Title: 21st Century Science Maps

Date: Sep 09, 2008 02:00 PM

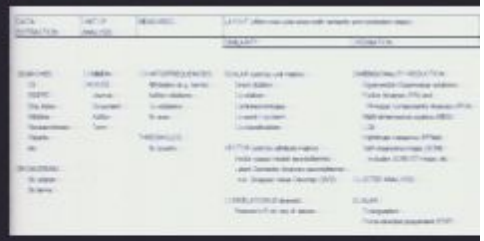
URL: http://pirsa.org/08090031

Abstract: Cartographic maps of physical places have guided mankind\'s explorations for centuries. They enabled the discovery of new worlds while also marking territories inhabited by unknown monsters. Domain maps of abstract semantic spaces, see scimaps.org, aim to serve today\'s explorers understanding and navigating the world of science. The maps are generated through scientific analysis of large-scale scholarly datasets in an effort to connect and make sense of the bits and pieces of knowledge they contain. They can be used to objectively identify major research areas, experts, institutions, collections, grants, papers, journals, and ideas in a domain of interest. Local maps provide overviews of a specific area: its homogeneity, import-export factors, and relative speed. They allow one to track the emergence, evolution, and disappearance of topics and help to identify the most promising areas of research. Global maps show the overall structure and evolution of our collective scholarly knowledge. This talk will present an overview of the techniques and cyber-technologies used to study science by scientific means together with sample science maps and their interpretations.

21st Century Science Maps

Dr. Katy Börner
Cyberinfrastructure for Network Science Center, Director
Information Visualization Laboratory, Director
School of Library and Information Science
Indiana University, Bloomington, IN
katy@indiana.edu

Science in the 21 st Century
Perimeter Institute, Waterloo, Ontario, Canada
Sept 8-12, 2008



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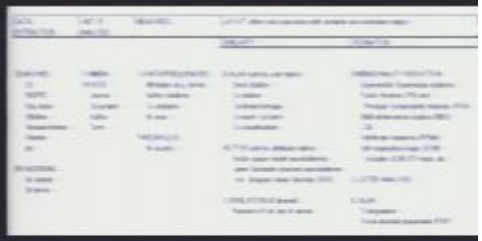

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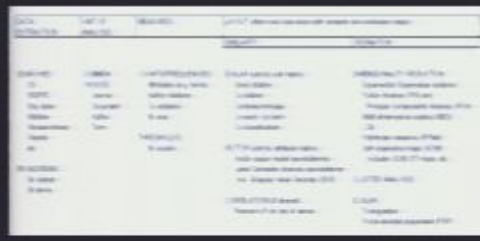

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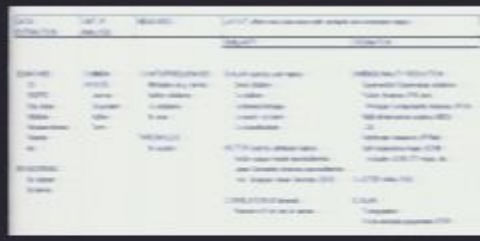

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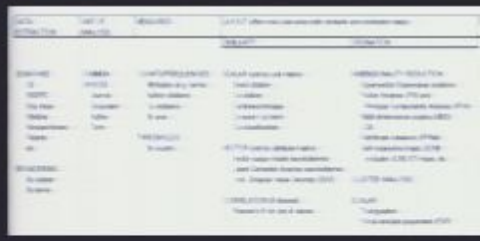

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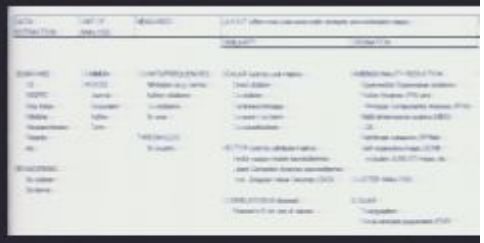

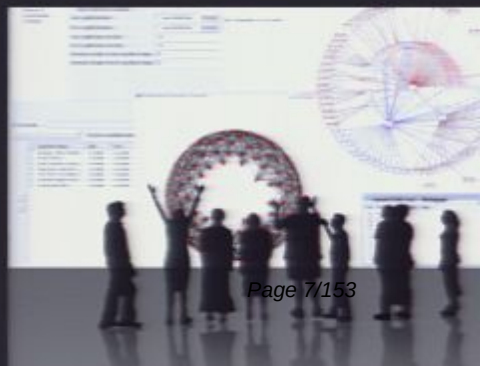

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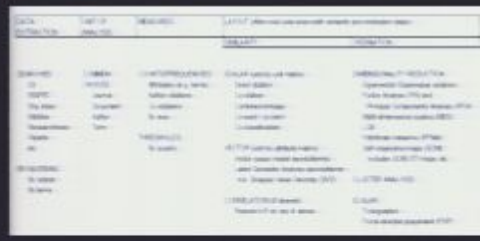
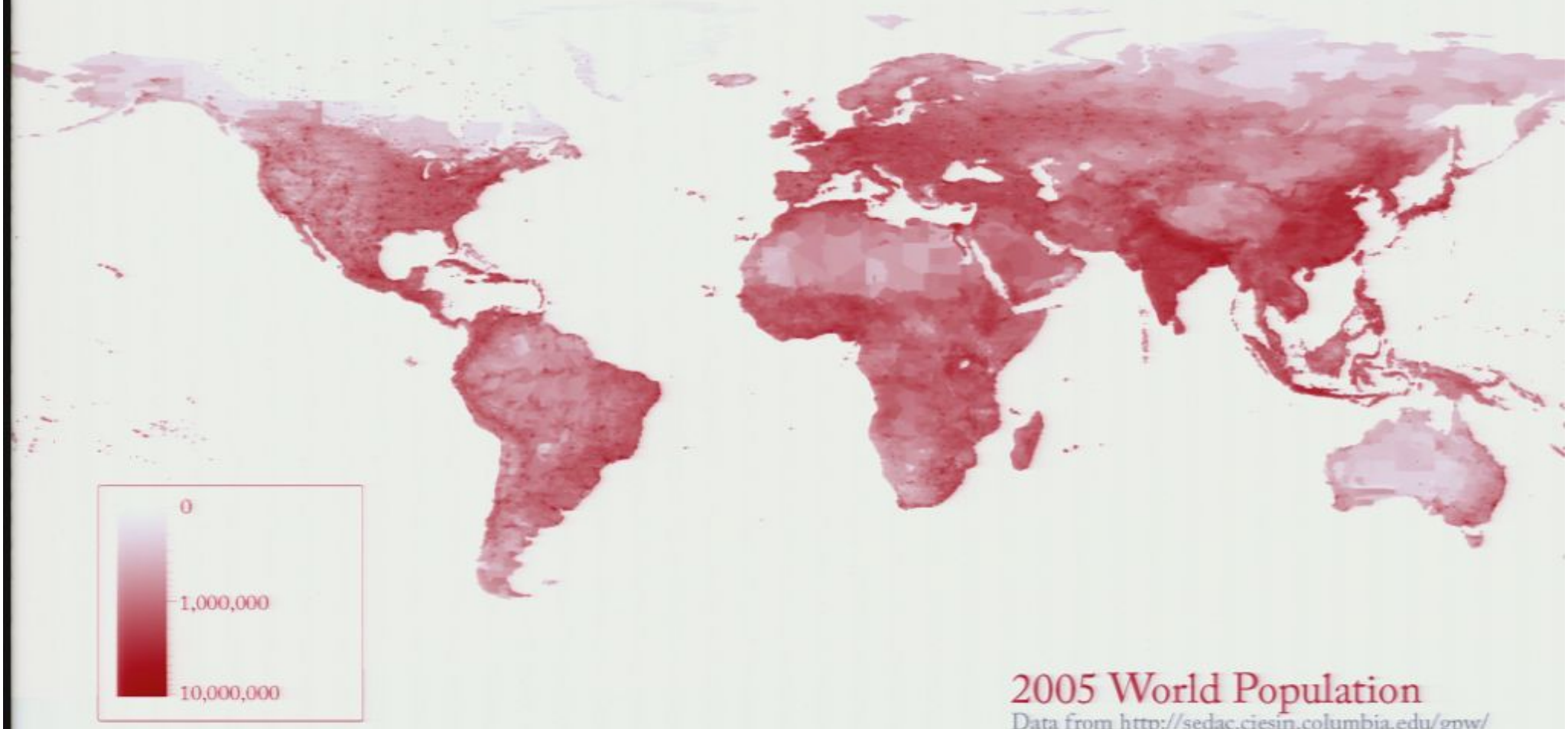


2005 World Population

The population map uses a quarter degree box resolution. Boxes with zero people are given in white. Darker shades of red indicate higher population counts per box using a logarithmic interpolation. The highest density boxes appear in Mumbai, with 11,687,850 people in the quarter degree block, Calcutta (10,816,010), and Shanghai (8,628,088).



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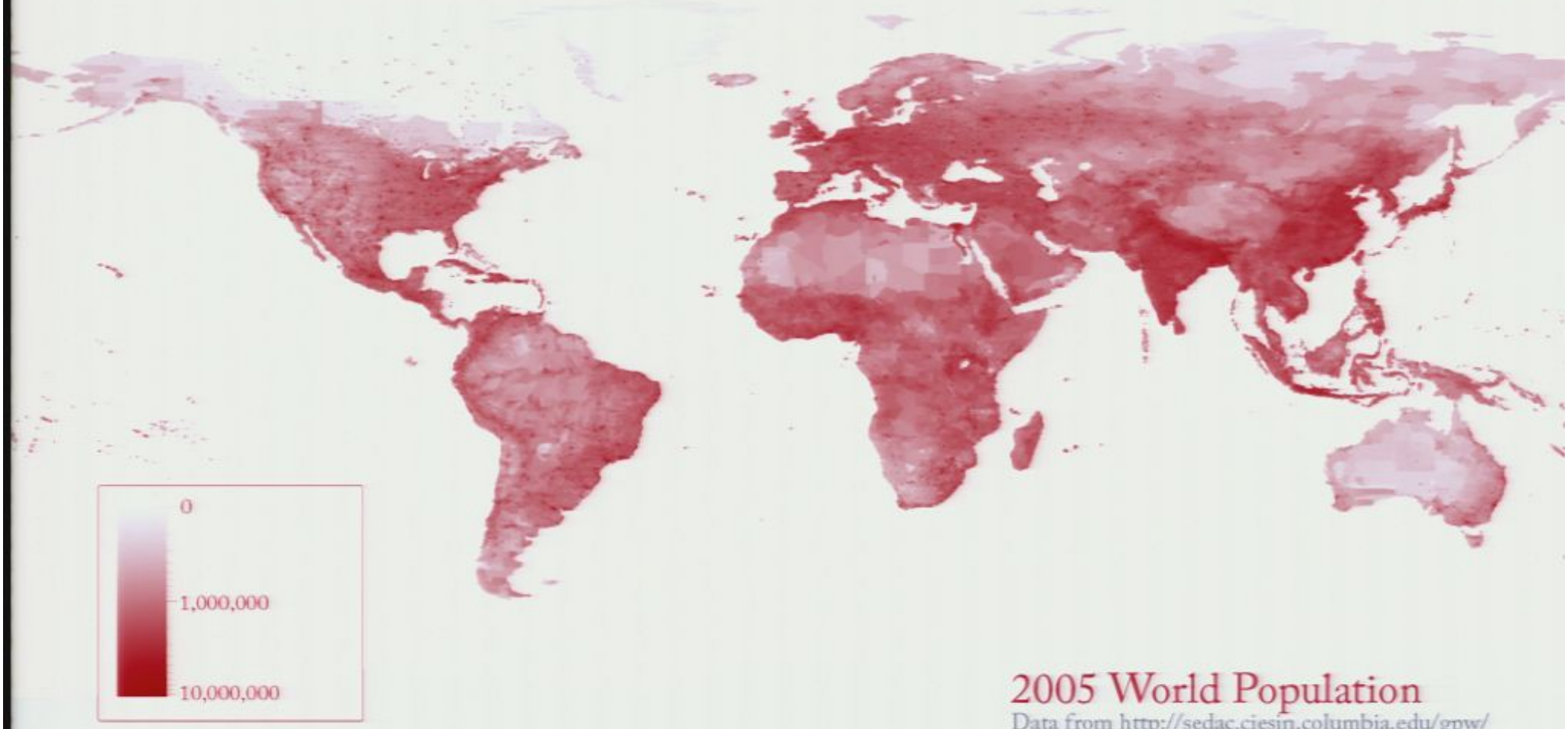

2000 Night on Earth

This image shows city lights at night. It was composed from hundreds of pictures made by orbiting satellites. The seaboards of Europe, the eastern United States, and Japan are particularly well lit. Many cities exist near rivers or oceans so that goods can be exchanged cheaply by boat. The central parts of South America, Africa, Asia, and Australia are rather dark despite their high population density, see map to the left.

