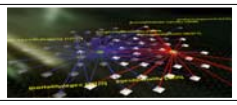
Managing Humanity's Knowledge & Expertise

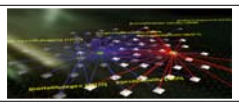
Katy Börner
School of Library and Information Science
INDIANA UNIVERSITY
BLOOMINGTON
katy@indiana.edu

NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004



Overview

- The Problem
- Maps of Science / Knowledge Domain Visualizations (KDVis)
- Cyberinfrastructure for InfoVis/KDVis Research



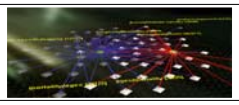
1. The Problem

Facing the Information Flood:

- Information available in electronic form doubles every 18 months.
- Human perception stays constant.

- Main means to access knowledge are search engines.
- Almost no development in online search interfaces. Can't pack more text.

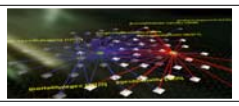
Let's see how little our means of accessing information have changed using http://www.archive.org/.



8 years back in time

Yahoo Oct 17, 1996

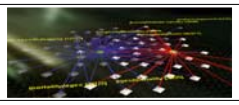
Yahoo Oct 19, 2004



5 years back in time

Amazon Sept 02, 1999

Amazon Oct 19, 2004

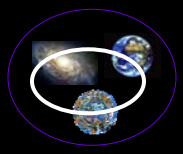


However, the problem is **not** how one person can access knowledge but how we can collectively access and manage humanity's knowledge.

Katy Börner, Managing Humanity's Knowledge & Expertise, NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004.

14th Century: One person can make major contributions to **many areas of science**

Humanity's Knowledge



use

contribute

Human Brain

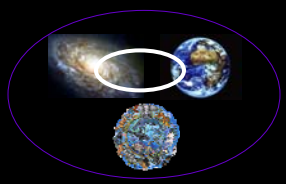
Amount of knowledge on person can mange

Leonardo da Vinci

Circle of Life was designed by Elaine Maier

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

Humanity's Knowledge



use

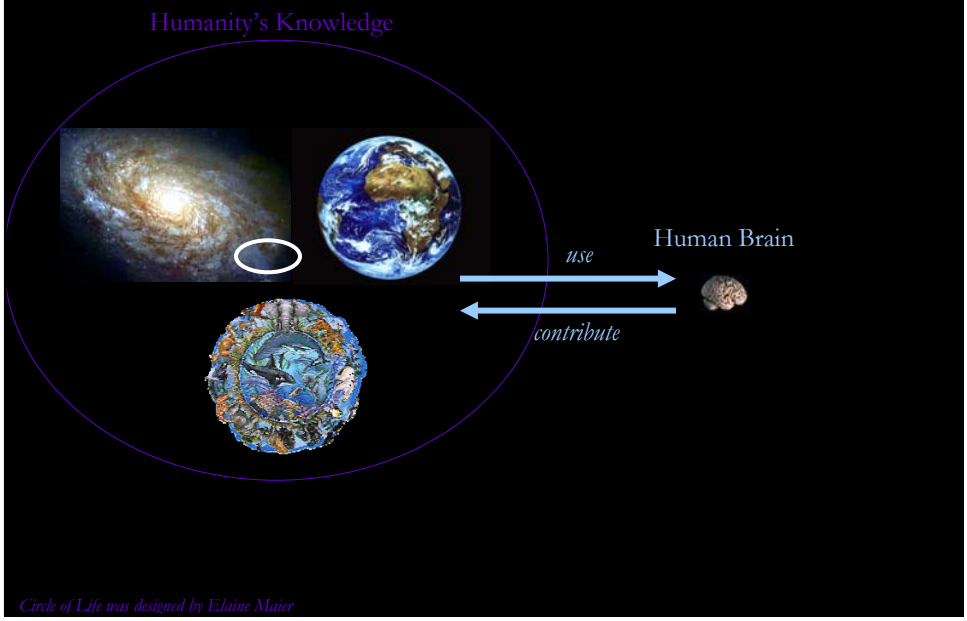
contribute

Human Brain

Albert Einstein

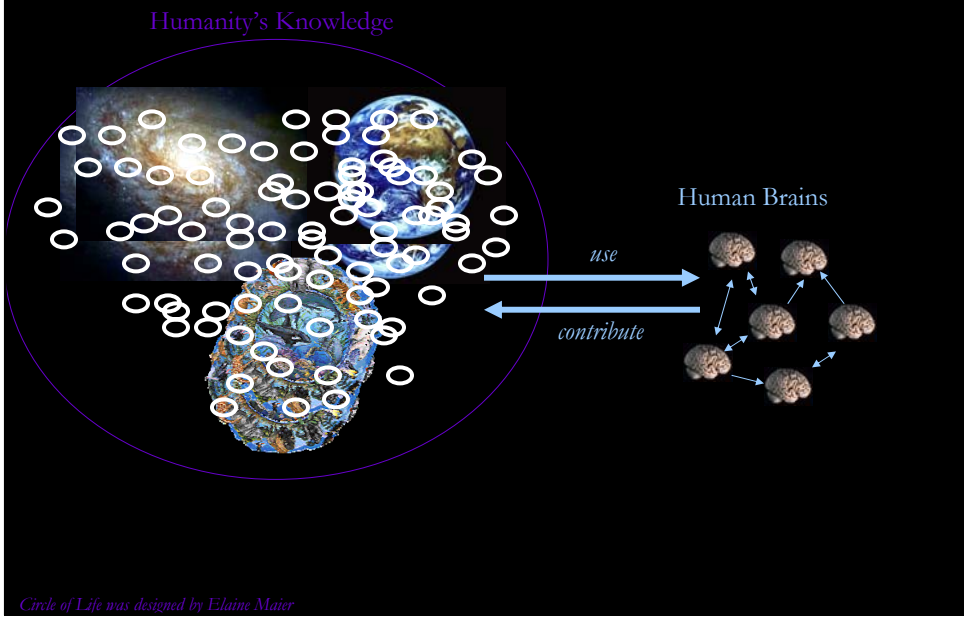
Circle of Life was designed by Elaine Maier

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

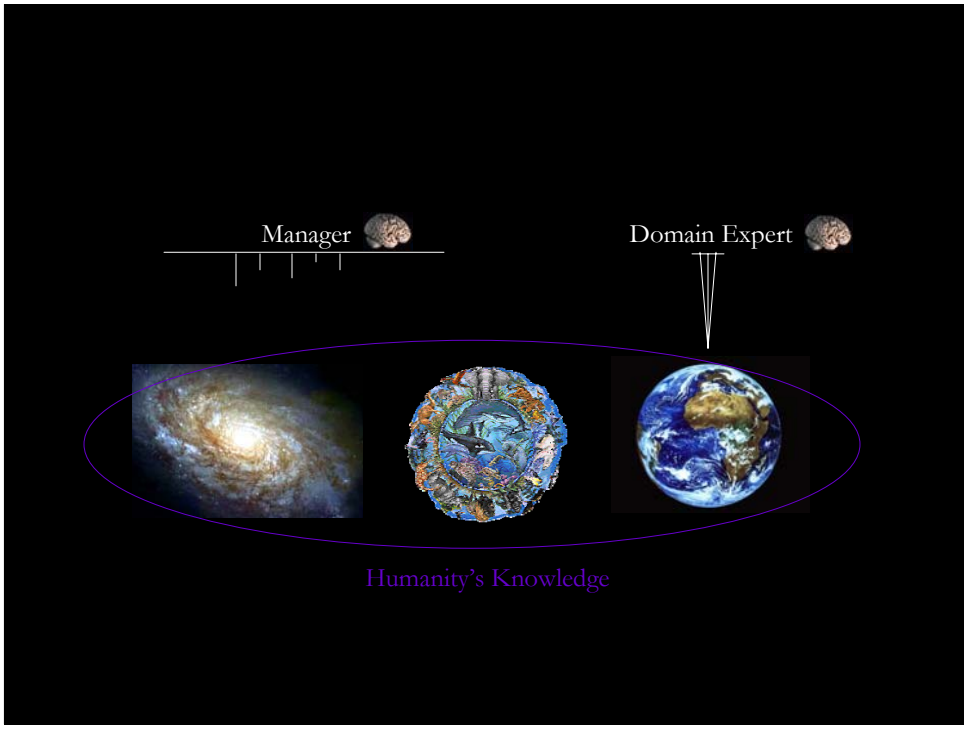


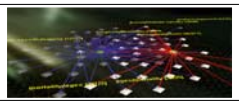
Circle of Life was designed by Elaine Maier

21th Century: How to collectively contribute to **all areas of science?**



Circle of Life was designed by Elaine Maier

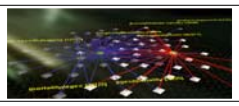




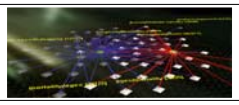
Given the steadily increasing flood of information, how can we keep track and make use of what we <u>collectively</u> know?

- Shift user's mental load from slow reading to faster perceptual processes such as visual pattern recognition.
- Give people global knowledge of the structure and evolution of scientific knowledge. → Global maps of science
- Provide access to knowledge and expertise. → … & expertise
- Aim for reusability of data and methods/approaches/algorithms and reproducibility of results. → Interrelate data, code, results, authors.
- Use usage log data to support social navigation and to create novel reputation systems. → … & usage data. = **A new infrastructure to keep track of knowledge.**

Katy Börner, Managing Humanity's Knowledge & Expertise, NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004.



2. Global Maps of Science / Knowledge Domain Visualizations

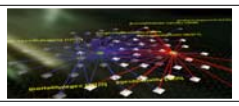


2. Global Maps of Science / Knowledge Domain Visualizations

Help answer questions such as:

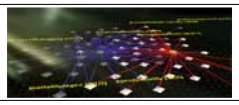
- What are the major research areas, experts, institutions, regions, nations, grants, publications, journals in xx research?
- Which areas are most insular?
- What are the main connections for each area?
- What is the relative speed of areas?
- Which areas are the most dynamic/static?
- What new research 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 Analyzing and 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.

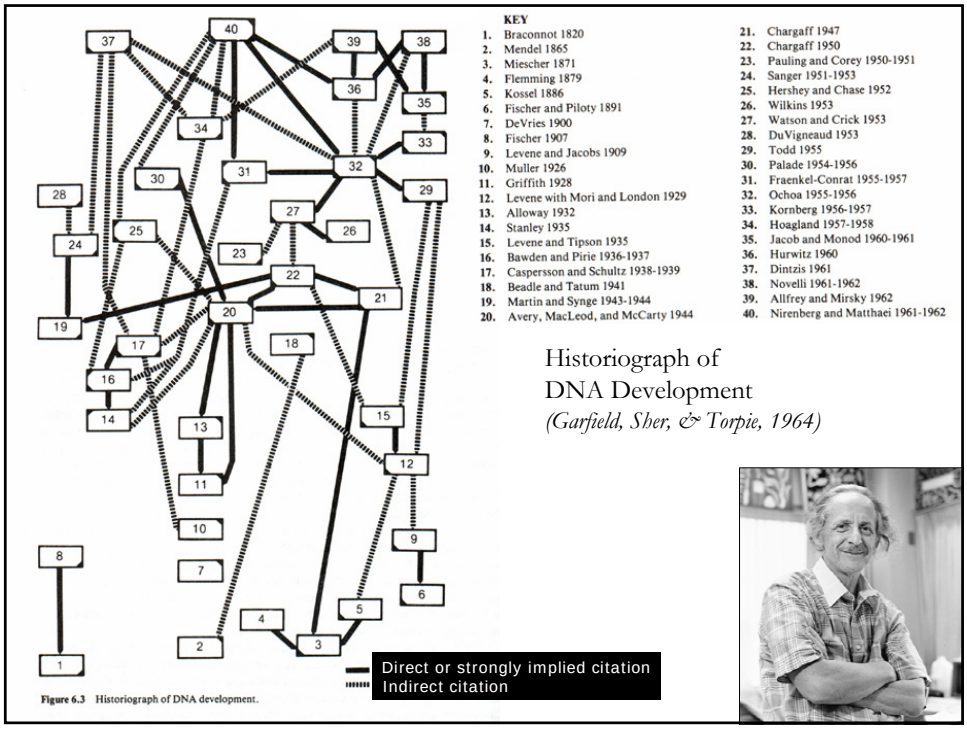
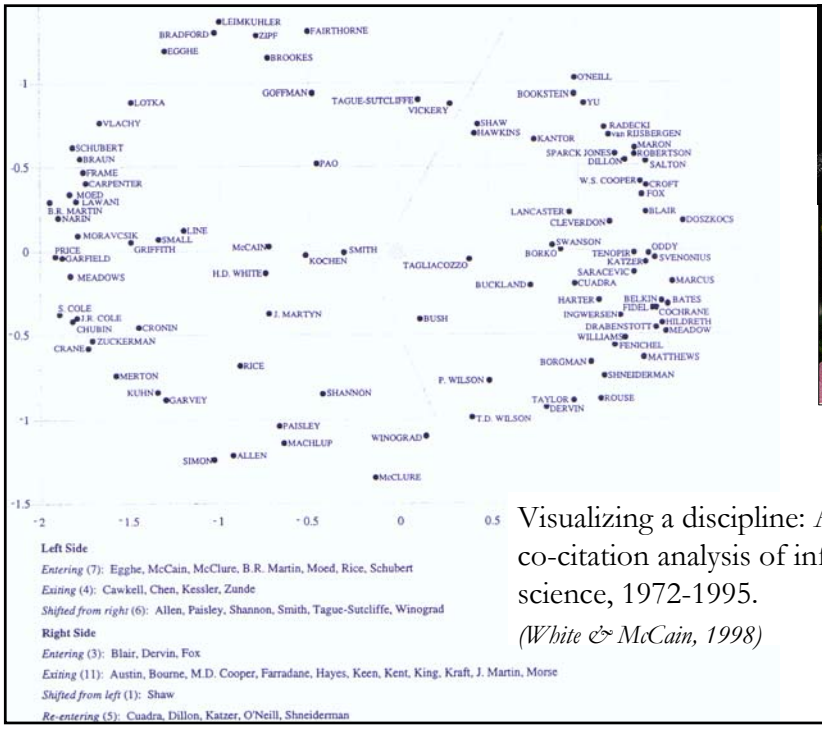


Figure 6.3 Historiograph of DNA development.

