Analyzing and Communicating the Structure and Evolution of Science

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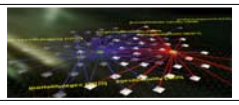
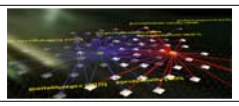
Colloquium Talk, Department of History and Philosophy of Science, IUB
Ballantine 003, Friday, Nov 12, 2004, 1:30 p.m. - 3:30 p.m.



Overview

1. Motivation for today's talk
   - Goals of History & Philosophy of Science vs. Scientometrics/Bibliometrics
   - Small-scale vs. large-scale data analysis & visualization
   - Opportunities and challenges for studying the structure and evolution of all of science
2. Overview of different data analysis and visualization techniques
   - Time space: Tree of life, genealogies, etc.
   - Time-geographic space: Lifelines, etc.
   - (Time-)semantic spaces: Mapping knowledge domains
   - (Time-)social spaces: Social networks
   - Etc.
3. Data bases, software & computing infrastructure at IUB
4. Related courses, talk series, workshops & conferences



1. Motivation

About 40 years ago, Derek J. deSolla Price suggested studying the structure and evolution of science using the scientific methods of science.

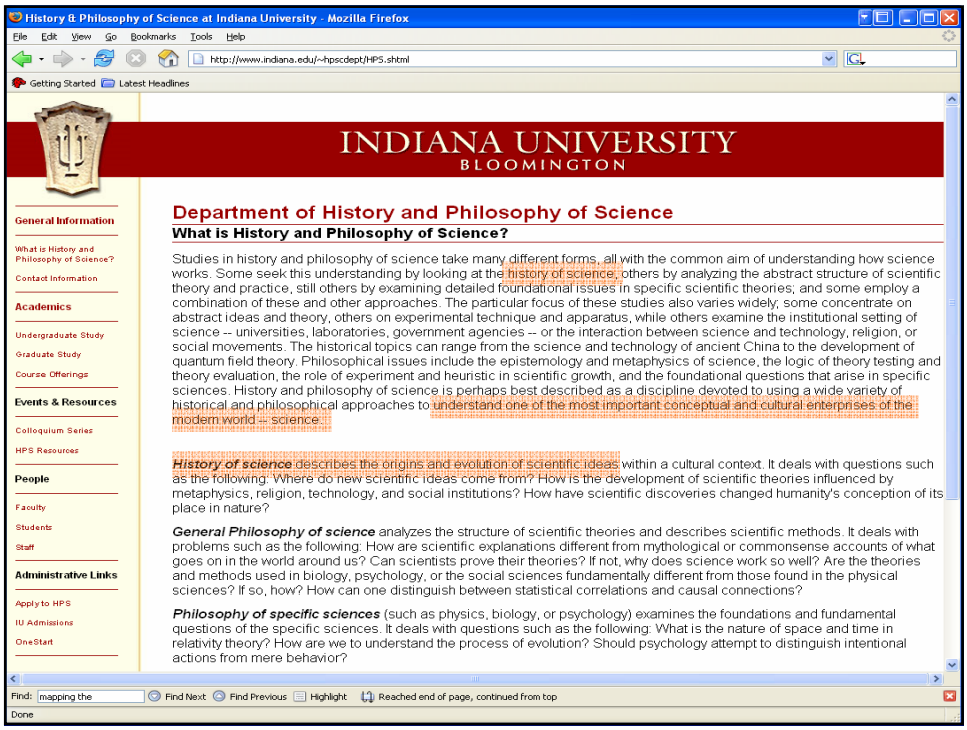
We now do have the data, code and compute power to do this!

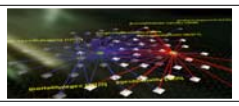
"Philosophy of science without history of science is empty; history of science without philosophy of science is blind."

Imre Lakatos (1970) evocatively rephrased Immanuel Kant's famous remark about the complementarity of 'concepts' and 'percepts'.

We need to understand the structure and evolution of science to make the scientific enterprise more effective – in terms of the production of new (interdisciplinary) research results as well as in terms of information diffusion.

Katy Börner: Analyzing and Communicating the Structure and Evolution of Science, History and Philosophy of Science Talk, IUB, Nov 12, 2004.

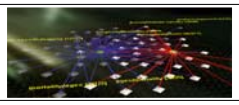




Goals of History & Philosophy of Science & Scientometrics/Bibliometrics

Maps of scientific disciplines (*Knowledge Domain Vis.*) attempt to support diverse 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**.



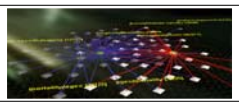
Small-scale vs. large-scale data analysis & visualization

- Many analyses in Bibliometrics/Scientometrics have been conducted on **small-scale** data sets 10-1000 entities (persons, papers, journals, etc.).
- The data was often acquired by hand (using interviews and questionnaires, digital libraries, etc.)
- Data analysis was done by hand or using simple analysis and layout techniques.
- Interpretation of results was possible through expert consultation.

Large-scale data sets require

- to analyze and map 1000-millions of entities – derived from multiple digital libraries.
- New means to validate results (nobody has knowledge of all of science any more).

What dataset sizes are common in today's History & Philosophy of Science studies?



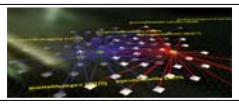
Opportunities and challenges for studying the structure and evolution of all of science

Opportunities:

- Today, many scientific publications are available in digital form (some full text journal data sets go as far back as 120 years).
- We do have algorithms and computing resources to analyze and map science on a large scale.
- Interdisciplinary collaborations are beneficial.

Challenges:

- Data access is difficult.
- Preservation is a big problem.
- Data integration, i.e., merging data from different databases, is a "hot" research topic as are scalable data analysis and visualization algorithms.
- Map interpretation is unresolved – can historians of science and philosophers of science help?



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Resource

- Robert J. O'Hara (1996). "Mapping the Space of Time: Temporal Representation in the Historical Science" *Memoirs of the California Academy of Sciences 20.*

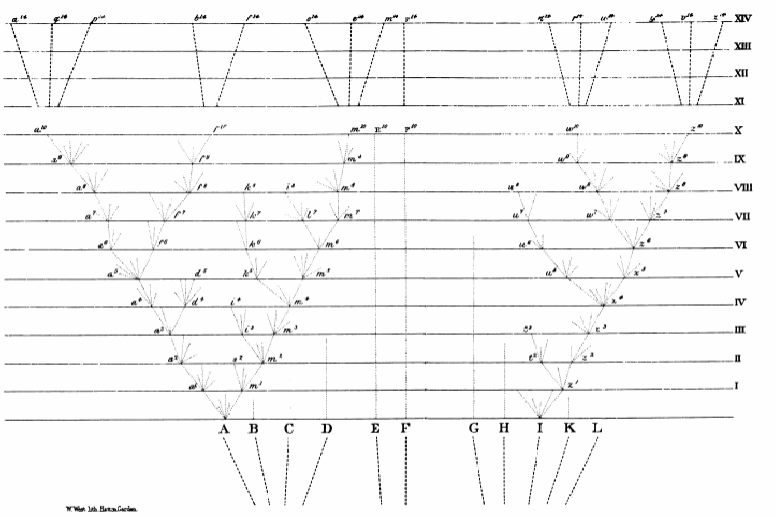

FIGURE 1. The hypothetical tree of life from Darwin's *Origin of Species* (1859). The vertical axis represents time, with each division standing for some arbitrary number of generations.

Robert J. O'Hara (1996). "Mapping the Space of Time: Temporal Representation in the Historical Science" Memoirs of the California Academy of Sciences 20.

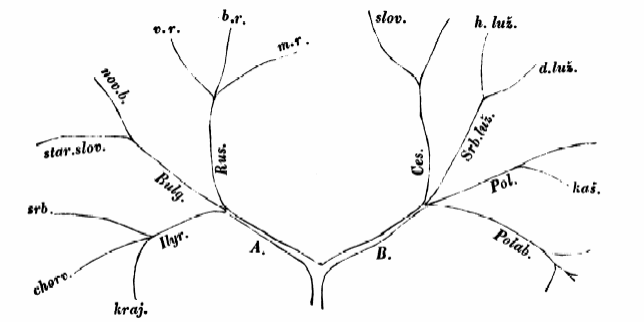

FIGURE 2. A genealogy of the Slavic languages drawn by František Celakovsky at Prague about 1852 and published in 1853 shortly after his death (Celakovsky, 1853; Priestly, 1975). For the only language tree earlier than Celakovsky's (a diagram drawn around 1800 by Félix Gallet) see Auroux (1990).

Robert J. O'Hara (1996). "Mapping the Space of Time: Temporal Representation in the Historical Science" Memoirs of the California Academy of Sciences 20.

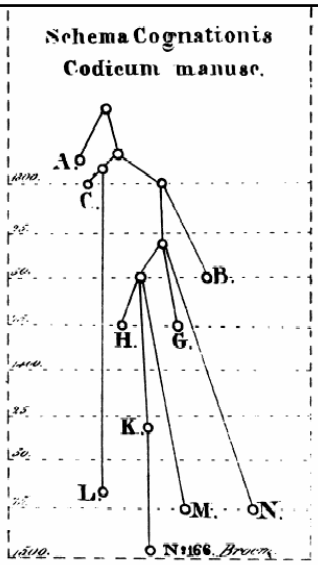

FIGURE 3. Carl Johan Schlyter's stemma of a group of medieval Swedish legal texts, the first diagram of textual transmission ever published (Collin and Schlyter, 1827; Holm, 1972). Notice the remarkable similarity to Darwin's evolutionary diagram, with the vertical axis representing absolute time and horizontal lines indicating time intervals.

Robert J. O'Hara (1996). "Mapping the Space of Time: Temporal Representation in the Historical Science" Memoirs of the California Academy of Sciences 20.

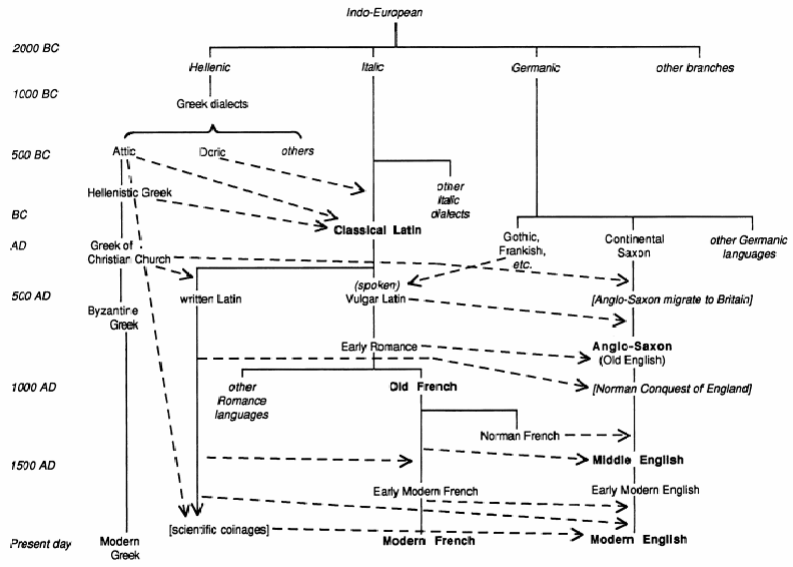

FIGURE 8. A genealogy of selected Indo-European languages, after Powell (1988). In contrast to Figures 6 and 7, which depict only direct transmission, this tree shows not only direct transmission but also borrowing of language elements across the tree.

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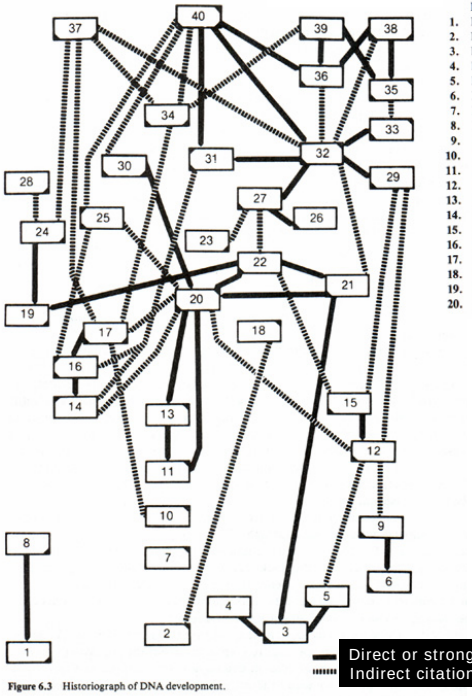


KEY

1. Braconnot 1820
2. Mendel 1865
3. Miescher 1871
4. Flemming 1879
5. Kossel 1886
6. Fischer and Piloty 1891
7. DeVries 1900
8. Fischer 1907
9. Levene and Jacobs 1909
10. Muller 1926
11. Griffith 1928
12. Levene with Mori and London 1929
13. Alloway 1932
14. Stanley 1935
15. Levene and Tipson 1935
16. Bawden and Pirie 1936-1937
17. Caspersson and Schultz 1938-1939
18. Beadle and Tatum 1941
19. Martin and Synge 1943-1944
20. Avery, MacLeod, and McCarty 1944
21. Chargaff 1947
22. Chargaff 1950
23. Pauling and Corey 1950-1951
24. Sanger 1951-1953
25. Hershey and Chase 1952
26. Wilkins 1953
27. Watson and Crick 1953
28. DuVigneaud 1953
29. Todd 1955
30. Palade 1954-1956
31. Fraenkel-Conrat 1955-1957
32. Ochoa 1955-1956
33. Kornberg 1956-1957
34. Hoagland 1957-1958
35. Jacob and Monod 1960-1961
36. Hurwitz 1960
37. Dintzis 1961
38. Novelli 1961-1962
39. Allfrey and Mirsky 1962
40. Nirenberg and Matthaei 1961-1962

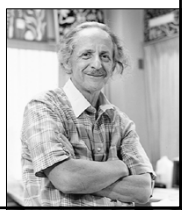
Direct or strongly implied citation
Indirect citation

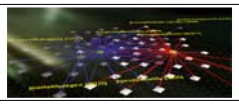
Figure 6.3 Historiograph of DNA development.

Historiograph of DNA Development

(Garfield, Sher, & Torpie, 1964)

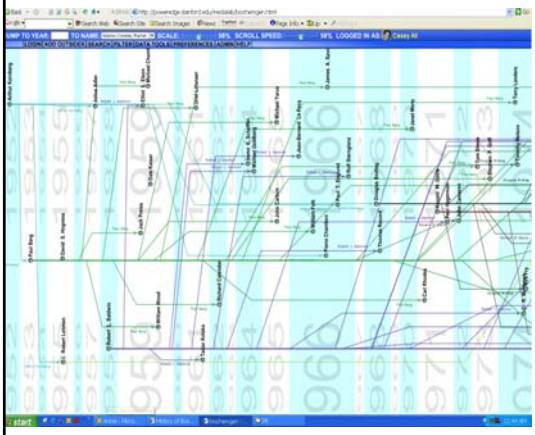
Garfield later developed the Science Citation Index patterned on Shepherd's index to legal citations.



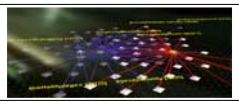


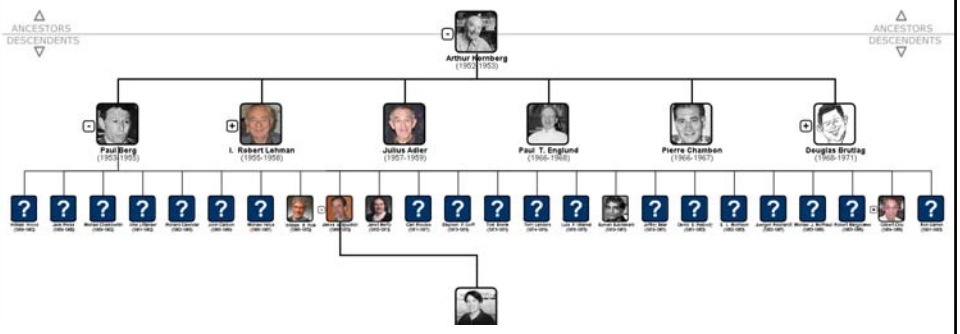
Demo of HistCite

Web-based collaborative timeline software
by Timothy Lenoir



"… allows historical actors to trace the categories, events, interactions that they deem crucial to understanding the in-depth details of major events" in order to "properly appreciate and give voice to the complex diversity of agents and objects involved in the establishment of this field" (bioinformatics).
http://hrst.mit.edu/hrs/bioinformatics/public/Timelines.htm





