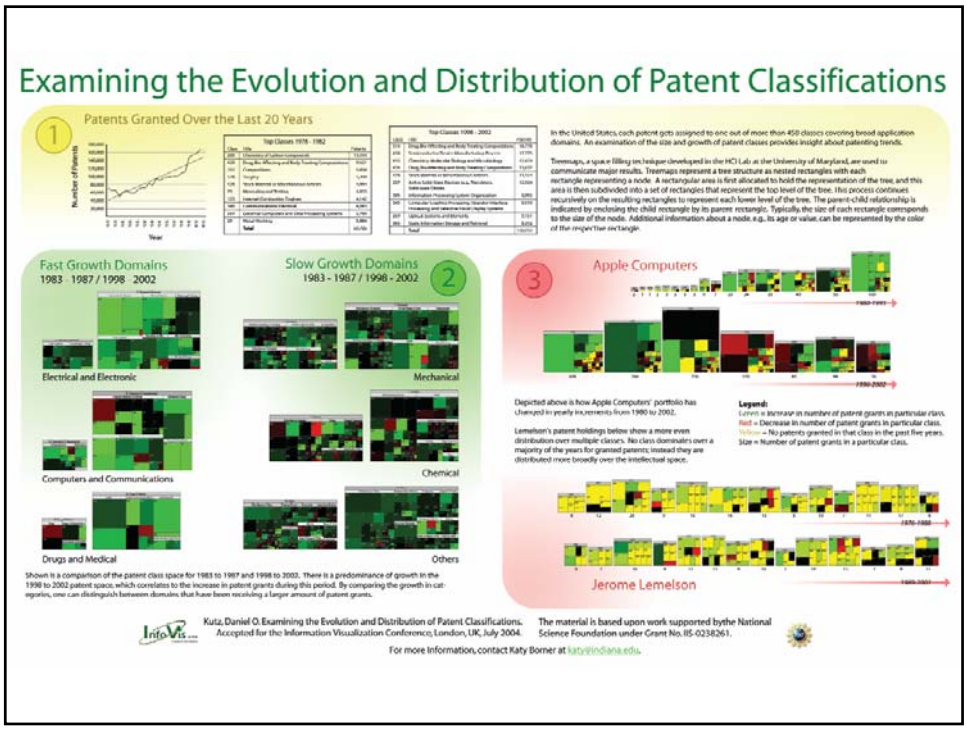
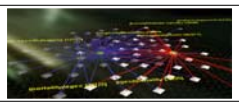

Examining the Evolution and Distribution of Patent Classifications
1
Patents Granted Over the Last 20 Years
Fast Growth Domains
1983 1987 / 1998 2002
Slow Growth Domains
1983 - 1987 / 1998 - 2002
2
Electrical and Electronic
Mechanical
Computers and Communications
Chemical
Drugs and Medical
Others
3
Apple Computers
Jerome Lemelson
InfoVis
Kutz, Daniel O. Examining the Evolution and Distribution of Patent Classifications. Accepted for the Information Visualization Conference, London, UK, July 2004.
The material is based upon work supported bythe National Science Foundation under Grant No. IIS-0238261.
For more Information, contact Katy Borner at katy@indiana.edu.

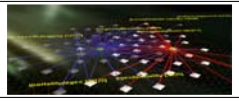


- Diverse attempts have been made to generate maps of science.
- Most have concentrated on specific knowledge domains due to data availability and scalability of algorithms.
- Cartographic metaphors seem to work well as they exploit the map reading skills people acquire in their education.
- Ideally, maps of science would resemble weather forecast maps in that they not only show the structure but also the dynamics of scientific evolution and progress.

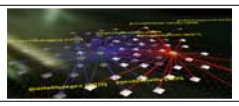
It is just today, that we have the data, code and compute power to study science using the scientific methods of science as suggested by Derek J. deSolla Price about 40 years ago.

