Information Visualizations that Improve Access to Scholarly Knowledge and Expertise

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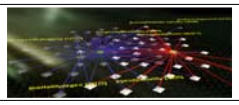
ACM Board Meeting, NYC, Oct 22nd, 2004



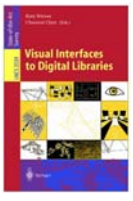
Users and Tasks

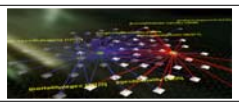
Michel Beaudouin-Lafon suggested to

- "explain the kind of things one can discover/understand with information visualization" and
- "what it takes to generate such visualizations (in terms of quality of the metadata, for example)."

Tasks that might benefit from visualizations:

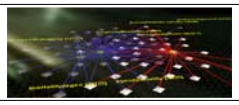
- New tools to access the DL, which could include visualization tools, e.g. in conjunction with the author pages, the co-authorship lists, etc.
- Supporting social navigation based on download statistics.
- Finding a new editor-in-chief for a journal.
- Evaluation of journal proposals (whether it's a timely proposal, whether there really is a field behind it, etc.).
- Proactive encouragement of new publications in a given area.





Overview

1. Visual Interfaces to Digital Libraries
2. Knowledge Domain Analysis and Visualizations
3. Cyberinfrastructure for InfoVis/KDVis Research
4. Managing Humanity's Knowledge and Expertise



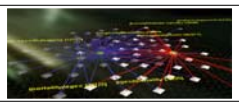
1) Visual Interfaces to Digital Libraries

Facing the Information Flood:

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

- Almost no development in online interfaces. Can't pack more text.

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

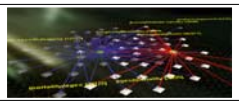


8 years back in time

Yahoo Oct 17, 1996

Yahoo Oct 19, 2004

Katy Börner, ACM Board Meeting in New York, Oct 22, 2004.



5 years back in time

Amazon Sept 02, 1999

Amazon Oct 19, 2004

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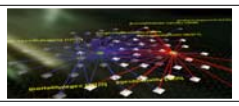

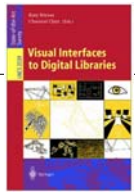

Facing the Information Flood:

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

Opportunity & Challenge:

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).

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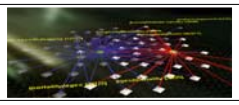
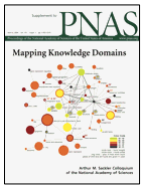


2) Knowledge Domain Analysis and Visualization

To 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.

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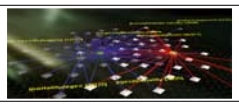
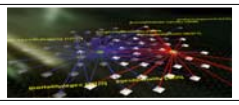


User Groups

- **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**.



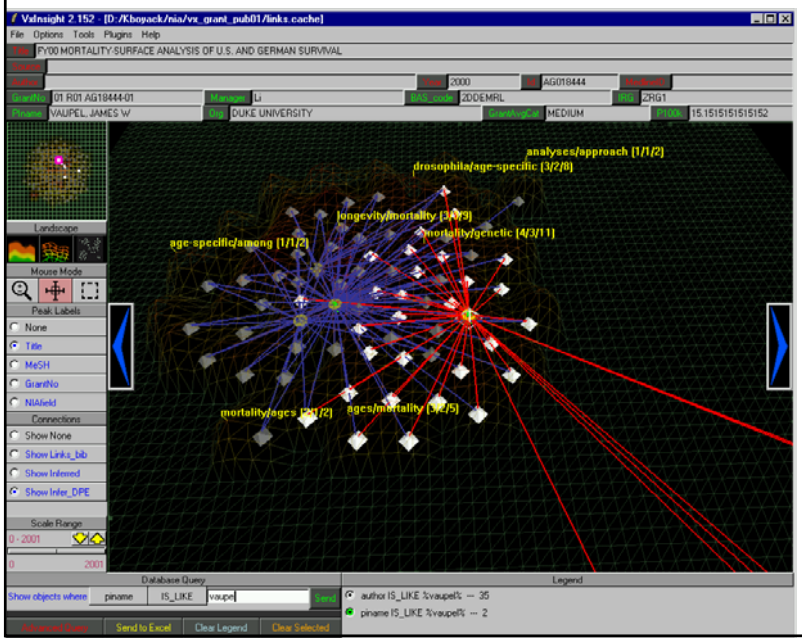
Process of Mapping Knowledge Domains

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

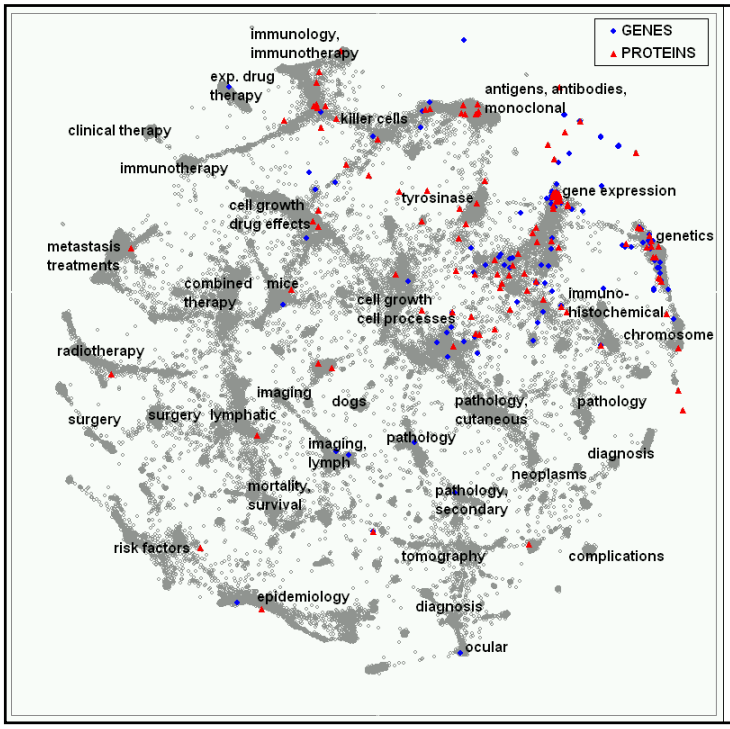
Visualizing the influence of grants on the number and citation counts of research papers (Boyack & Börner, 2003)



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.



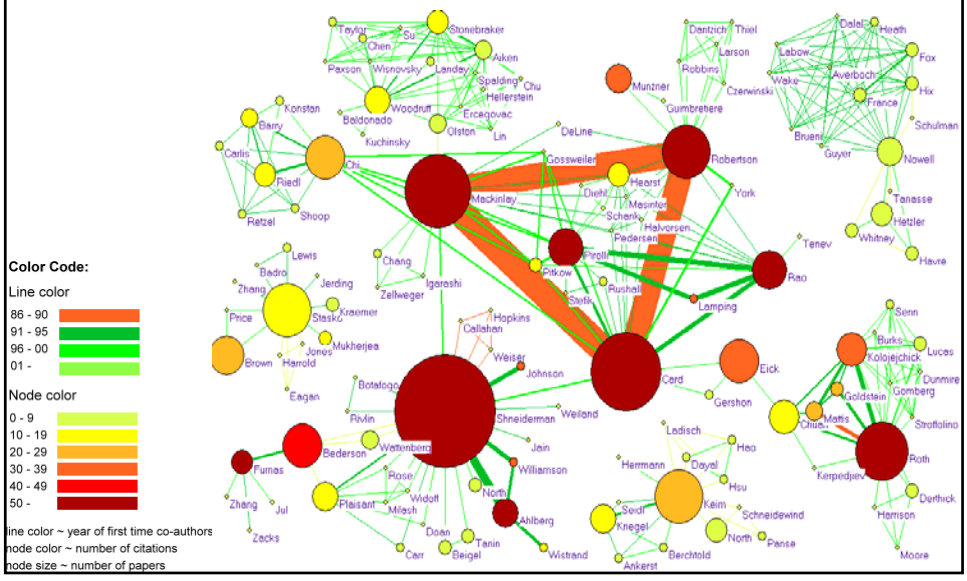
Mapping Medline Papers, Genes, and Proteins Related to Melanoma Research