- http://hpslab.stanford.edu:16080/projects/StanfordBiochemistry

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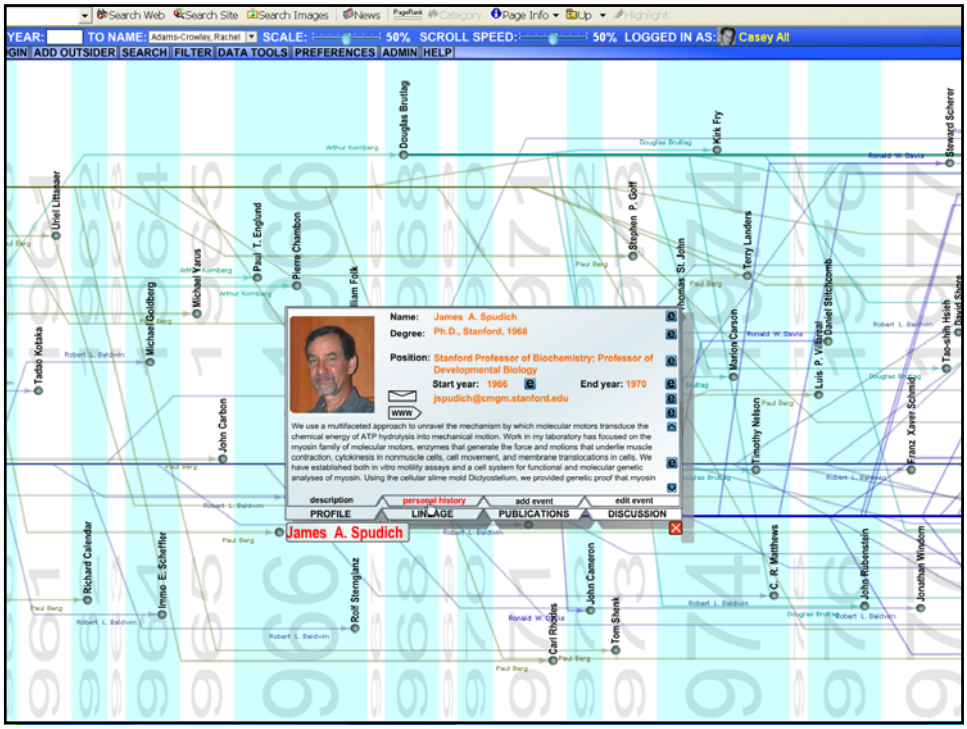
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Name: James A. Spudich
Degree: Ph.D., Stanford, 1968
Position: Stanford Professor of Biochemistry; Professor of Developmental Biology
Start year: 1966
End year: 1970
jspudich@cmgm.stanford.edu
We use a multifaceted approach to unravel the mechanism by which molecular motors transduce the chemical energy of ATP hydrolysis into mechanical motion. Work in my laboratory has focused on the myosin family of molecular motors, enzymes that generate the force and motions that underlie muscle contraction, cytokinesis in nonmuscle cells, cell movement, and membrane translocations in cells. We have established both in vitro motility assays and a cell system for functional and molecular genetic analyses of myosin. Using the cellular slime mold Dictyostelium, we provided genetic proof that myosin
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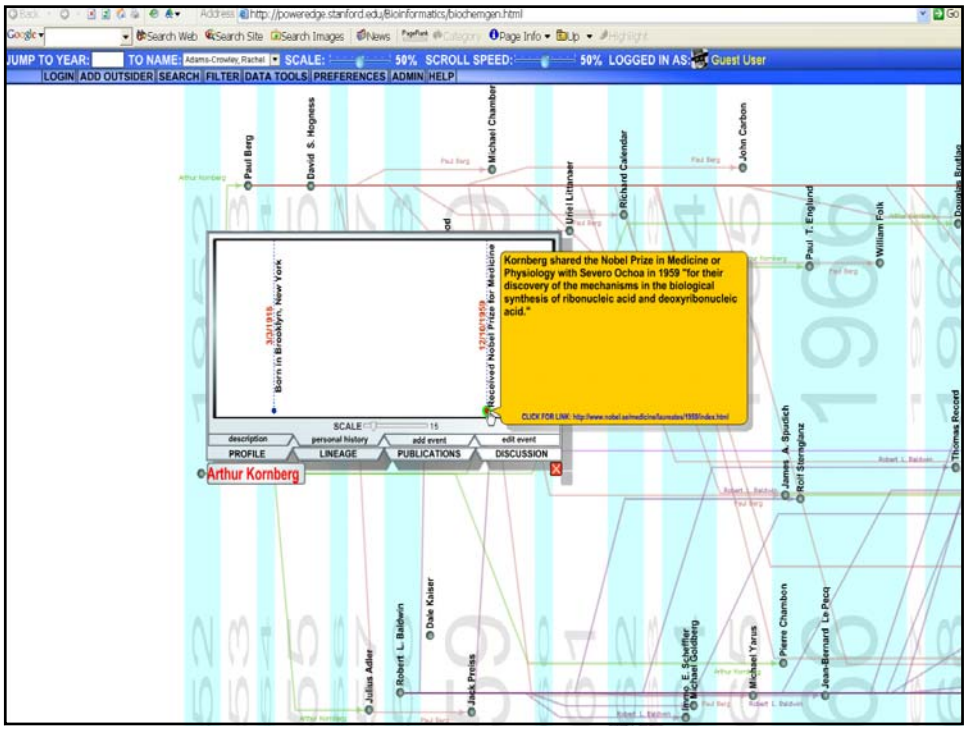
James A. Spudich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Born in Brooklyn, New York
Received Nobel Prize for Medicine
Kornberg shared the Nobel Prize in Medicine or Physiology with Severo Ochoa in 1959 "for their discovery of the mechanisms in the biological synthesis of ribonucleic acid and deoxyribonucleic acid."
CLICK FOR LINK: http://www.nobel.se/medicine/laureates/1959/index.html
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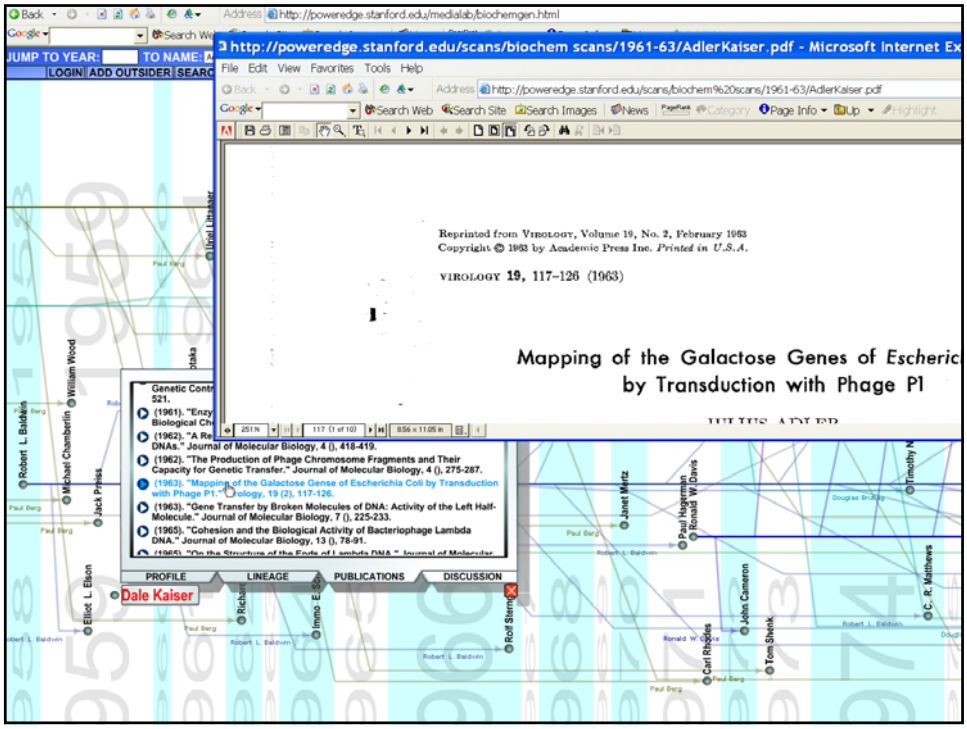
Arthur Kornberg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VIROLOGY 19, 117–126 (1963)
Mapping of the Galactose Genes of Escheric
by Transduction with Phage P1
(1963). "Mapping of the Galactose Genes of Escherichia Coli by Transduction with Phage P1." Virology, 19 (2), 117-126.
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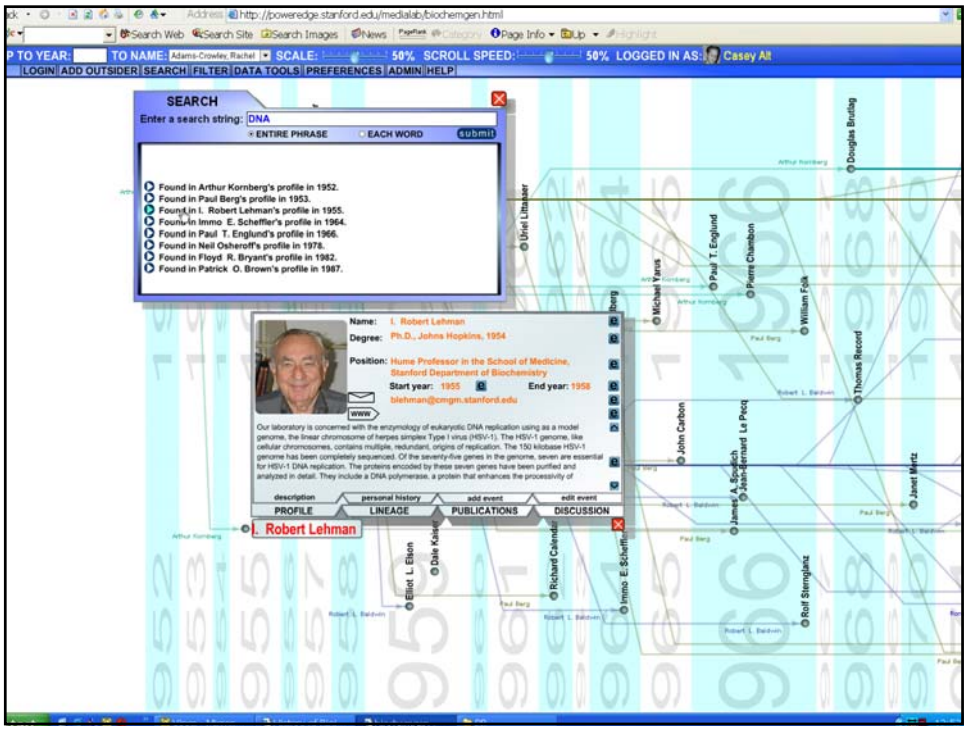
Dale Kaiser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Found in Paul Berg's profile in 1953.
Found in I. Robert Lehman's profile in 1955.
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Found in Paul T. Englund's profile in 1966.
Found in Neil Osheroff's profile in 1978.
Found in Floyd R. Bryant's profile in 1982.
Found in Patrick O. Brown's profile in 1987.
Name: I. Robert Lehman
Degree: Ph.D., Johns Hopkins, 1954
Position: Hume Professor in the School of Medicine, Stanford Department of Biochemistry
Start year: 1955
End year: 1958
biehman@cmgm.stanford.edu
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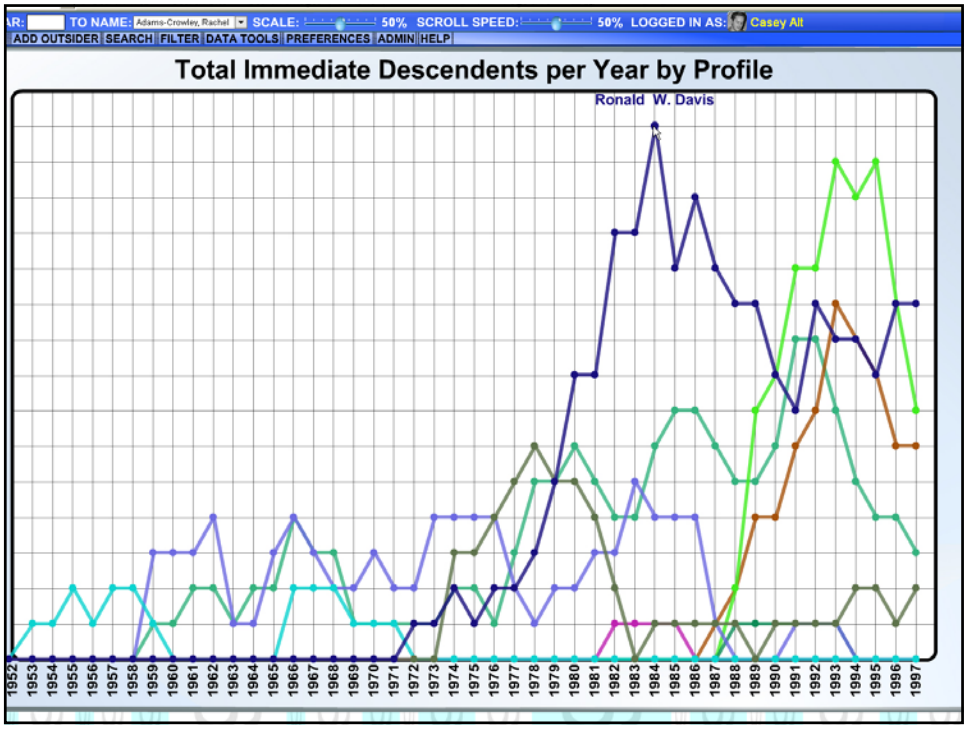
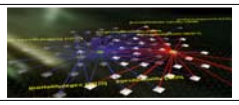
I. Robert Lehman





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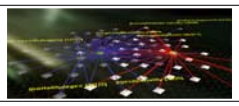
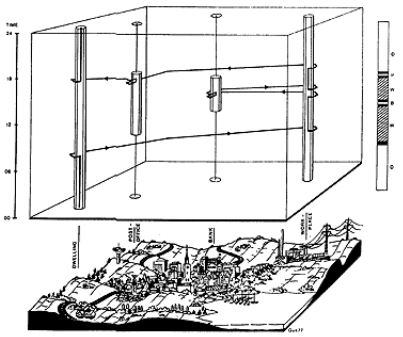
Challenges:

- Tracking tangible objects (e.g., people, products) and intangible objects (e.g., ideas) over time and geographic space.
- Tracking relationships between tangible and intangible objects.
- Puzzling together small and seemingly unconnected events over long periods of time to gain insight into local and global patterns of activity.



Lifelines for visualizing Migrations, Transitions and Trajectories

Figure represents the movements of a person over a single day. Individual starts from the home and visits his workplace, a bank, his workplace and finally a post office, before returning home. The shaded bar at the right identifies periods spent traveling (in black) and at work (cross-hatched).



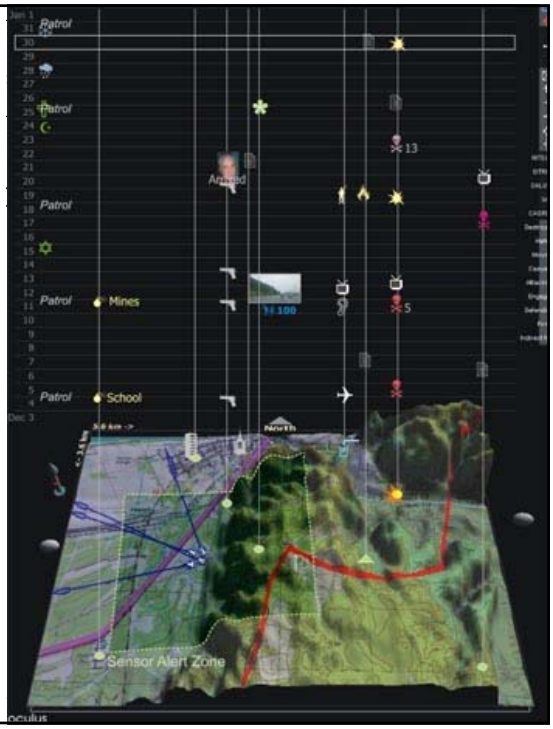
Lenntop's chapter in Carlstein et al.

http://www.geog.port.ac.uk/lifeline/consult/essay.html

GeoTime

www.oculusinfo.com

(Thomas Kapler & William Wright, 2004)



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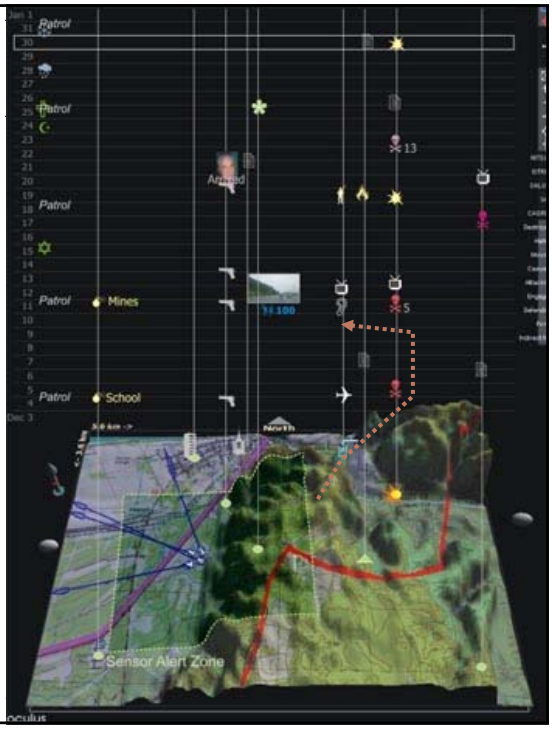
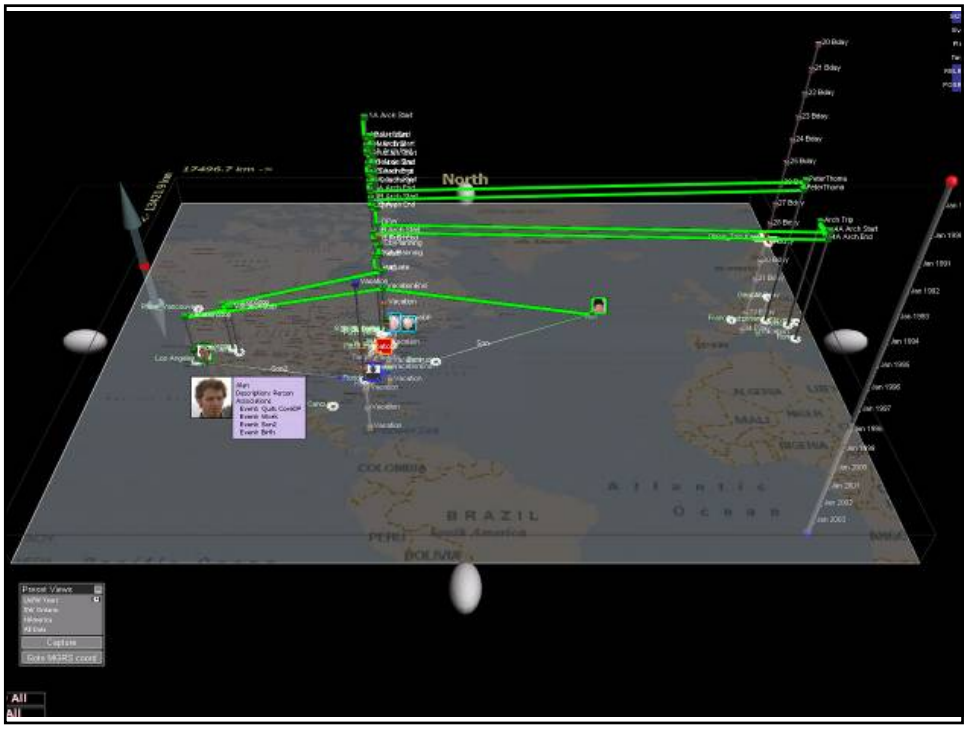
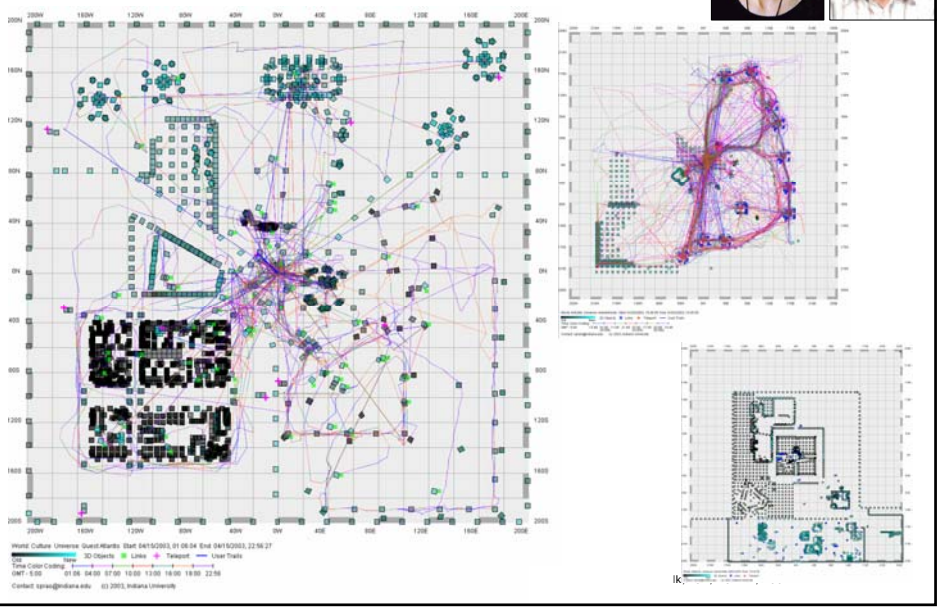




Visualizing Social Diffusion Patterns in 3D (Virtual Worlds)

(Börner & Penumarthy, 2003 & 2004)

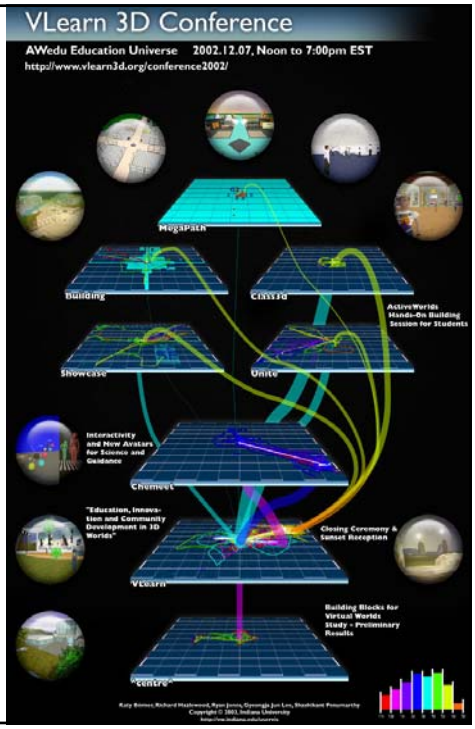


VLearn 3D Vis

(Börner, Hazlewod, Jones, Lee & Penumarthy, 2003)

Temporal-spatial distribution of Conference attendees

- Conference worlds are represented by square, perspective maps, each labeled by its name.
- Worlds accessed at the beginning of the conference are placed at the bottom, worlds accessed later toward the top.
- Next to each world is a circular snapshot of the virtual venue. Short descriptions of the main sessions are added as text.
- Major jumps between worlds are visualized by transparent lines. The thickness of each line corresponds to the number of traveling users. Color coding was used to denote the chronological paths of the conference sessions.