However, generating a map of science requires a computational effort common in physics or biology but not in the social sciences.

However, maps of science will benefit every field.



3. Cyberinfrastructure for InfoVis / KDVis Research



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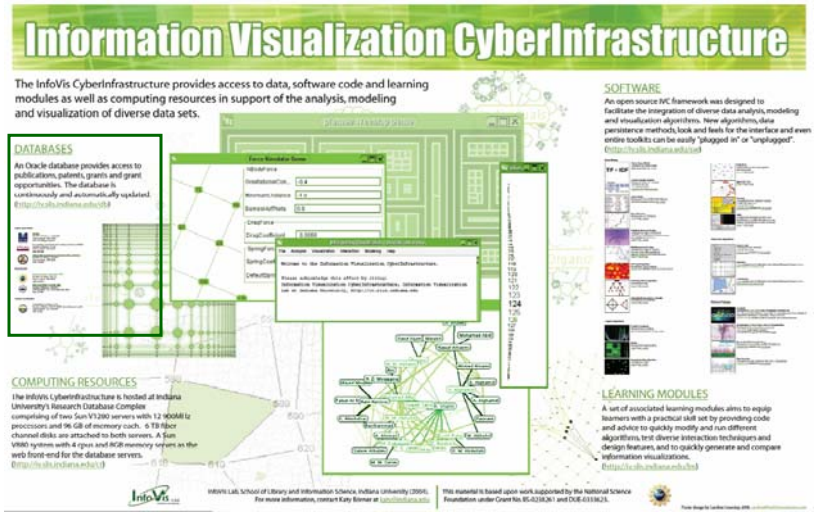
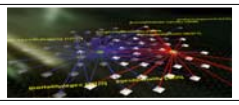




IVC Database (*http://iv.slis.indiana.edu/db*)

Papers and Patents

Medline
Number of Entries: 11,693,477
Years covered: 1963-2002
Size: 135 MB (gunzipped)

Proceedings of the Natioanl Academy of Science (PNAS)
Number of Entries: 16,169
Years covered: 1997-2002
Size: 583 MB

United States Patent and Trademark Office (Patents)
Number of Entries: 2,582,647
Years covered: 1976-2003
Size: 350 MB