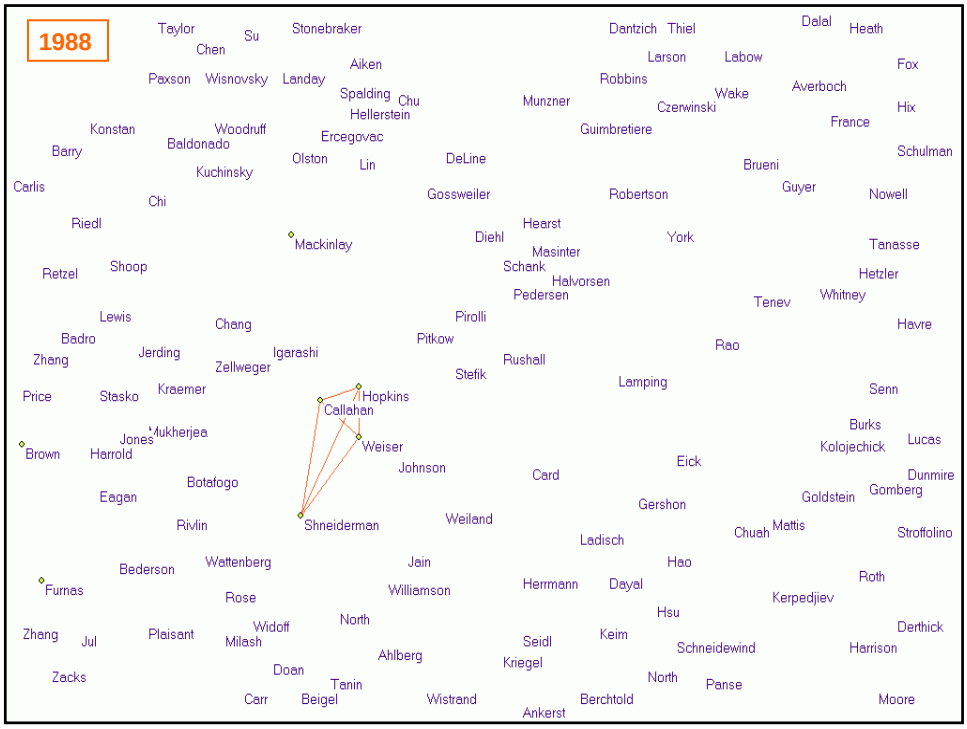
(Boyack, Mane & Börner, 2004)

Mapping the Evolution of Co-Authorship Networks

Won 1st price at the IEEE InfoVis Contest

(Ke, Visvanath & Börner, 2004)