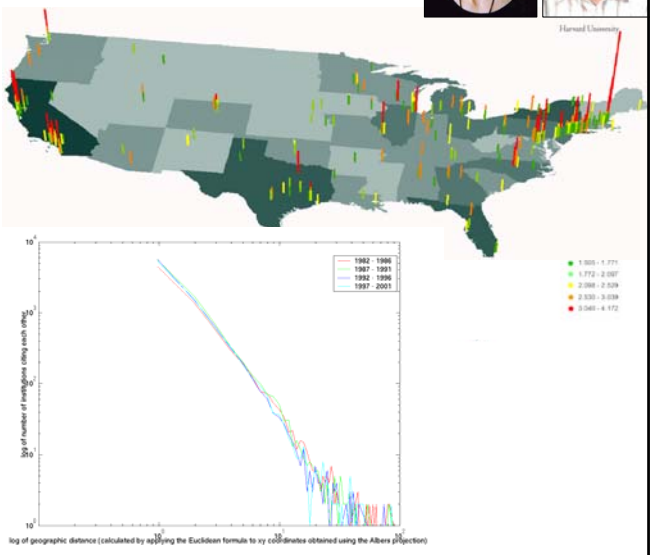


Information Diffusion Patterns
(Börner & Penumarthy, 2004)

Top 500 most highly cited U.S. institutions.

Each institution is assumed to produce and consume information.

Does Internet lead to more global citation patterns, i.e., more citation links between papers produced at geographically distant research instructions?



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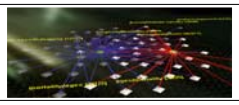

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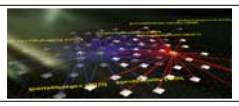
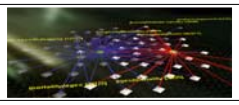


Mapping knowledge domains

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.

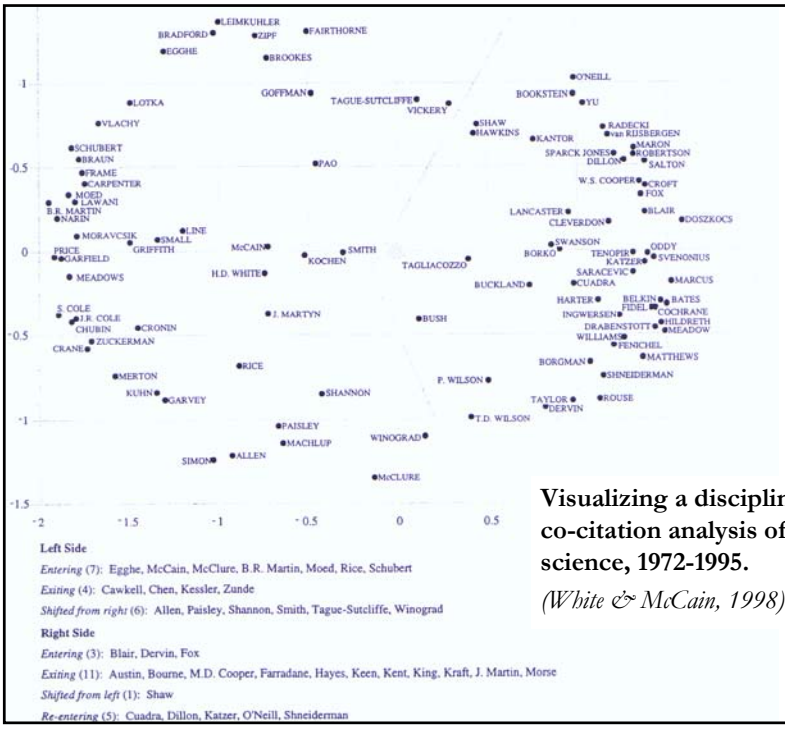


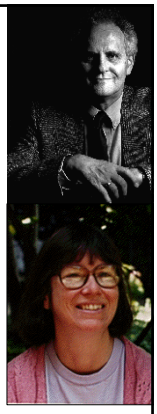
Process of Analyzing and Mapping Knowledge Domains

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

Review article:

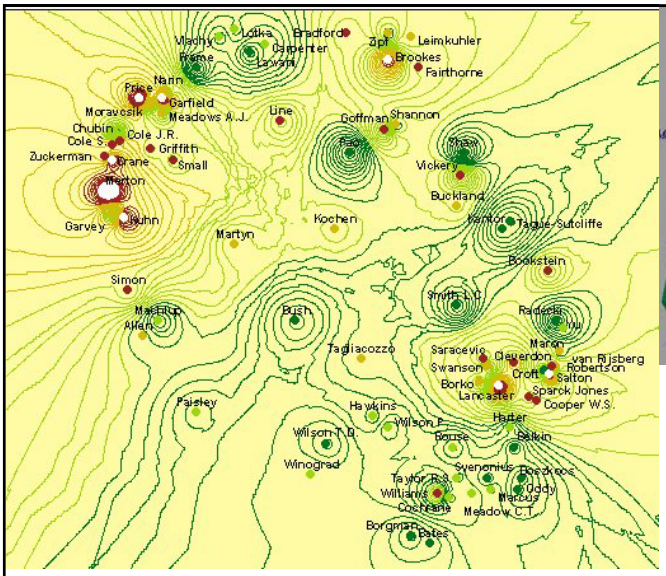
Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003) Visualizing Knowledge Domains. In Blaise Cronin (Ed.), *Annual Review of Information Science & Technology*, Volume 37, Medford, NJ: Information Today, Inc./American Society for Information Science and Technology, chapter 5, pp. 179-255.

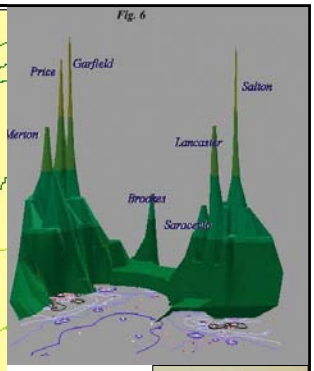


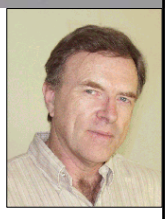


Visualizing a discipline: An author co-citation analysis of information science, 1972-1995.

(White & McCain, 1998)

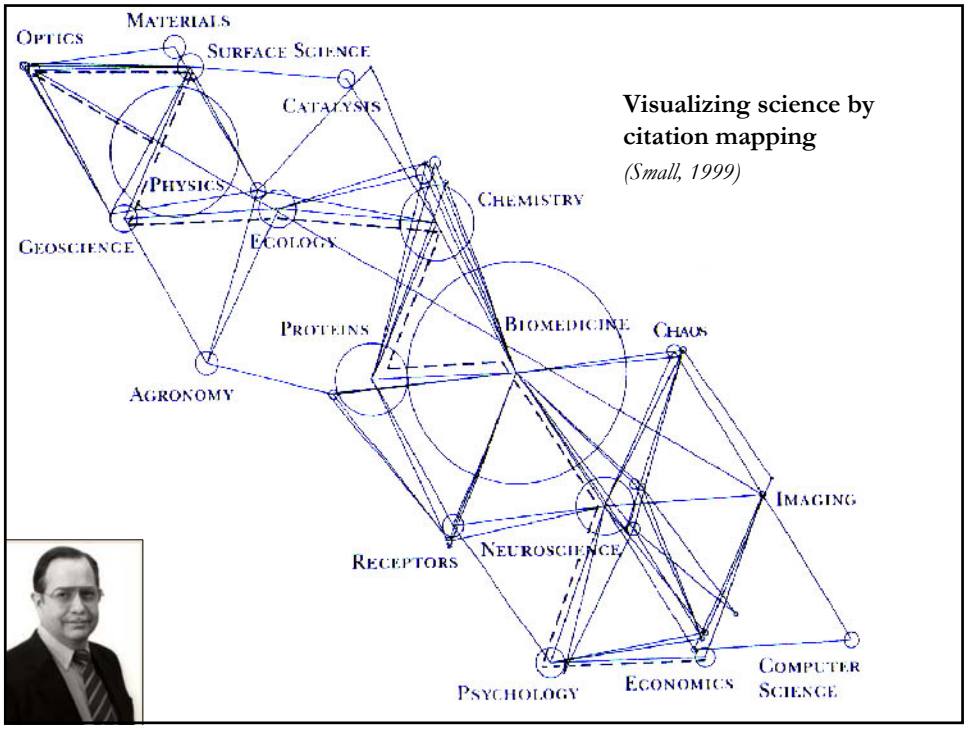






Utilizing Spatial Information Systems for Non-Spatial-Data Analysis

(Old, 2001) and http://php.indiana.edu/~jold/SLIS/L710/L710.htm



Visualizing science by citation mapping

(Small, 1999)

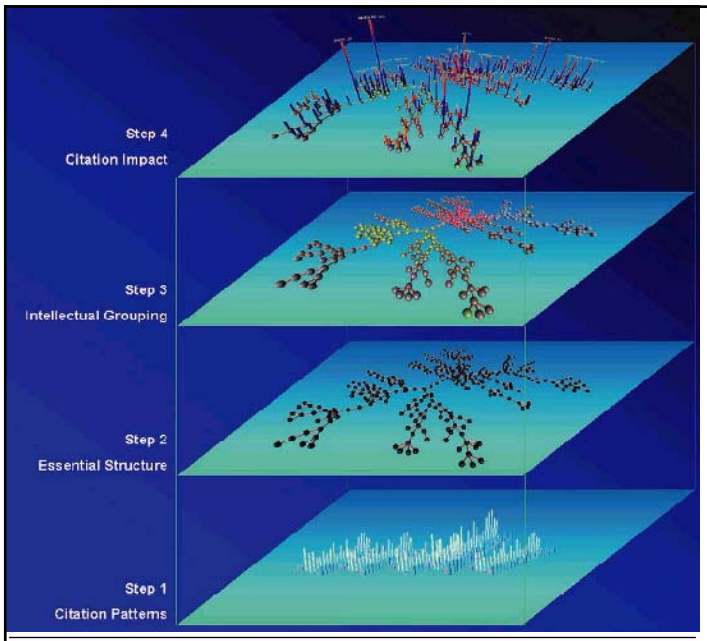
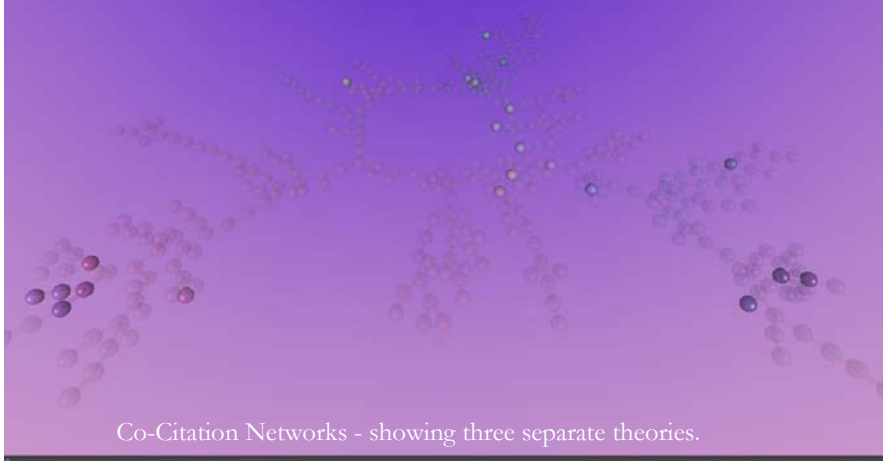


Figure 2. A four-step procedure for visualizing intellectual structures. The process starts from the lowest level and works its way up by incrementally overlaying more visual-spatial features at each consecutive step to clarify the essence of intellectual structures.

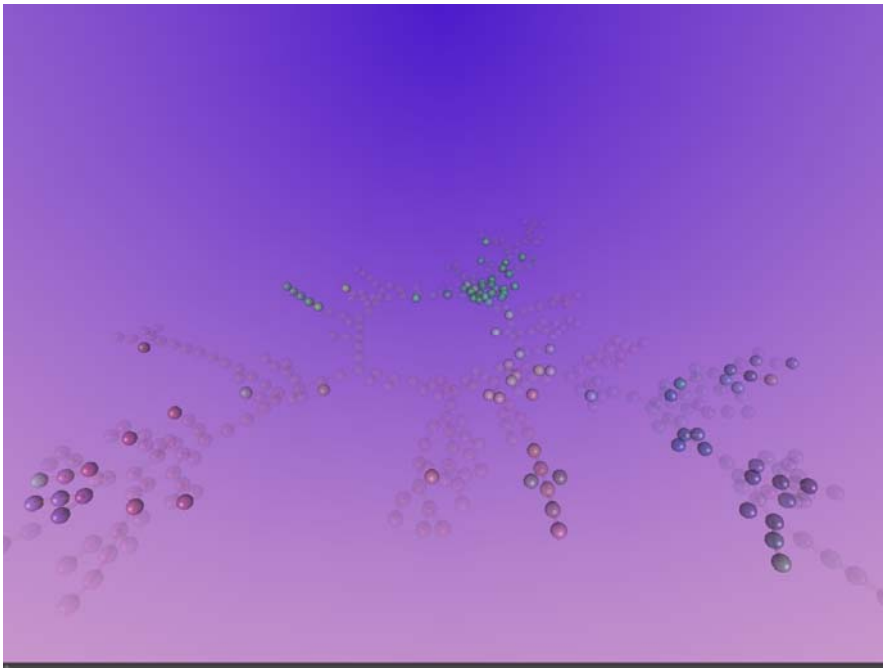
Visualizing a knowledge domain's intellectual structure

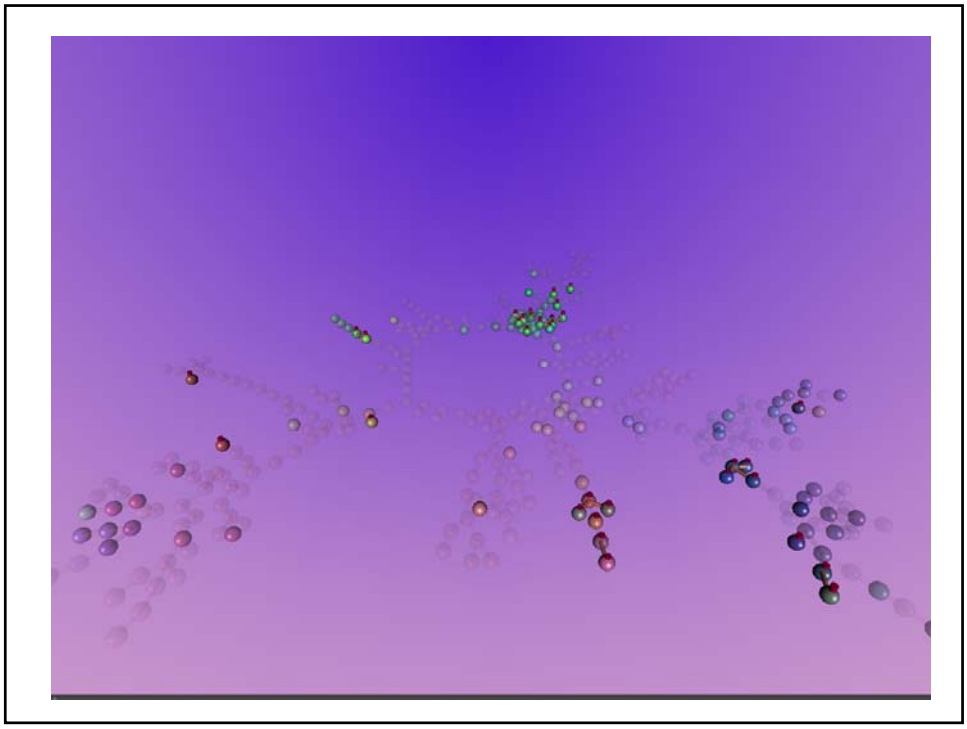
(Chen & Paul, 2001)

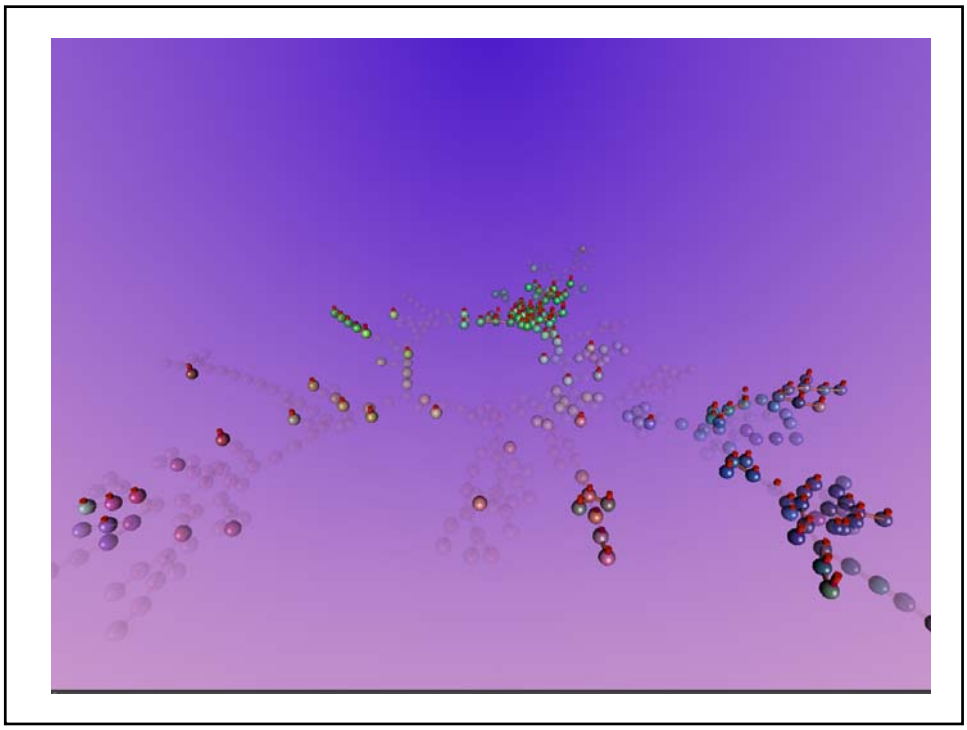
The rising landscape:
A visual exploration of superstring revolutions in physics.
(Chen & Kuljis, 2003)

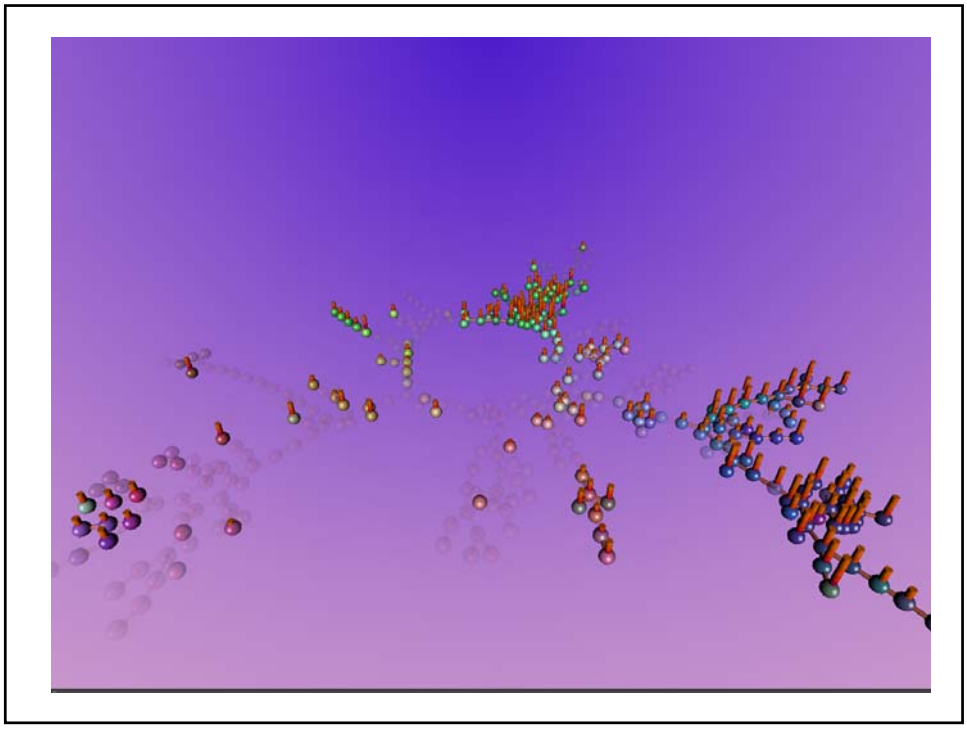


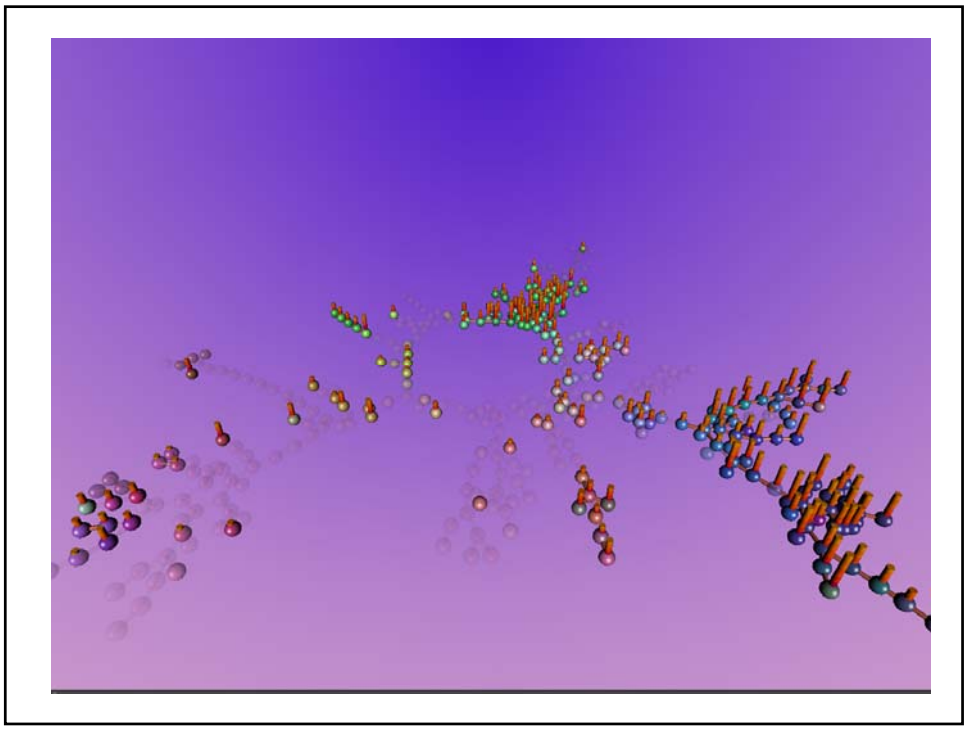
Co-Citation Networks - showing three separate theories.