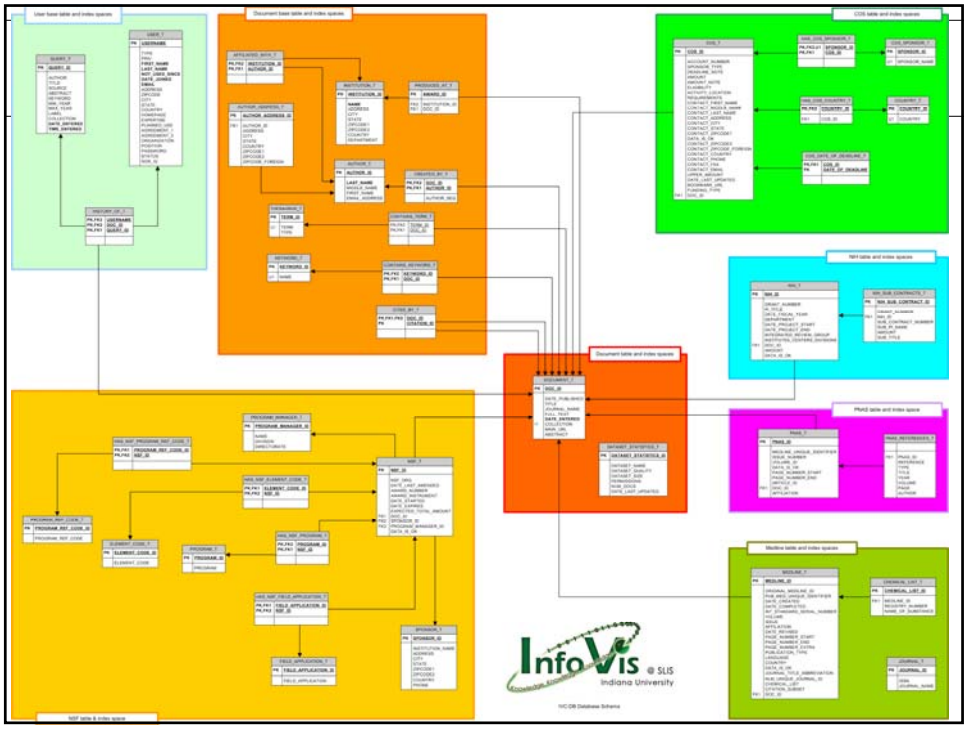
Grant Awards

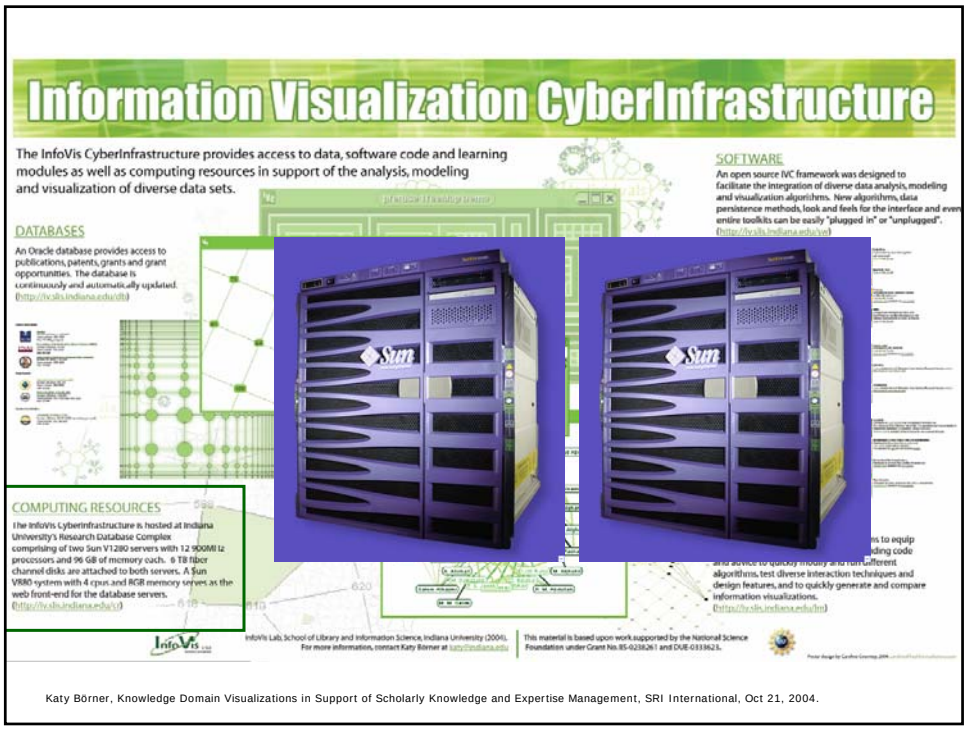
National Science Foundation (NSF)
Number of Entries: 181,132
Years covered: 1985-2002
Size: 400 MB

National Institute of Health (NIH)
Number of Entries: 1,003,521
Years covered: 1972-1992 and 1994-2002
Size: 2.3 GB