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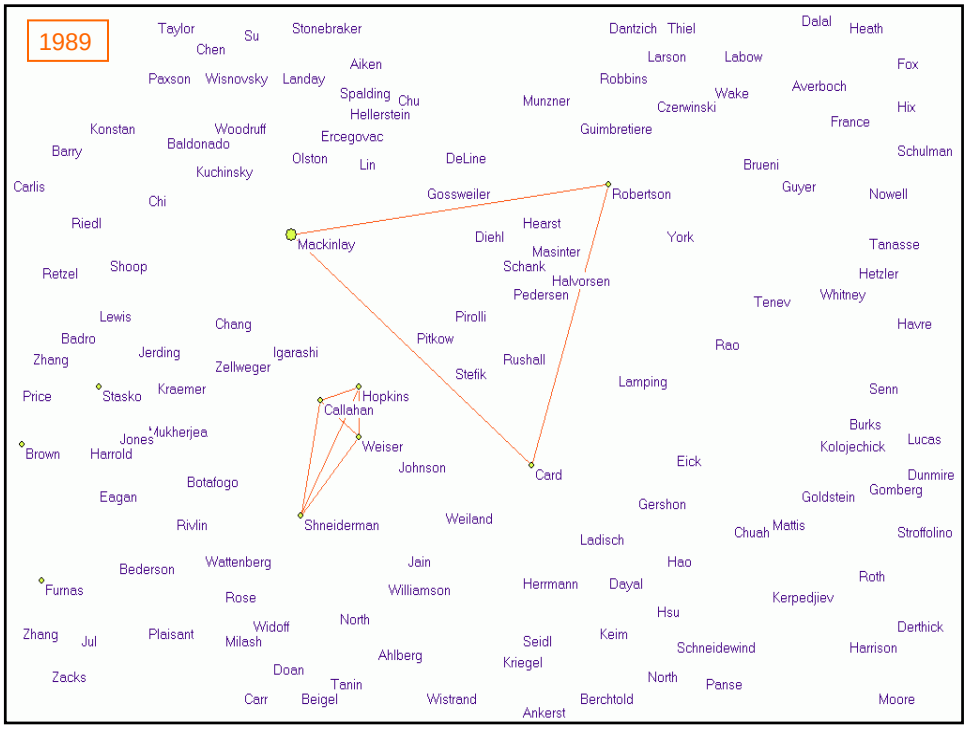
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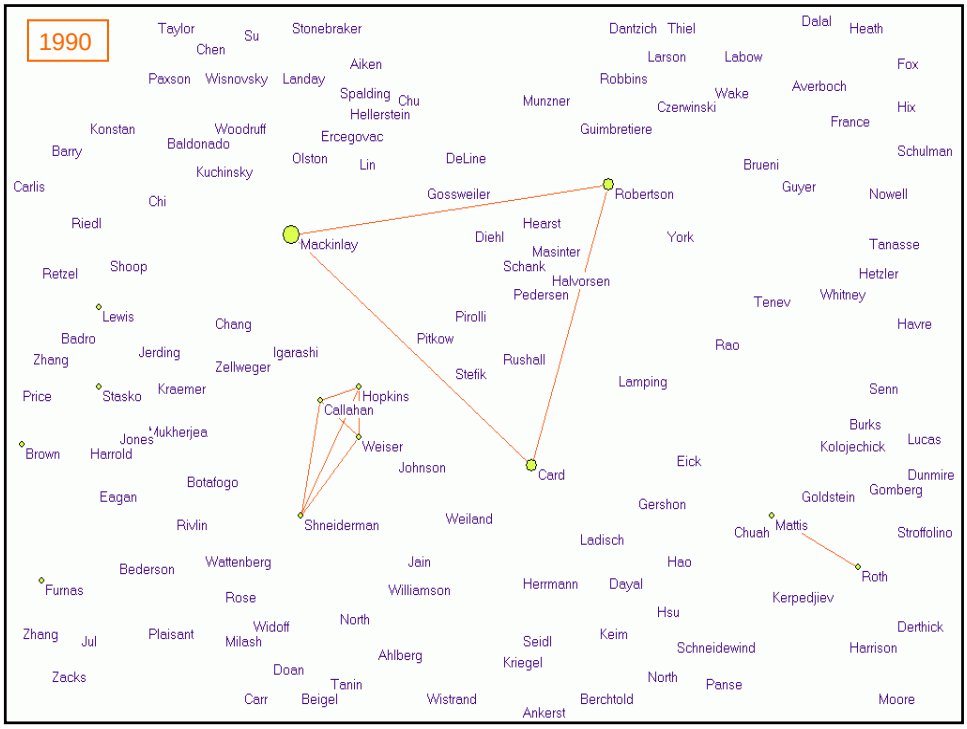
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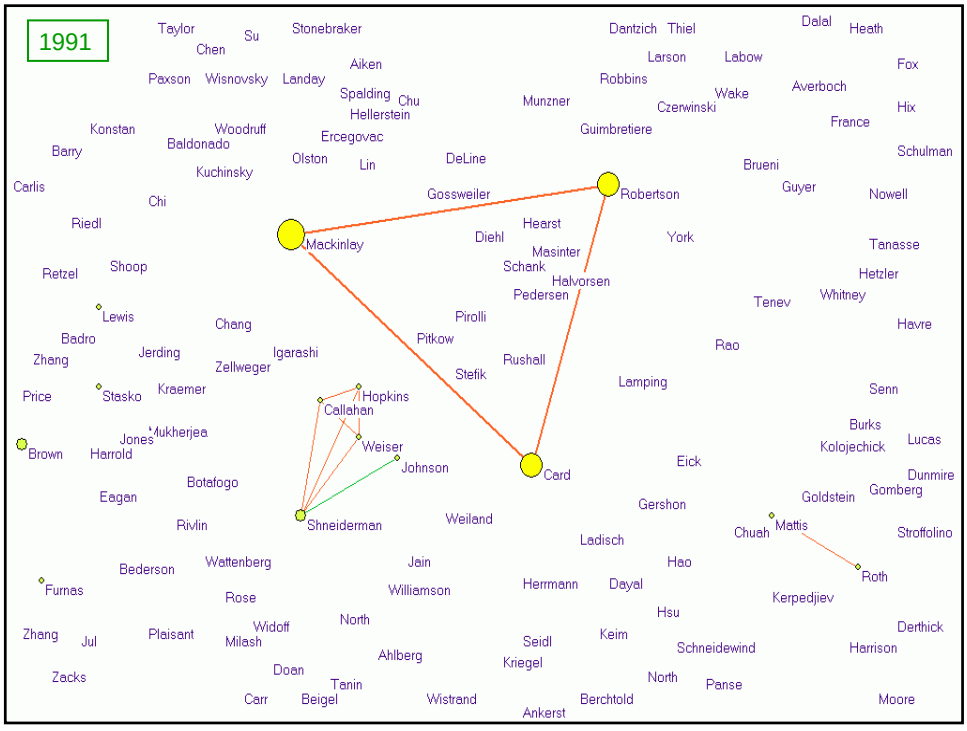
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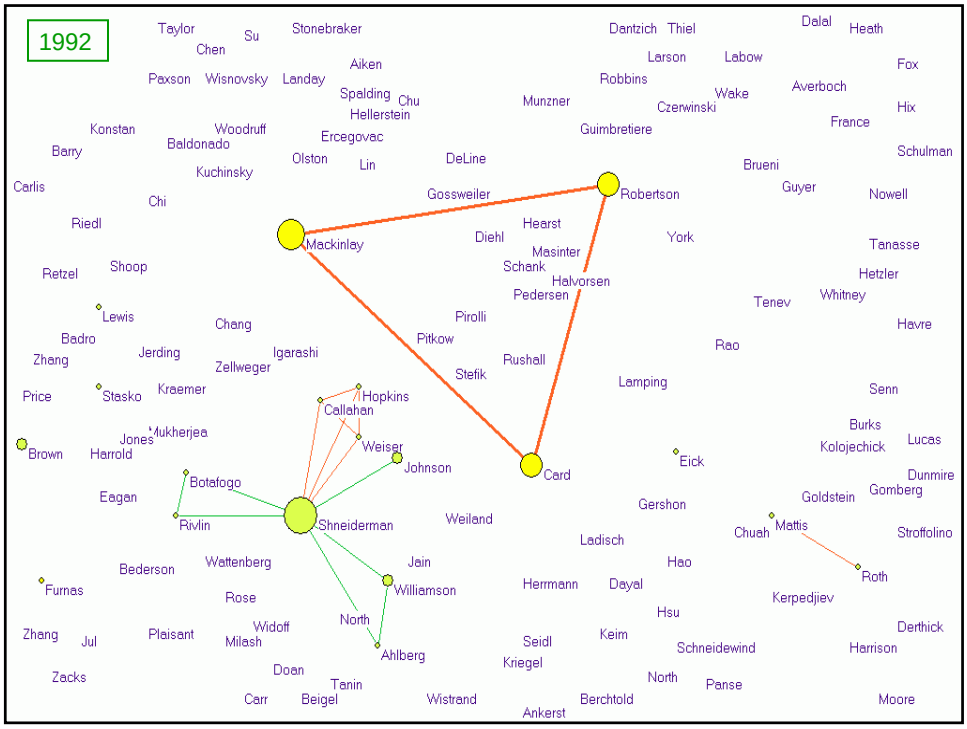
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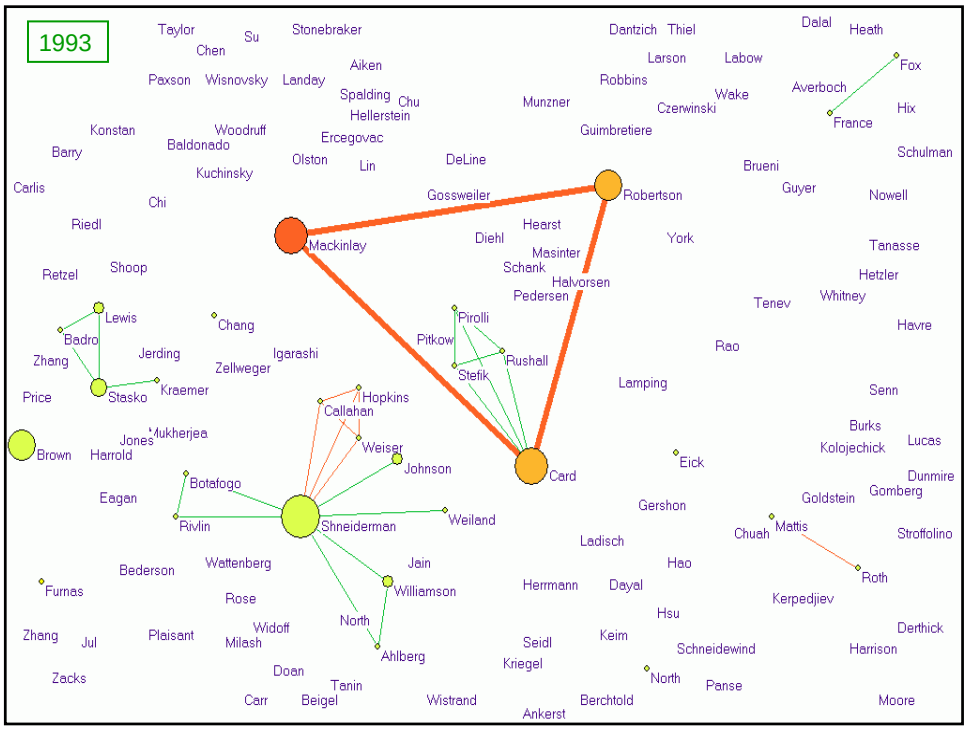