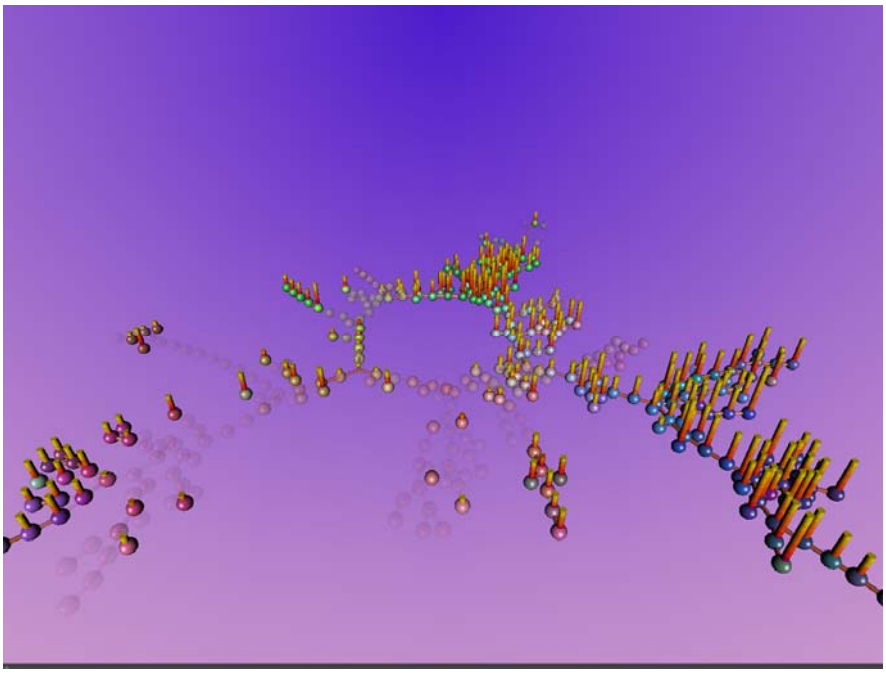


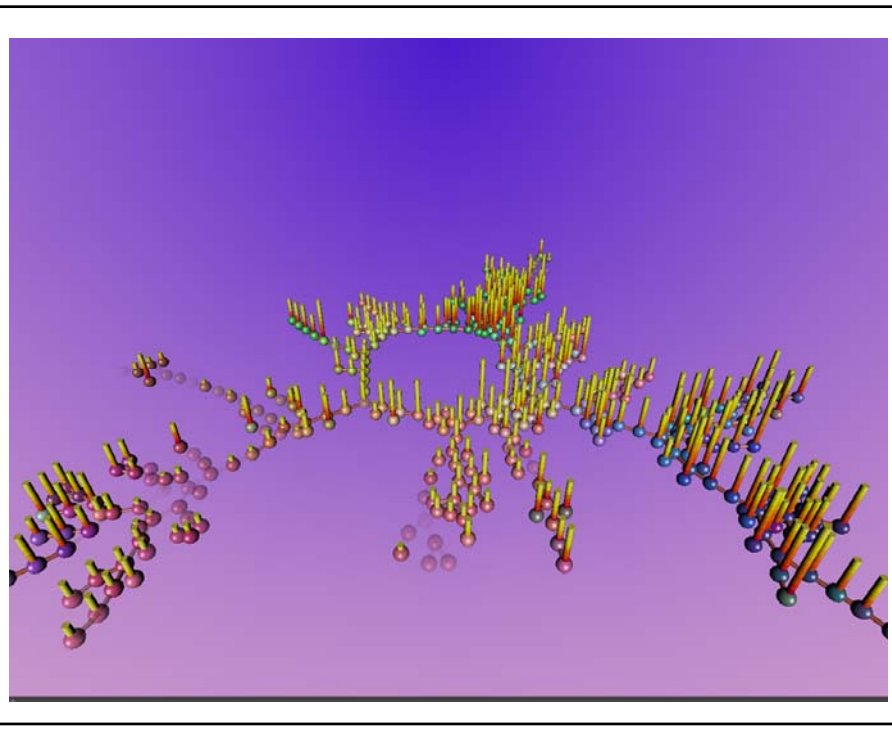


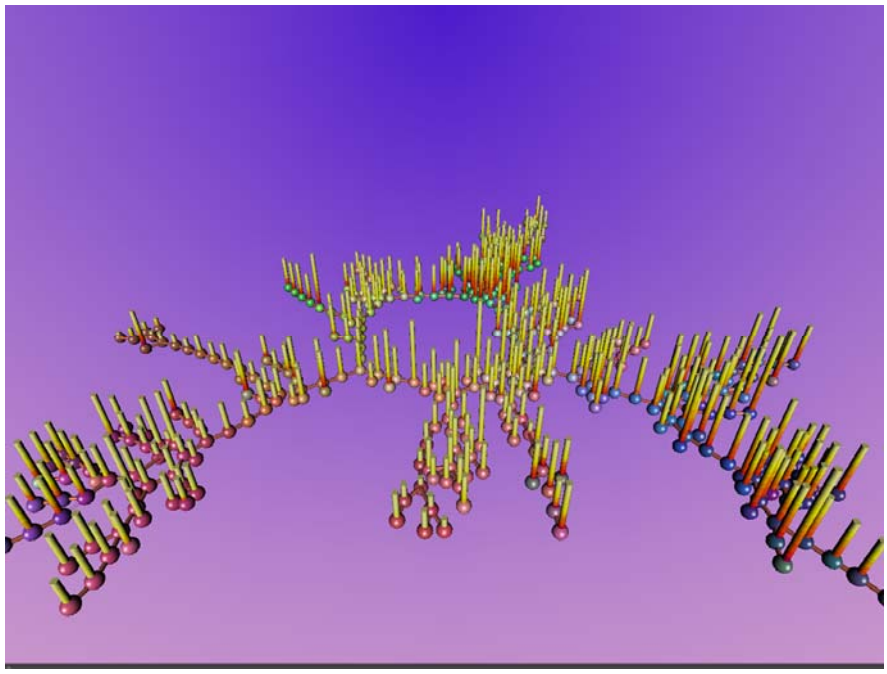


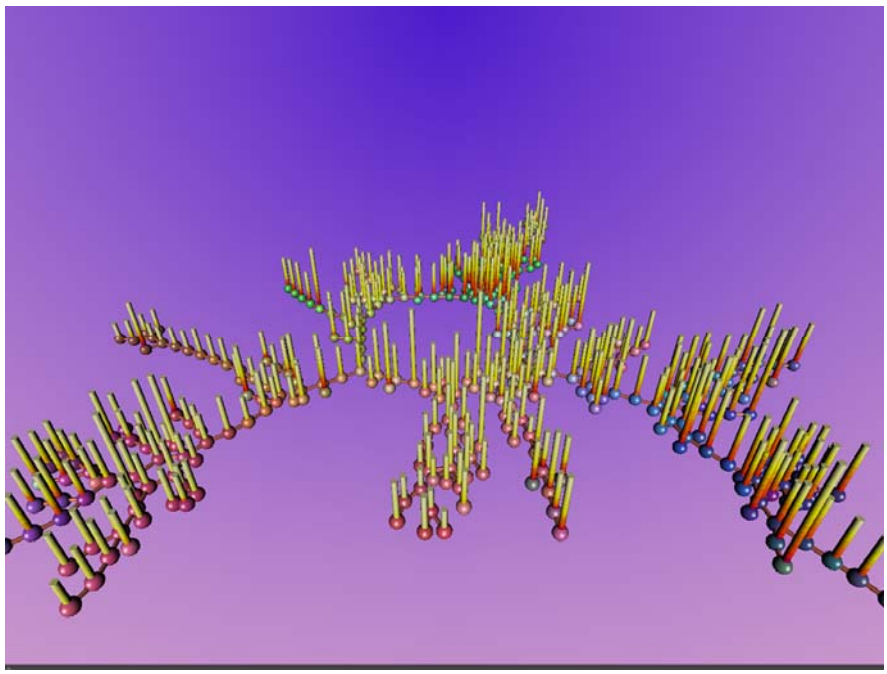






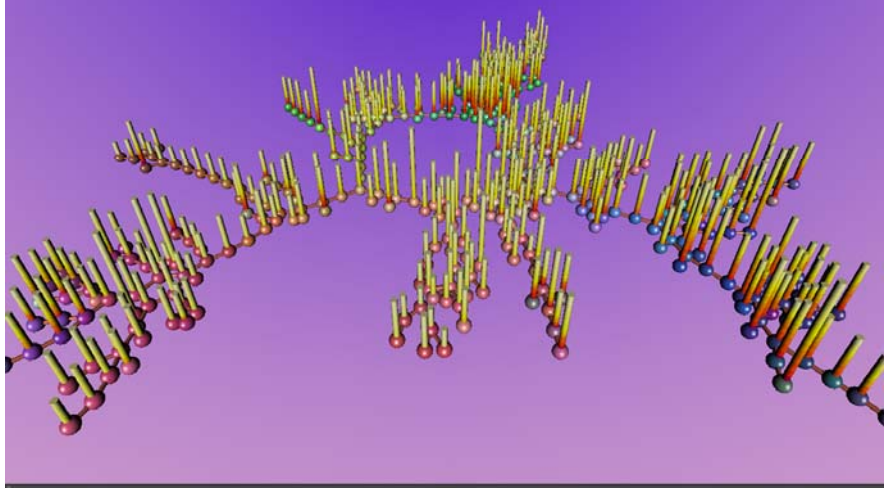






Co-Citation Networks –

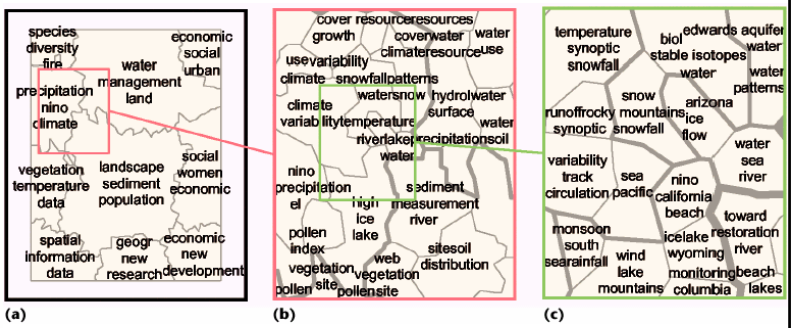
The three separate theories are now interconnected.

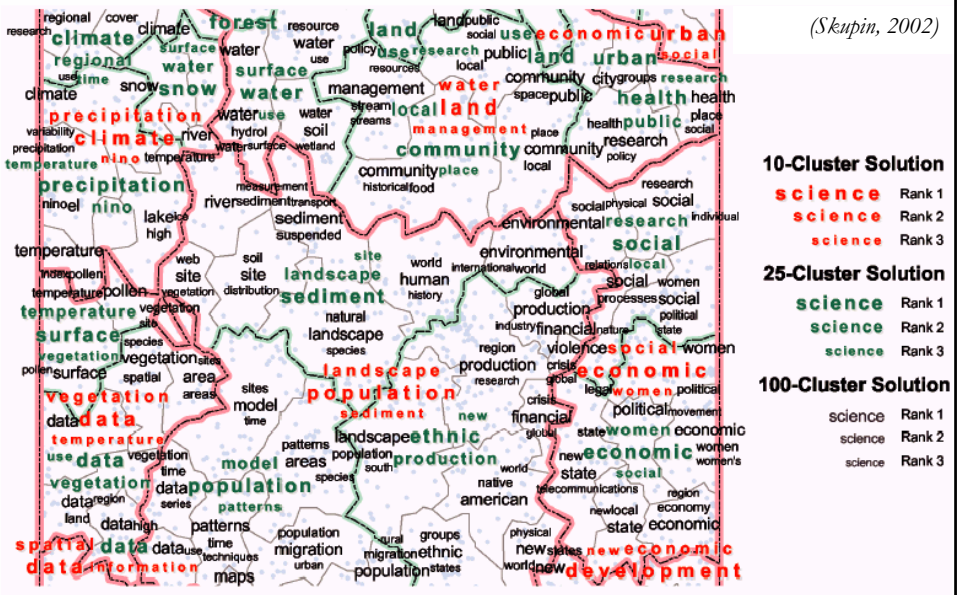


Cartographic Information Visualization

(Skupin, 2002)

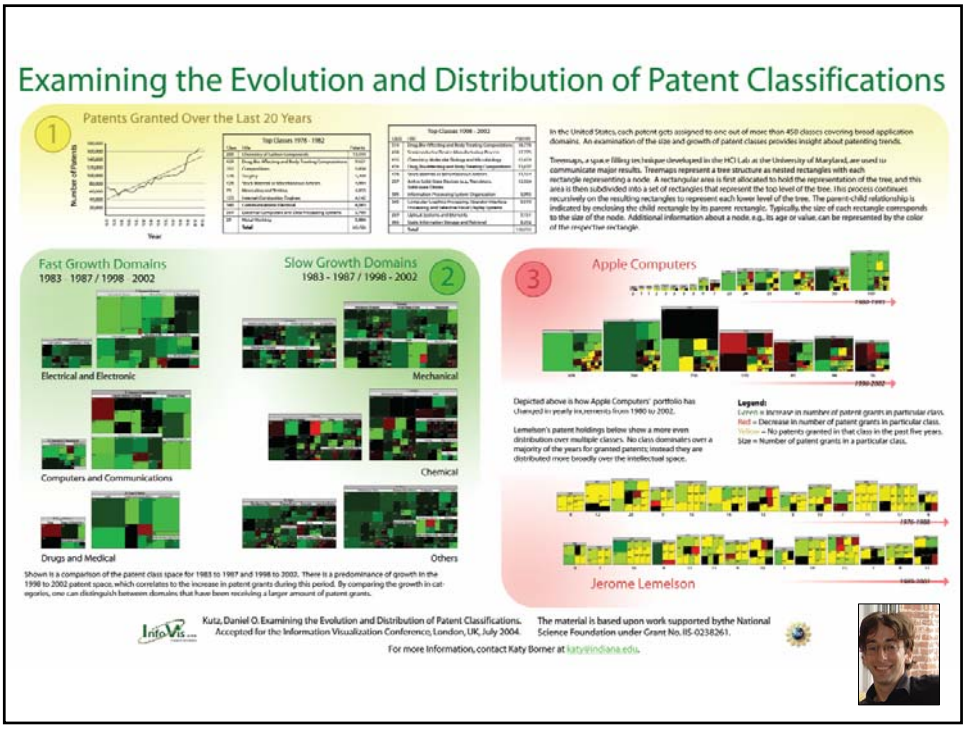
6 Three different zoom levels in a visualization of conference abstracts: (a) complete map shown in a 10-cluster solution and map portions for (b) a 100-cluster and (c) 800-cluster solution. Higher level boundaries are accentuated to provide context during zoom operations.





(Skupin, 2002)

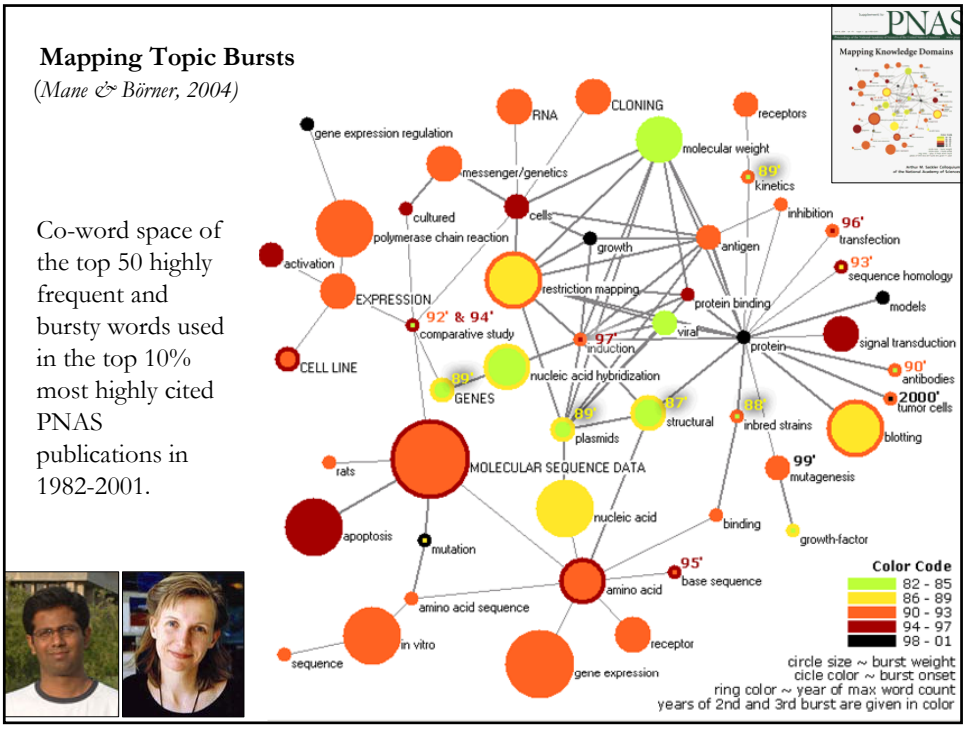
7 Visualization of 2,220 conference abstracts with simultaneous overlay of three levels of a hierarchical clustering tree of SOM neurons: 10-cluster solution (red); 25-cluster solution (green); and 100-cluster solution (black). Cluster labels are scaled according to rank within the respective cluster.