Historiograph of DNA Development
(Garfield, Sher, & Torpie, 1964)



Left Side

Entering (7): Egghe, McCain, McClure, B.R. Martin, Moed, Rice, Schubert

Exiting (4): Cawkell, Chen, Kessler, Zunde

Shifted from right (6): Allen, Paisley, Shannon, Smith, Tague-Sutcliffe, Winograd

Right Side

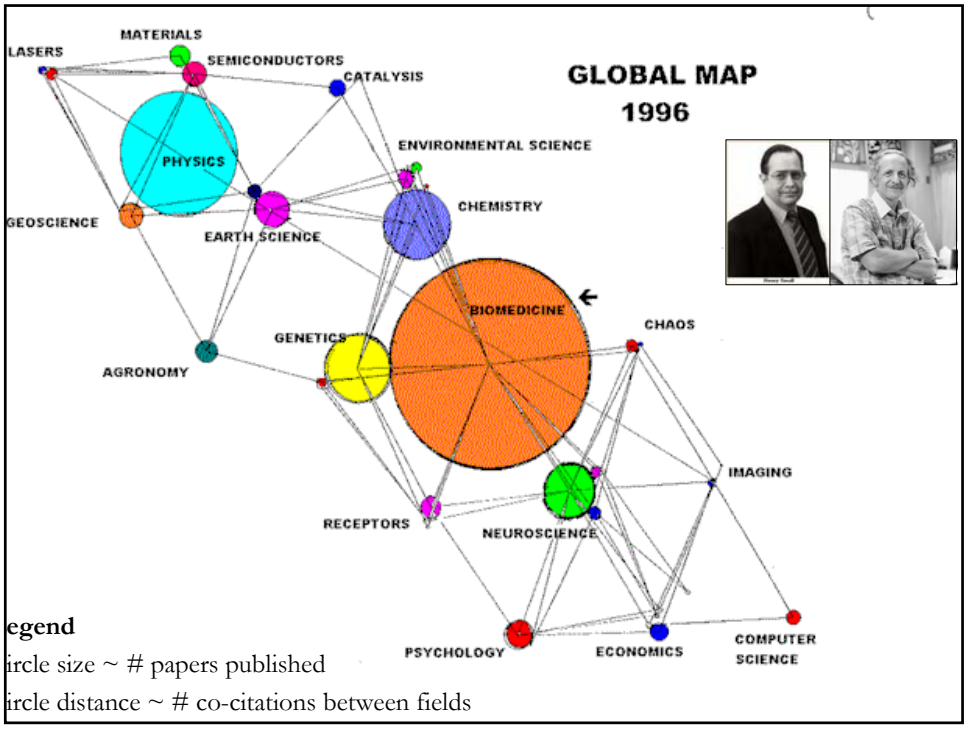
Entering (3): Blair, Dervin, Fox

Exiting (11): Austin, Bourne, M.D. Cooper, Farradane, Hayes, Keen, Kent, King, Kraft, J. Martin, Morse

Shifted from left (1): Shaw

Re-entering (5): Cuadra, Dillon, Katzer, O'Neill, Shneiderman

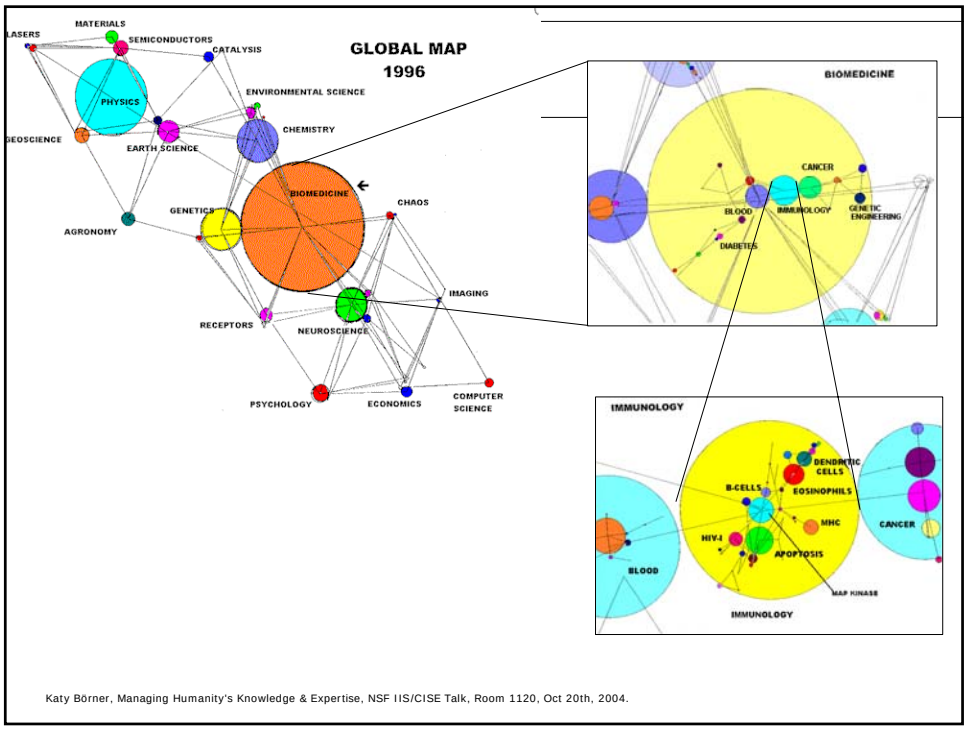
Visualizing a discipline: An author co-citation analysis of information science, 1972-1995.
(White & McCain, 1998)



egend

ircle size ~ # papers published

ircle distance ~ # co-citations between fields



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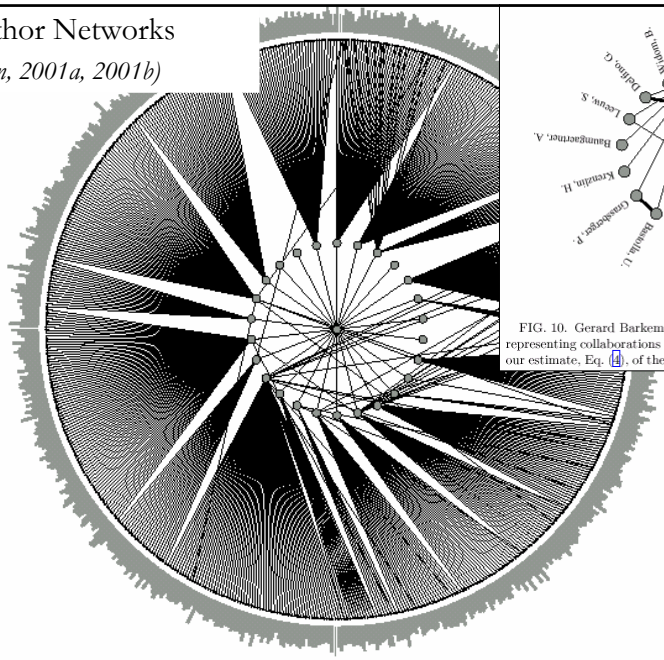
Co-author Networks

(Newman, 2001a, 2001b)



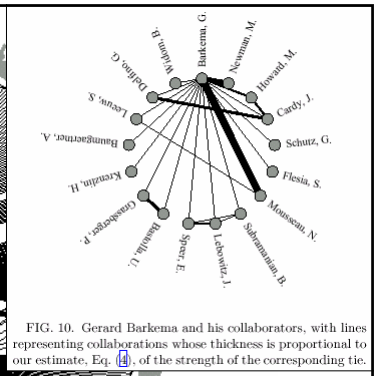


FIG. 10. Gerard Barkema and his collaborators, with lines representing collaborations whose thickness is proportional to our estimate, Eq. (4), of the strength of the corresponding tie.

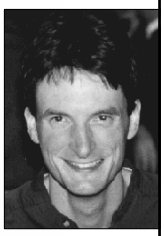


FIG. 6. The point in the center of the figure represents the author of the paper you are reading, the first ring his collaborators, and the second ring their collaborators. Collaborative ties between members of the same ring, of which there are many, have been omitted from the figure for clarity.

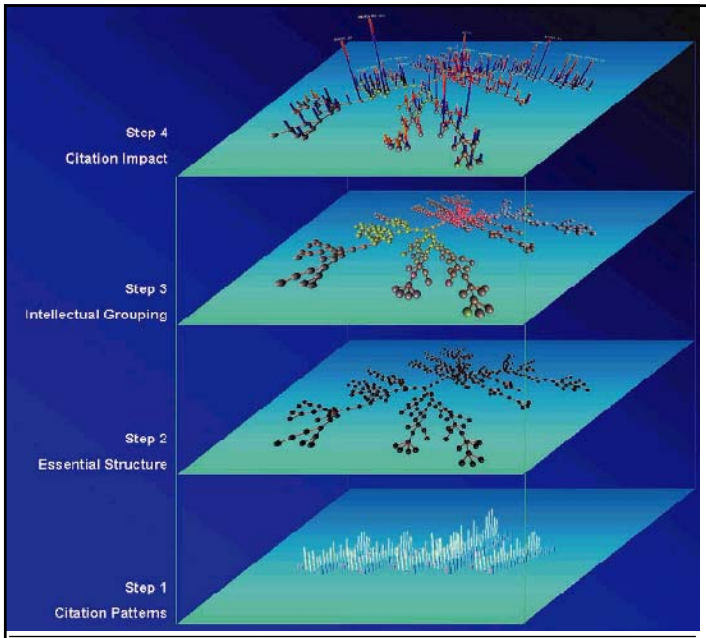
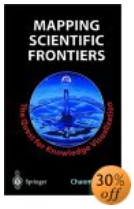


Figure 2. A four-step procedure for visualizing intellectual structures. The process starts from the lowest level and works its way up by incrementally overlaying more visual-spatial features at each consecutive step to clarify the essence of intellectual structures.

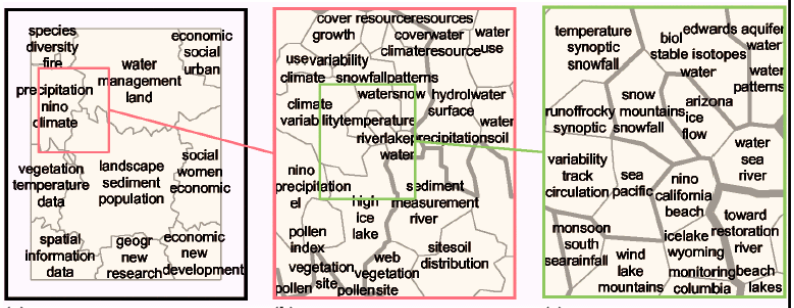
Visualizing a knowledge domain's intellectual structure.

(Chen & Paul, 2001)



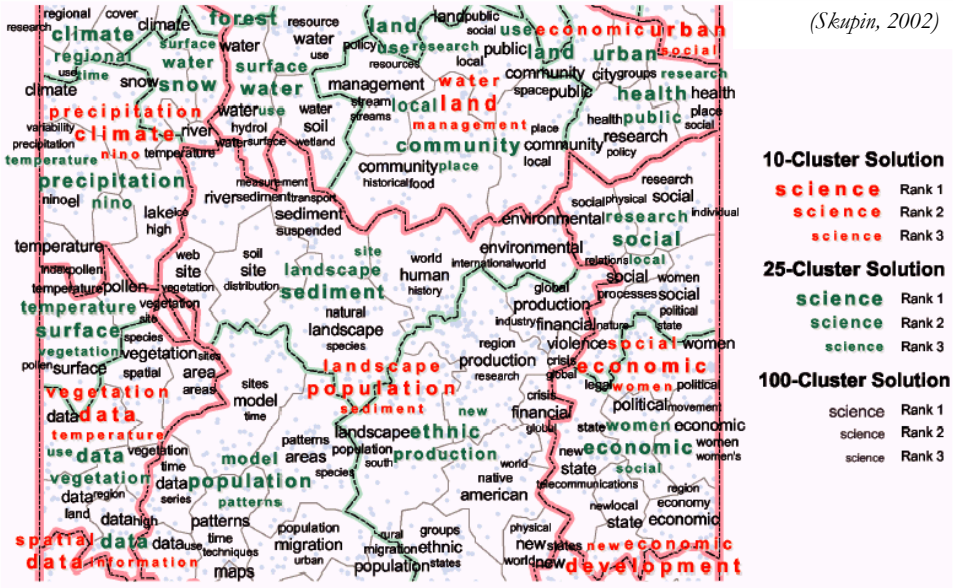
Cartographic Information Visualization

(Skupin, 2002)



6 Three different zoom levels in a visualization of conference abstracts: (a) complete map shown in a 10-cluster solution and map portions for (b) a 100-cluster and (c) 800-cluster solution. Higher level boundaries are accentuated to provide context during zoom operations.