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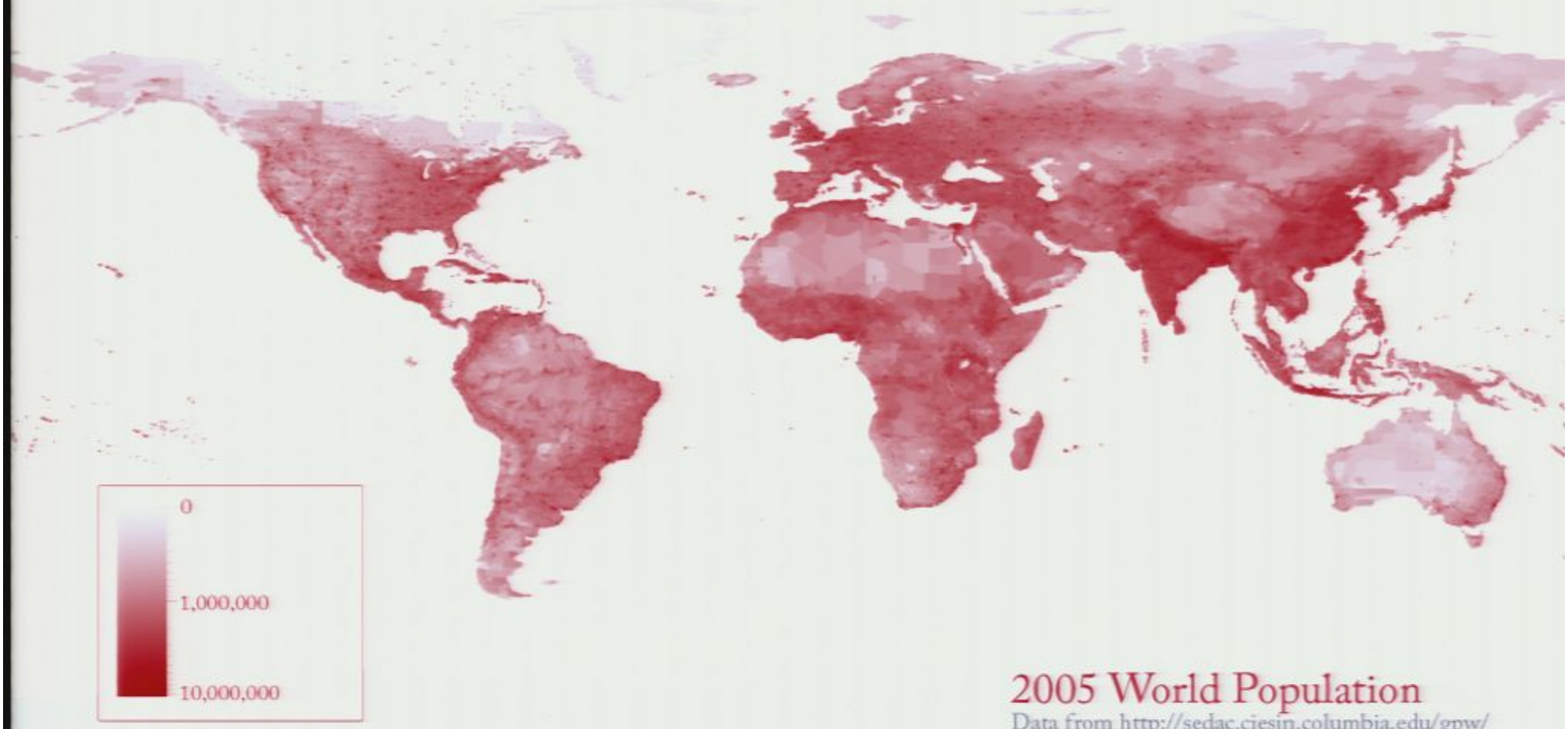

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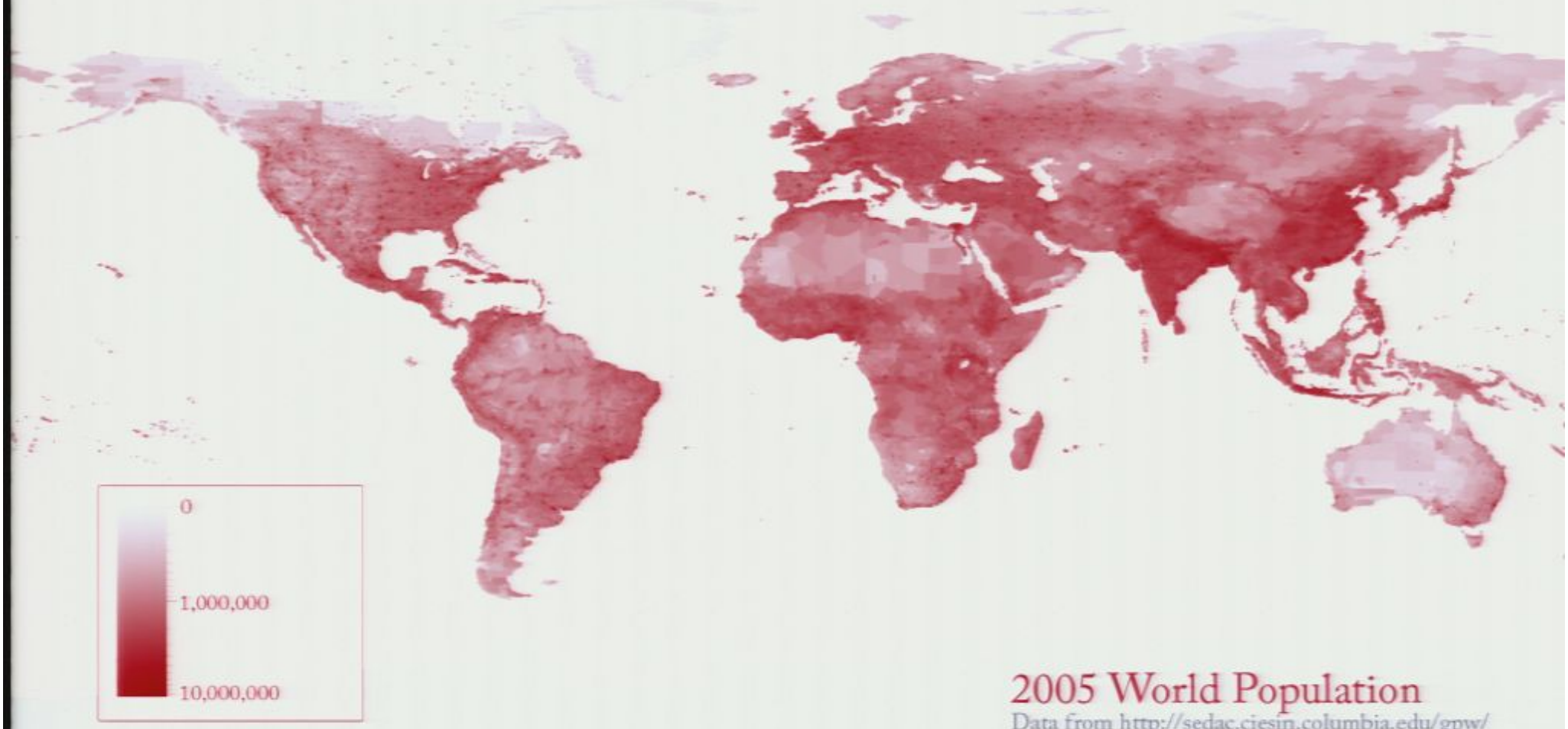

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2007 IP Address Ownership

This map shows IP address ownership by location. Each owner is represented by a circle and the area size of
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(560 million), Japan (130 million), Great Britain (47 million).

2003 Scientific Productivity

Shown is where science is performed today. Each circle indicates a geographic location at which scholarly pap
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2003 Scientific Productivity
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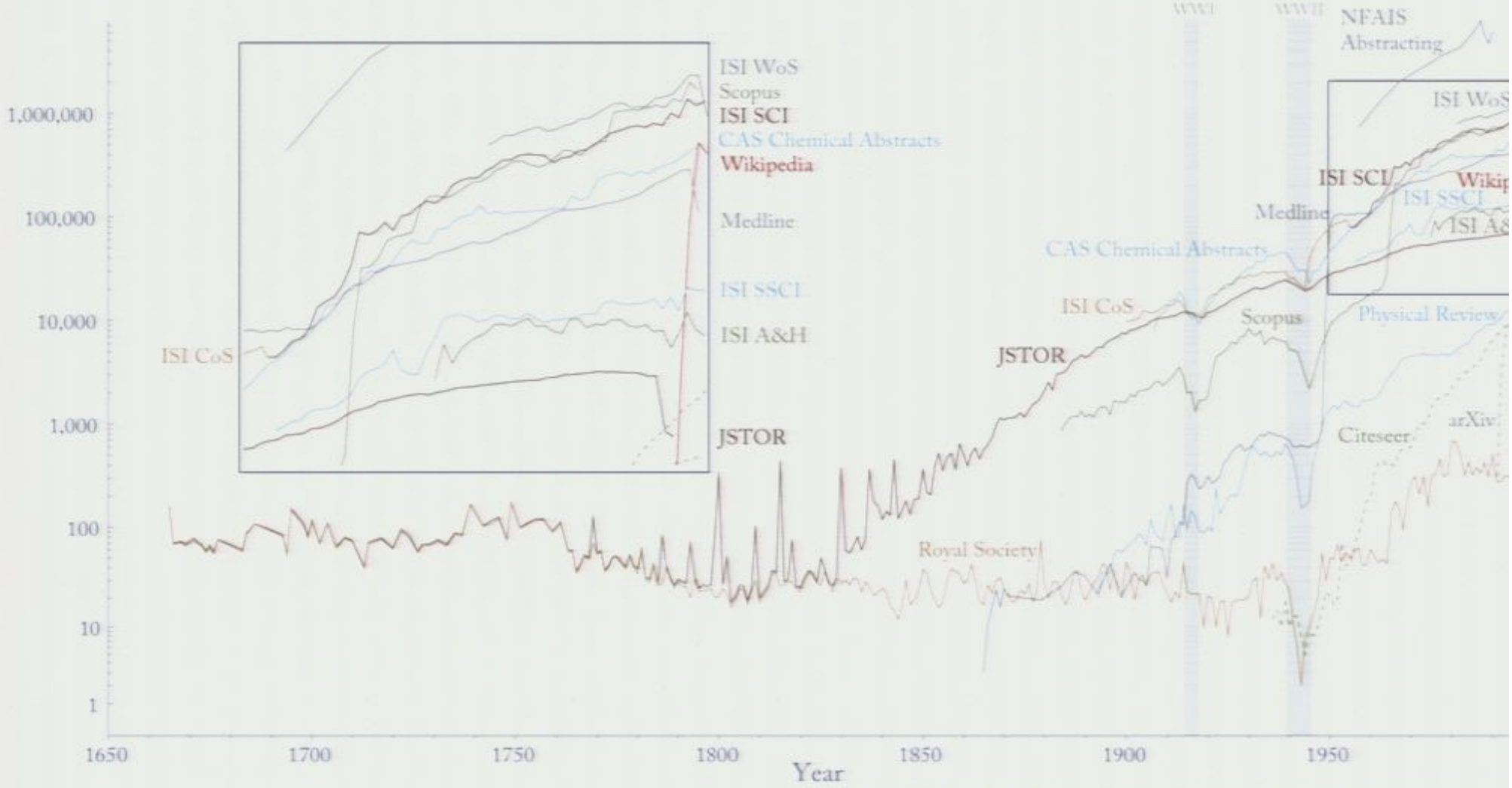
"Human history becomes more and more a race between education and catastrophe."

Herman G. Wells (1938) World Brain

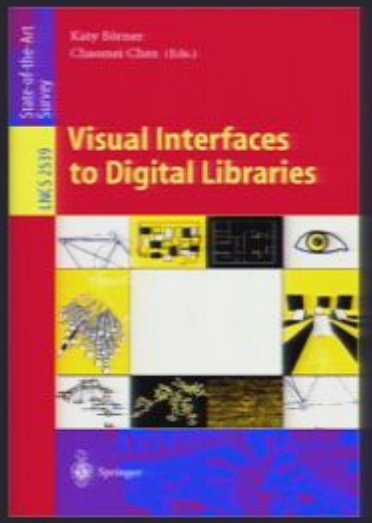
In the 1960's, Richard Buckminster Fuller proposed the "World Peace Game" or "World Game", a comprehensive, anticipatory, design science approach to the problems of the world. The playing of World Game was intended to

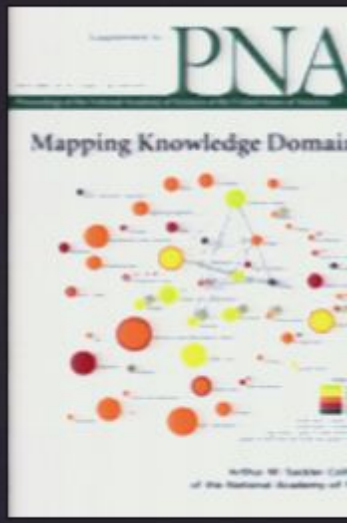
"make the world work for 100% of humanity in the shortest possible time through spontaneous cooperation without ecological damage or disadvantage to anyone."

Growth of Scientific Knowledge, 1665 to 2006



Computational Scientometrics: Studying Science by Scientific Means





- *Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003).* ***Visualizing Knowledge Domains.*** *Blaise Cronin (Ed.), Annual Review of Information Science & Technology, Medford, NJ: Information Today, Inc./American Society for Information Science and Technology, Volume 37, Chapter 5, pp. 179-255.* http://ivl.slis.indiana.edu/km/pub/2003-borner-arist.pdf
- *Shiffrin, Richard M. and Börner, Katy (Eds.) (2004).* ***Mapping Knowledge Domains.*** *Proceedings of the National Academy of Sciences of the United States of America, 101(Suppl_1).* http://www.pnas.org/content/vol101/suppl_1/
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- ***Places & Spaces: Mapping Science*** *exhibit, see also* http://scimaps.org.