Mapping Topic Bursts

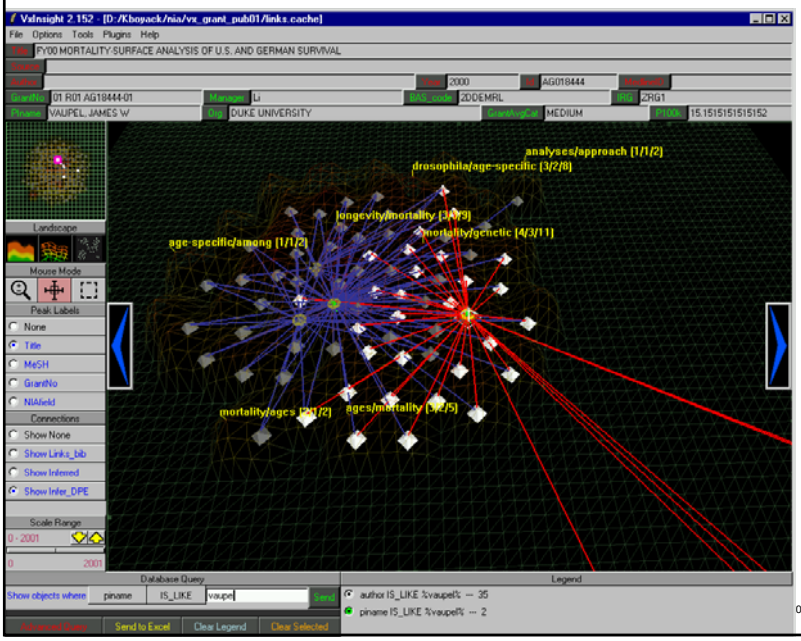
(Mane & Börner, 2004)

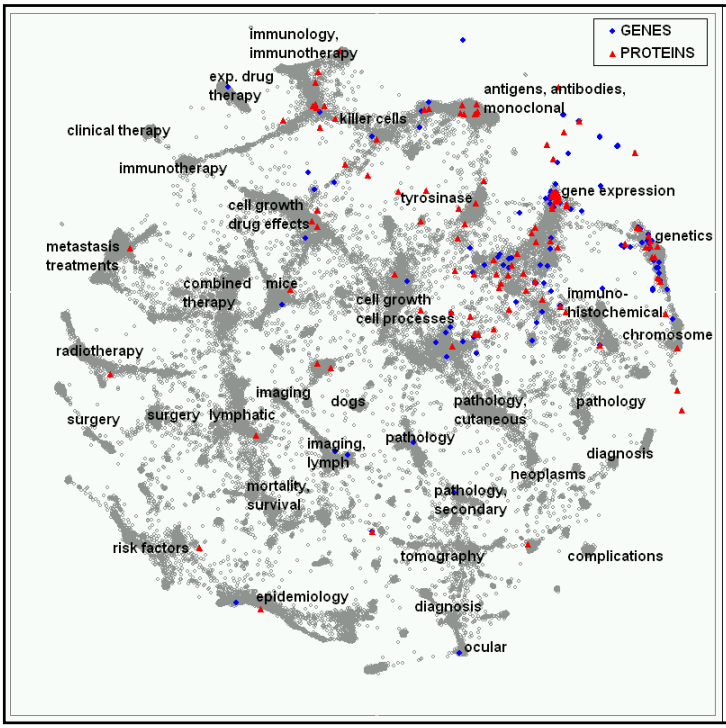
Co-word space of the top 50 highly frequent and bursty words used in the top 10% most highly cited PNAS publications in 1982-2001.



Indicator-Assisted Evaluation and Funding of Research

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



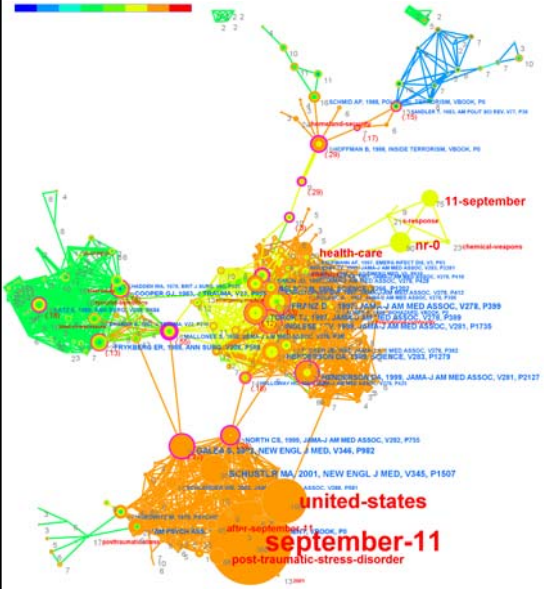


Mapping Medline Papers, Genes, and Proteins Related to Melanoma Research

(Boyack, Mane & Börner, 2004)

Visualizing Trends and Research Frontiers in CiteSpace *(Chaomei Chen, 2004)*

http://cluster.cis.drexel.edu/~cchen/citespace/

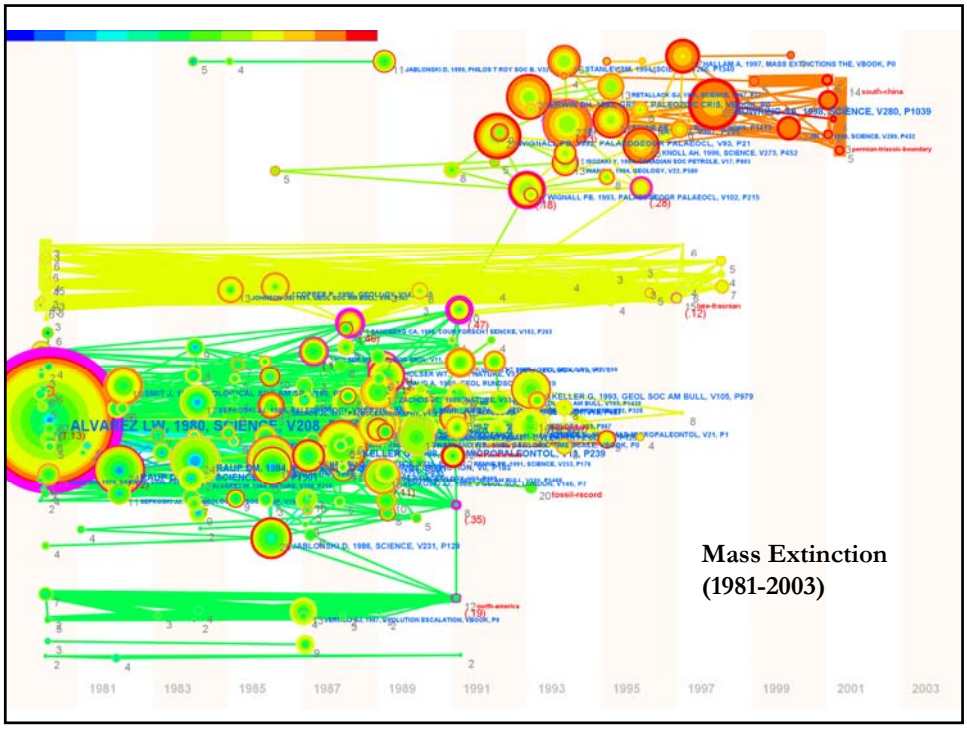


Trends and turning points of **Terrorism (1990-2003)** visualized in CiteSpace

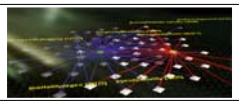
Nodes - terms / papers
Size – frequency / # citations
Color – red / blue

Purple circle & label – betweeness centrality

Links - co-occurrence, co-citation, citations
Color - first year in which a connection was found.
Width - connection strength

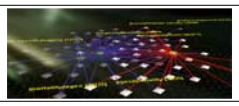


Mass Extinction (1981-2003)



Demo of CiteSpace

Katy Börner: Analyzing and Communicating the Structure and Evolution of Science, History and Philosophy of Science Talk, IUB, Nov 12, 2004.



2. Overview of different data analysis and visualization techniques

- Time space: Tree of life, genealogies, etc.
- Time-geographic space: Lifelines, etc.
- (Time-)semantic spaces: Mapping knowledge domains
- (Time-)social spaces: Social networks

Resources:

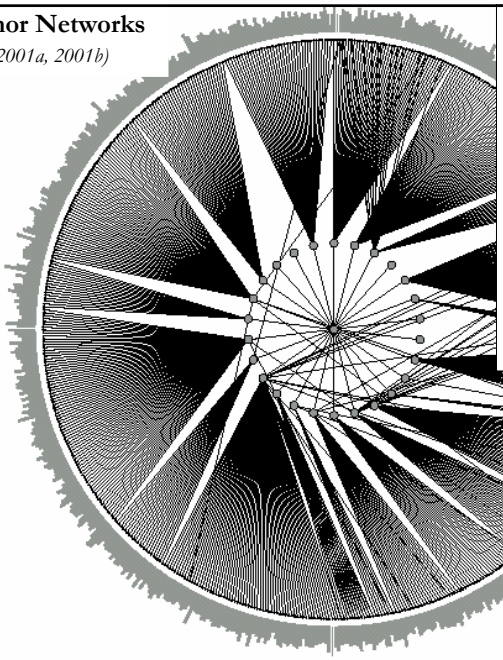
Linton C. Freeman (2000) Visualizing Social Networks. Journal of Social Structure, 1 (1).

Linton C. Freeman (2004) The Development of Social Network Analysis: A Study in the Sociology of Science. Empirical Press.

Stanley Wasserman, Katherine Faust, Dawn Iacobucci (1994). Social Network Analysis: Methods and Applications: Cambridge Univ Press.

Co-author Networks

(Newman, 2001a, 2001b)



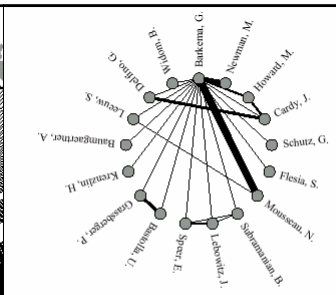


FIG. 10. Gerard Barkema and his collaborators, with lines representing collaborations whose thickness is proportional to our estimate, Eq. (4), of the strength of the corresponding tie.

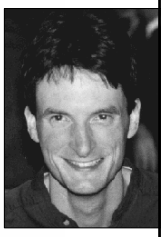
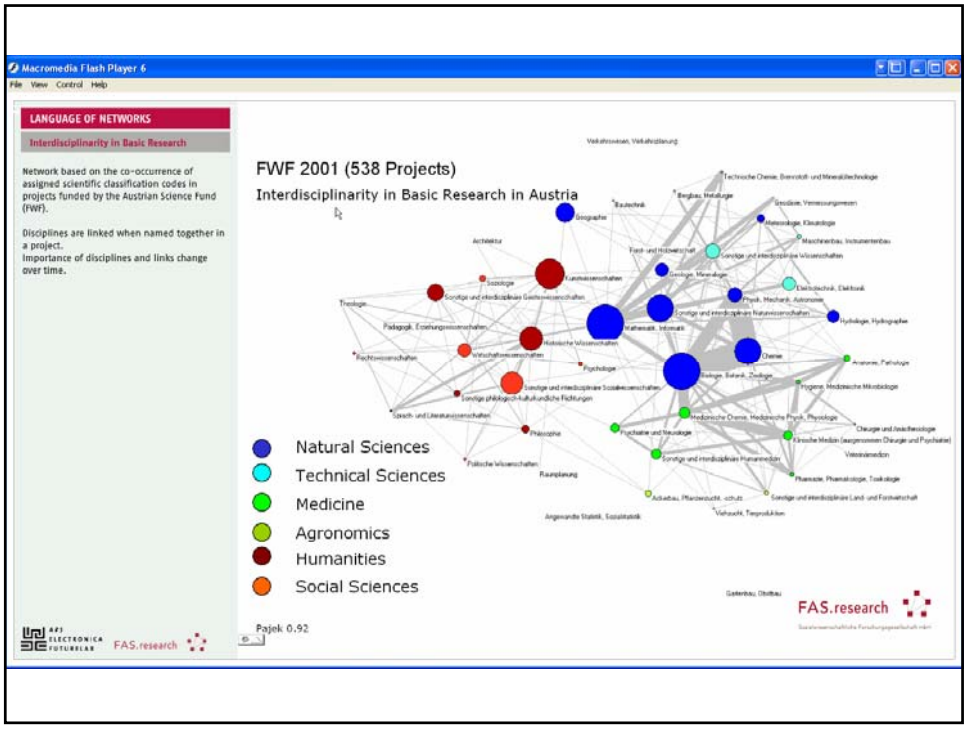
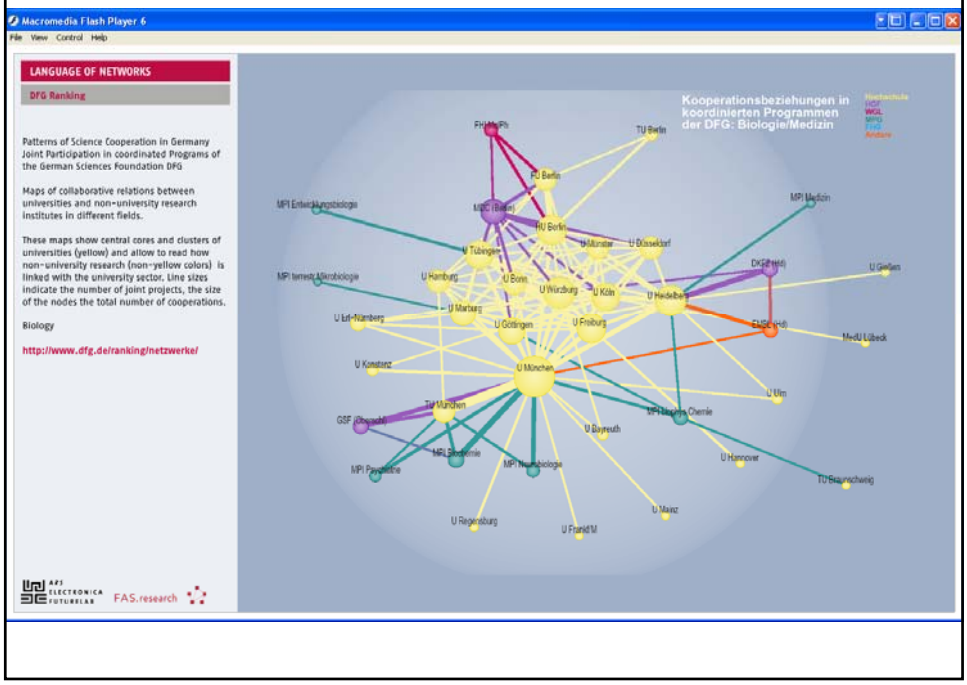


FIG. 6. The point in the center of the figure represents the author of the paper you are reading, the first ring his collaborators, and the second ring their collaborators. Collaborative ties between members of the same ring, of which there are many, have been omitted from the figure for clarity.


Macromedia Flash Player 6
File View Control Help
LANGUAGE OF NETWORKS
Interdisciplinarity in Basic Research
Network based on the co-occurrence of assigned scientific classification codes in projects funded by the Austrian Science Fund (FWF).
Disciplines are linked when named together in a project.
Importance of disciplines and links change over time.
FWF 2001 (538 Projects)
Interdisciplinarity in Basic Research in Austria
Natural Sciences
Technical Sciences
Medicine
Agronomics
Humanities
Social Sciences
FAS.research
Pajek 0.92
FAS.research


Macromedia Flash Player 6
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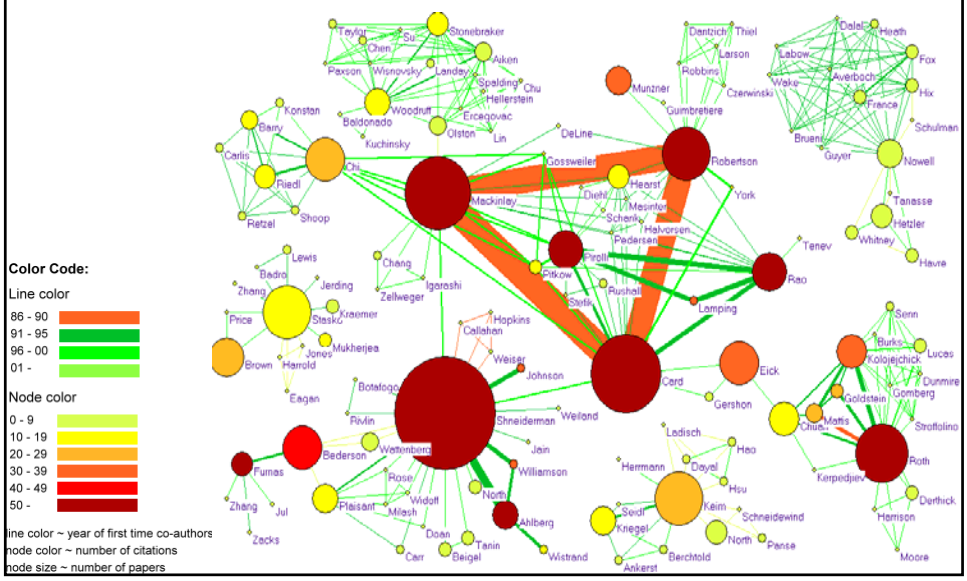
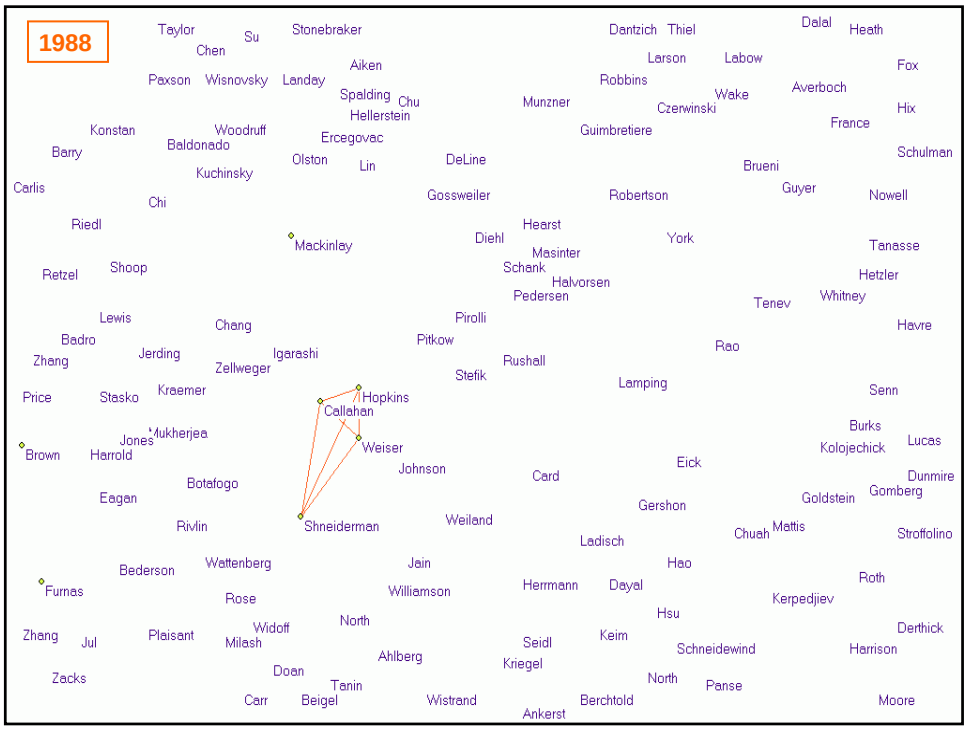
LANGUAGE OF NETWORKS
DFG Ranking
Patterns of Science Cooperation in Germany
Joint Participation in coordinated Programs of the German Sciences Foundation DFG
Maps of collaborative relations between universities and non-university research institutes in different fields.
These maps show central cores and clusters of universities (yellow) and allow to read how non-university research (non-yellow colors) is linked with the university sector. Line sizes indicate the number of joint projects, the size of the nodes the total number of cooperations.
Biology
http://www.dfg.de/ranking/netzwerke/
Kooperationsbeziehungen in koordinierten Programmen der DFG: Biologie/Medizin
FAS.research