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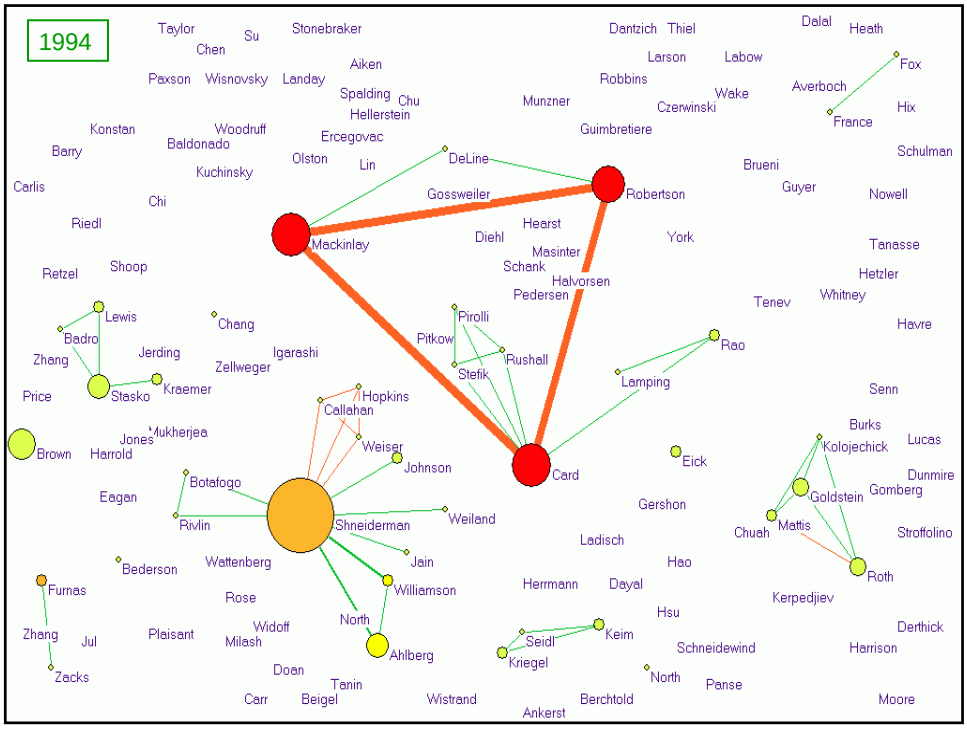
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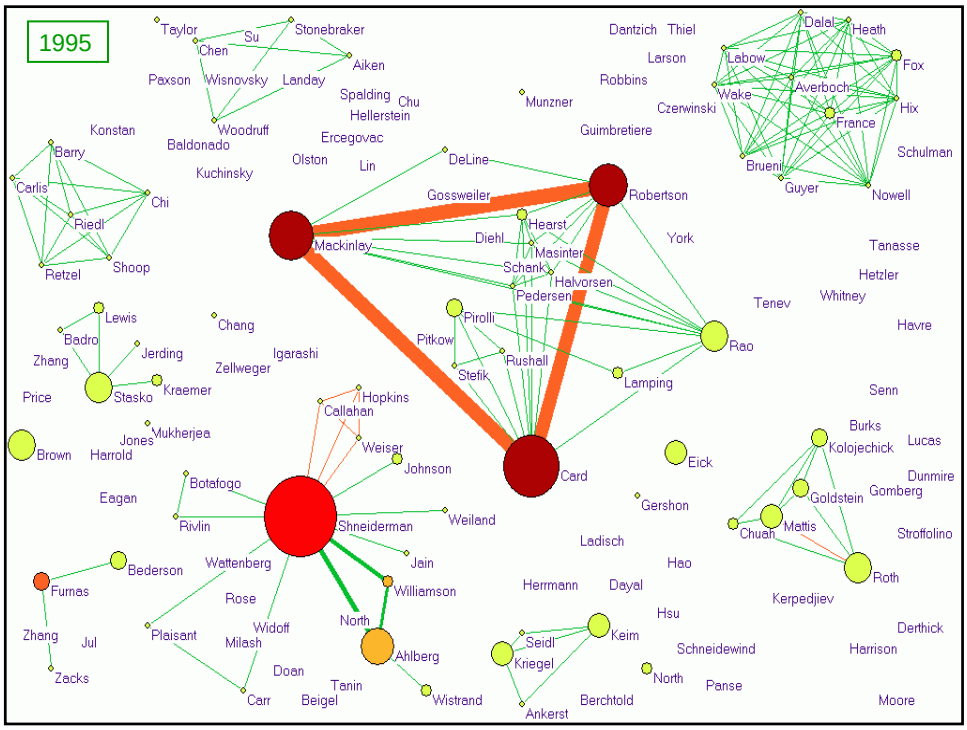
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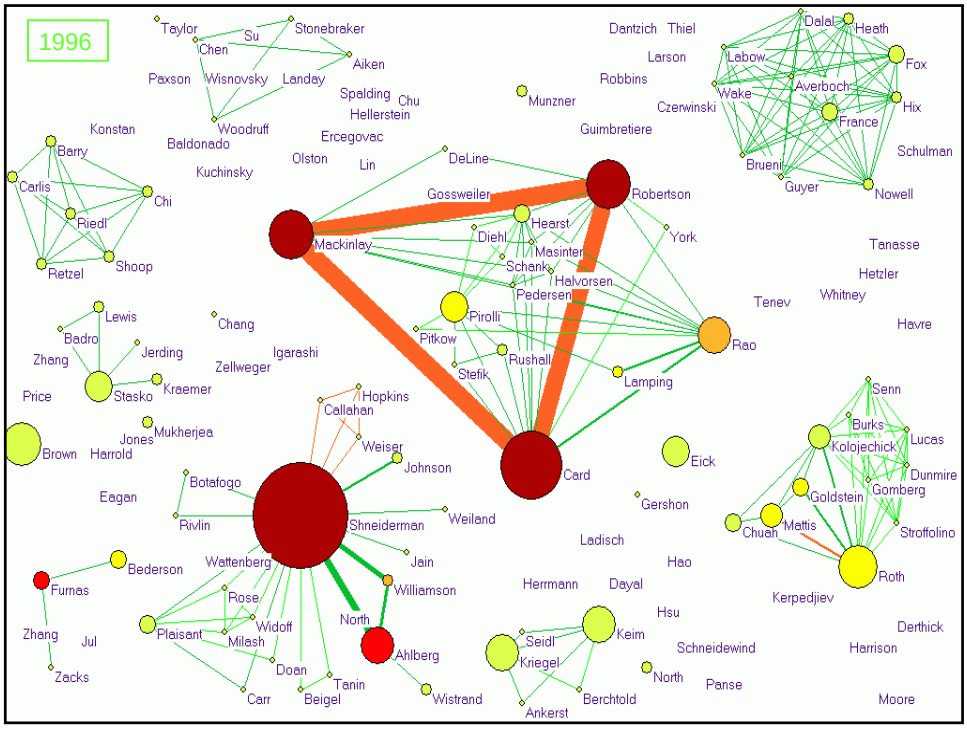
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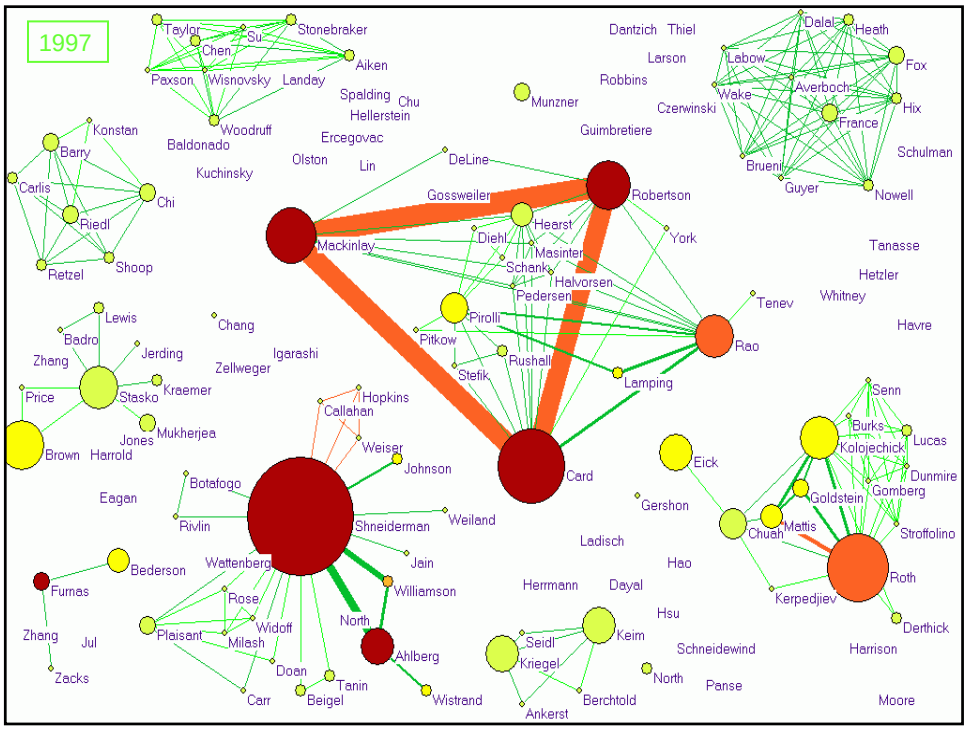