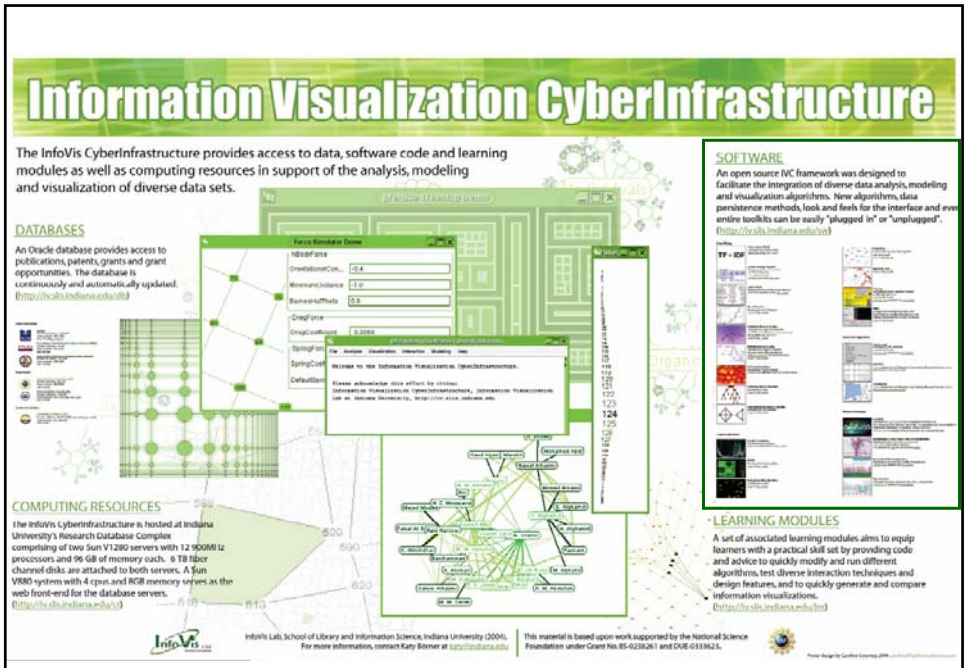
Funding Opportunities

Community of Science (COS)
Number of Entries: 38,154 (5,000 new entries per month)
Years covered: 2001-present
Size: 60 MB

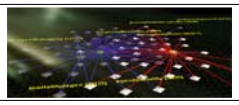




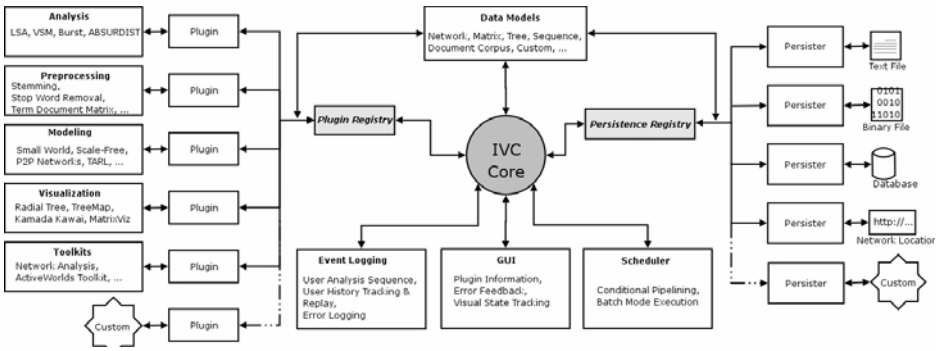
Katy Börner, Knowledge Domain Visualizations in Support of Scholarly Knowledge and Expertise Management, SRI International, Oct 21, 2004.