(Skupin, 2002)



10-Cluster Solution

science Rank 1
science Rank 2
science Rank 3

25-Cluster Solution

science Rank 1
science Rank 2
science Rank 3

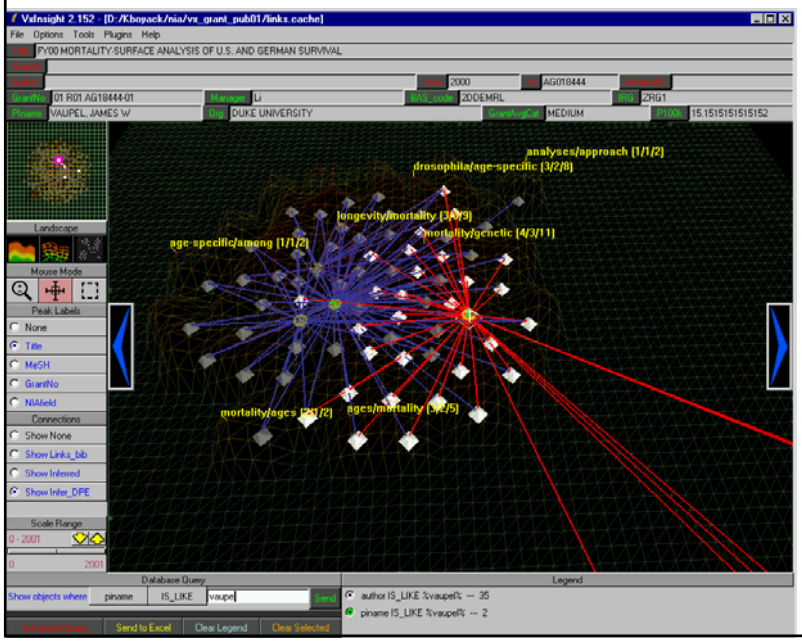
100-Cluster Solution

science Rank 1
science Rank 2
science Rank 3

7 Visualization of 2,220 conference abstracts with simultaneous overlay of three levels of a hierarchical clustering tree of SOM neurons: 10-cluster solution (red); 25-cluster solution (green); and 100-cluster solution (black). Cluster labels are scaled according to rank within the respective cluster.

Indicator-Assisted Evaluation and Funding of Research

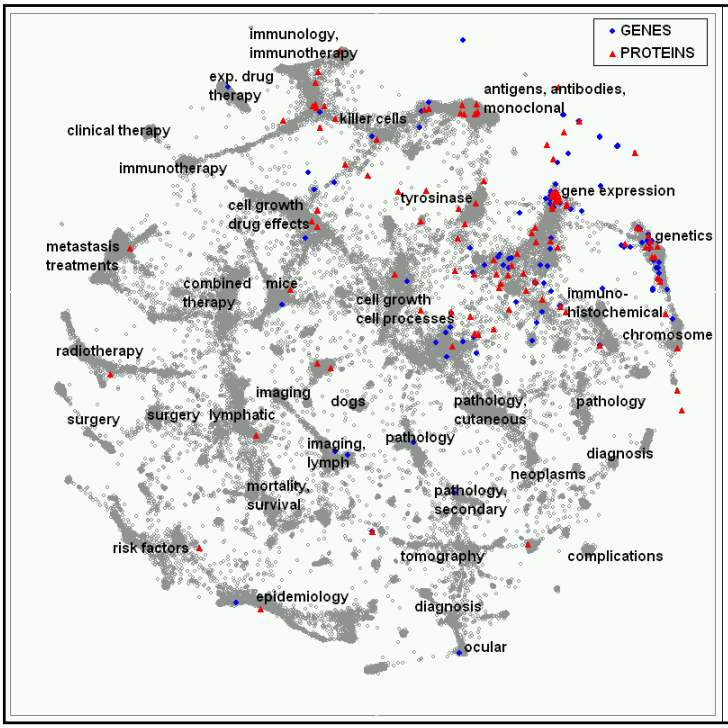
Visualizing the influence of grants on the number and citation counts of research papers (Boyack & Börner, 2003)



Mapping Topic Bursts

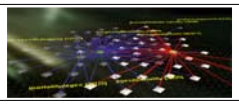
(Mane & Börner, 2004)

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.



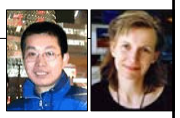
Mapping Medline Papers, Genes, and Proteins Related to Melanoma Research

(Boyack, Mane & Börner, 2004)



Co-PI Map of Current IDM Awardees

(Ke & Börner, 2004)



Legend

Node size: # awarded grants

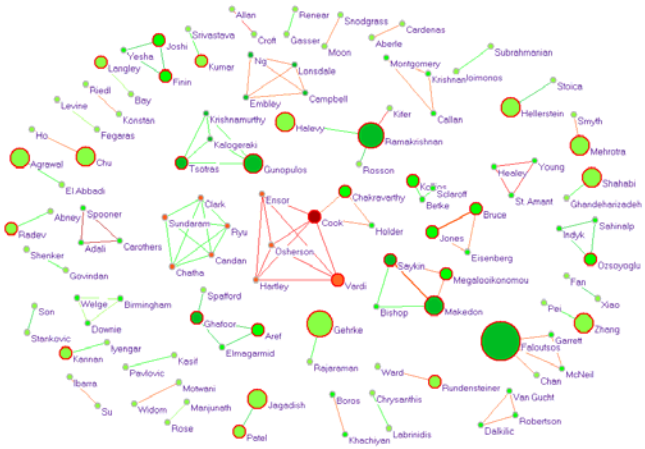
Node Inner Color: # unique Co-PIs (0 white; 1 YellowGreen; 2 Green; 3 PineGreen; 4 Orange; 5 Red; 6 Maroon)

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

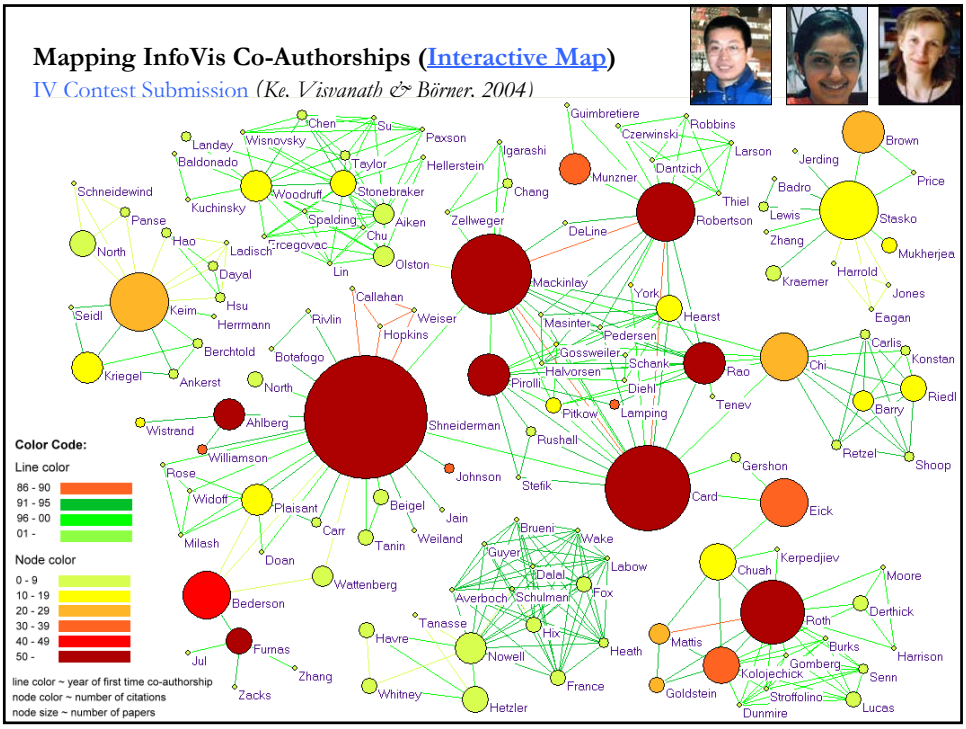
Edge Color: First year of Co-PIship (1999 Maroon; 2000 Red; 2001 Orange; 2002 PineGreen; 2003 Green; 2004 YellowGreen)

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



Mapping InfoVis Co-Authorships (Interactive Map)

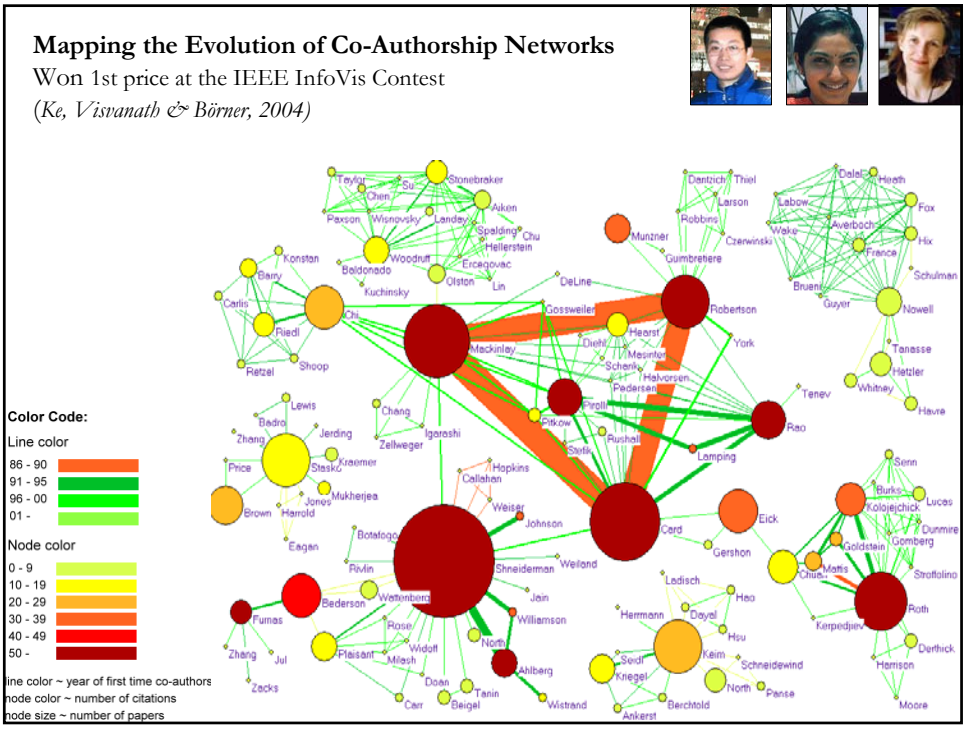
IV Contest Submission *(Ke, Visvanath & Börner, 2004)*

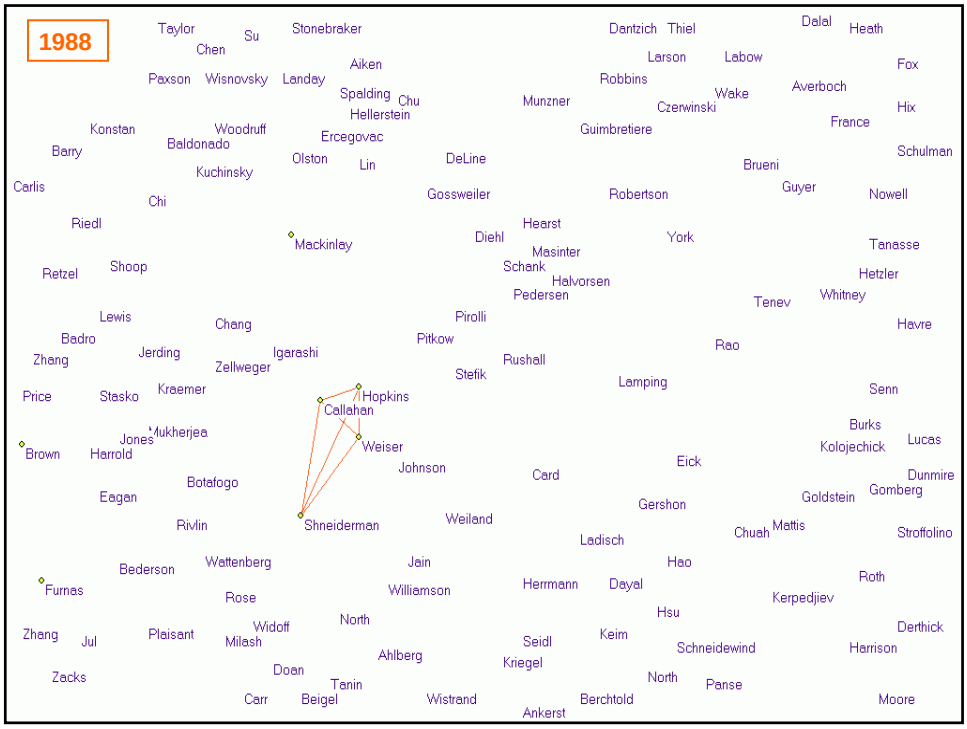


Mapping the Evolution of Co-Authorship Networks

Won 1st price at the IEEE InfoVis Contest

(Ke, Visvanath & Börner, 2004)