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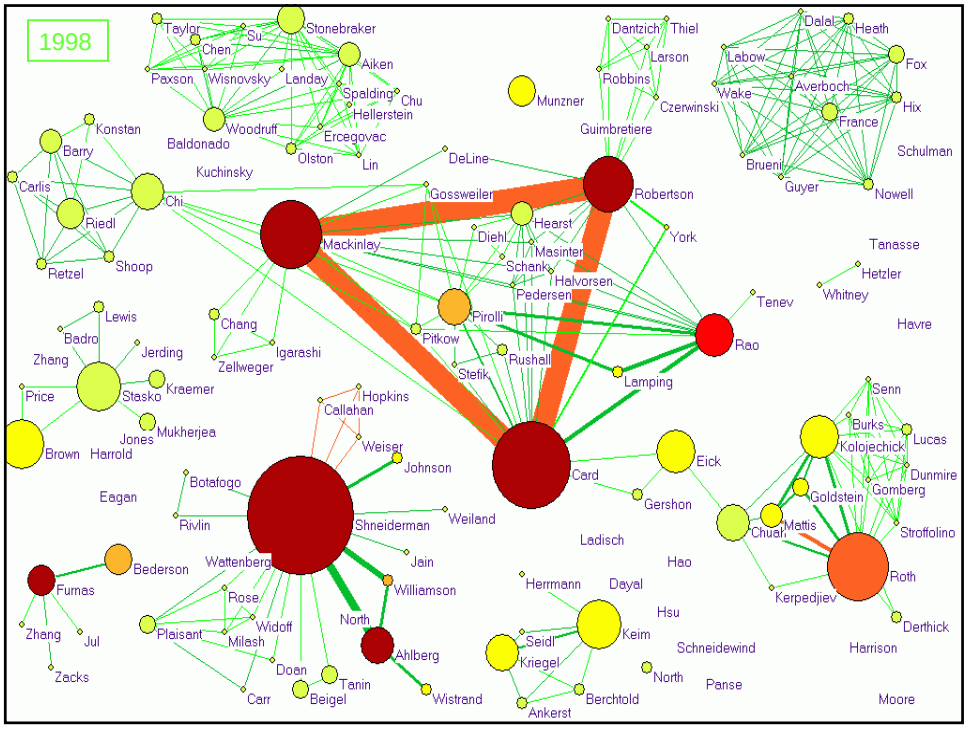
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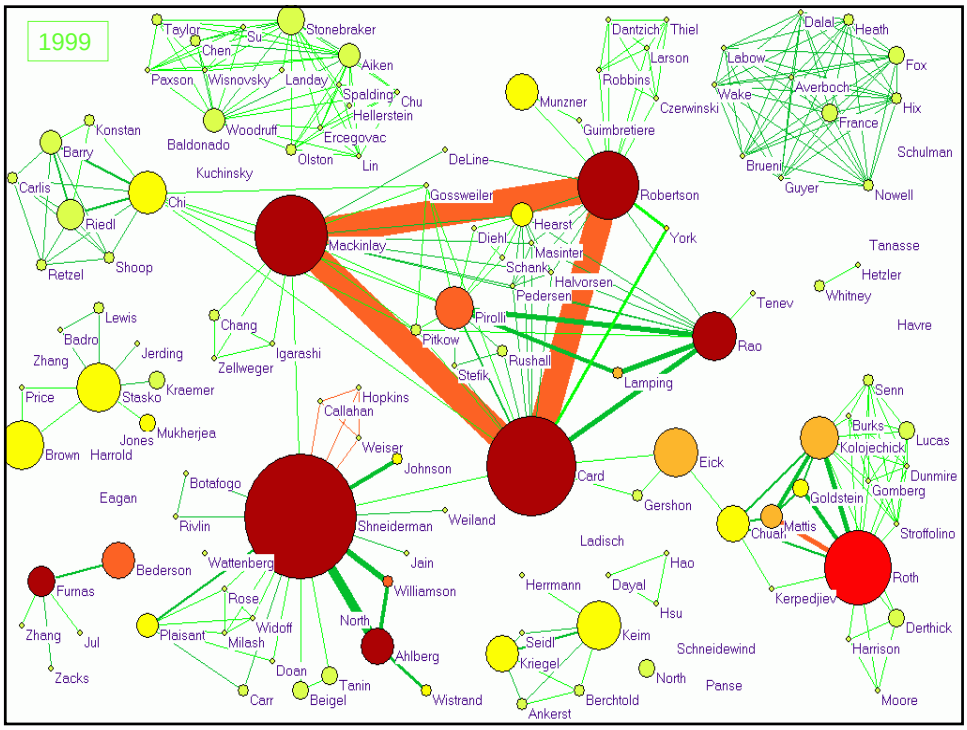
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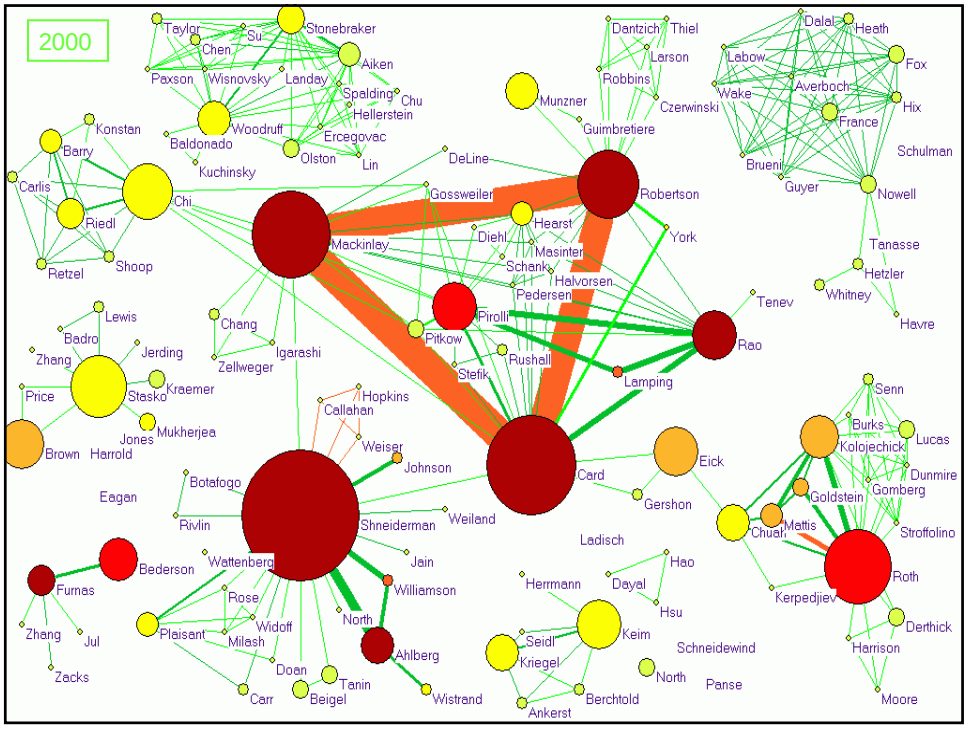
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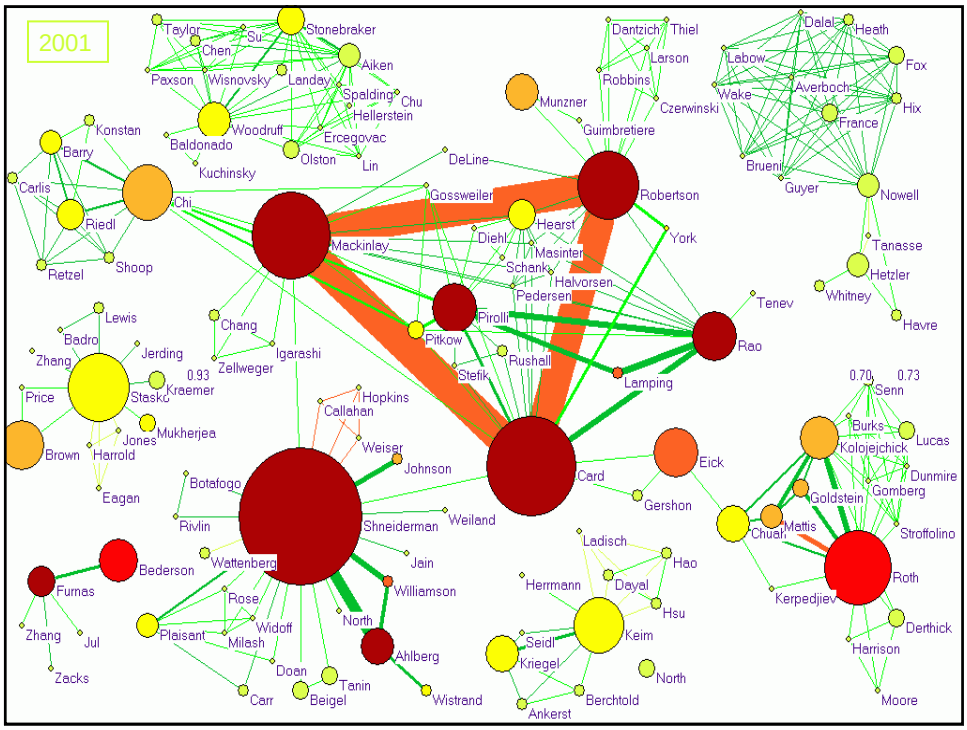
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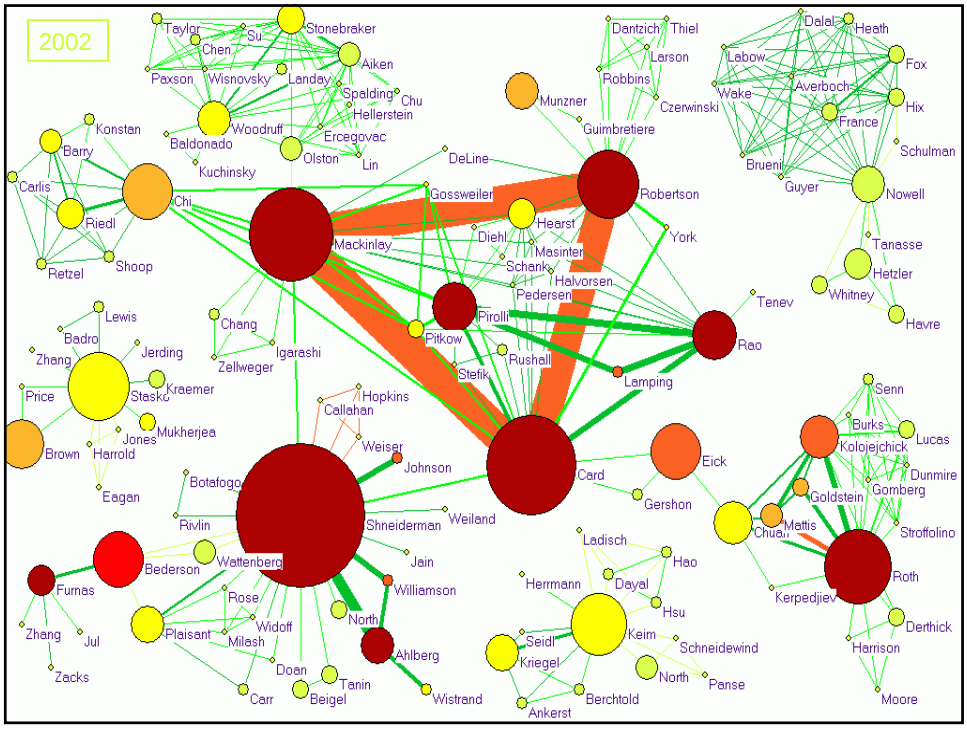