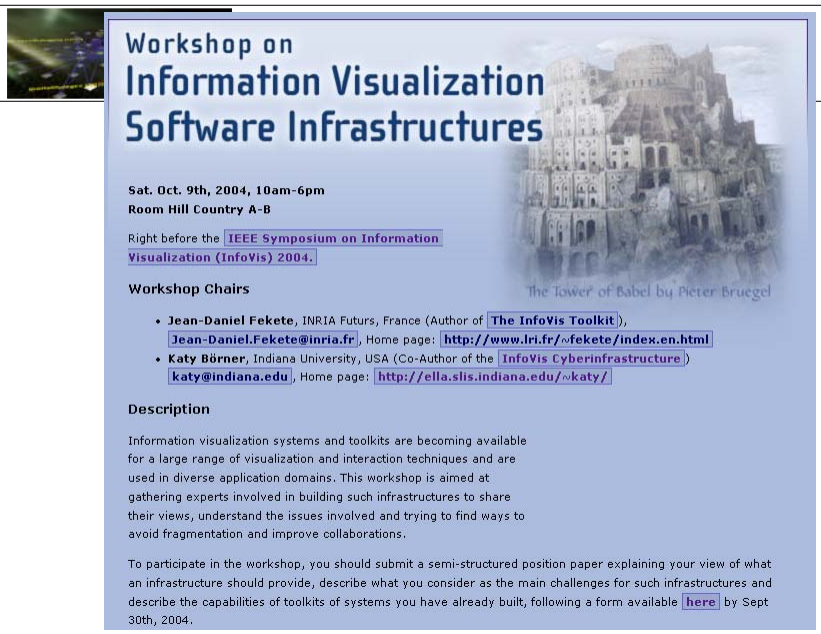
Katy Börner, Knowledge Domain Visualizations in Support of Scholarly Knowledge and Expertise Management, SRI International, Oct 21, 2004.



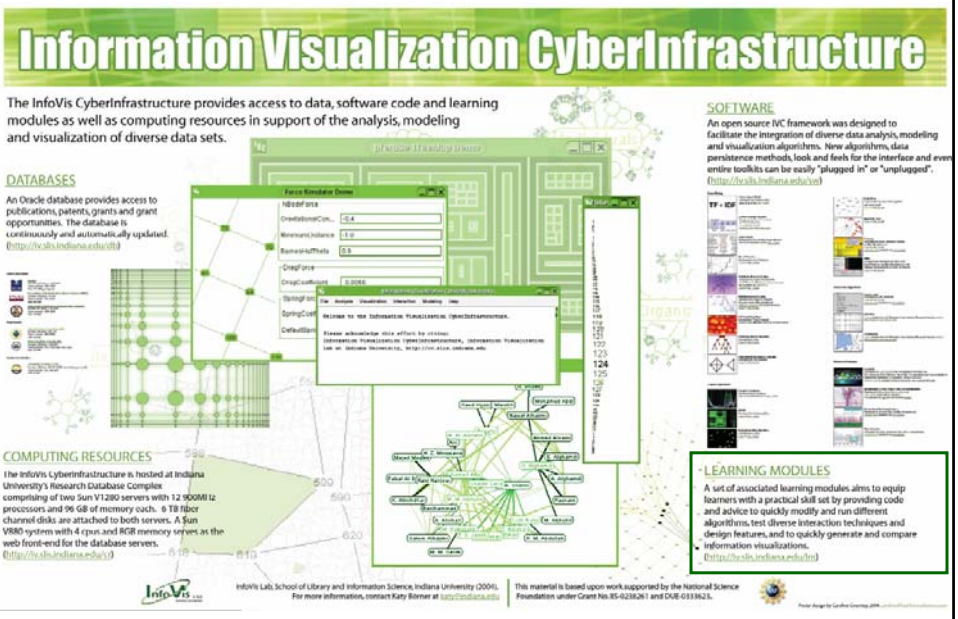
IVC Software Framework (*http://iv.slis.indiana.edu/iv*)



Katy Börner, Knowledge Domain Visualizations in Support of Scholarly Knowledge and Expertise Management, SRI International, Oct 21, 2004.



http://vw.indiana.edu/iwsi2004/



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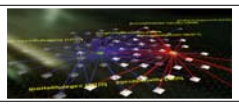


IVC Learning Modules (http://iv.slis.indiana.edu/lm)

InfoVis CyberInfrastructure

A Data-Code-Compute Resource for Research and Education in Information Visualization

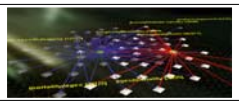
Home | Learning Modules | Software | Data Bases | Compute Resources | References

Learning Modules

Most information visualizations are highly interactive. While a number of excellent textbooks exist, the two-dimensional printouts on paper often cannot convey their true visual appearance and interactive performance. Several textbooks come with accompanying web sites that contain snapshots of user interfaces as well as animations and movies. However, none of them facilitates the exploration, application, evaluation, and comparison of algorithms.