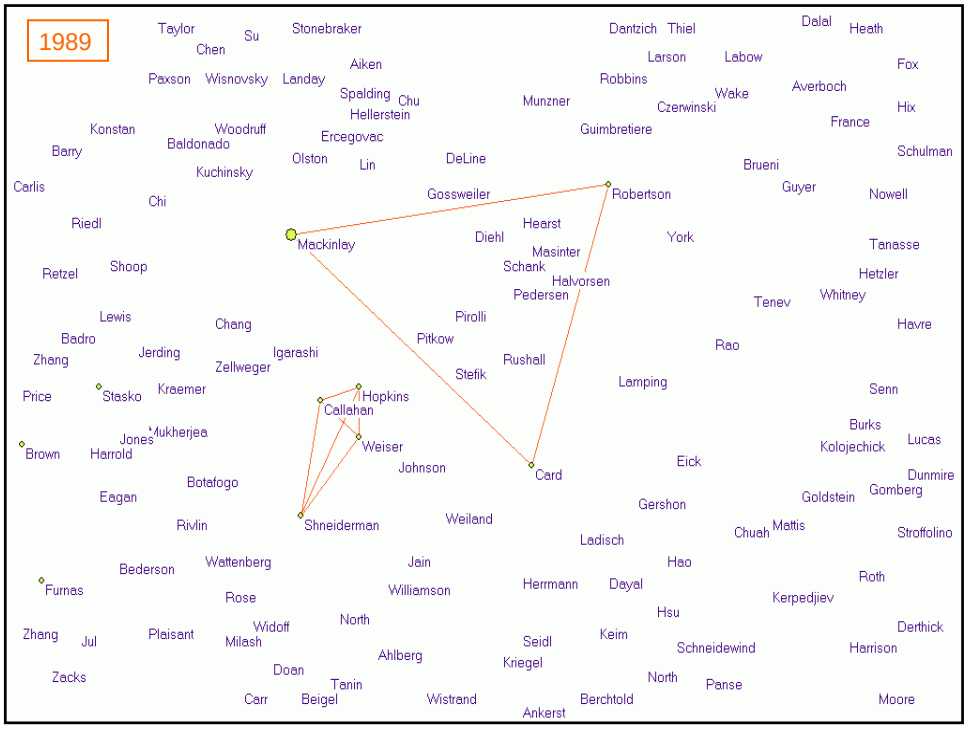
Mapping the Evolution of Co-Authorship Networks

Won 1st price at the IEEE InfoVis Contest

(Ke, Visvanath & Börner, 2004)