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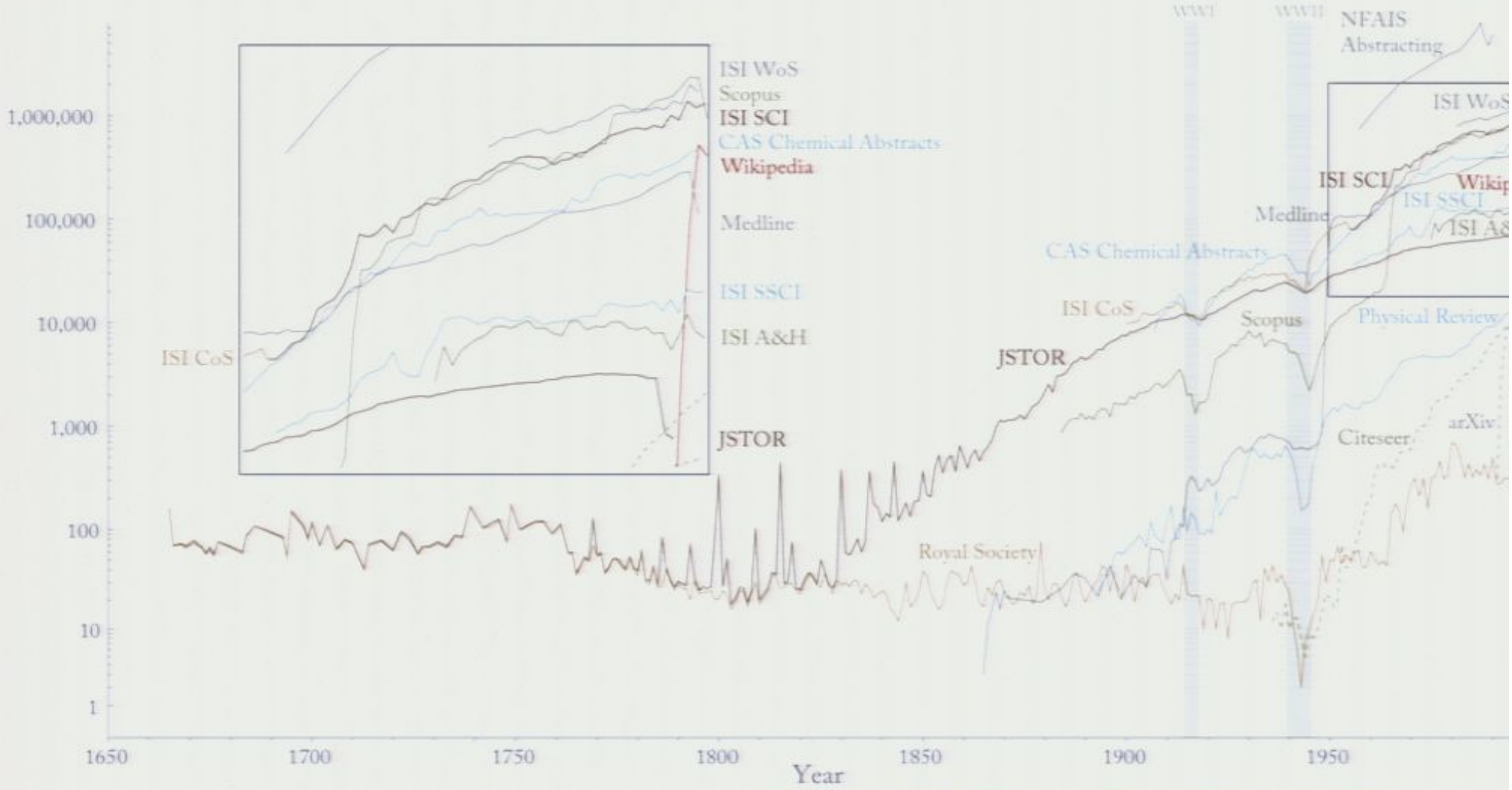

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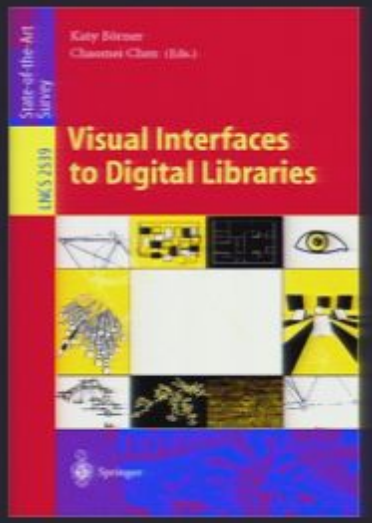

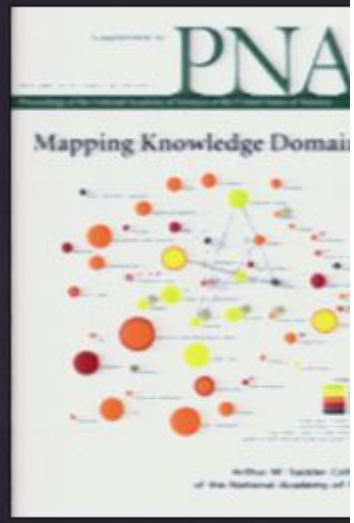

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"Science of Science" Opportunities

Advantages for Funding Agencies

- Supports monitoring of (long-term) money flow and research developments, evaluation of funding strategies for different programs, decisions on project durations, funding patterns.
- Staff resources can be used for scientific program development, to identify areas for future development, and the stimulation of new research areas.

Advantages for Researchers

- Easy access to research results, relevant funding programs and their success rates, potential collaborators, competitors, related projects/publications **(research push).**
- More time for research and teaching.

Advantages for Industry

- Fast and easy access to major results, experts, etc.
- Can influence the direction of research by entering information on needed technologies **(industry-pull)**.

Advantages for Publishers

- Unique interface to their data.
- Publicly funded development of databases and their interlinkage.

For Society

- Dramatically improved access to scientific knowledge and expertise.

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)	INTERACTIO Browse Pan Zoom Filter Query Detail on de ANALYSIS

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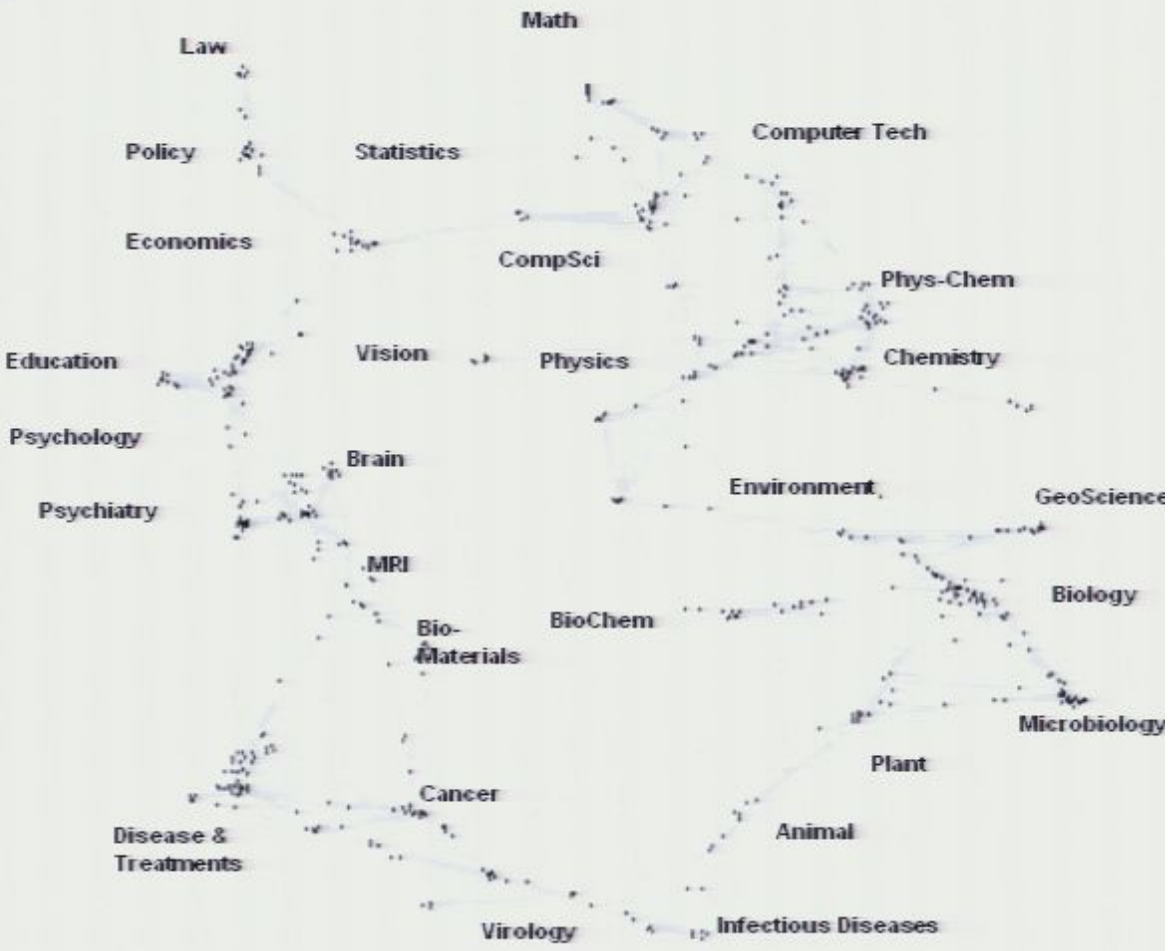
Latest 'Base Map' of Science

Kevin W. Boyack, Katy Borner, & Richard Klavans (2007). Mapping the Structure and Evolution of Chemistry Research. 11th International Conference on Scientometrics and Informetrics. pp. 112-123.

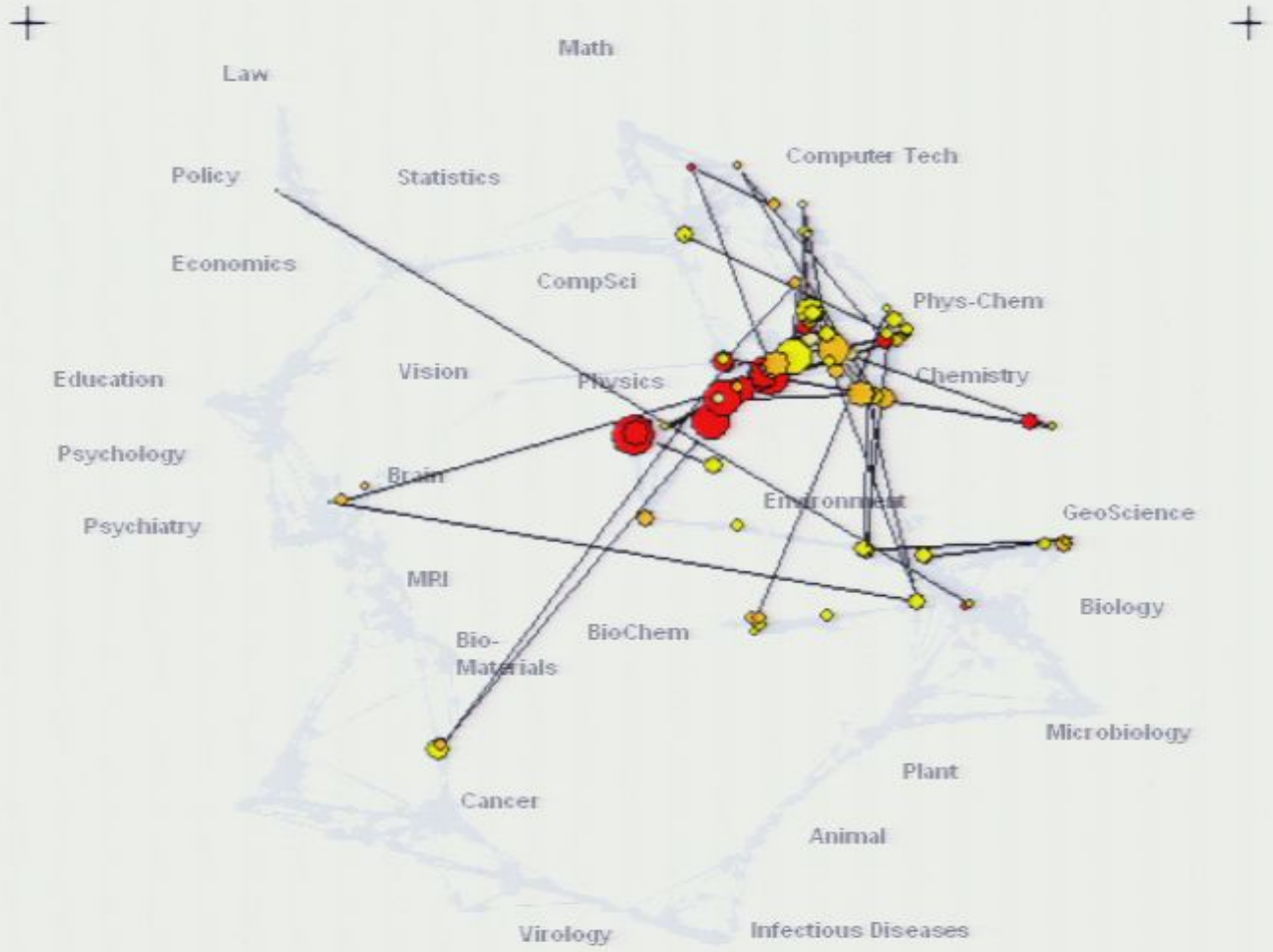
- Uses combined SCI/SSCI from 2002
  - 1.07M papers, 24.5M references, 7,300 journals
  - Bibliographic coupling of papers, aggregated to journals
- Initial ordination and clustering of journals gave 671 clusters
- Coupling counts were reaggregated at the journal cluster level to calculate the
  - (x,y) positions for each journal cluster
  - by association, (x,y) positions for each journal



Science map applications: Identifying core competency

Kevin W. Boyack, Katy Borner, & Richard Klavans (2007).