This web page will provide access to a number of learning modules. Each learning module comes with an:

- Introduction
- Discussion of Existing Algorithms
- Learning Task
  - A challenging scenario to use the code in the XML Toolkit to visualize a data set to support a specfic user group.
- Programming Exercise
  - An programming exercise plus an explanation of possible solutions.
- Opportunities & Challenges, and
- References to research papers, online demos, (commercial) applications)



Time Series Analysis & Visualization

http://iv.slis.indiana.edu/lm/lm-time-series.html

InfoVis CyberInfrastructure

A Data-Code-Compute Resource for Research and Education in Information Visualization

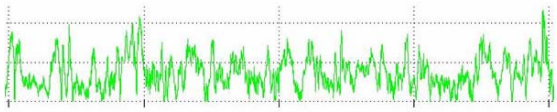
Home | Learning Modules | Software | Data Bases | Compute Resources | References

Learning Modules > Visualizing Time Series Data

Description | Usage Hints | Learning Task | Discussion | References | Acknowledgments

Description

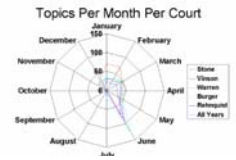
A time series is a sequence of events/observations which are ordered in one dimension, e.g., time. Frequently, successive observations depend on each other and it makes sence to display them in a (time) sorted fashion, e.g., as a scatter plot. Alternatively, one could be interested to know how many observations of a certain value have been made. Here one would sort the observations by value, count the number of observations for each value and derive a histogram. Time series data can be continuous, i.e., there is an observation at every instant of time see figure below, or discrete, i.e., observations exist for regularly or irregularly spaced intervals.

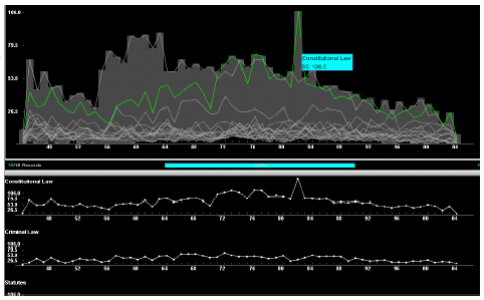


Time series are recorded, analized and used in diverse domains of science. Check out the Time Series Data Library maintained by Rob Hyndman and Muhammad Akram for numerous data sets from Agriculture, Chemistry, Crime, Demography, Ecology, Finance, Health, Hydrology, Industry, Labour market, Macro-Economics, Meteorology, Micro-Economics, Physics, Production, Sales, Simulated series, Sport, Transport & Tourism or Utilities.

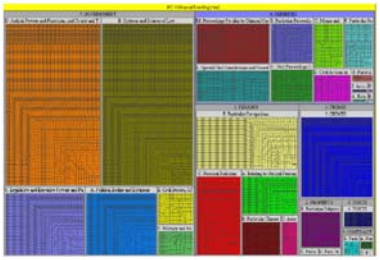
Visualizing the Work of the United States Supreme Court Based on Time Data and Top Level West Topics

by Peter A. Hook & Rongke Gao

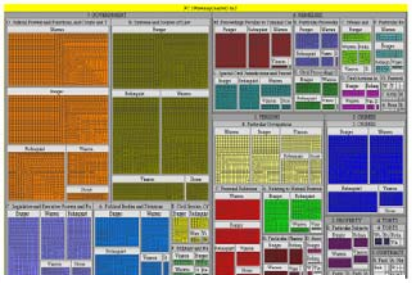




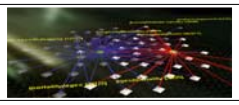
Top fifteen most occurring topics from 1944 to 2004 in Timesearcher