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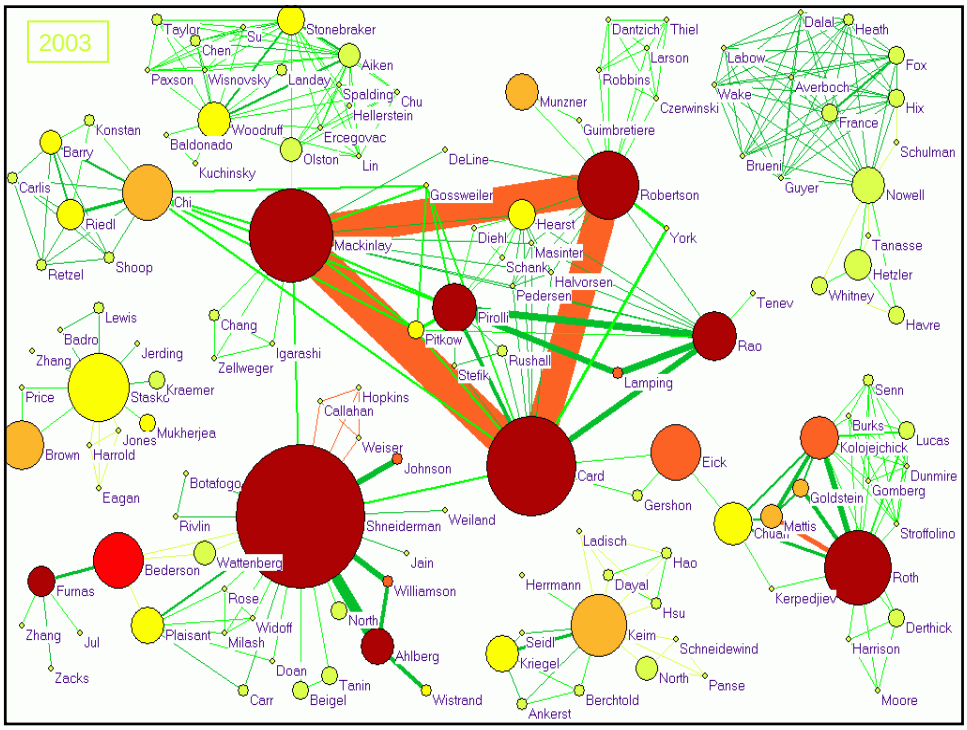
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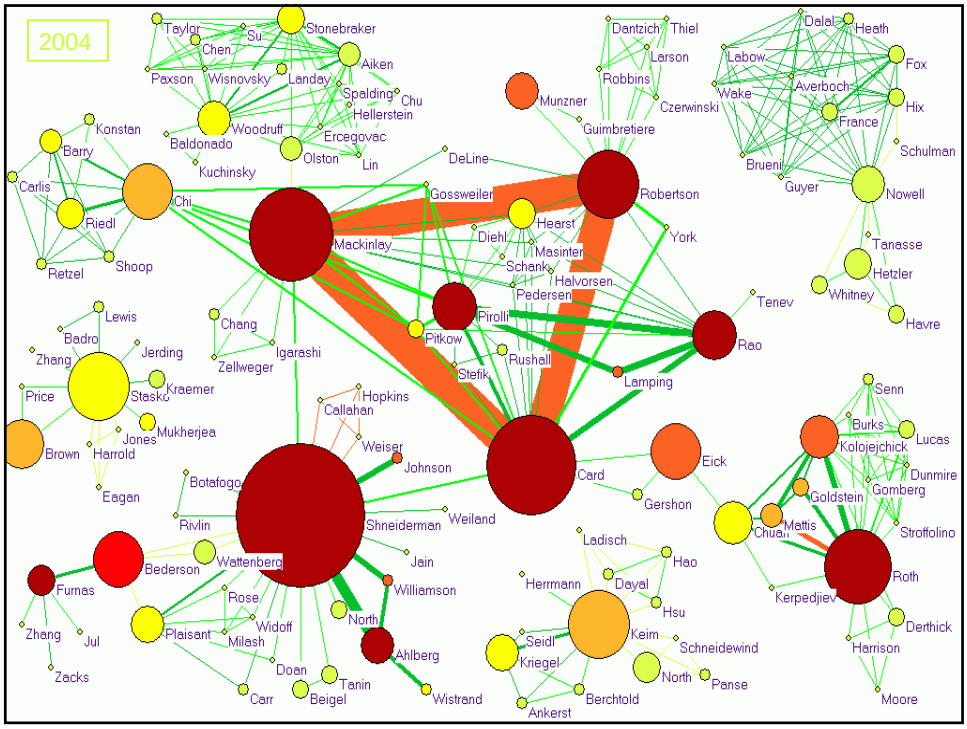
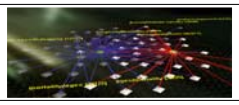
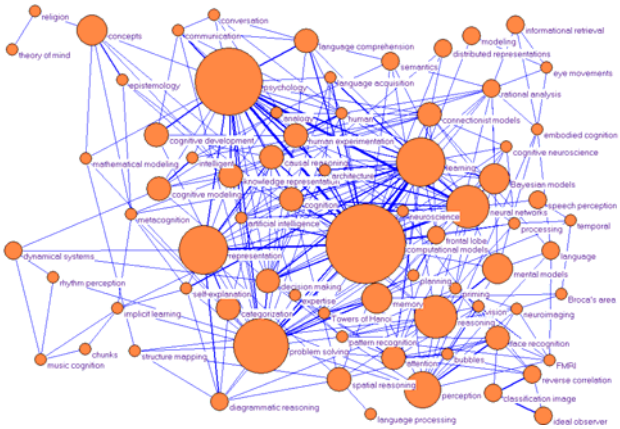
Goldstein
Gomberg
Chua
Mattis
Stroffolino
Roth
Kerpedjiev
Derthick
Harrison
Moore
Ladisch
Hao
Herrmann
Dayal
Hsu
Keim
Schneidewind
Seidl
Kriegel
North
Panse
Berchtold
Ankerst