1988
Taylor
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Diehl
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Zellweger
Rushall
Zhang
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Price
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Kraemer
Hopkins
Callahan
Weiser
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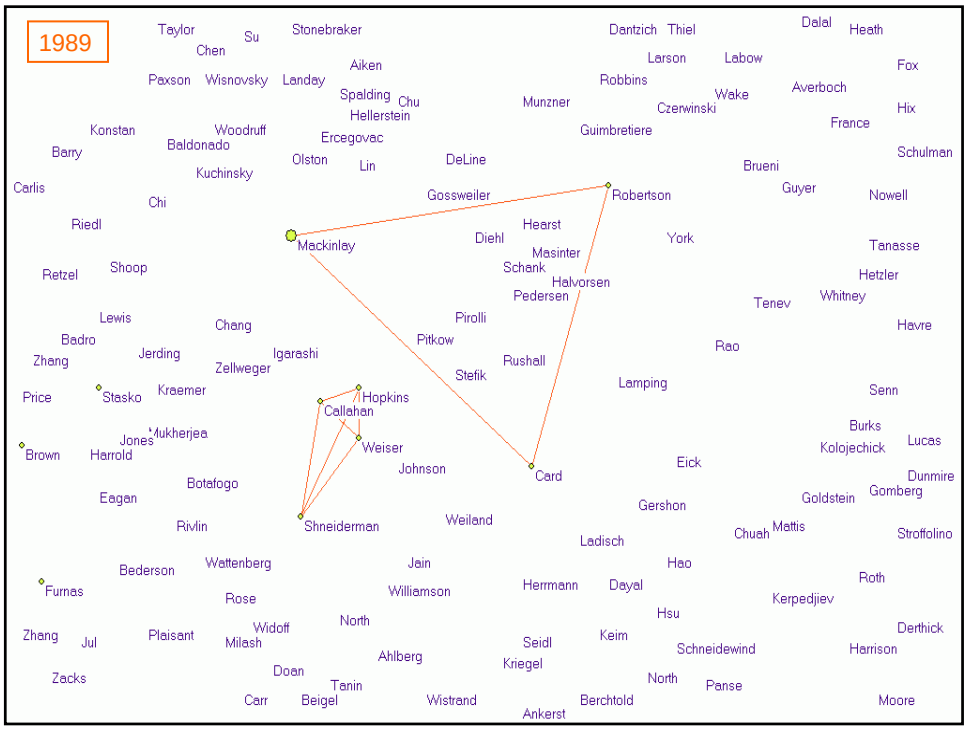
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Callahan
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Larson
Labow
Fox
Robbins
Averboch
Munzner
Wake
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Brueni
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Tanasse
Hetzler
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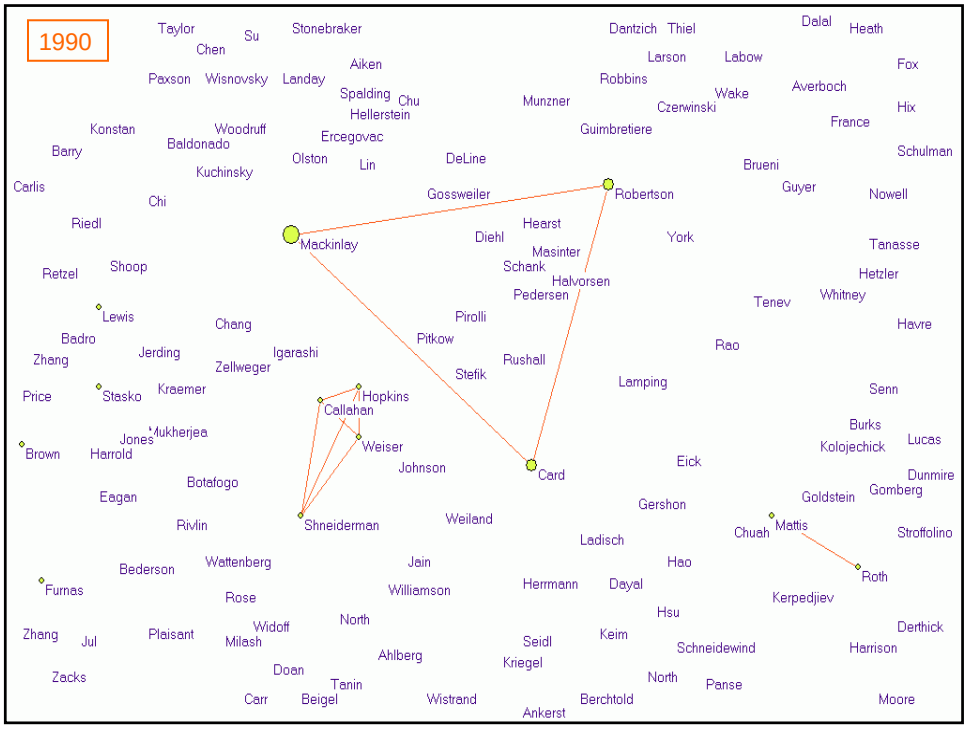