Funding patterns of the US Department of Energy (DOE)



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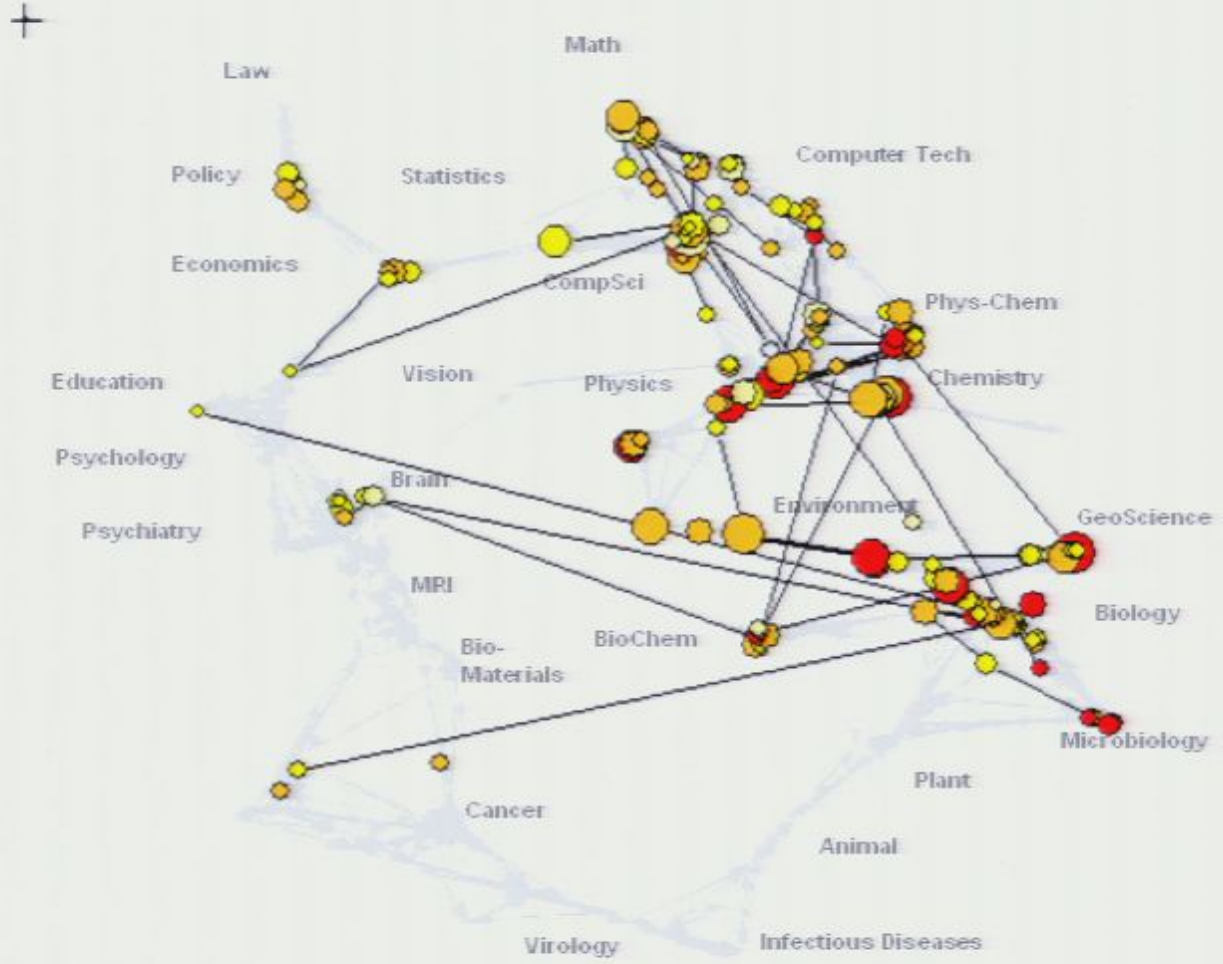

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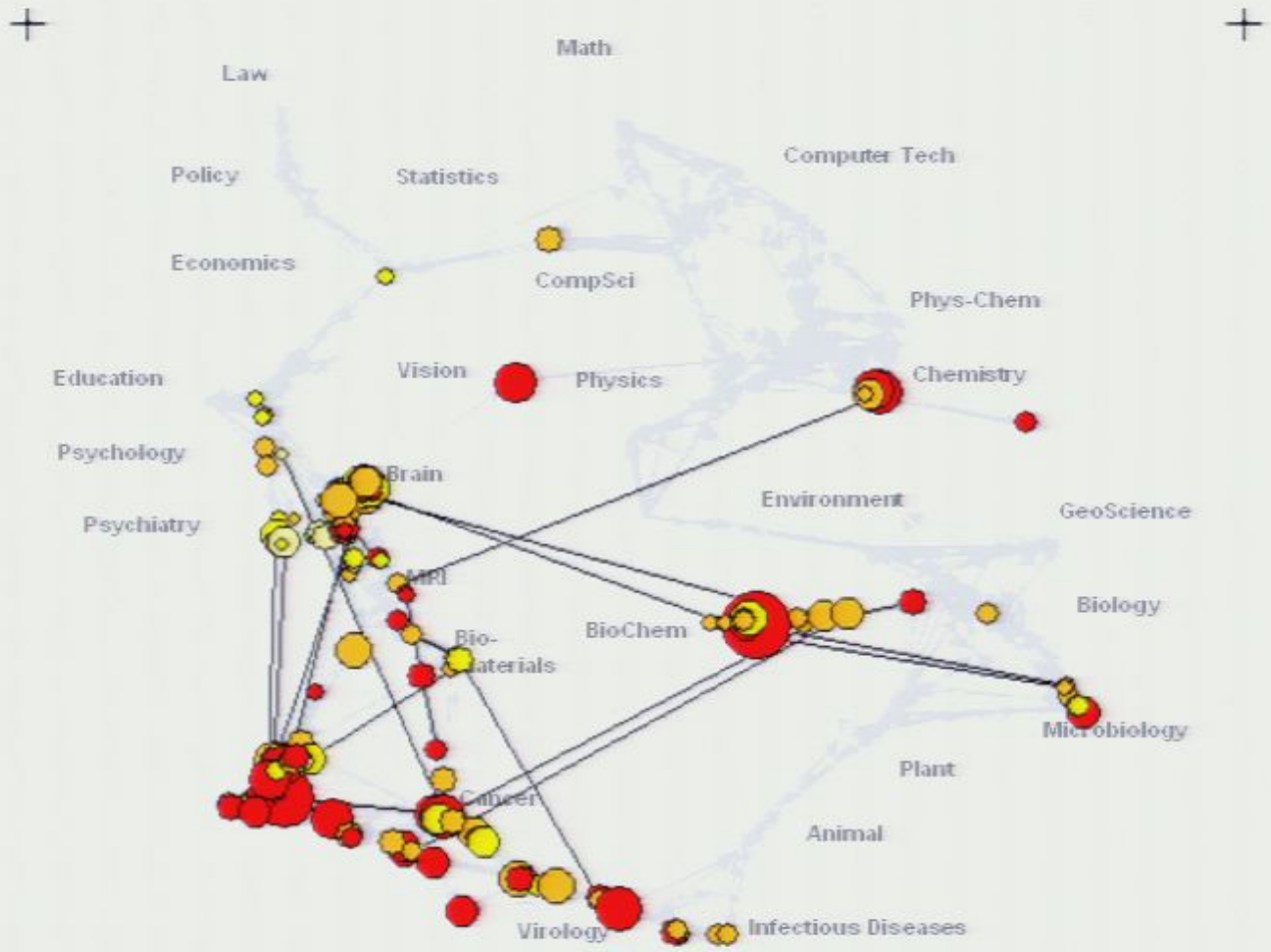

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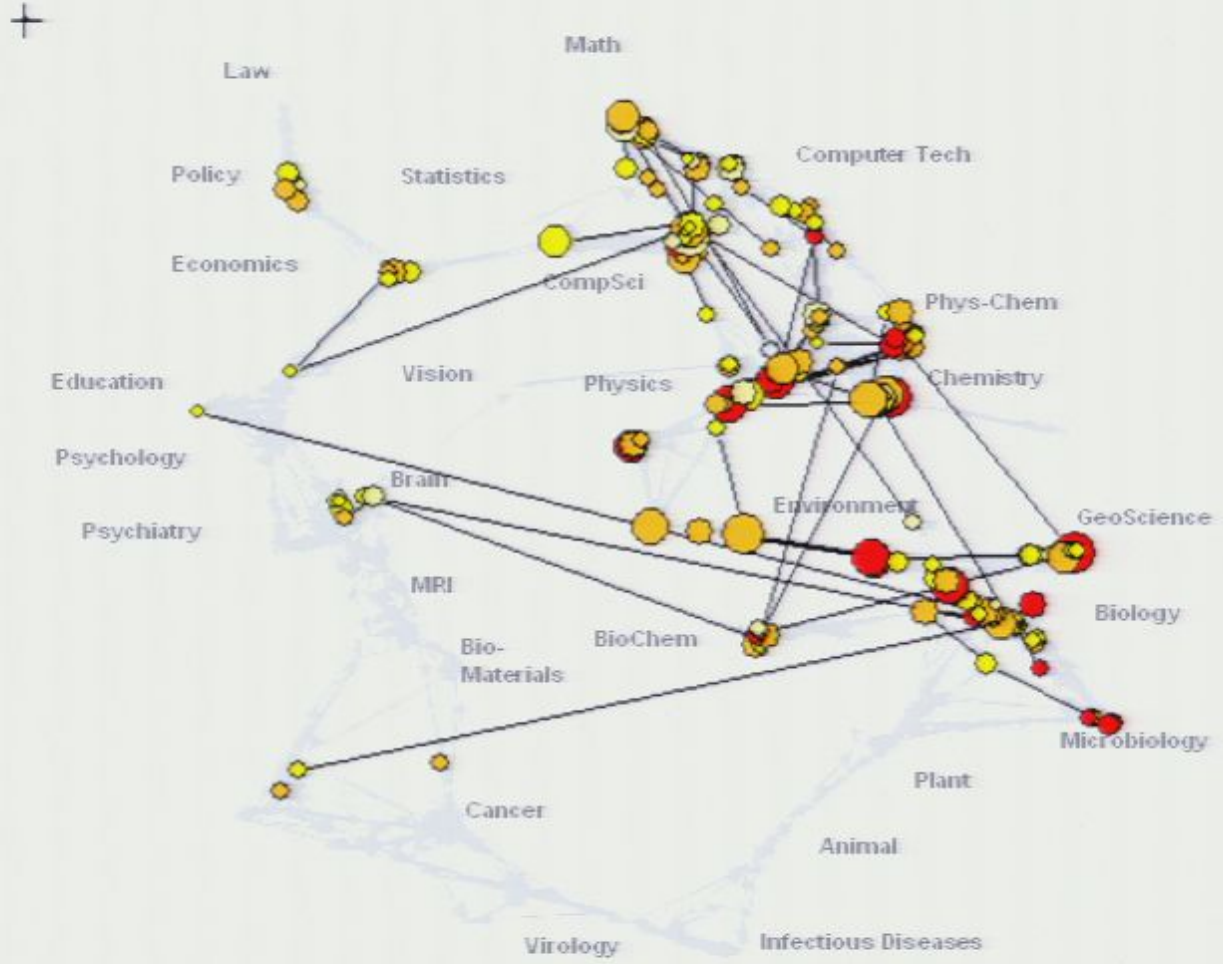