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Paxson
Wisnovsky
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Ercegovac
Barry
Olston
Lin
DeLine
Kuchinsky
Carlis
Chi
Gossweiler
Riedl
Mackinlay
Diehl
Hearst
Retzel
Shoop
Schank
Masinter
Pedersen
Lewis
Chang
Pirolli
Badro
Pitkow
Zhang
Jerding
Igarashi
Zellweger
Rushall
Stefik
Price
Stasko
Kraemer
Hopkins
Callahan
Weiser
Jones
Mukherjea
Brown
Harrold
Johnson
Botafogo
Eagan
Rivlin
Shneiderman
Weiland
Bederson
Wattenberg
Jain
Furnas
Rose
Williamson
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Widoff
Zhang
Jul
Plaisant
Milash
Ahlberg
Doan
Zacks
Tanin
Carr
Beigel
Wistrand
Dantzich
Thiel
Dalal
Heath
Larson
Labow
Fox
Robbins
Averboch
Munzner
Wake
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Schulman
Brueni
Guyer
Nowell
Robertson
York
Tanasse
Hetzler
Halvorsen
Whitney
Tenev
Havre
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Lamping
Senn
Burks
Kolojechick
Lucas
Eick
Dunmire
Gomberg
Goldstein
Gershon
Mattis
Chuah
Stroffolino
Ladisch
Hao
Roth
Herrmann
Dayal
Kerpedjiev
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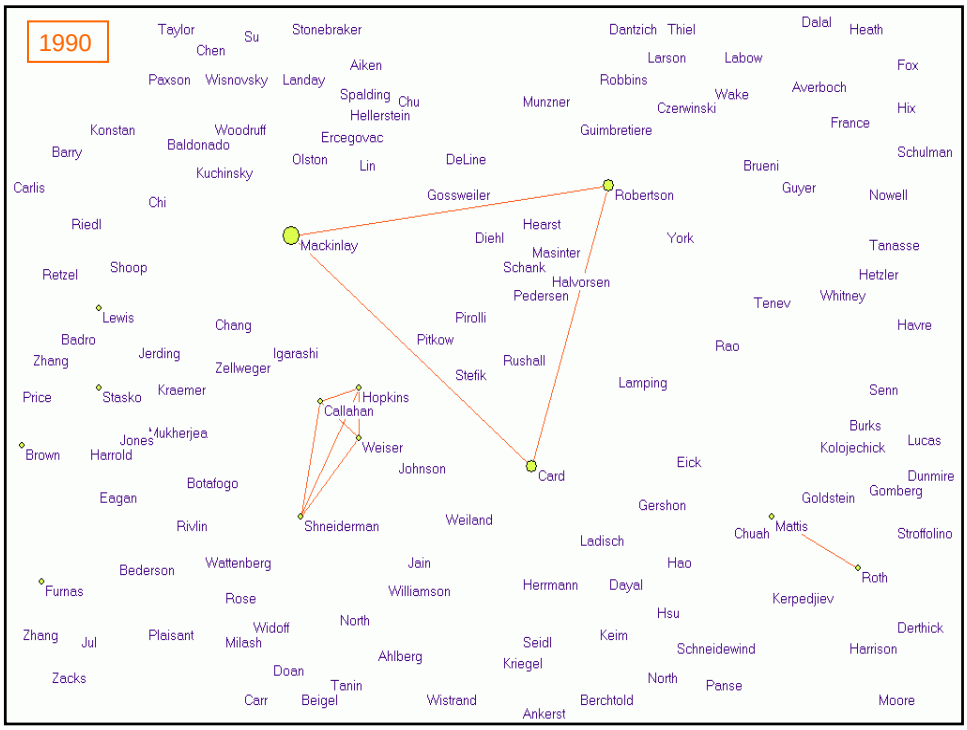
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Barry
Olston
Lin
DeLine
Kuchinsky
Carlis
Chi
Gossweiler
Riedl
Mackinlay
Diehl
Hearst
Retzel
Shoop
Schank
Masinter
Pedersen
Lewis
Chang
Pirolli
Badro
Pitkow
Zhang
Jerding
Igarashi
Zellweger
Rushall
Stefik
Price
Stasko
Kraemer
Hopkins
Callahan
Weiser
Jones
Mukherjea
Brown
Harrold
Johnson
Botafogo
Eagan
Rivlin
Shneiderman
Weiland
Bederson
Wattenberg
Jain
Furnas
Rose
Williamson
North
Widoff
Zhang
Jul
Plaisant
Milash
Ahlberg
Doan
Zacks
Tanin
Carr
Beigel
Wistrand
Dantzich
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Robbins
Averboch
Munzner
Wake
Czerwinski
Hix
Guimbretiere
France
Schulman
Brueni
Guyer
Nowell
Robertson
York
Tanasse
Hetzler
Halvorsen
Whitney
Tenev
Havre
Rao
Lamping
Senn
Burks
Kolojechick
Lucas
Eick
Dunmire
Gomberg
Goldstein
Gershon
Mattis
Chuah
Stroffolino
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Roth
Herrmann
Dayal
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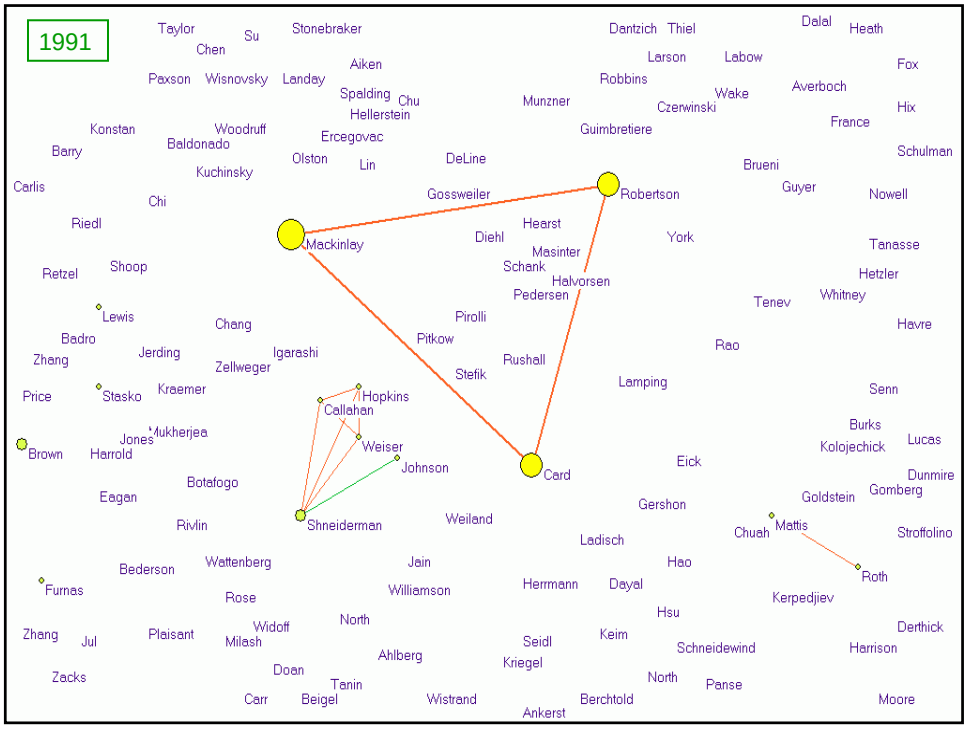
1991
Taylor
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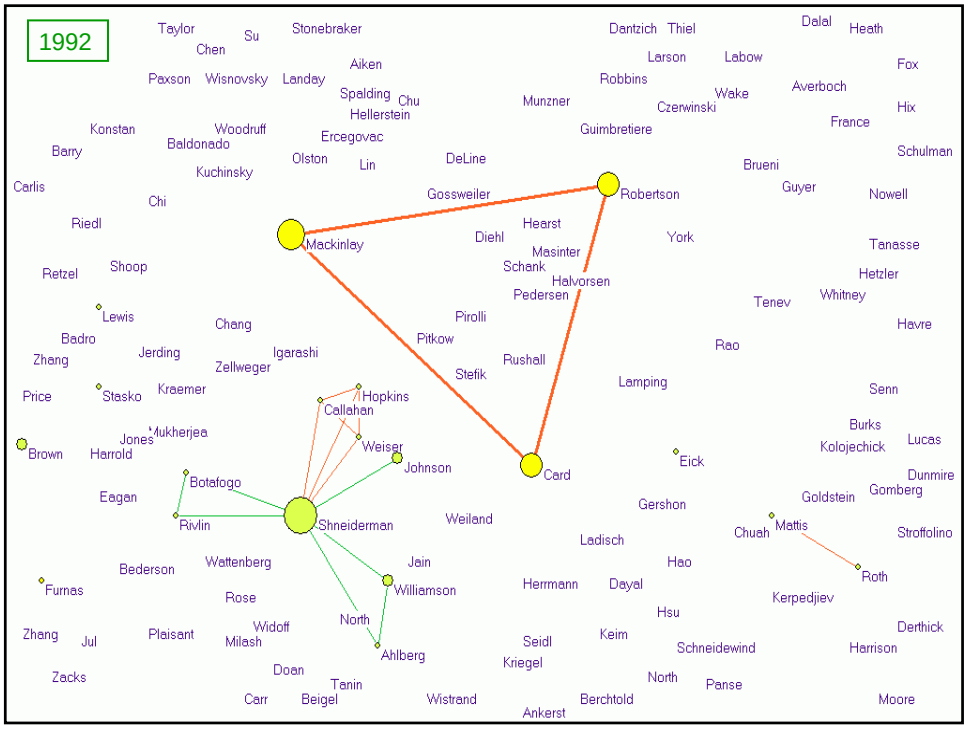
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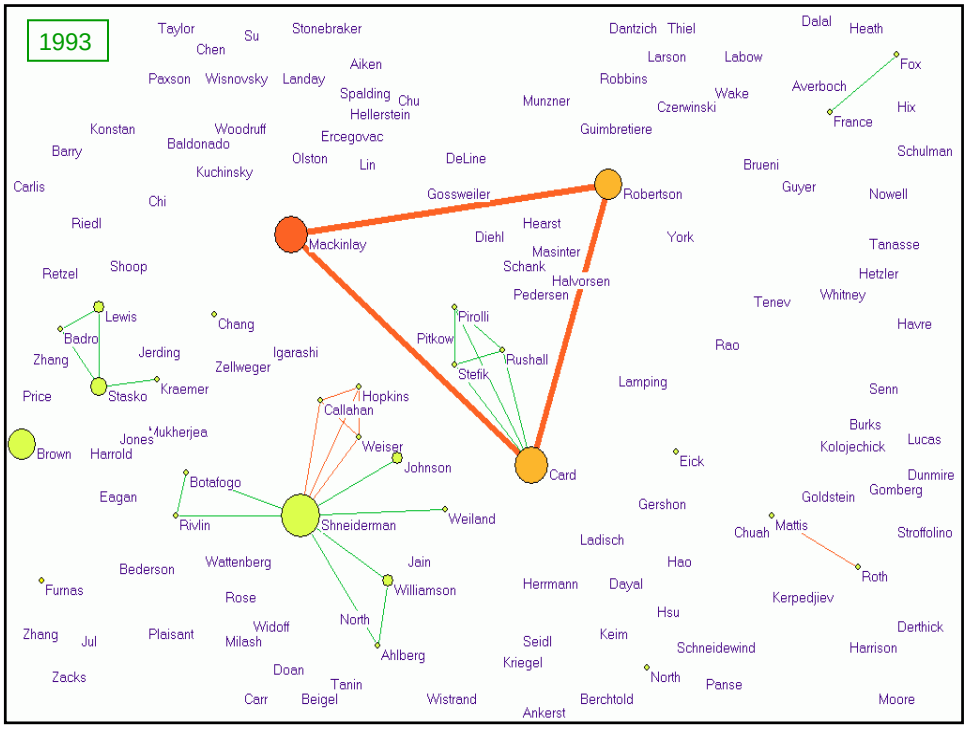
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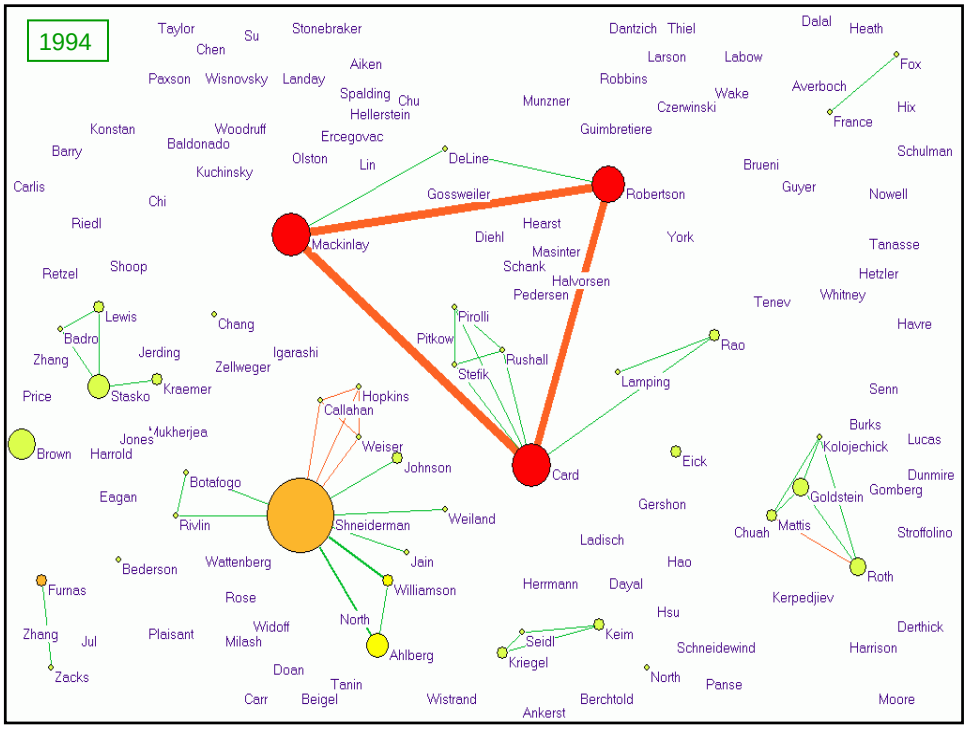
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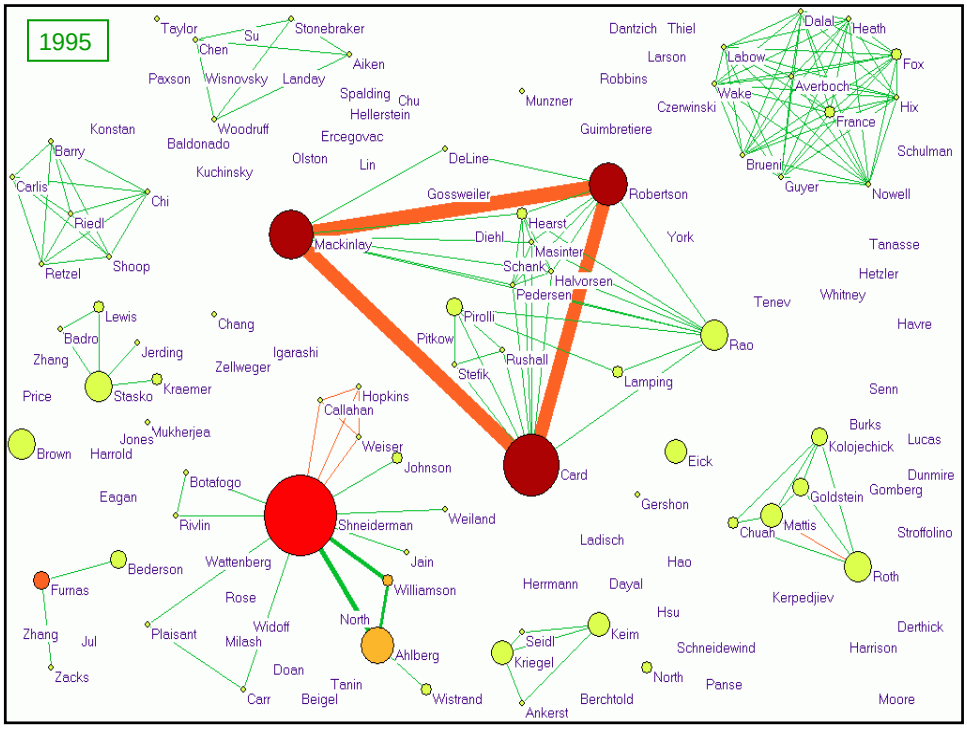
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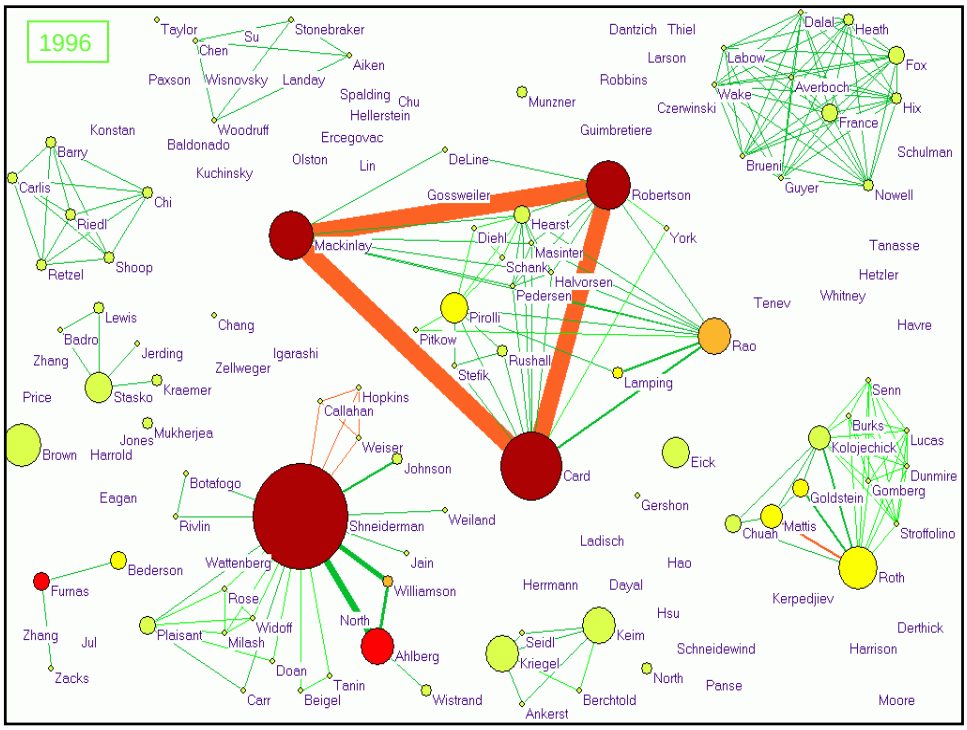
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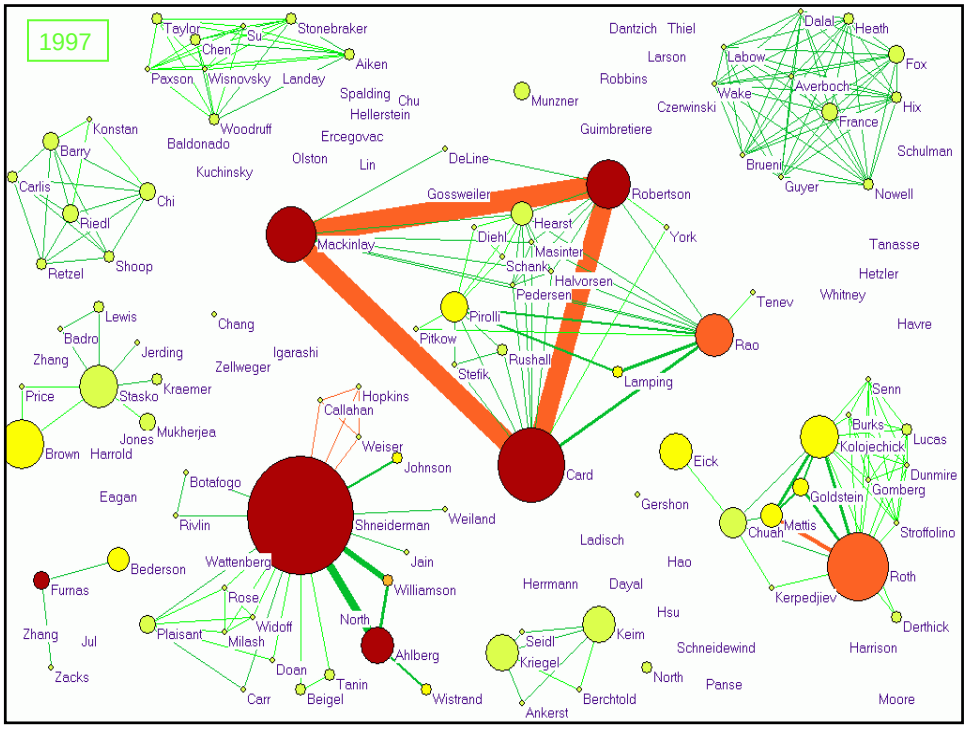
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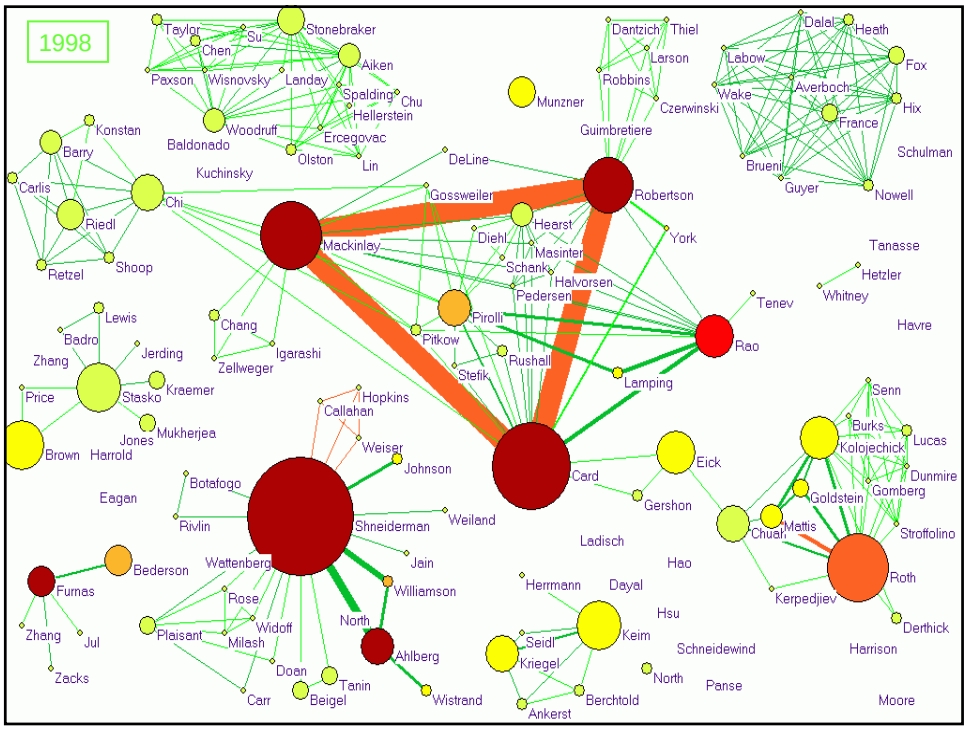
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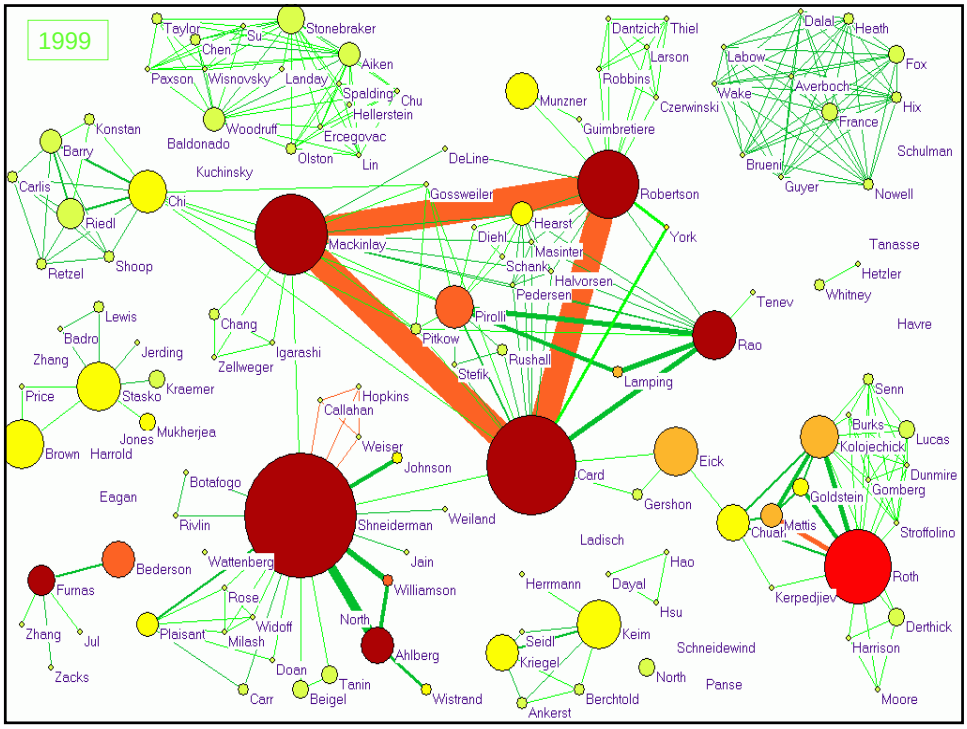
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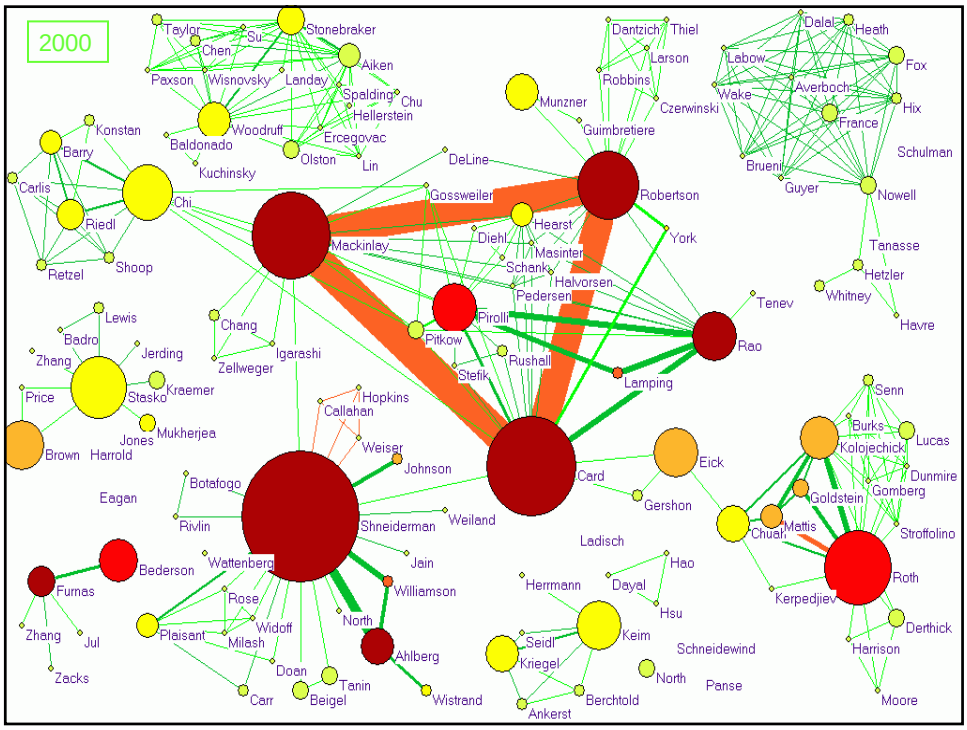
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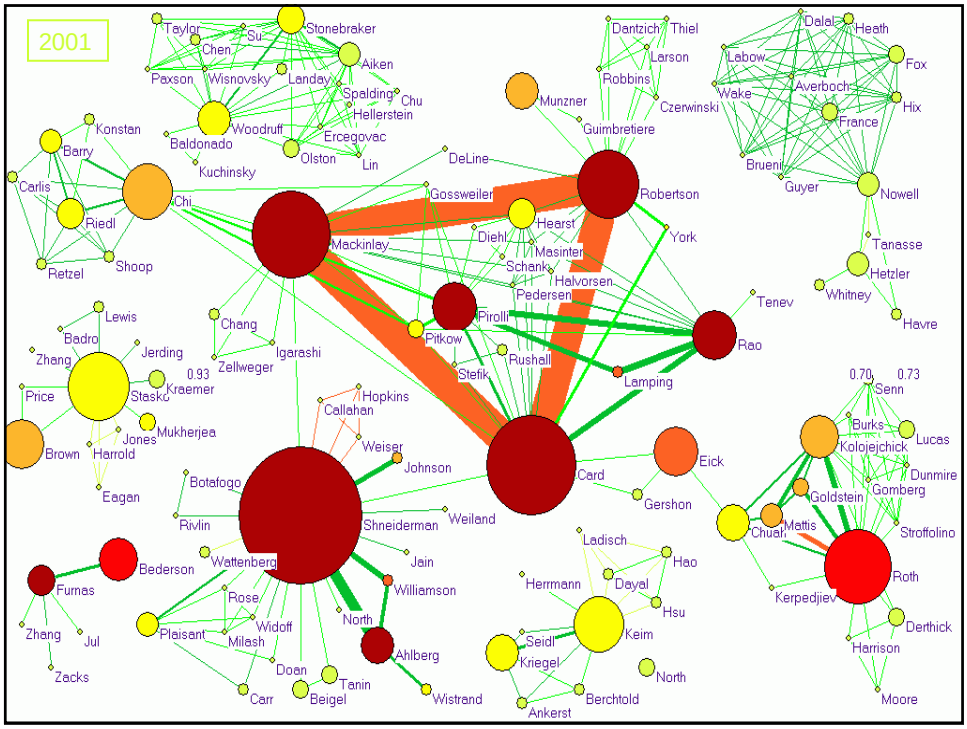
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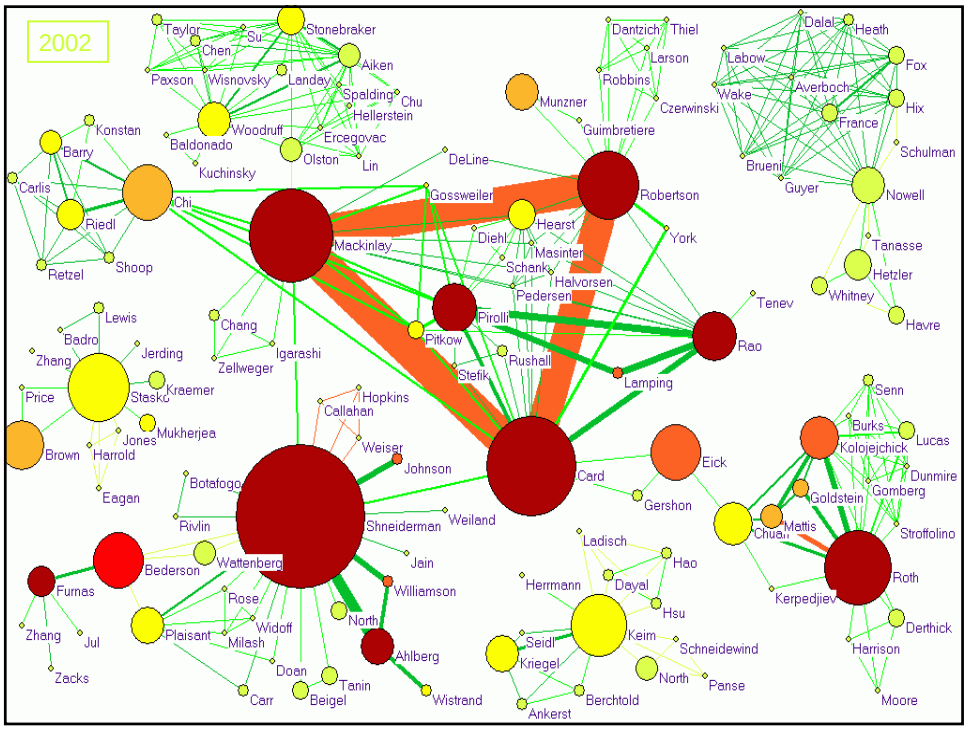
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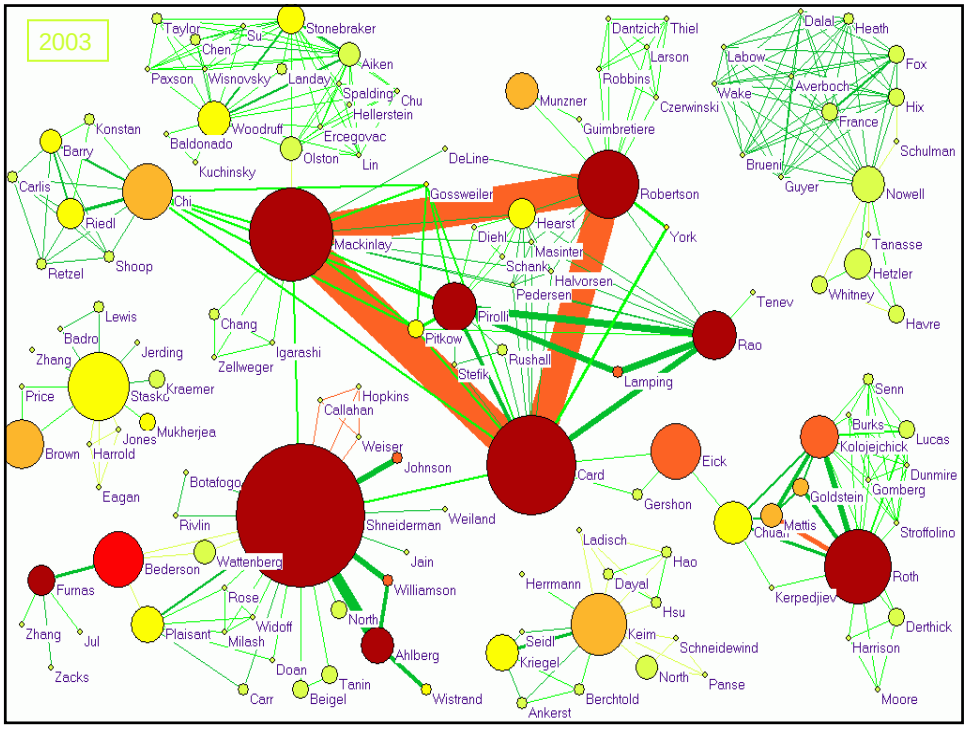
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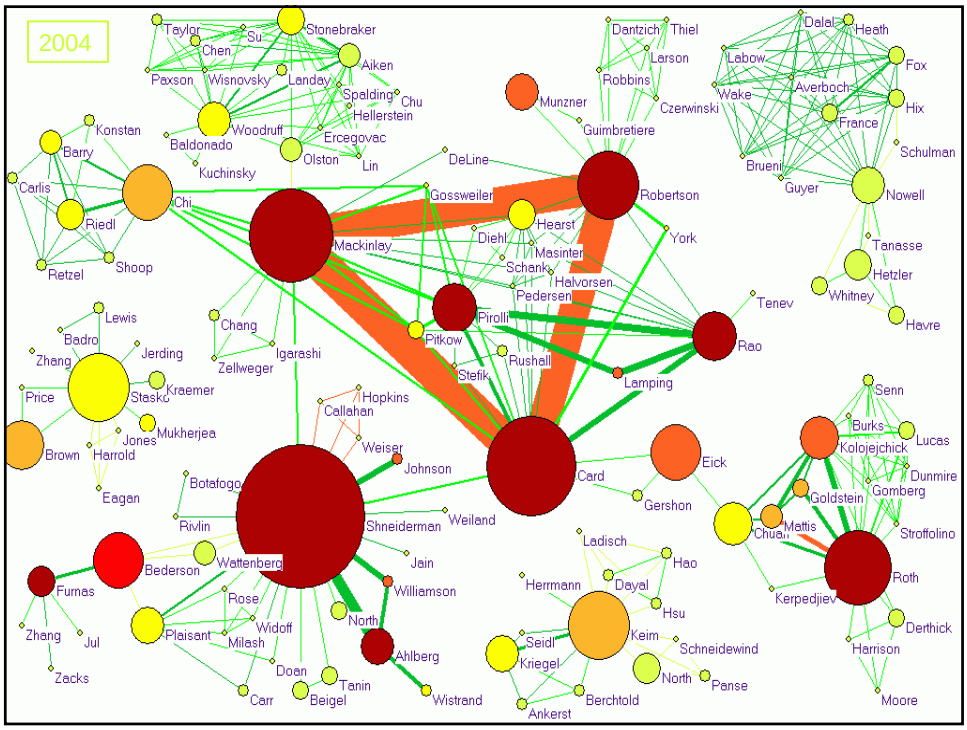
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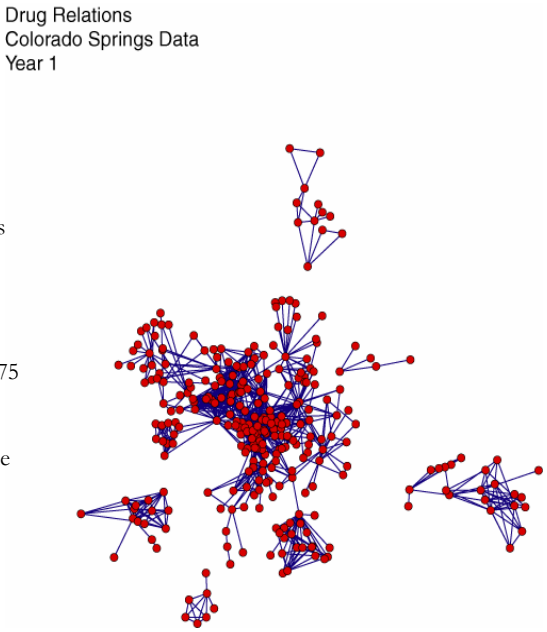
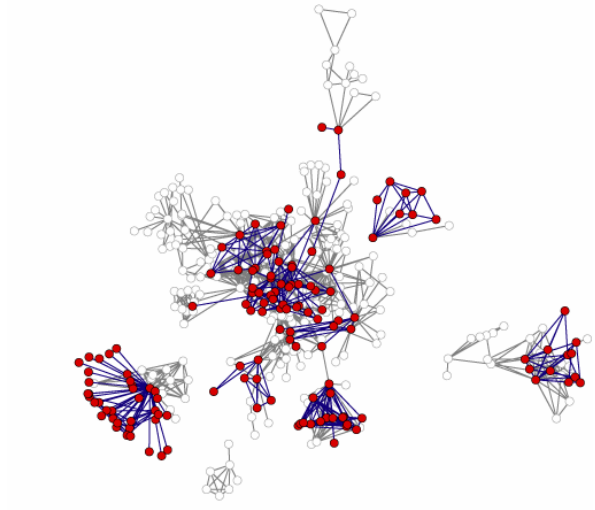
How do viral epidemics spread in sexual contact networks?
(James Moody, 2000)