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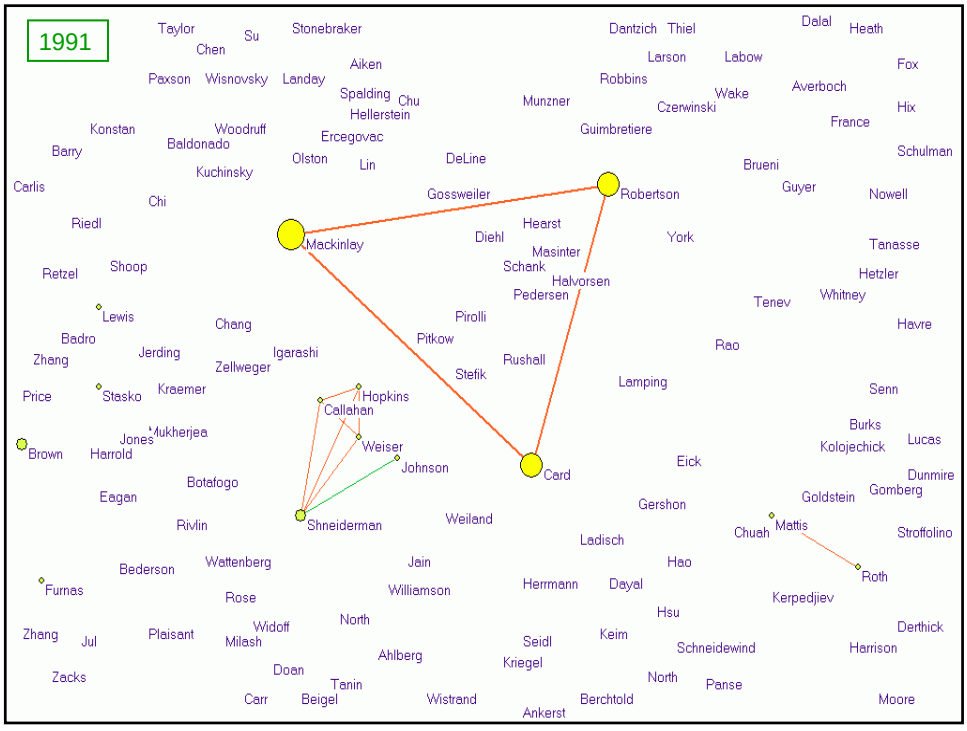
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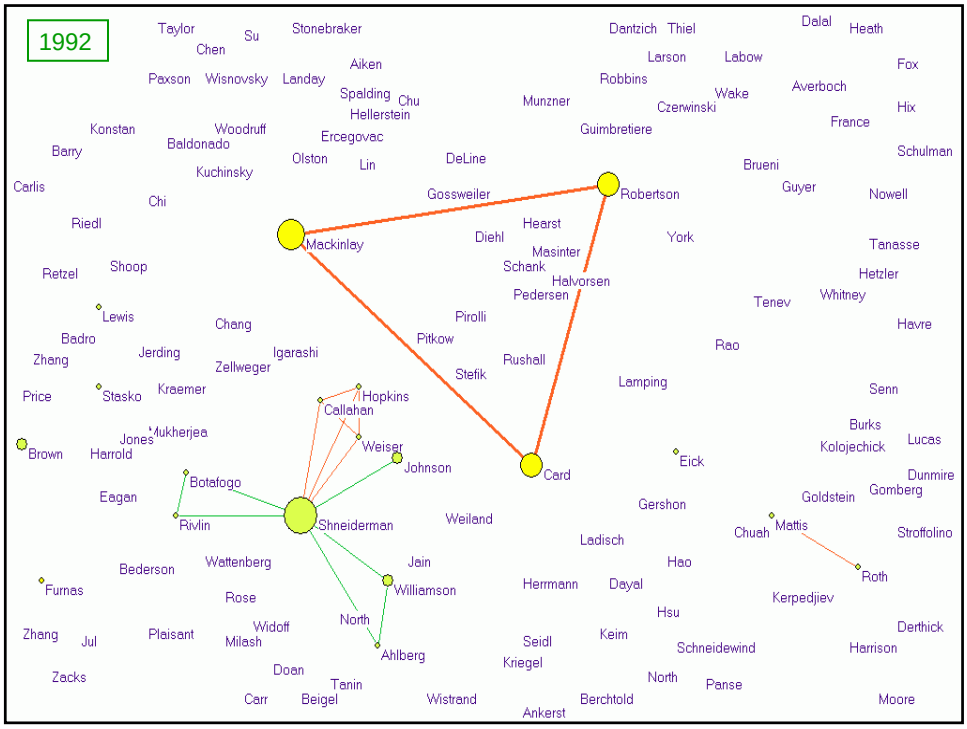
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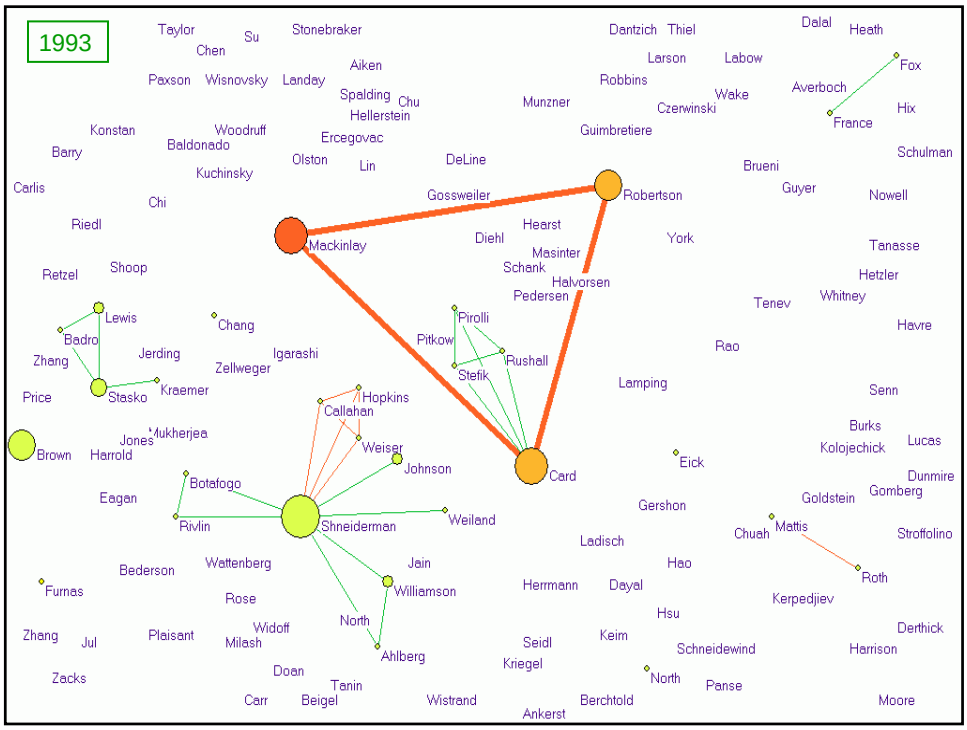
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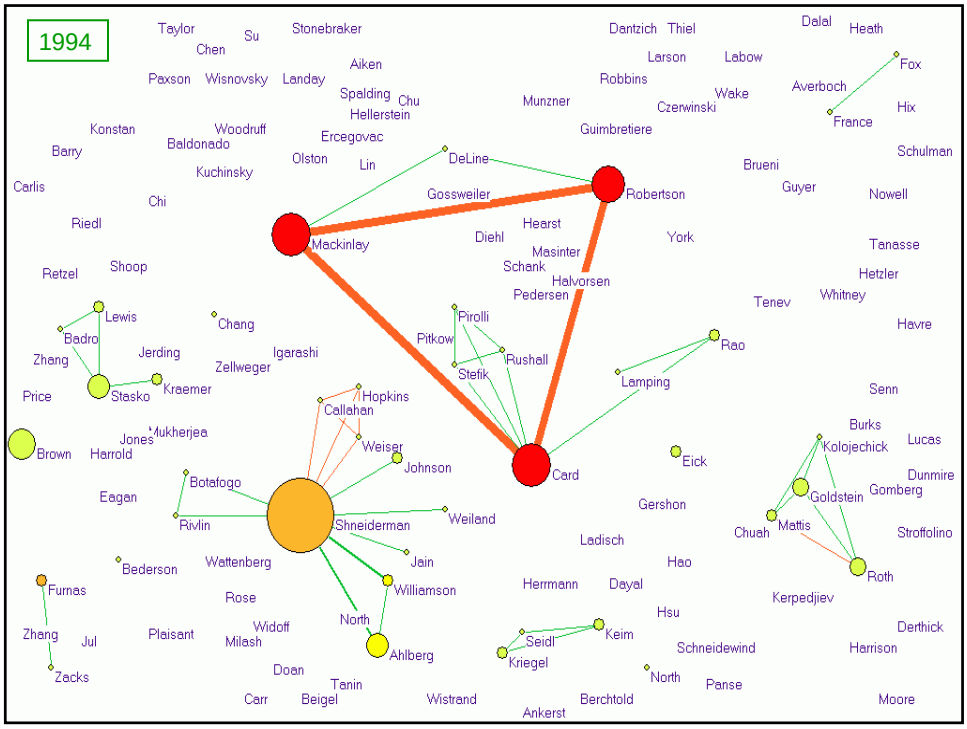
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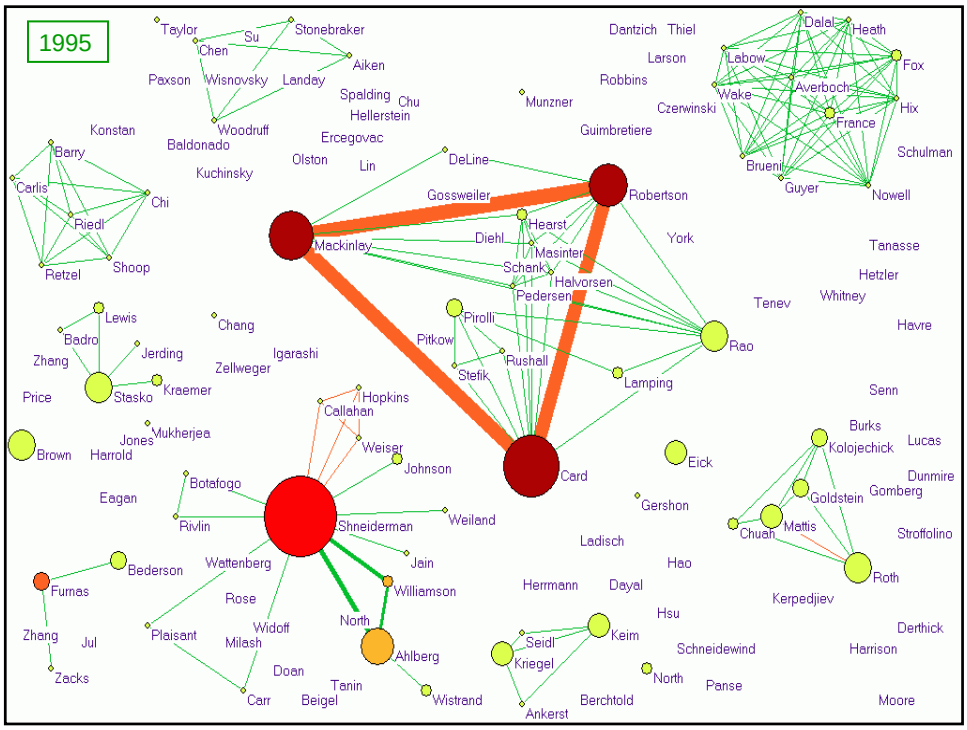
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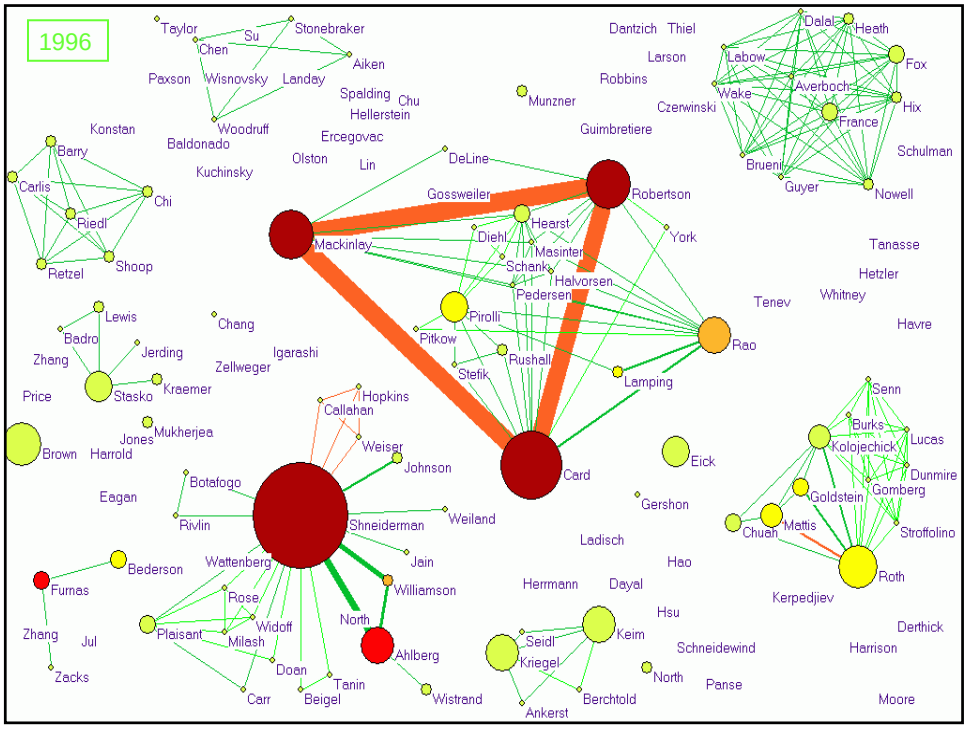
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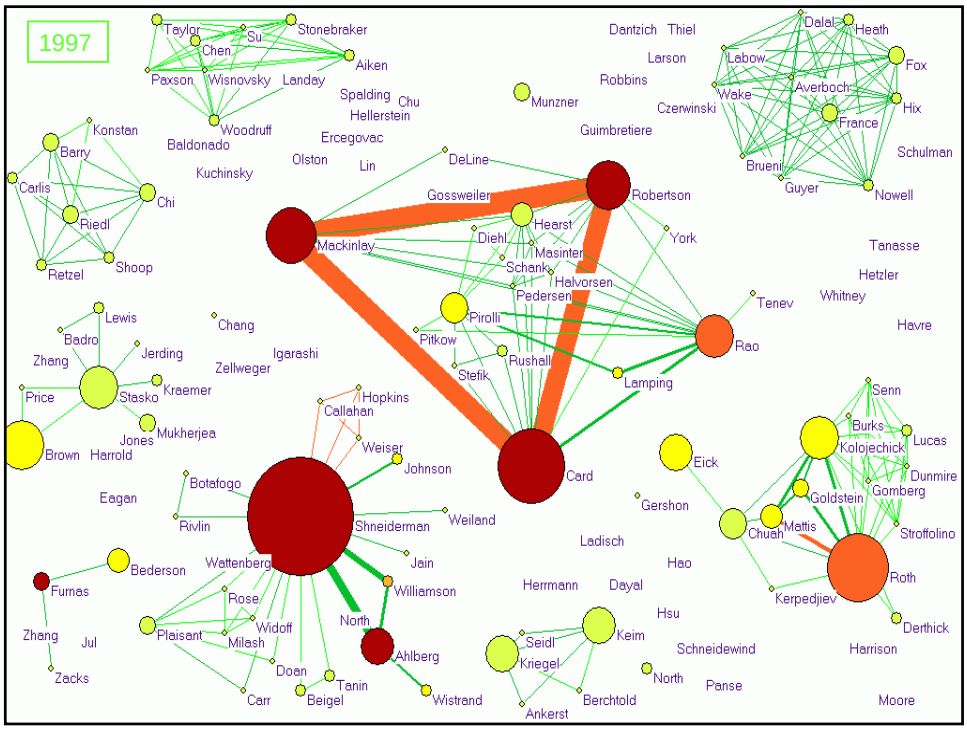
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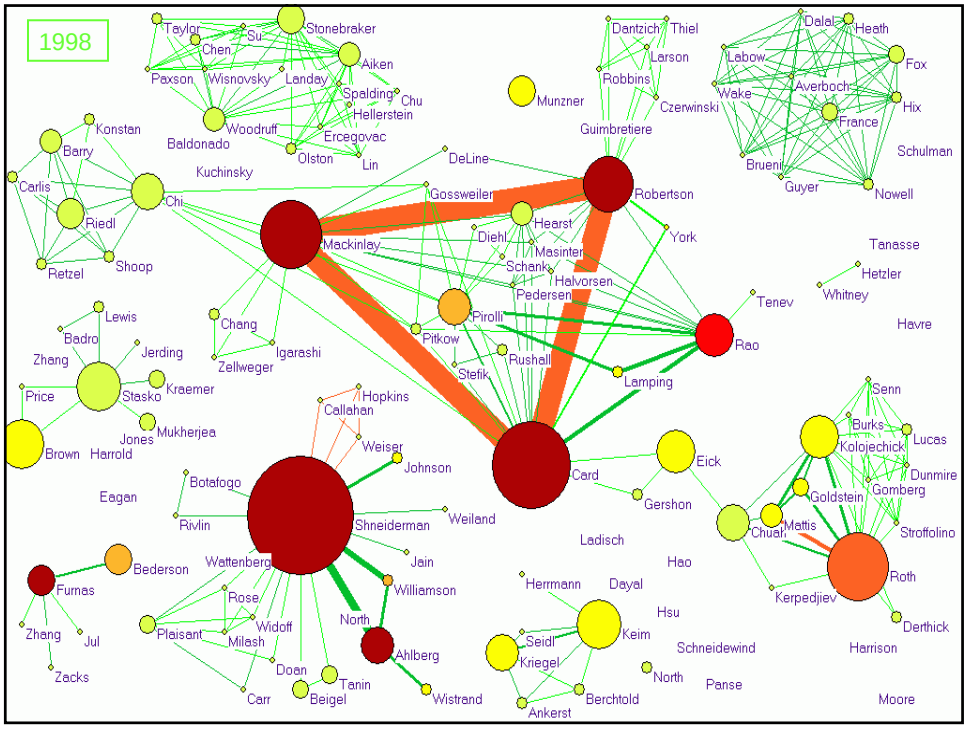