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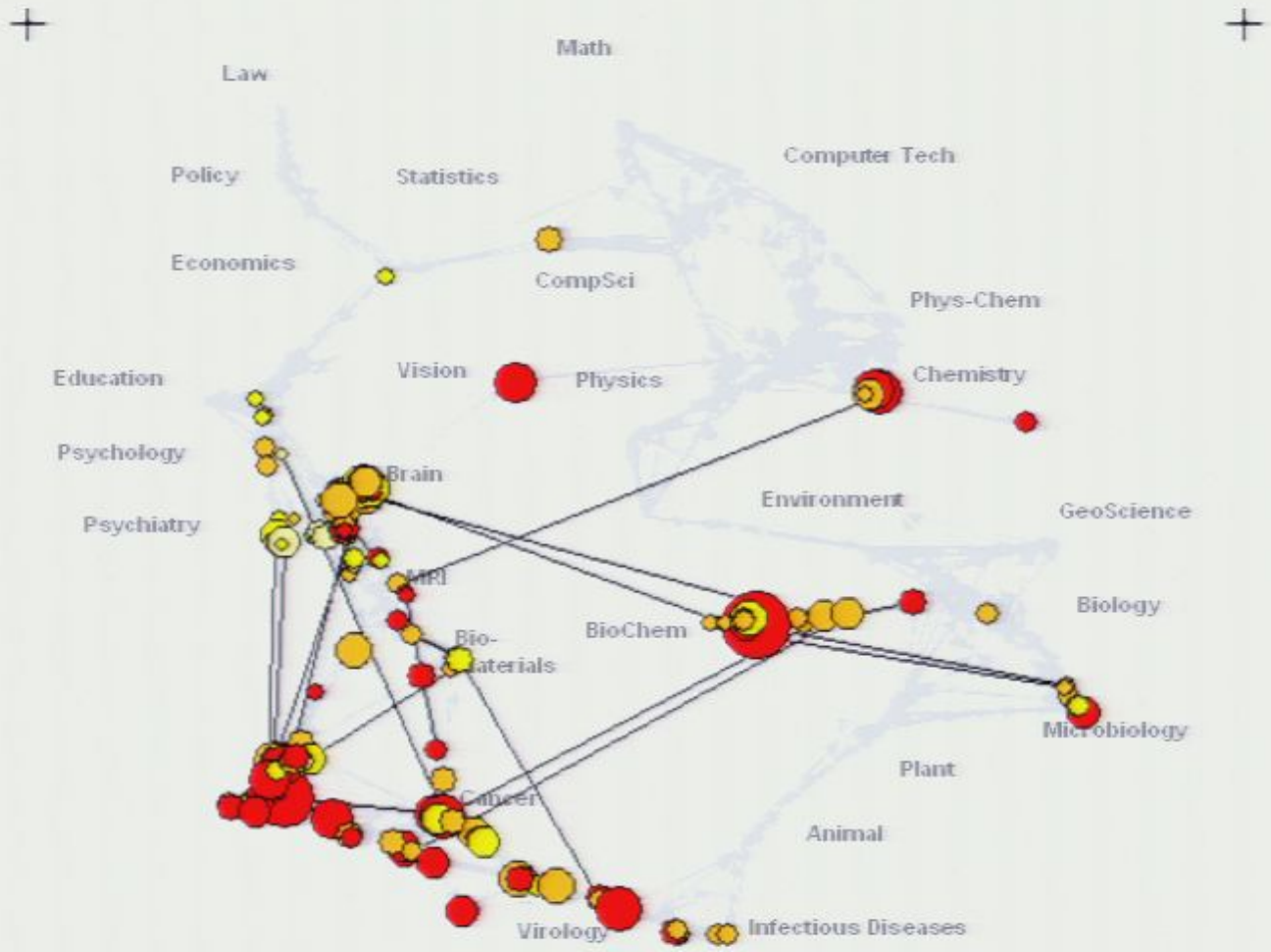
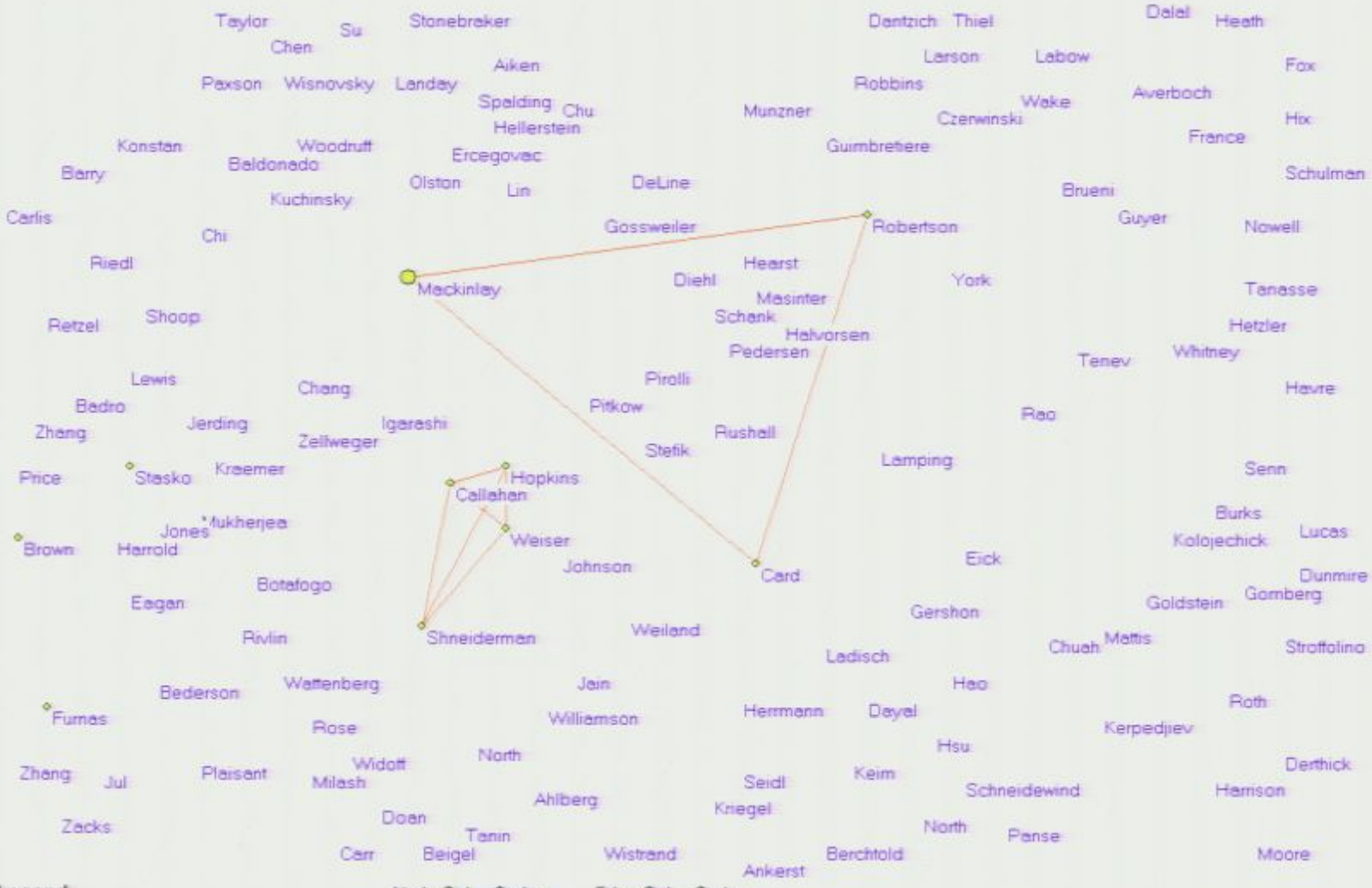


Sample Science Studies

Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Borner, (2004) Won 1st price at the IEEE InfoVis Contest.



Legend

Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Number of citations

Edges ~ Co-authorship relations
Edge color ~ Year of first co-authorship

Node Color Code

0 - 9
10 - 19
20 - 29
30 - 39
40 - 49
50 -

Edge Color Code

86 - 90
91 - 95
96 - 00
01 -

Displayed Year: 1989

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Weimao Ke, Lalitha Visvanath & Katy Borner
InfoVis Lab @ Indiana University
2004

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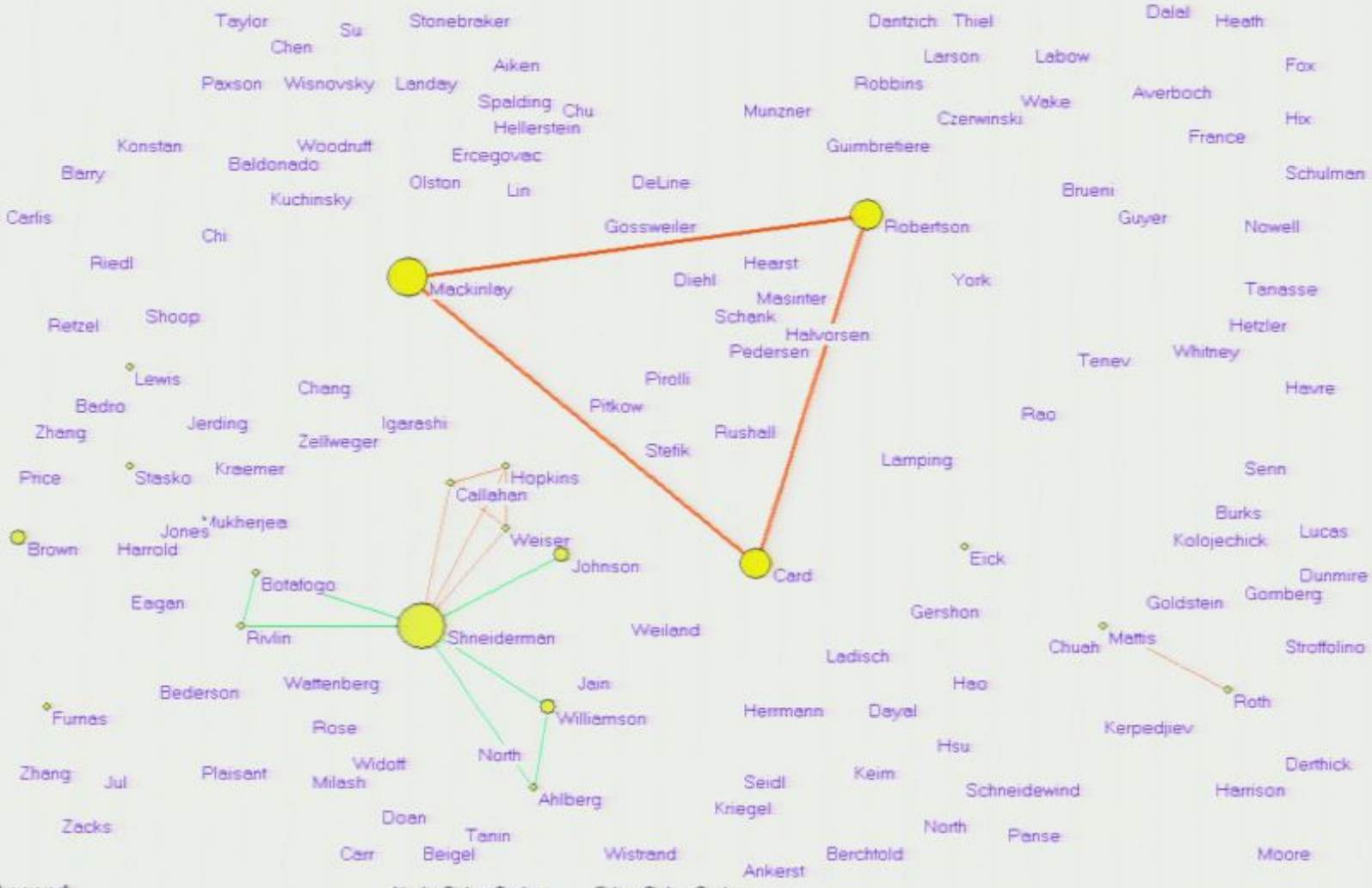

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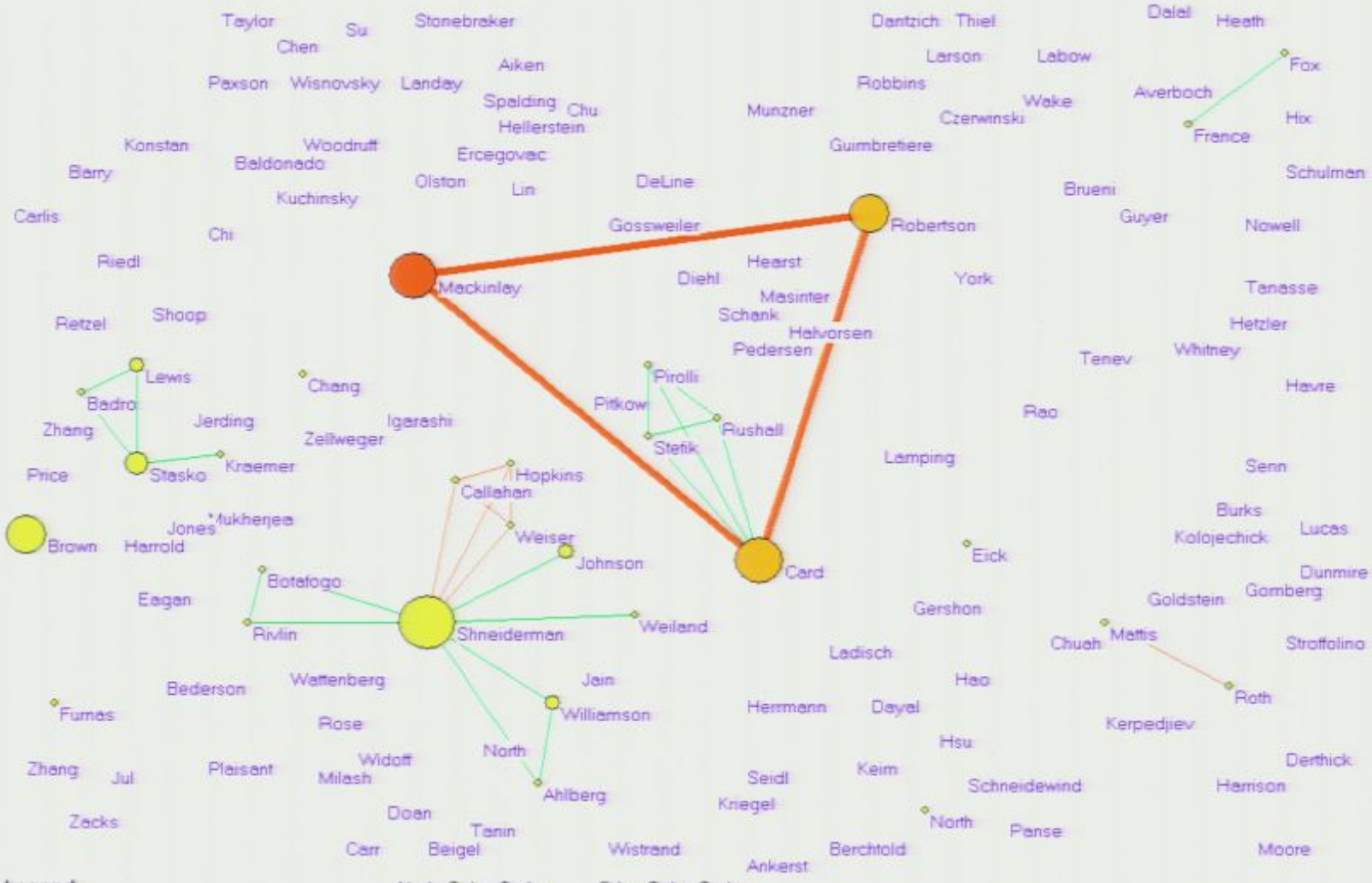