All topics grouped by West Category and Sub-Category grouped over the entire lengths of the data set



All topics by West Category and Sub-Category grouped corresponding to the five chief justices

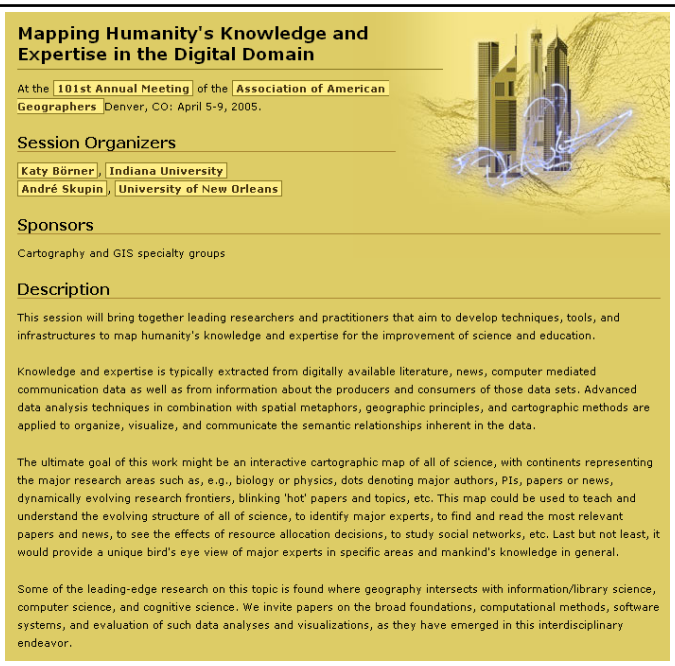


4. Conclusions

Given access to appropriate databases knowledge domain analysis and visualization techniques can be employed to

- Understand the structure and evolution of scientific disciplines.
- Correlate research input (funding) and research output.
- Track and communicate the development of S&E fields at proper levels of detail.
- Identify major players (individuals or institutions).
- Understand the result of / the need for cross-disciplinary S&E.
- Correlate taxonomies with the data they describe.

Katy Börner, Knowledge Domain Visualizations in Support of Scholarly Knowledge and Expertise Management, SRI International, Oct 21, 2004.



Mapping Humanity's Knowledge and Expertise in the Digital Domain

At the 101st Annual Meeting of the Association of American Geographers Denver, CO: April 5-9, 2005.

Session Organizers

Katy Börner, Indiana University
André Skupin, University of New Orleans

Sponsors

Cartography and GIS specialty groups

Description

This session will bring together leading researchers and practitioners that aim to develop techniques, tools, and infrastructures to map humanity's knowledge and expertise for the improvement of science and education.

Knowledge and expertise is typically extracted from digitally available literature, news, computer mediated communication data as well as from information about the producers and consumers of those data sets. Advanced data analysis techniques in combination with spatial metaphors, geographic principles, and cartographic methods are applied to organize, visualize, and communicate the semantic relationships inherent in the data.

The ultimate goal of this work might be an interactive cartographic map of all of science, with continents representing the major research areas such as, e.g., biology or physics, dots denoting major authors, PIs, papers or news, dynamically evolving research frontiers, blinking 'hot' papers and topics, etc. This map could be used to teach and understand the evolving structure of all of science, to identify major experts, to find and read the most relevant papers and news, to see the effects of resource allocation decisions, to study social networks, etc. Last but not least, it would provide a unique bird's eye view of major experts in specific areas and mankind's knowledge in general.

Some of the leading-edge research on this topic is found where geography intersects with information/library science, computer science, and cognitive science. We invite papers on the broad foundations, computational methods, software systems, and evaluation of such data analyses and visualizations, as they have emerged in this interdisciplinary endeavor.

http://vw.indiana.edu/aag05