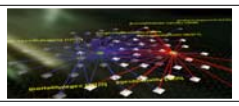
Cognitive Science 1989-2004, Editorial by R. Goldstone

(*Ke & Börner, 2004*)

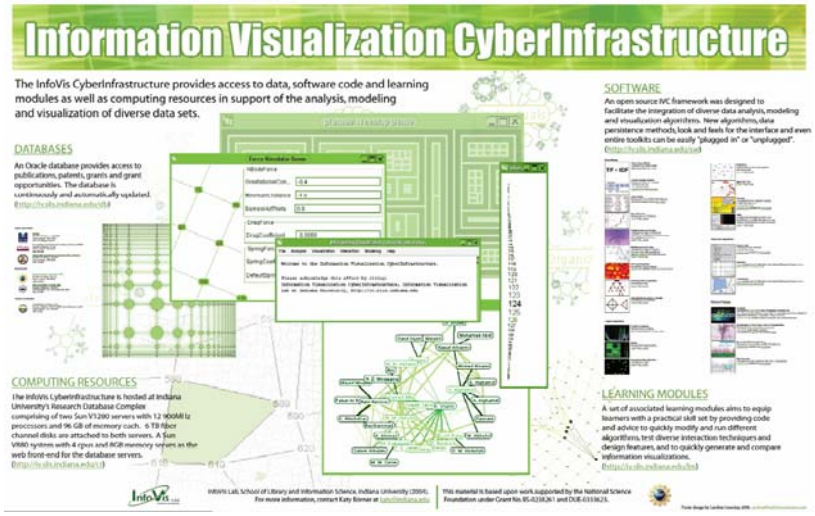


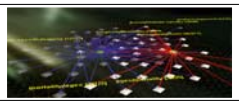
"As Figure 1 shows, there is some danger of *Cognitive Science* becoming too dominated by psychology. In the journal's recent past, we have had strong representation from many mainstays of cognitive science including learning, neuroscience, problem solving, language, reasoning, computational modeling, and representation. However, the presence of philosophy, anthropology, artificial intelligence, and machine learning seems sparser than is warranted by their historical influence on cognitive science. Monitoring the diversity of the journal and field is critical if we wish to cultivate future developments of general principles that govern intelligent systems in all of their guises."

Katy Börner, ACM Board Meeting in New York, Oct 22, 2004.



3) Cyberinfrastructure for InfoVis and KDVis Research





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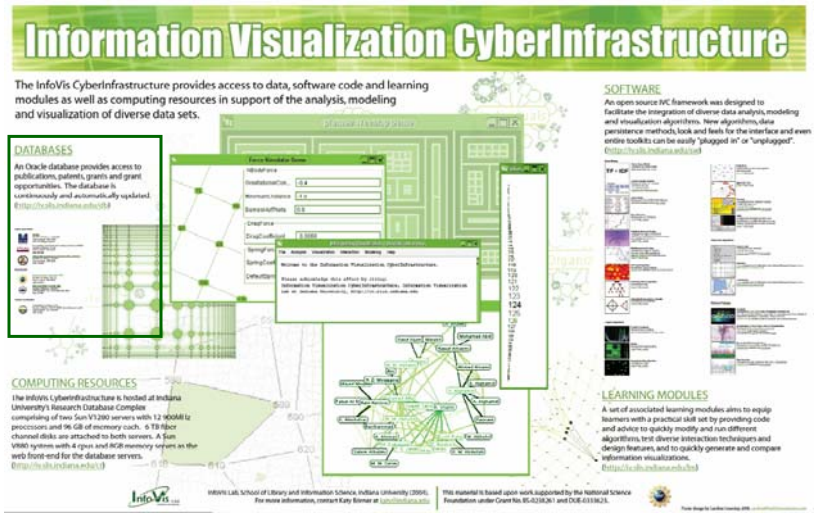
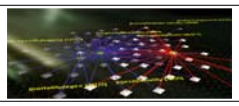