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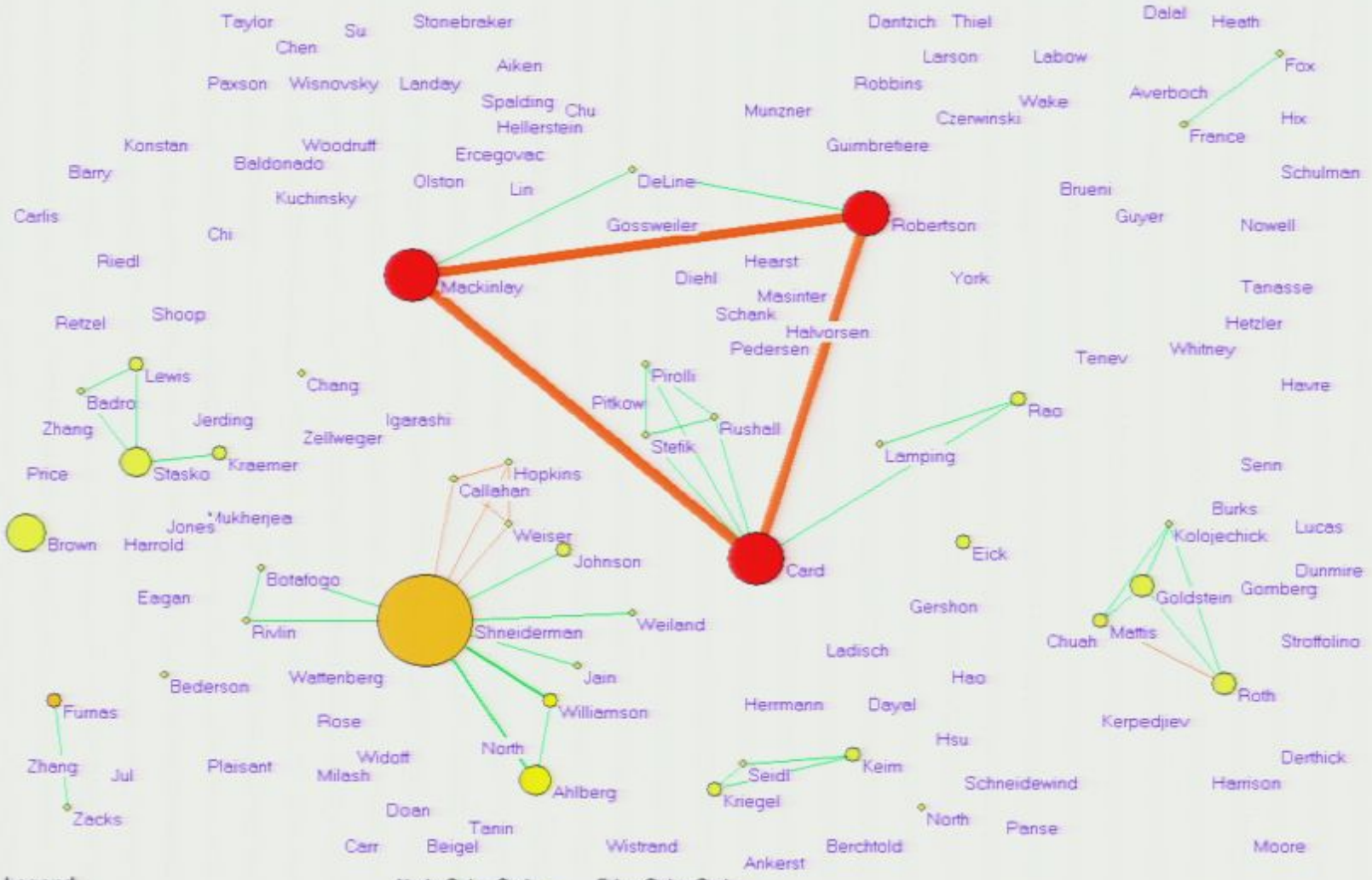

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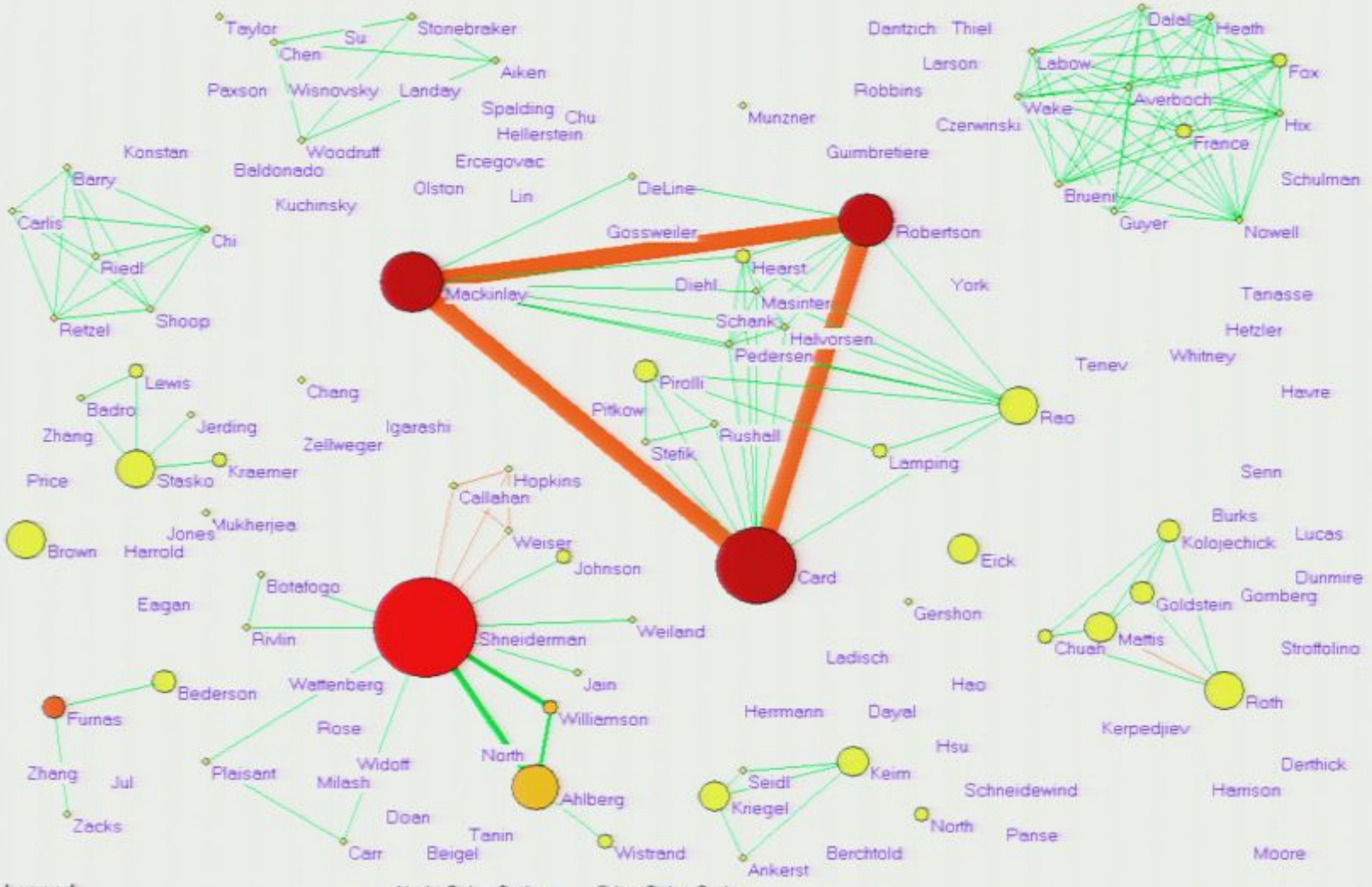

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Edge Color Code

86 - 90
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Displayed Year: 1995

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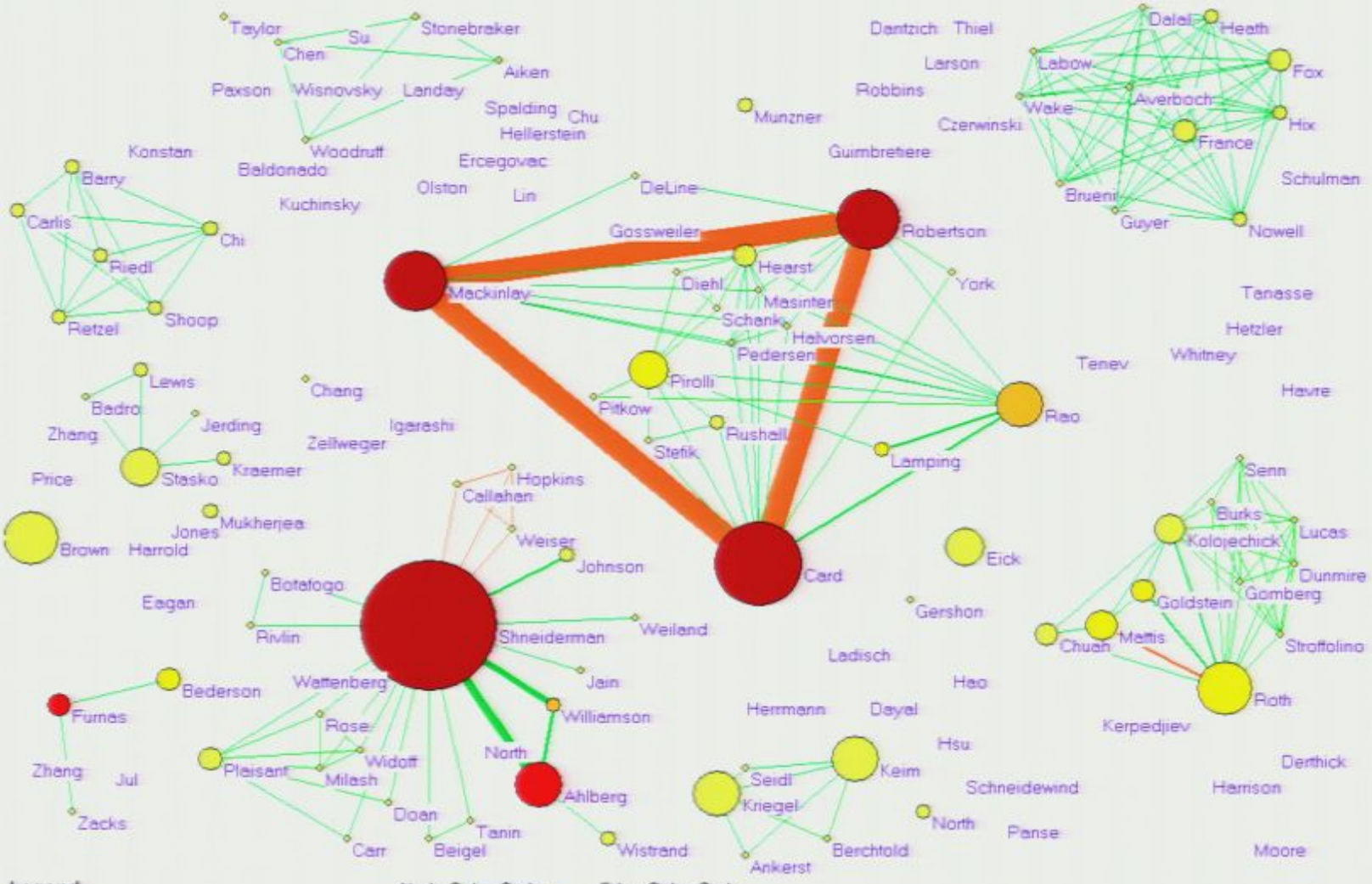