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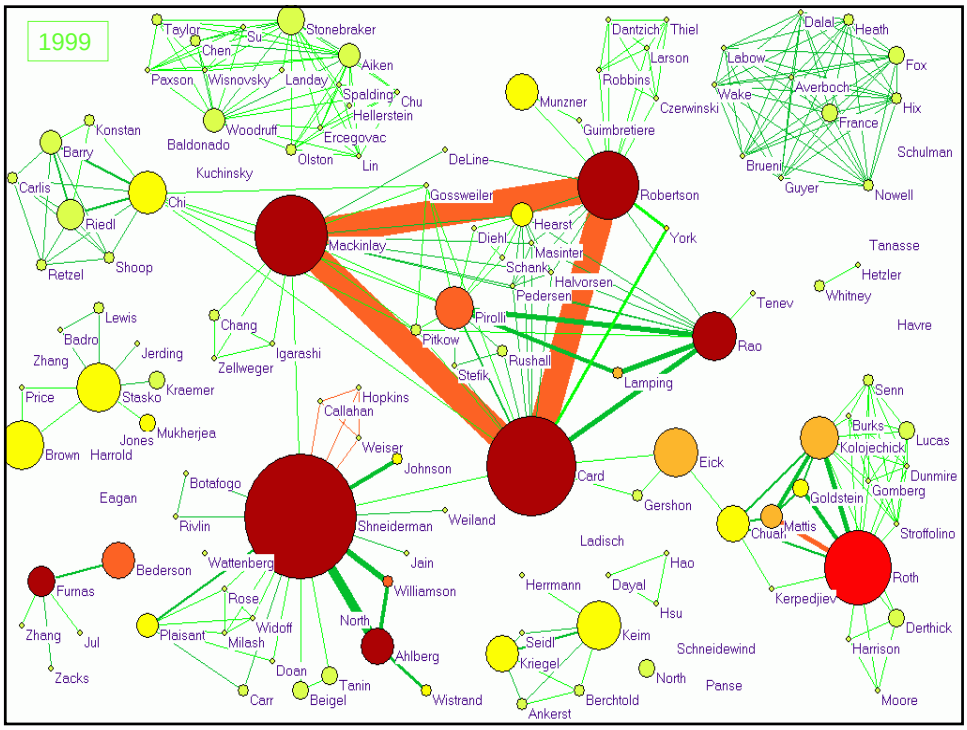
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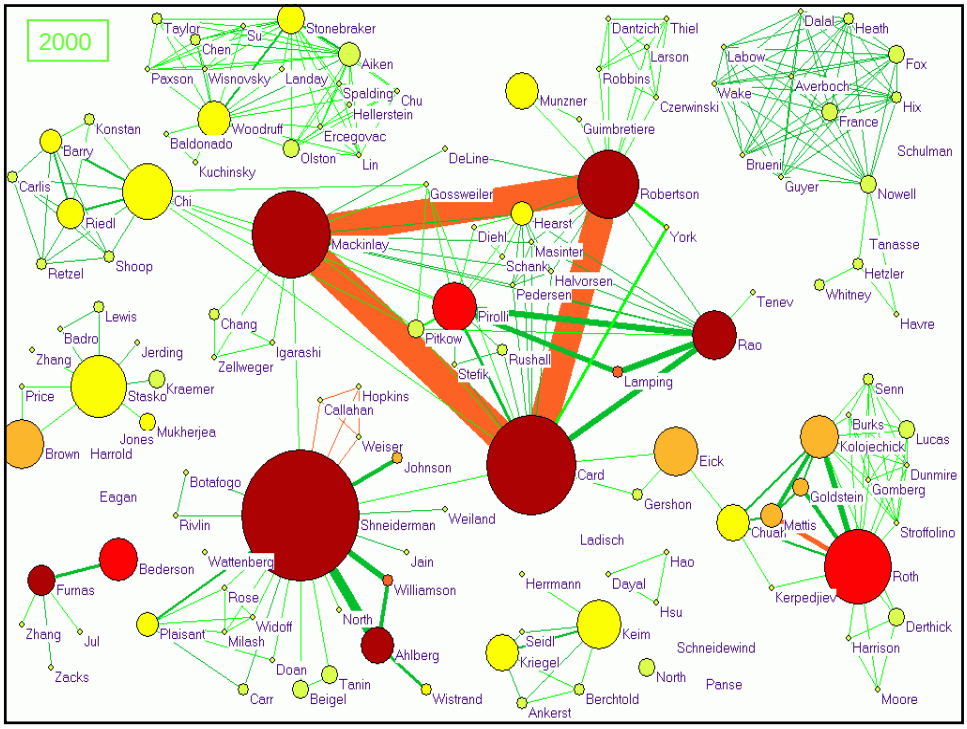
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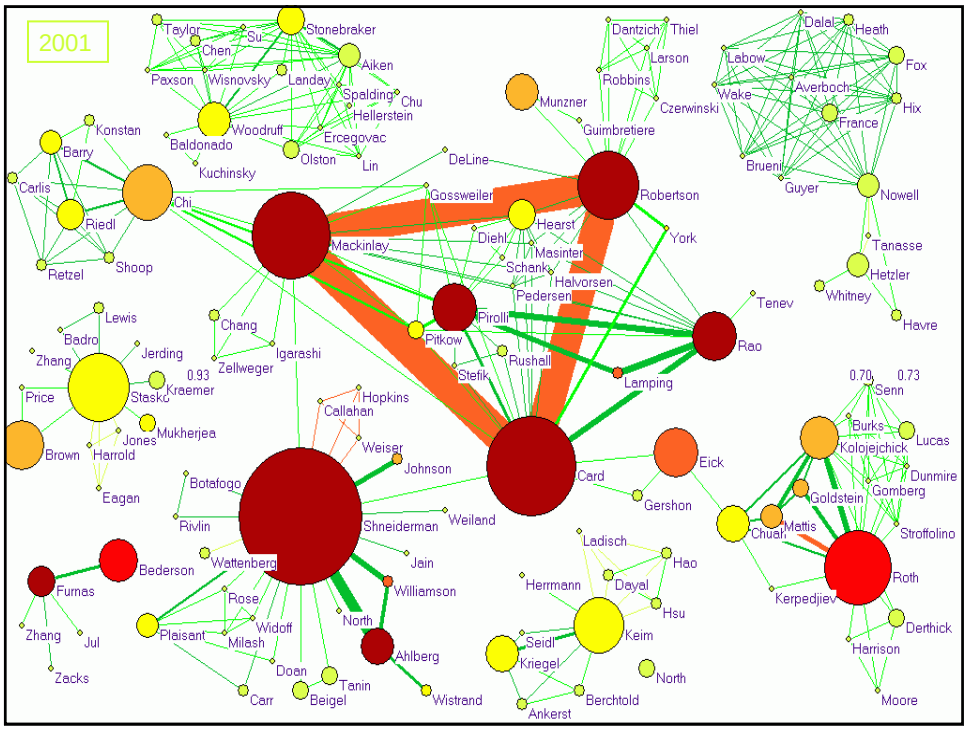
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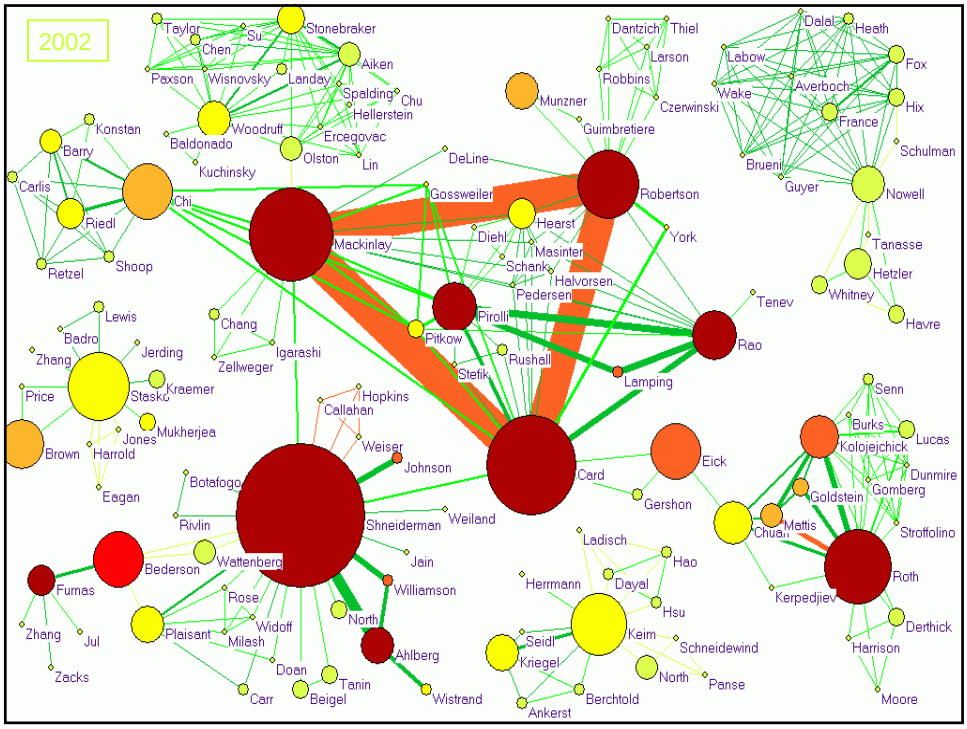
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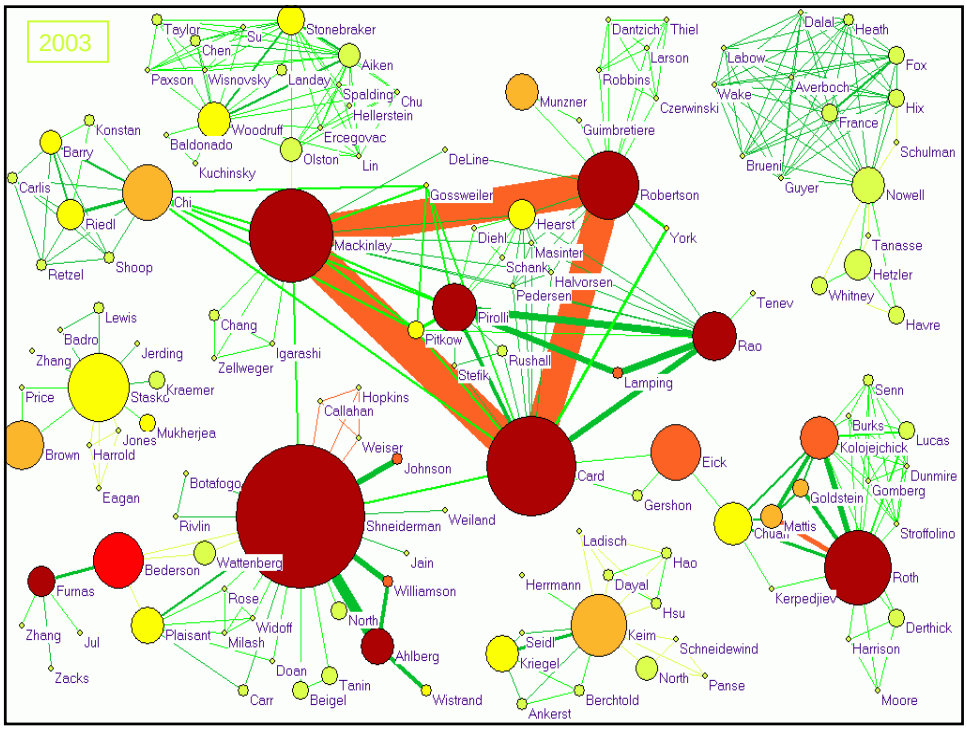
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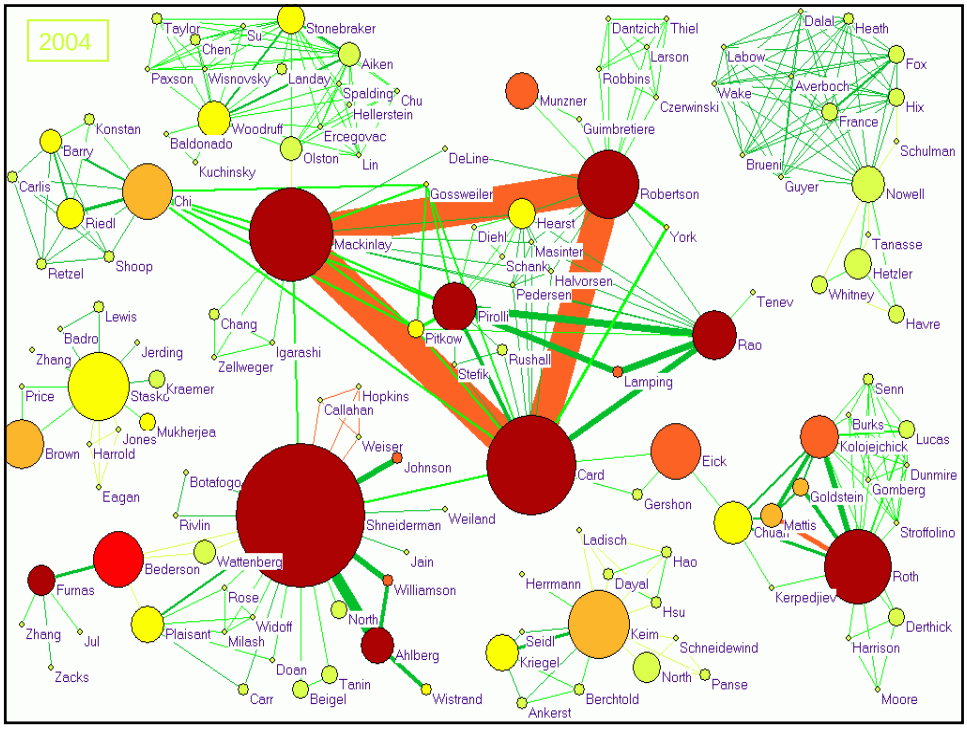
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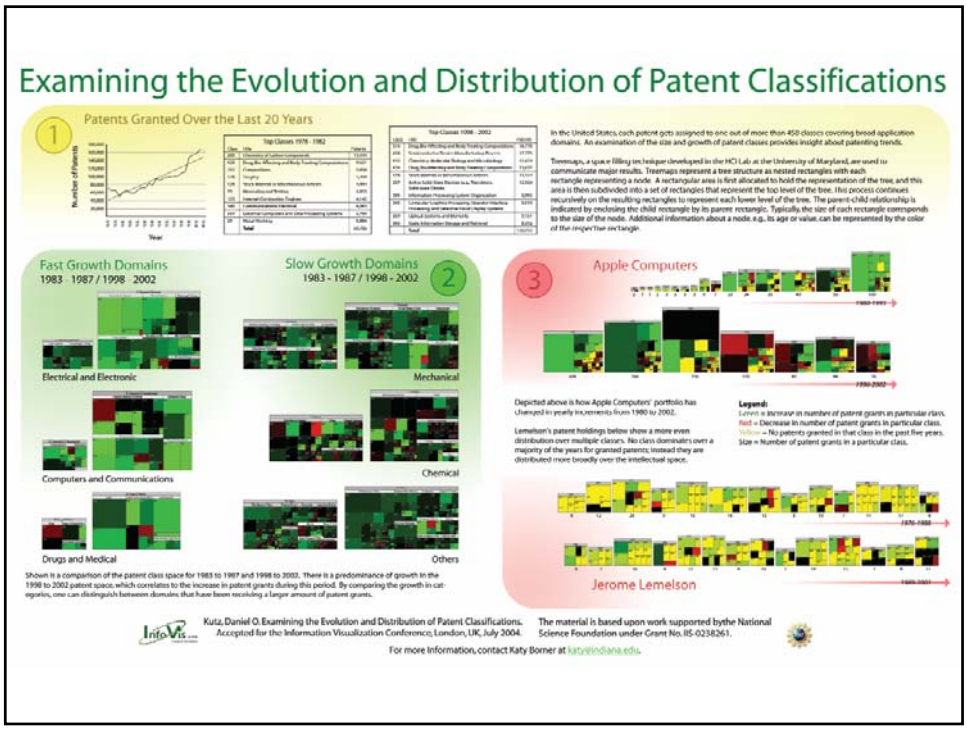
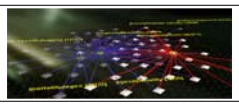