- High-risk actors in Colorado Springs over 4 years
- 695 people represented
- Longest path is 17 steps
- Average distance is about 5 steps
- Average person is within 3 steps of 75 other people
- 137 people connected through 2 independent paths, core of 30 people connected through 4 independent paths

Drug Relations
Colorado Springs Data
Year 1

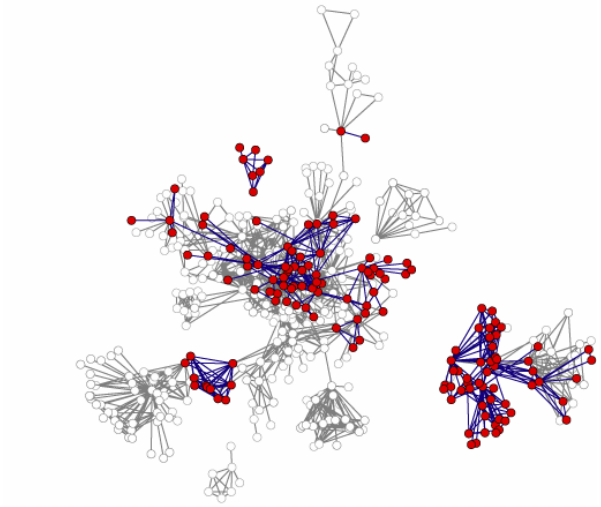


Drug Relations
Colorado Springs Data
Year 2



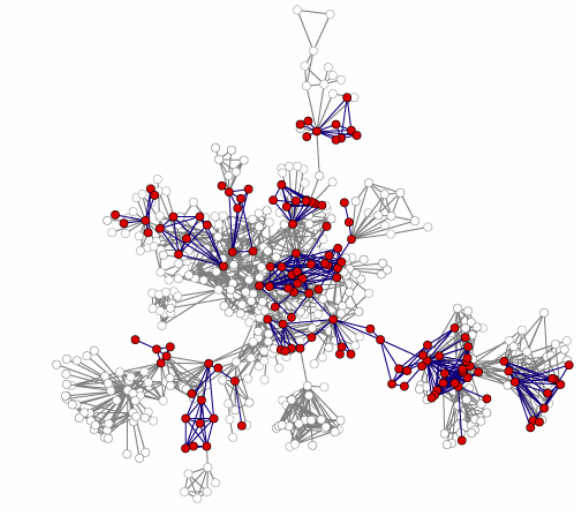
Year 2 points in red, previous points in gray

Drug Relations
Colorado Springs Data
Year 3



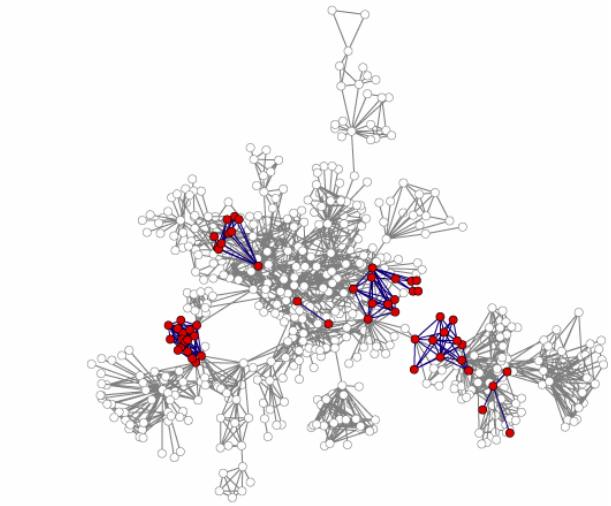
Year 3 points in red, previous points in gray

Drug Relations
Colorado Springs Data
Year 4

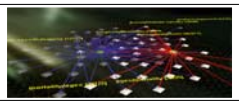


Year 4 points in red, previous points in gray

Drug Relations
Colorado Springs Data
Year 5



Year 5 points in red, previous points in gray



Opportunities and challenges for studying the structure and evolution of all of science

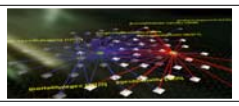
Opportunities:

- Today, many scientific publications are available in digital form (some full text journal data sets go as far back as 120 years).
- We do have algorithms and computing resources to analyze and map science on a large scale.
- Let's benefit from what we collectively know.

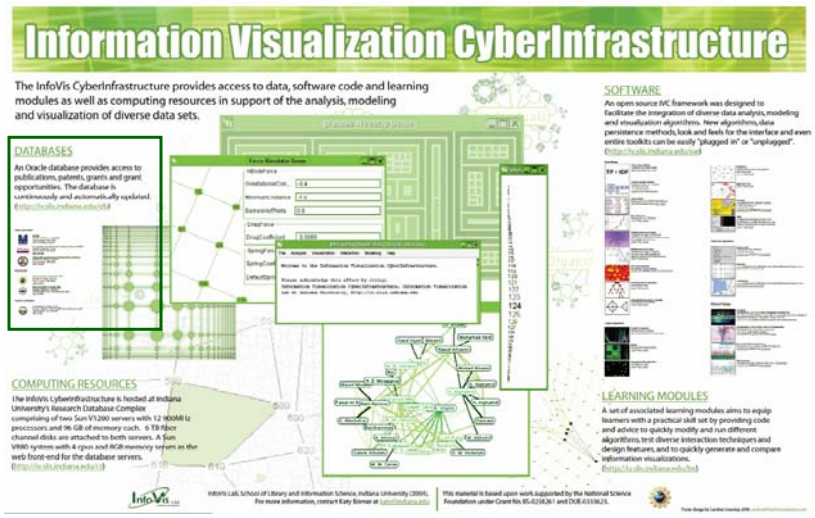
Challenges:

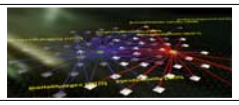
- Data access is difficult.
- Preservation is a big problem.
- Data integration, i.e., merging data from different databases, is a "hot" research topic as are scalable data analysis and visualization algorithms.
- Map interpretation is unresolved – can historians of science and philosophers of science help?

Katy Börner: Analyzing and Communicating the Structure and Evolution of Science, History and Philosophy of Science Talk, IUB, Nov 12, 2004.



3. Data bases, software & computing infrastructure at IUB





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

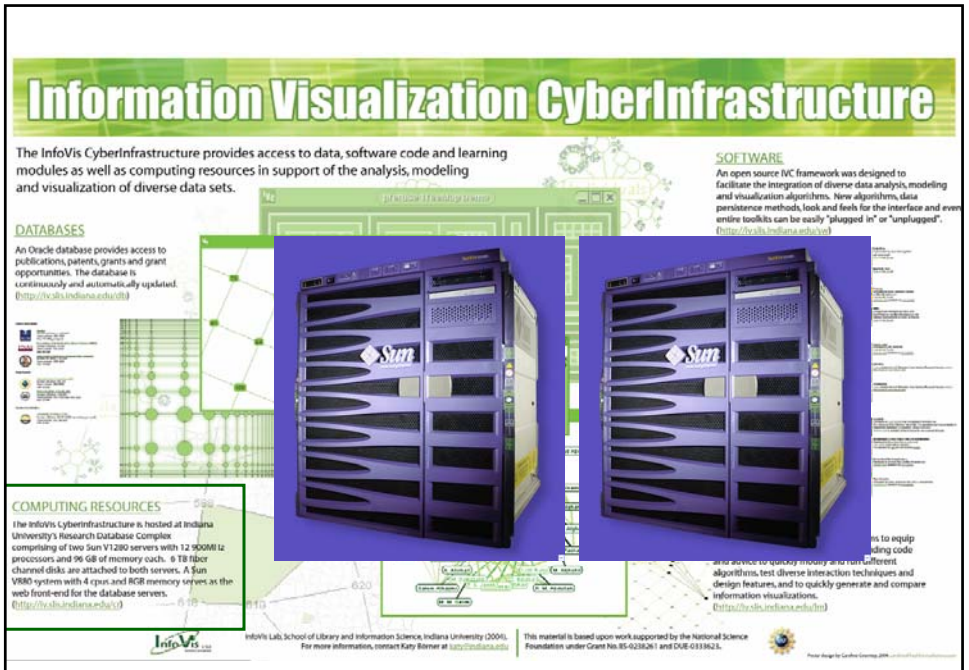
Grant Awards

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



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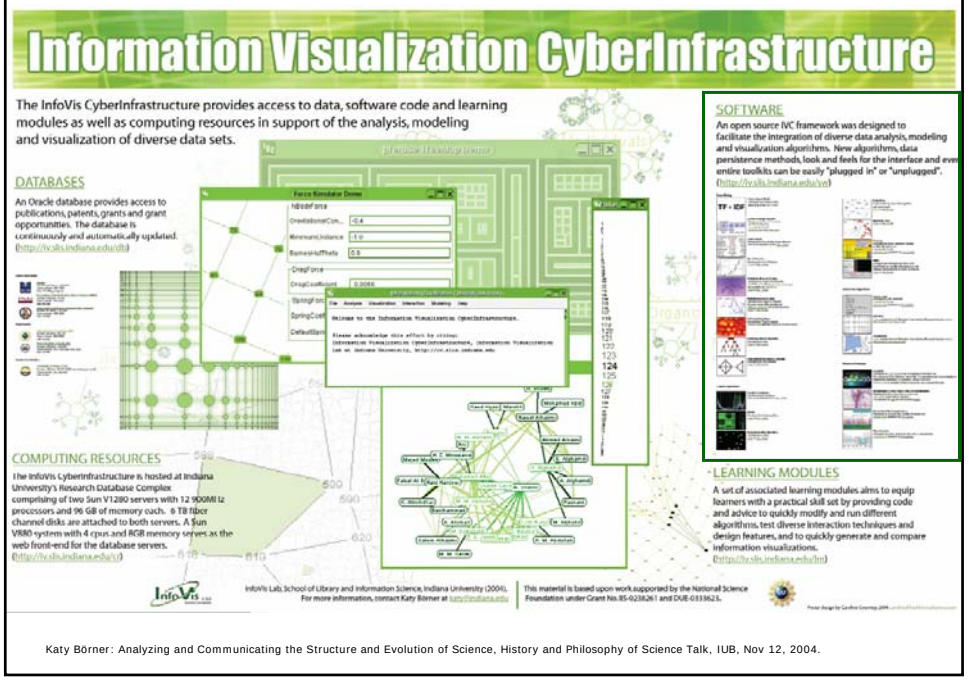

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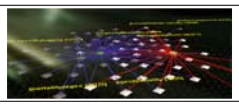
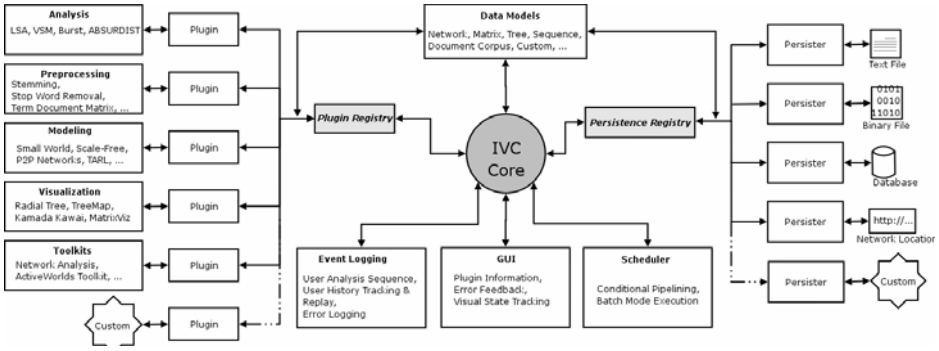
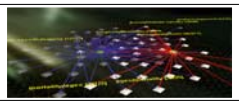


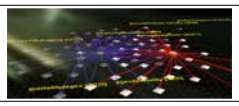
IVC Software Framework (http://iv.slis.indiana.edu/iv)



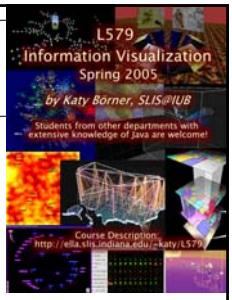


4. Related courses, talk series, and events

- Related Courses
- Fall 2004 Talk Series on "Networks and Complex Systems"
- Workshops and Conferences



L579 Information Visualization



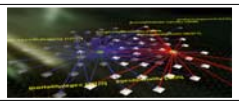
This course covers

- Perceptual basis of information visualization.
- Data mining algorithms that enable extraction of relationships in data.
- Visualization and interaction techniques.
- Discussions of systems that drive research and development, and
- Future trends and remaining fundamental problems in the field.

Students do weekly readings, provide a presentation on specific readings, do projects, and participate in class & online discussion.

Class Webpage: http://ella.slis.indiana.edu/~katy/L579

Katy Börner: Analyzing and Communicating the Structure and Evolution of Science, History and Philosophy of Science Talk, IUB, Nov 12, 2004.

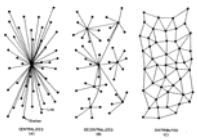


L597 Structural Data Mining and Modeling

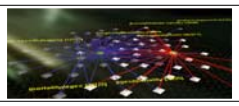
This course

- Introduces students to major methods, theories, and applications of structural data mining and modeling.
- Covers elementary graph theory and matrix algebra, data collection, structural data mining, data modeling, and applications.

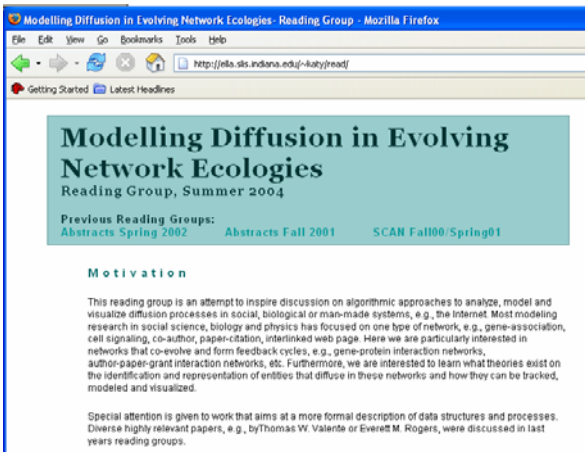
Upon taking this course students will be able to analyze and describe real networks (power grids, WWW, social networks, etc.) as well as relevant phenomena such as disease propagation, search, organizational performance, social power, and the diffusion of innovations.

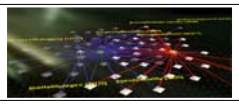


Format: Lectures and 4-5 labs.
Class Webpage: http://ella.slis.indiana.edu/~katy/L597



Summer Reading Group





Talk Series – will be continued in Spring 2005

Fall 2004 Talk Series on

Networks and Complex Systems

Every Monday 6-7p, LI 001 ~ Optional Dinner Afterwards

Description
This talk series is open to all Indiana University faculty and students interested in network analysis, modeling, visualization and complex systems research.

A major intent is to cross-fertilize between research done in the **social and behavioral sciences** and research in **'hard core' sciences** such as biology or physics.

Links to people, projects, groups, students, courses and news related to complex systems and networks research at Indiana University are also available via the **CSN web site**.

The slides of all talks will be be available online.
Most talks will be video taped.

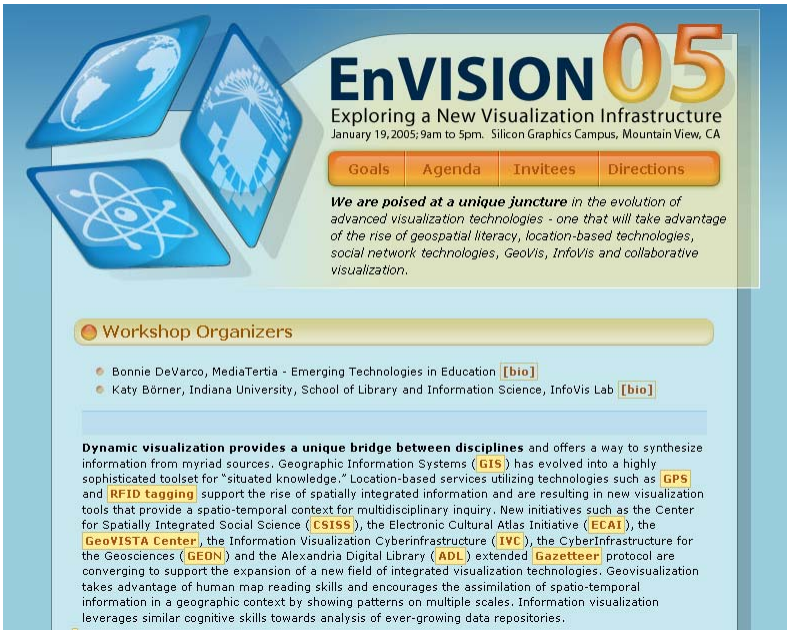
Organizer
Katy Börner <**katy@indiana.edu**> Assistant Professor of Information Science, SLIS, IUB.

Time & Place
Every Monday 6:00-7:00pm in the **Main Library** LI 001, Indiana University, Bloomington. Right after the **Cognitive Science Colloquium Series**.

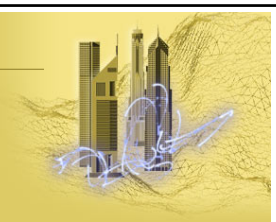
There is an optional dinner afterwards 7-9p at **Lennie's**.

http://vw.indiana.edu/talks-fall04/

http://vw.indiana.edu/vda2005/



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

The fourth International Symposium on Knowledge Domain Visualization (KDViz'05)

Knowledge Domain Visualization (KDViz) aims to improve our understanding of the development of a knowledge domain through the study of a wide variety of quantitative and qualitative properties of a knowledge domain. KDViz emphasizes the great potential of an approach that integrates techniques such as information visualization, exploratory data analysis, information retrieval, and information science.

Aims
International Symposium on KDViz aims to provide an inter-disciplinary forum for researchers and practitioners from a wide variety of disciplines to address theories, methodologies, techniques, applications, evaluations and case studies in relation to KDViz. The symposium also aims to promote the cross-disciplinary awareness between disciplines such as information visualization and information science. For the purpose of this symposium, a knowledge domain is broadly defined as a dynamic, evolving intellectual structure of a given subject matter. Knowledge domain visualization aims to reveal the dynamics of a knowledge domain by utilizing a wide variety of techniques involving visual thinking, visual discovery, visual exploration, and visual analysis.

Scope
The symposium will seek original papers concerning, but not limited to, the following topics. Submitted papers must clearly demonstrate a connection between information visualization and the study of a knowledge domain:

- **Fundamentals of KDViz**
- **Case Studies**
- **Citation Analysis**
- **Domain Analysis and Modeling**
- **Historical, Sociological, or Philosophical Approaches**
- **Knowledge Discovery, Knowledge Representation, and Knowledge Diffusion**
- **Invisible Colleges, Scientific Networks, Social Networks, Scientific Paradigms**
- **Qualitative and Quantitative Methodologies**
- **Scientometrics**
- **Dynamic Models of Scientific Disicplines**
- **Growth Models of Science and Technology**

Highlights
A major goal of the symposium is to demonstrate and compare different techniques, algorithms, and approaches that can be utilized to analyze and visualize knowledge domains. In order to facilitate this goal a large-scale data set from the information visualization domain will be made available and participants will be encouraged to utilize this data set to demonstrate new approaches and algorithms.

http://www.graphicslink.demon.co.uk/IV05/KDViz.htm