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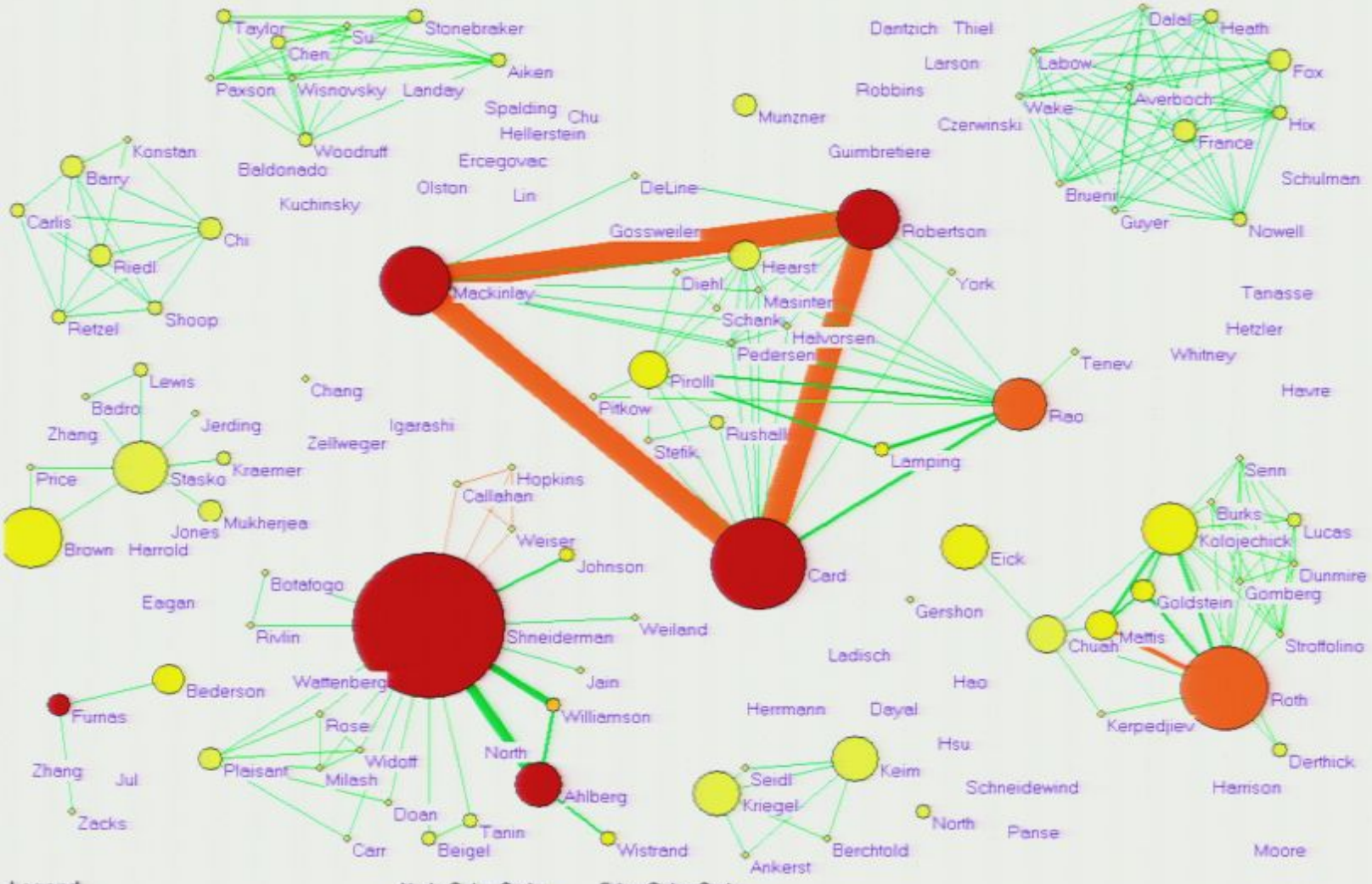

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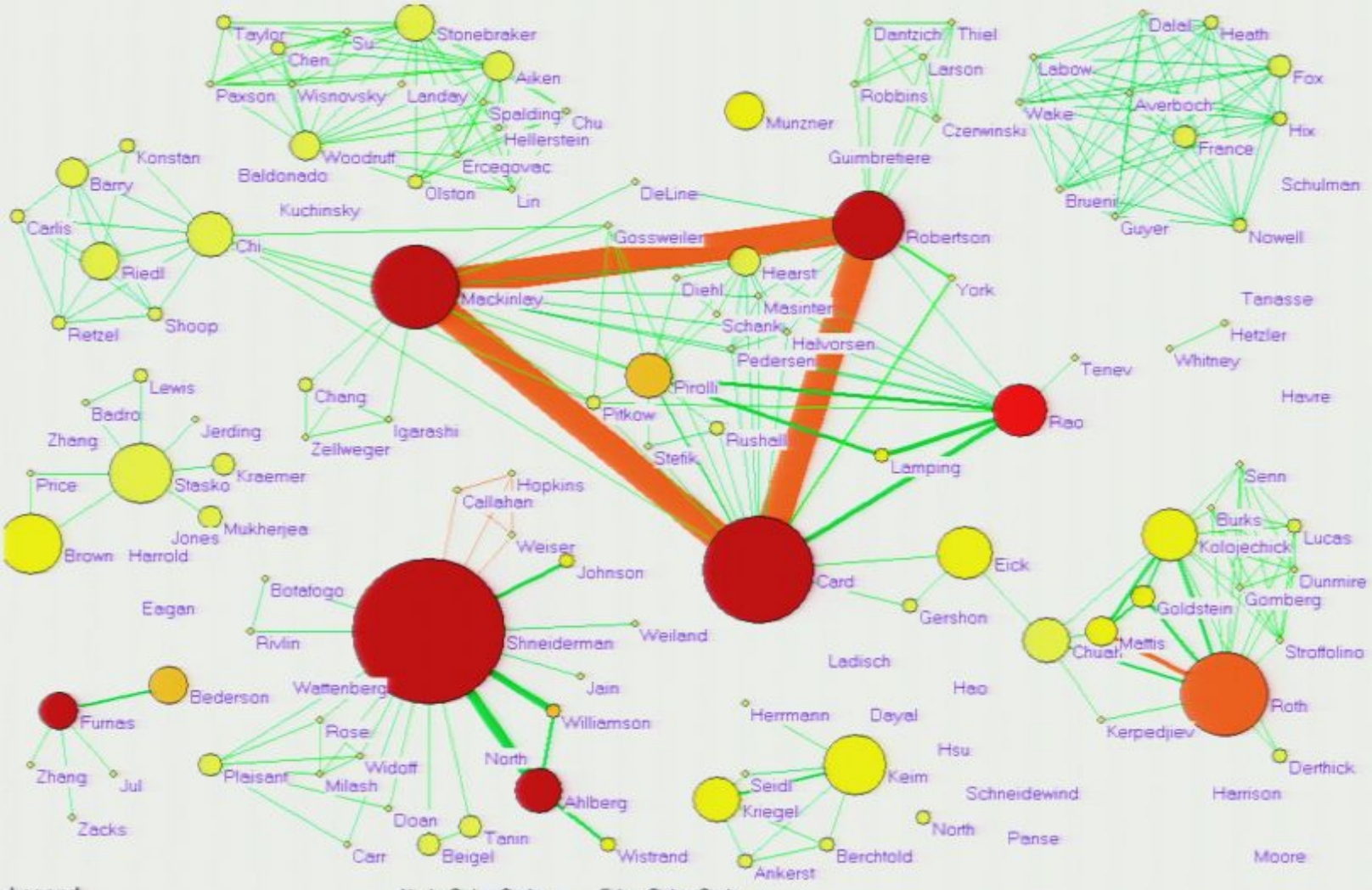

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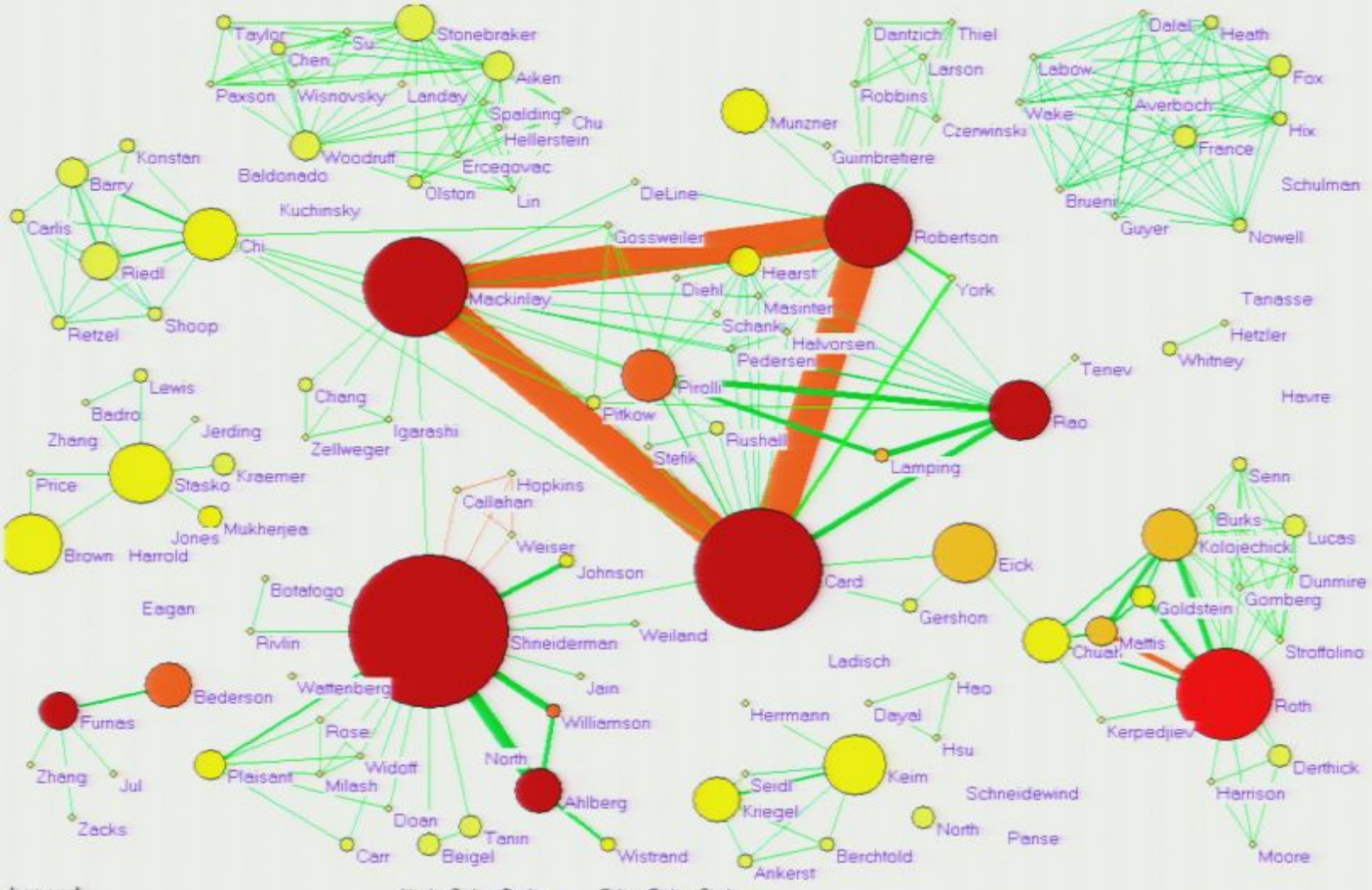

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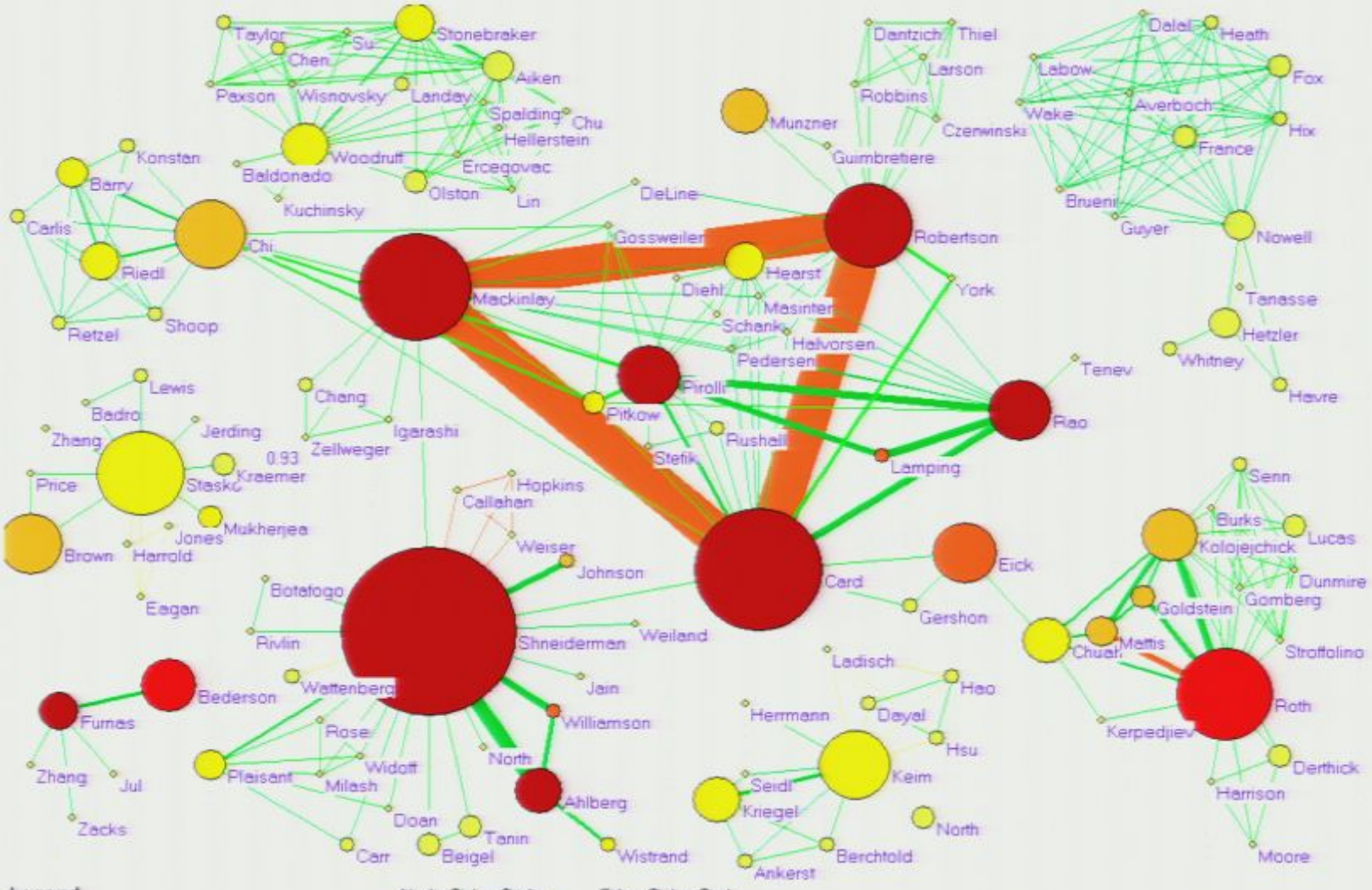