Examining the Evolution and Distribution of Patent Classifications
1
Patents Granted Over the Last 20 Years
Fast Growth Domains
1983 1987 / 1998 2002
Slow Growth Domains
1983 - 1987 / 1998 - 2002
2
Electrical and Electronic
Mechanical
Computers and Communications
Chemical
Drugs and Medical
Others
3
Apple 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.

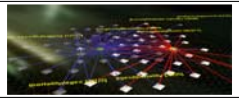


- Diverse attempts have been made to generate maps of science.
- Most have concentrated on specific knowledge domains due to data availability and scalability of algorithms.
- Cartographic metaphors seem to work well as they exploit the map reading skills people acquire in their education.
- Ideally, 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.

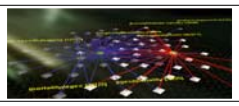
It is just today, that we have the data, code and compute power to study science using the scientific methods of science as suggested by Derek J. deSolla Price about 40 years ago.

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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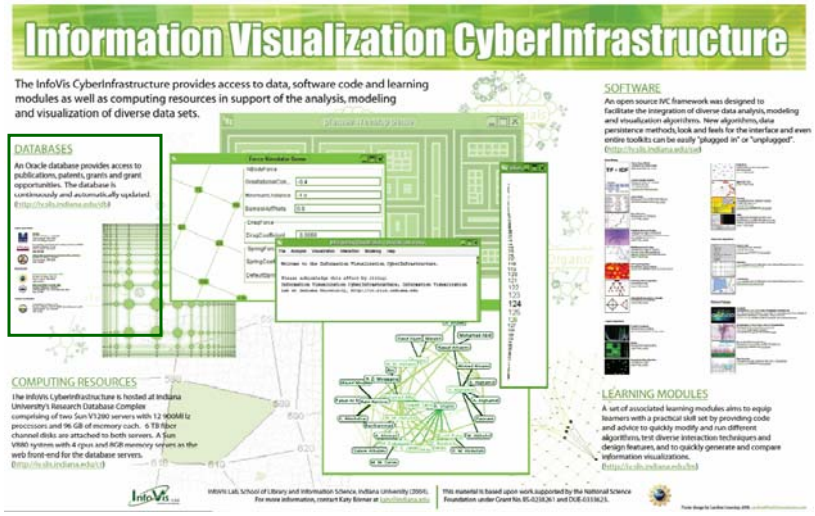
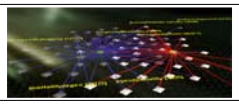


Katy Börner, Managing Humanity's Knowledge & Expertise, NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004.



IVC Database (*http://ivc.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

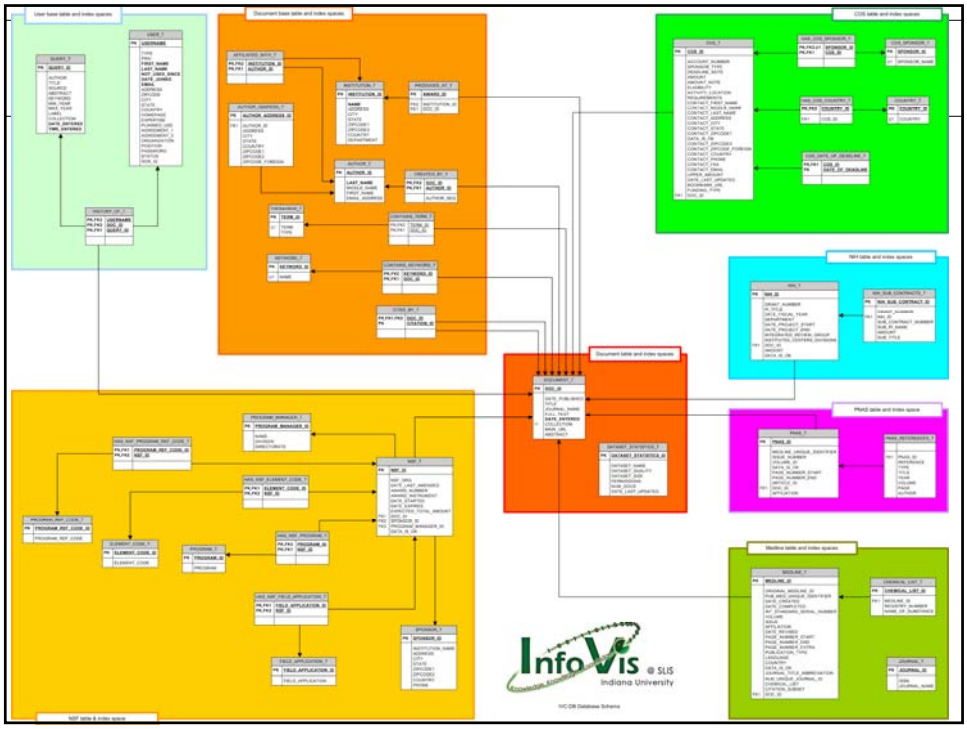
National Science Foundation (NSF)
Number of Entries: 181,132
Years covered: 1985-2002
Size: 400 MB

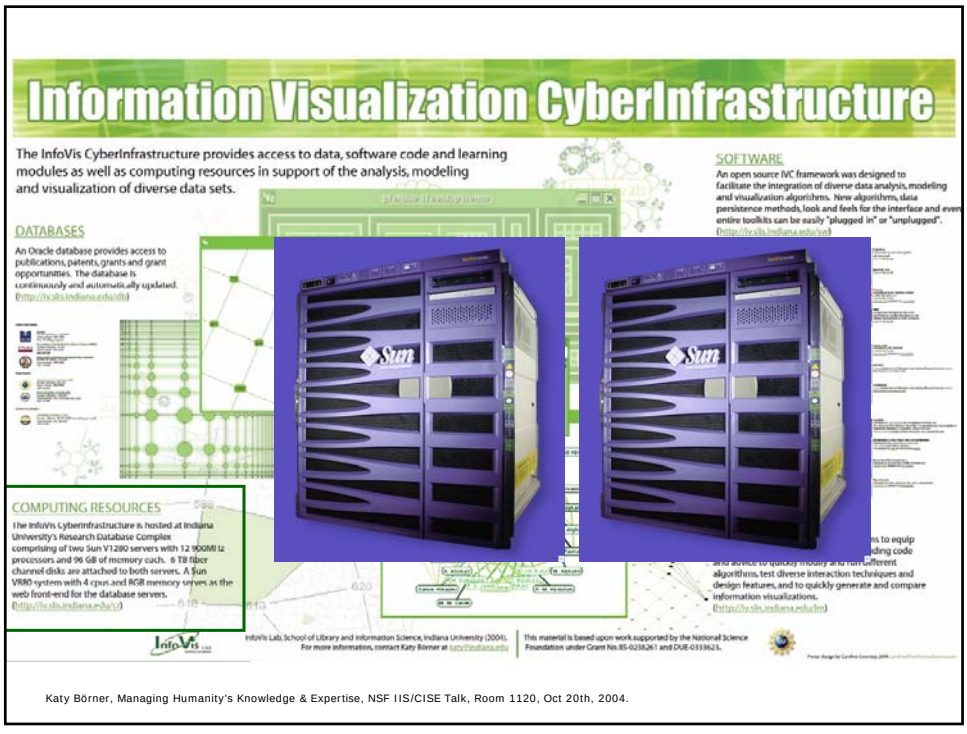
National Institute of Health (NIH)
Number of Entries: 1,003,521
Years covered: 1972-1992 and 1994-2002
Size: 2.3 GB

Funding Opportunities

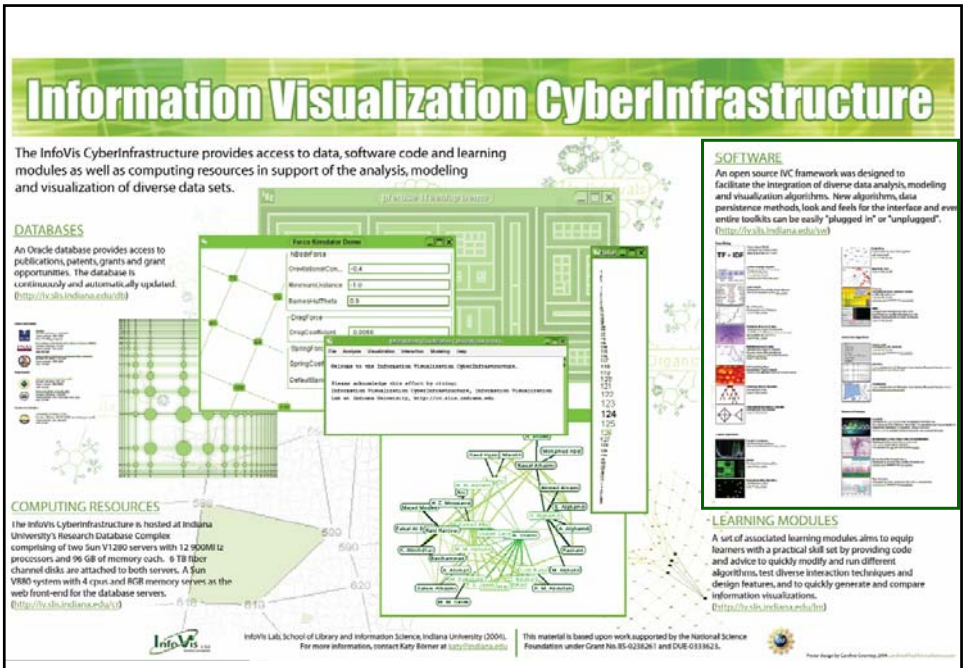
Community of Science (COS)
Number of Entries: 38,154 (5,000 new entries per month)
Years covered: 2001-present
Size: 60 MB

Katy Börner, Managing Humanity's Knowl





Katy Börner, Managing Humanity's Knowledge & Expertise, NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004.



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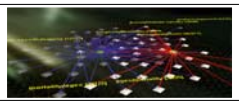
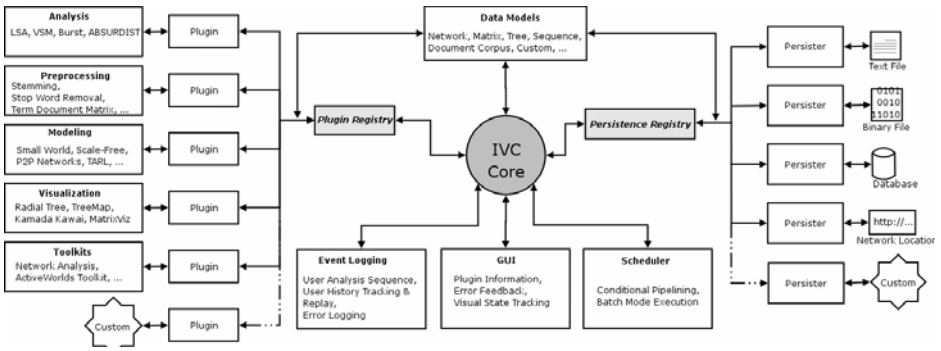


IVC Software Framework (*http://iv.slis.indiana.edu/iv*)



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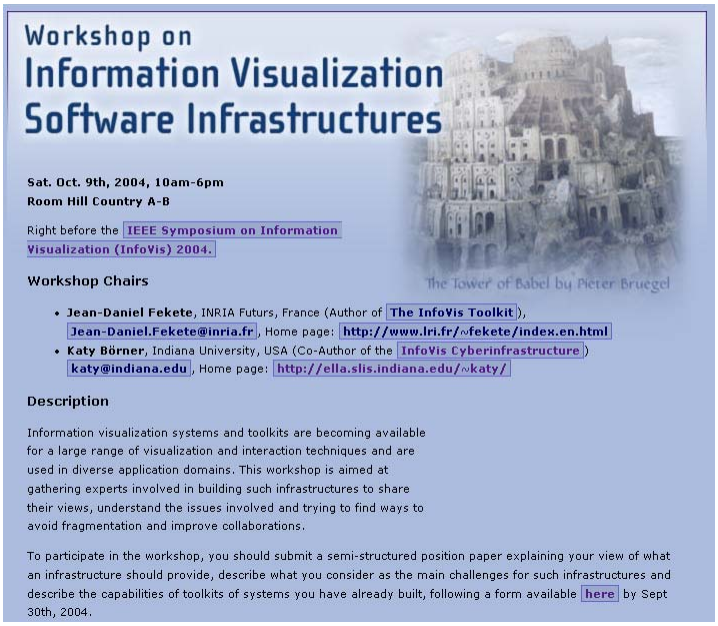


Workshop on
Information Visualization Software Infrastructures

Sat. Oct. 9th, 2004, 10am-6pm
Room Hill Country A-B

Right before the **IEEE Symposium on Information Visualization (InfoVis) 2004.**

Workshop Chairs

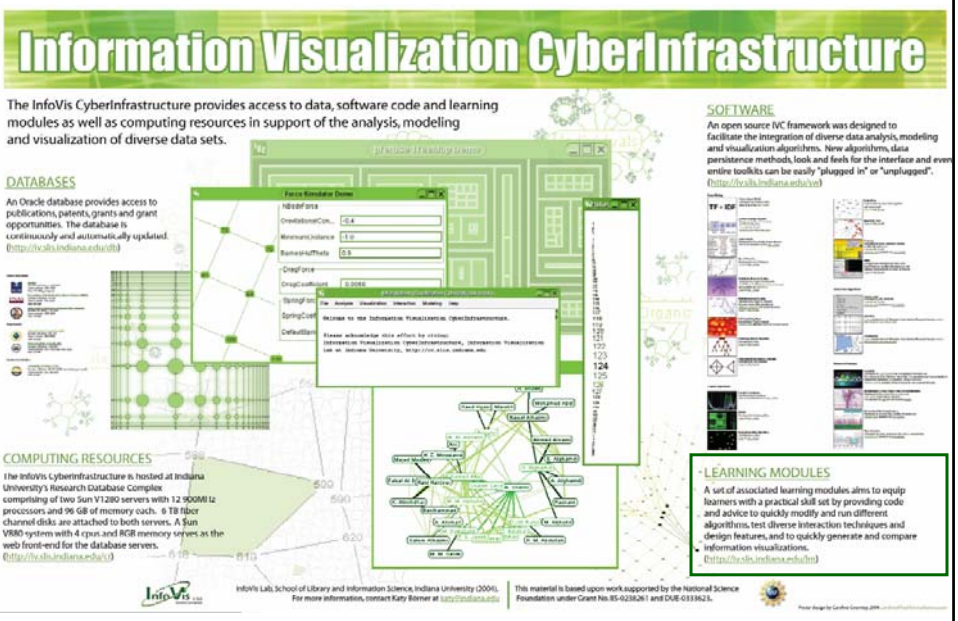
- **Jean-Daniel Fekete**, INRIA Futurs, France (Author of **The InfoVis Toolkit**), **Jean-Daniel.Fekete@inria.fr**, Home page: **http://www.lri.fr/~fekete/index.en.html**
- **Katy Börner**, Indiana University, USA (Co-Author of the **InfoVis Cyberinfrastructure**) **katy@indiana.edu**, Home page: **http://ella.slis.indiana.edu/~katy/**

Description

Information visualization systems and toolkits are becoming available for a large range of visualization and interaction techniques and are used in diverse application domains. This workshop is aimed at gathering experts involved in building such infrastructures to share their views, understand the issues involved and trying to find ways to avoid fragmentation and improve collaborations.