Information Visualization CyberInfrastructure
The InfoVis CyberInfrastructure provides access to data, software code and learning modules as well as computing resources in support of the analysis, modeling and visualization of diverse data sets.
DATABASES
An Oracle database provides access to publications, patents, grants and grant opportunities. The database is continuously and automatically updated.
SOFTWARE
An open source IVC framework was designed to facilitate the integration of diverse data analysis, modeling and visualization algorithms. New algorithms, data persistence methods, look and feels for the interface and even entire toolkits can be easily "plugged in" or "unplugged".
COMPUTING RESOURCES
The InfoVis CyberInfrastructure is hosted at Indiana University's Research Database Complex comprising of two Sun V1280 servers with 12 900MHz processors and 96 GB of memory each. 6 TB fiber channel disks are attached to both servers. A Sun V880 system with 4 cpus and 8GB memory serves as the web front-end for the database servers.
LEARNING MODULES
A set of associated learning modules aims to equip learners with a practical skill set by providing code and advice to quickly modify and run different algorithms, test diverse interaction techniques and design features, and to quickly generate and compare information visualizations.
InfoVis Lab, School of Library and Information Science, Indiana University (2004).
This material is based upon work supported by the National Science Foundation under Grant No. IIS-0238261 and DUE-0333623.

Katy Börner, ACM Board Meeting in New York, Oct 22, 2004.



IVC DB Data Sets (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

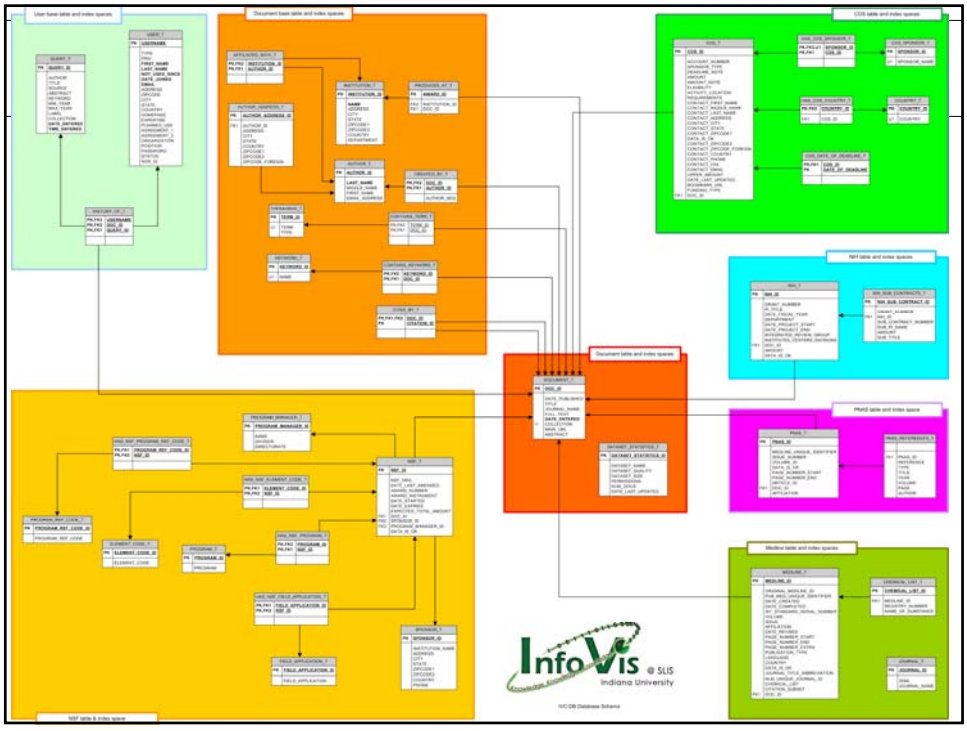
Grant Awards

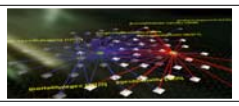
National Science Foundation (NSF)
Number of Entries: 181,132
Years covered: 1985-2002
Size: 400 MB

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



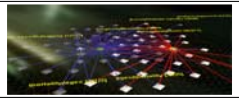


4) How to Manage Humanity's Knowledge and Expertise

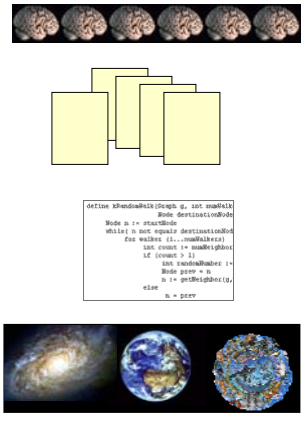
Given the steadily increasing flood of information, how can we keep track and make use of what we collectively know?

- Shift user's mental load from slow reading to faster perceptual processes such as visual pattern recognition.
- 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.**
- Give people global knowledge of the structure and evolution of scientific knowledge. → Global maps of science
- Provide access to knowledge and expertise. → … & expertise

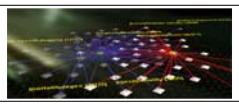
Katy Börner, ACM Board Meeting in New York, Oct 22, 2004.



Interrelate Data, Code, Papers, Authors & Usage Data



Katy Börner, ACM Board Meeting in New York, Oct 22, 2004.

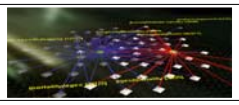


Data-code-computing cyberinfrastructures that interrelate data, code, results, authors, and usage data

- 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, ACM Board Meeting in New York, Oct 22, 2004.



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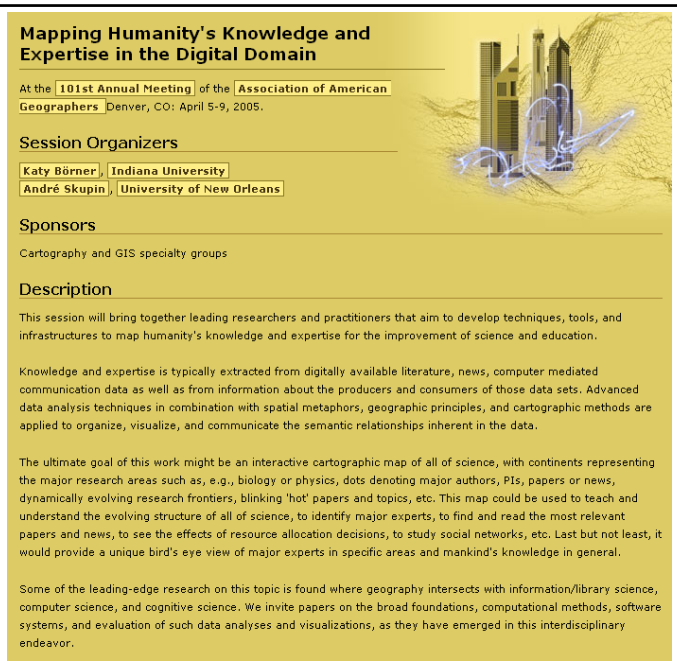


Mapping Humanity's Knowledge and Expertise in the Digital Domain

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

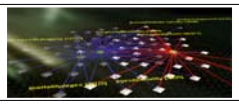
This session will bring together leading researchers and practitioners that aim to develop techniques, tools, and infrastructures to map humanity's knowledge and expertise for the improvement of science and education.

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



Acknowledgements & References

Support comes from the School of Library and Information Science, Indiana University's High Performance Network Applications Program, a Pervasive Technology Lab Fellowship, an Academic Equipment Grant by SUN Microsystems, NIA, and an SBC (formerly Ameritech) Fellow Grant. This material is based upon work supported by the National Science Foundation under Grant No. DUE-0333623 and IIS-0238261.

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