To participate in the workshop, you should submit a semi-structured position paper explaining your view of what an infrastructure should provide, describe what you consider as the main challenges for such infrastructures and describe the capabilities of toolkits of systems you have already built, following a form available **here** by Sept 30th, 2004.

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



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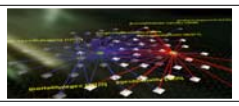


IVC Learning Modules (http://iv.slis.indiana.edu/lm)

InfoVis CyberInfrastructure

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

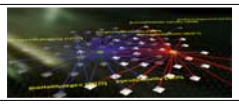
Home | Learning Modules | Software | Data Bases | Compute Resources | References

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)



Visualizing Tree Data

http://iv.slis.indiana.edu/lm/lm-trees.html

InfoVis CyberInfrastructure

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

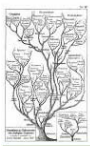
Home | Learning Modules | Software | Data Bases | Compute Resources | References

Learning Modules > Visualizing Tree Data

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

Description

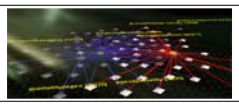
Many data sets come in tree format. There are family trees, organizational charts, classification hierarchies, and directory structures. The figure below shows an inheritance tree by Ernst Haeckel ('Stammbaum' in German). Read also To Draw a Tree by Pat Hanrahan.



Click image for larger version

A tree graph is a set of straight line segments (edges) connected at their ends containing no closed loops (cycles). You can also call it a simple, undirected, connected, acyclic graph (or, equivalently, a connected forest). A tree with n nodes has n-1 graph edges. All trees are bipartite graphs.

Many trees have a root node and are called rooted trees. Trees without a root node are called free trees. Subsequently, we will only consider rooted trees. In rootes trees, all nodes except the root node have only one parent node. Nodes which have no children are called leave nodes. All other nodes are referred to as intermediate nodes.



Student's Project Results

User & Task Analysis for Visualizing Tree Data

- Visualizing the structure of IU's Decision Support System
- Visualizing the co-occurences of keywords in DLib Magazine articles.
- Visualization of the Java API
- Visualizing the the Library of Congress Classification System to retrieve legal materials in a library.

See Handin pages at
http://ella.slis.indiana.edu/~katy/handin/L579-S04/cgi/handinlogin.cgi

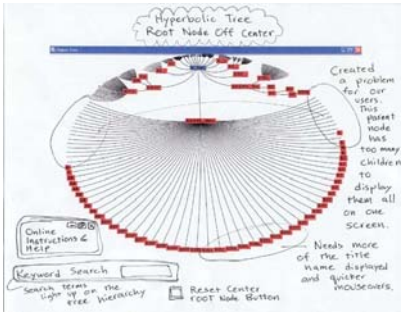
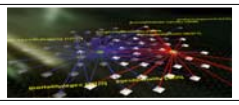
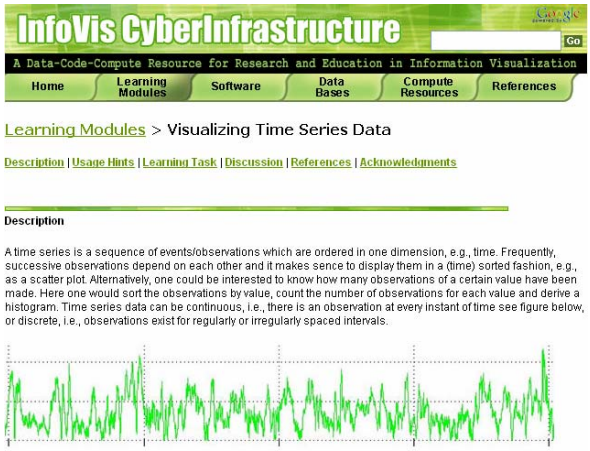


Image by Peter Hook and Rongke Gao



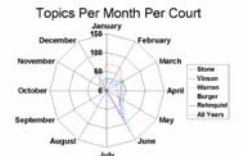
Time Series Analysis & Visualization

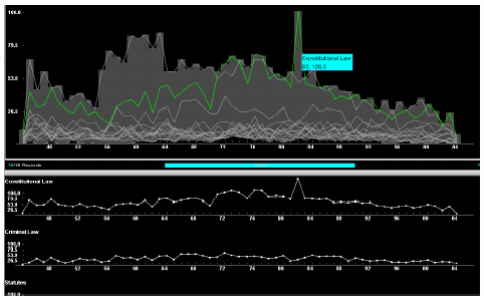
http://iv.slis.indiana.edu/lm/lm-time-series.html



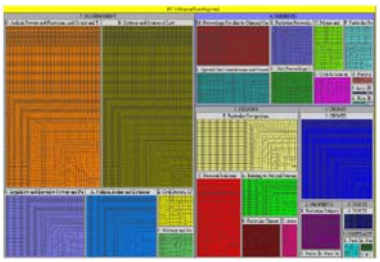
Visualizing the Work of the United States Supreme Court Based on Time Data and Top Level West Topics

by Peter A. Hook & Rongke Gao

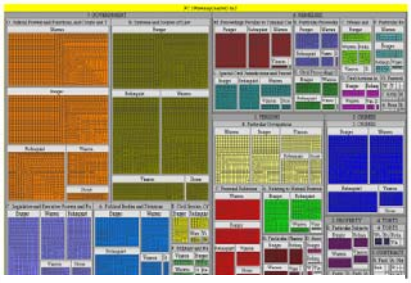




Top fifteen most occurring topics from 1944 to 2004 in Timesearcher



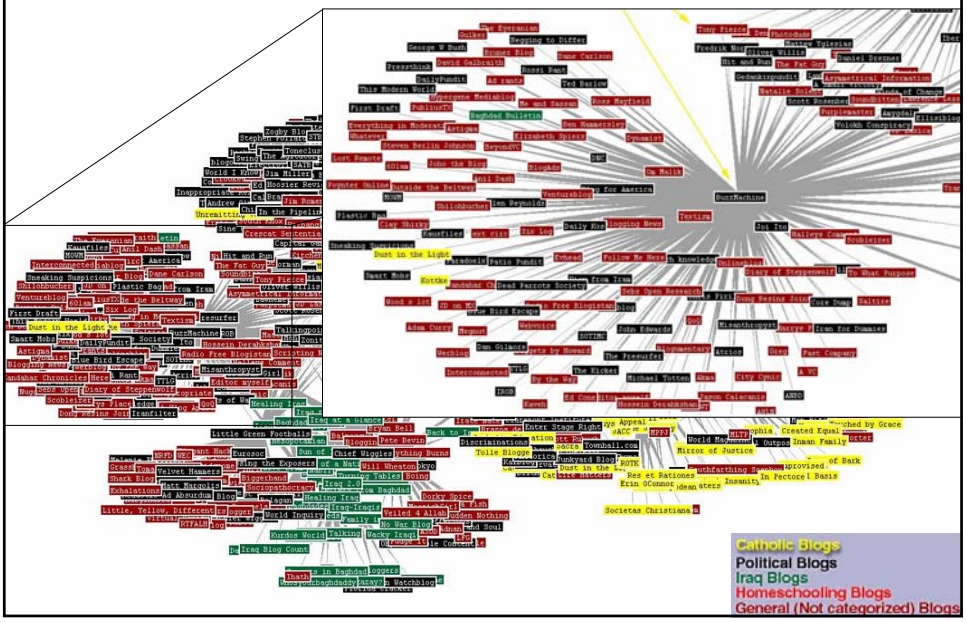
All topics grouped by West Category and Sub-Category grouped over the entire lengths of the data set

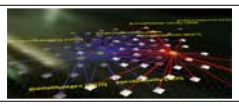


All topics by West Category and Sub-Category grouped corresponding to the five chief justices

Visualizing Niches of the Blog Universe

By Mike Tyworth and Elijah Wright

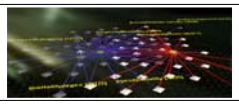




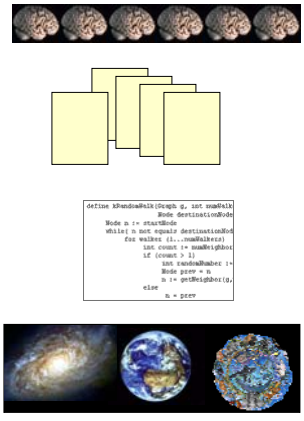
Given the steadily increasing flood of information, how can we keep track and make use of what we <u>collectively</u> know?

- Shift user's mental load from slow reading to faster perceptual processes such as visual pattern recognition.
- Give people global knowledge of the structure and evolution of scientific knowledge. → Global maps of science
- Provide access to knowledge and expertise. → … & expertise
- Aim for reusability of data and methods/approaches/algorithms and reproducibility of results. → Interrelate data, code, results, authors.
- Use usage log data to support social navigation and to create novel reputation systems. → … & usage data. **Basically, a new infrastructure to keep track of knowledge.**

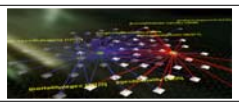
Katy Börner, Managing Humanity's Knowledge & Expertise, NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004.



Data-Code-Computing Cyberinfrastructures that Interrelate Data, Code, Papers, Authors & Usage Data



Katy Börner, Managing Humanity's Knowledge & Expertise, NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004.

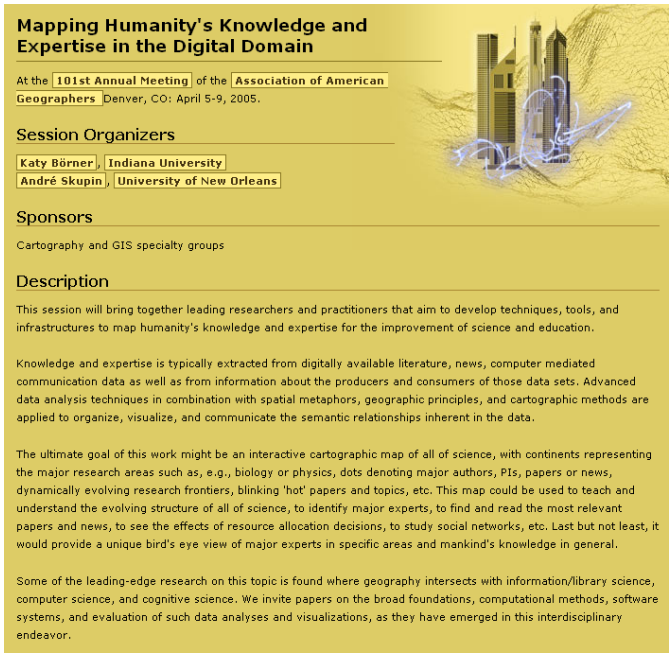


Data-code-computing cyberinfrastructures that interrelate data, code, results, authors, and usage data

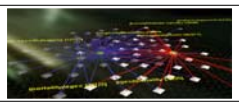
- Enable data/algorithm/result comparison at data/code/data level.
- Facilitate new types of searches, e.g., retrieve all users that worked with data set x, retrieve all papers that used algorithm y.
- Support algorithm comparison and re-use, e.g., the re-application of an algorithm sequence reported in a paper to a different data set.

- Do provide bridges between algorithm developers and users.
- Could provide a great testbed application for novel ways to store, preserve, integrate, correlate, access, analyze, map or interact with data.
- Are of interest to diverse communities.

Katy Börner, Managing Humanity's Knowledge & Expertise, NSF IIS/CISE Talk, Room 1120, Oct 20th, 2004.



http://vw.indiana.edu/aag05



Acknowledgements & References

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