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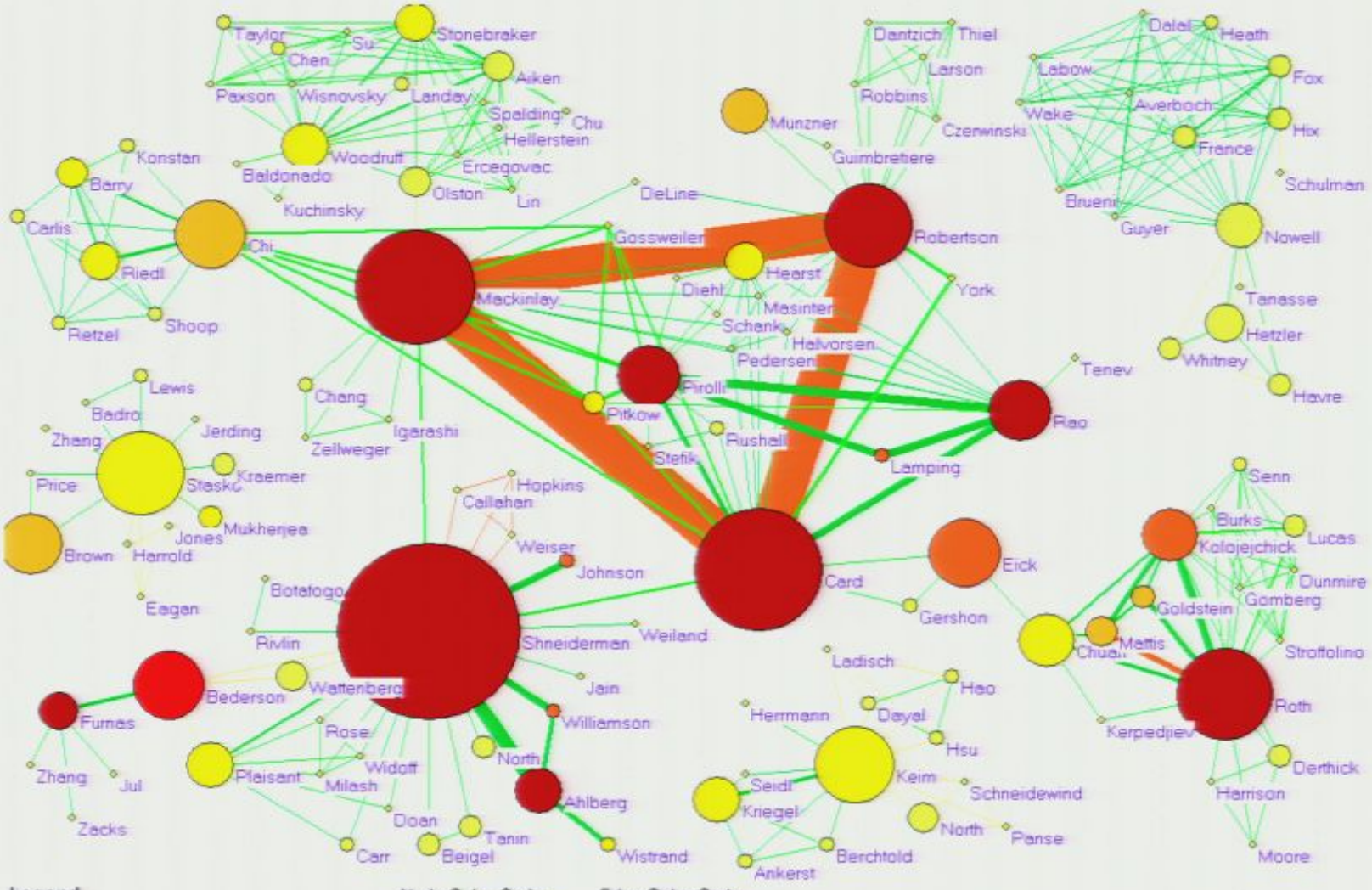

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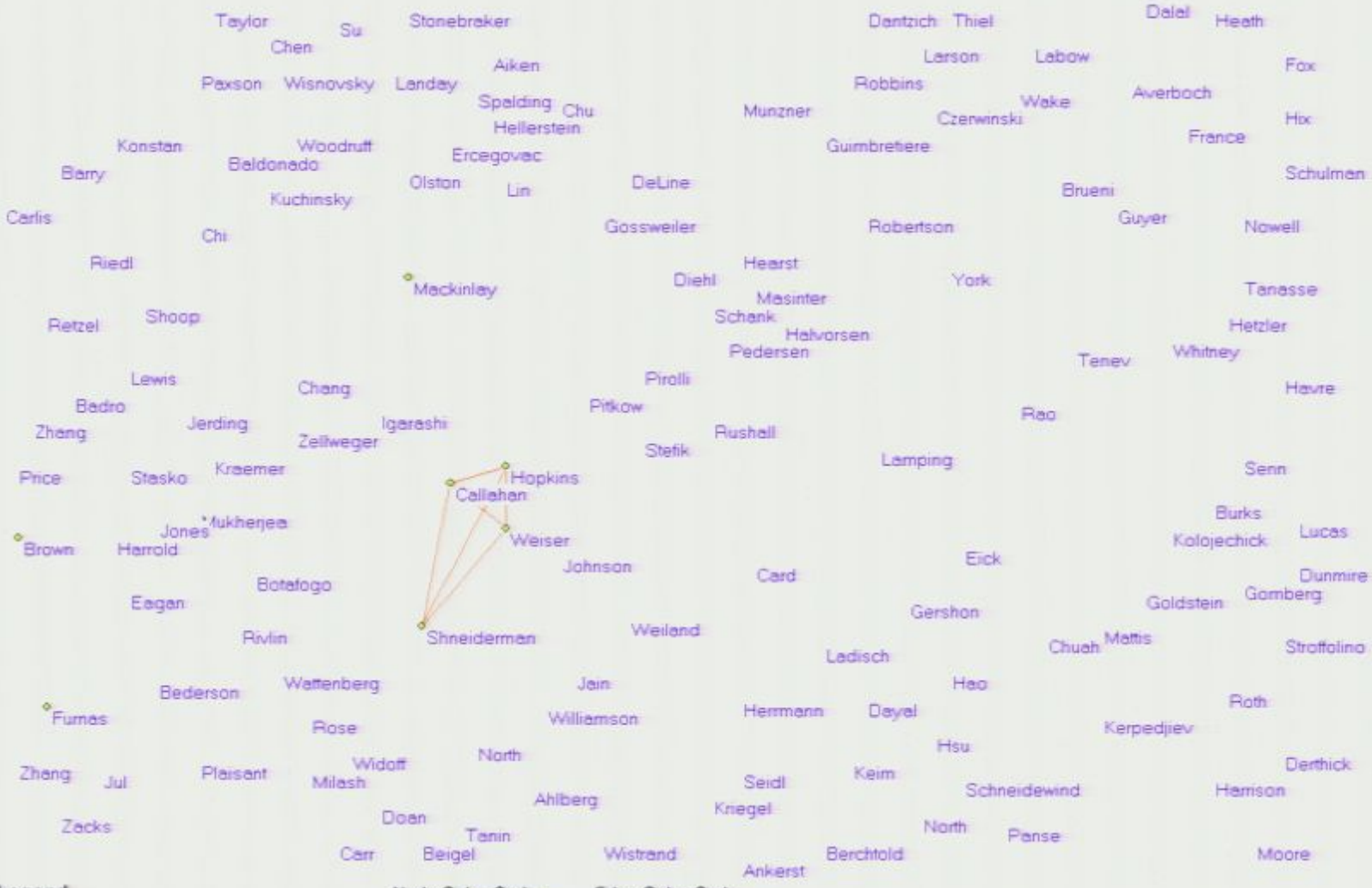

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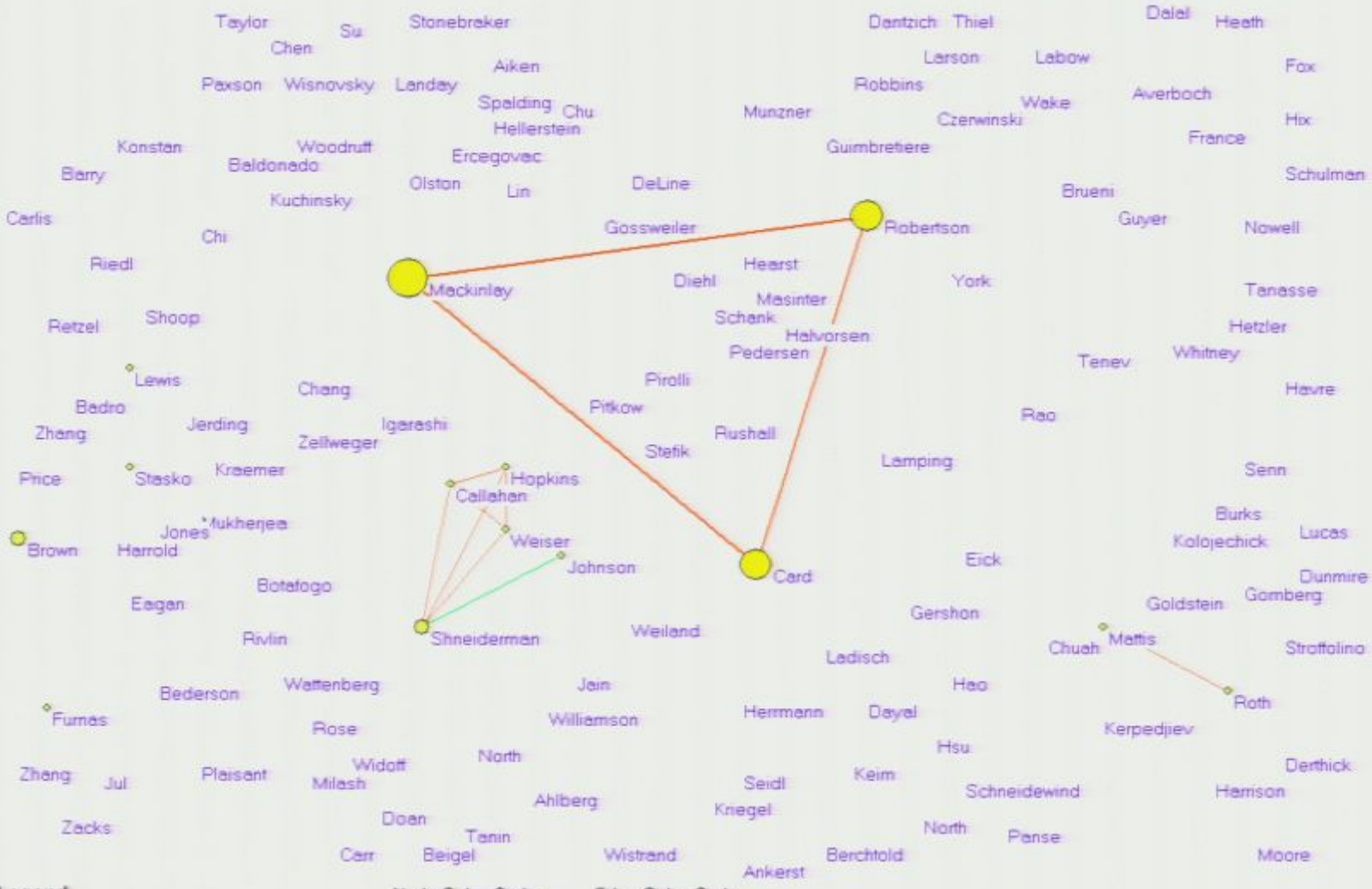

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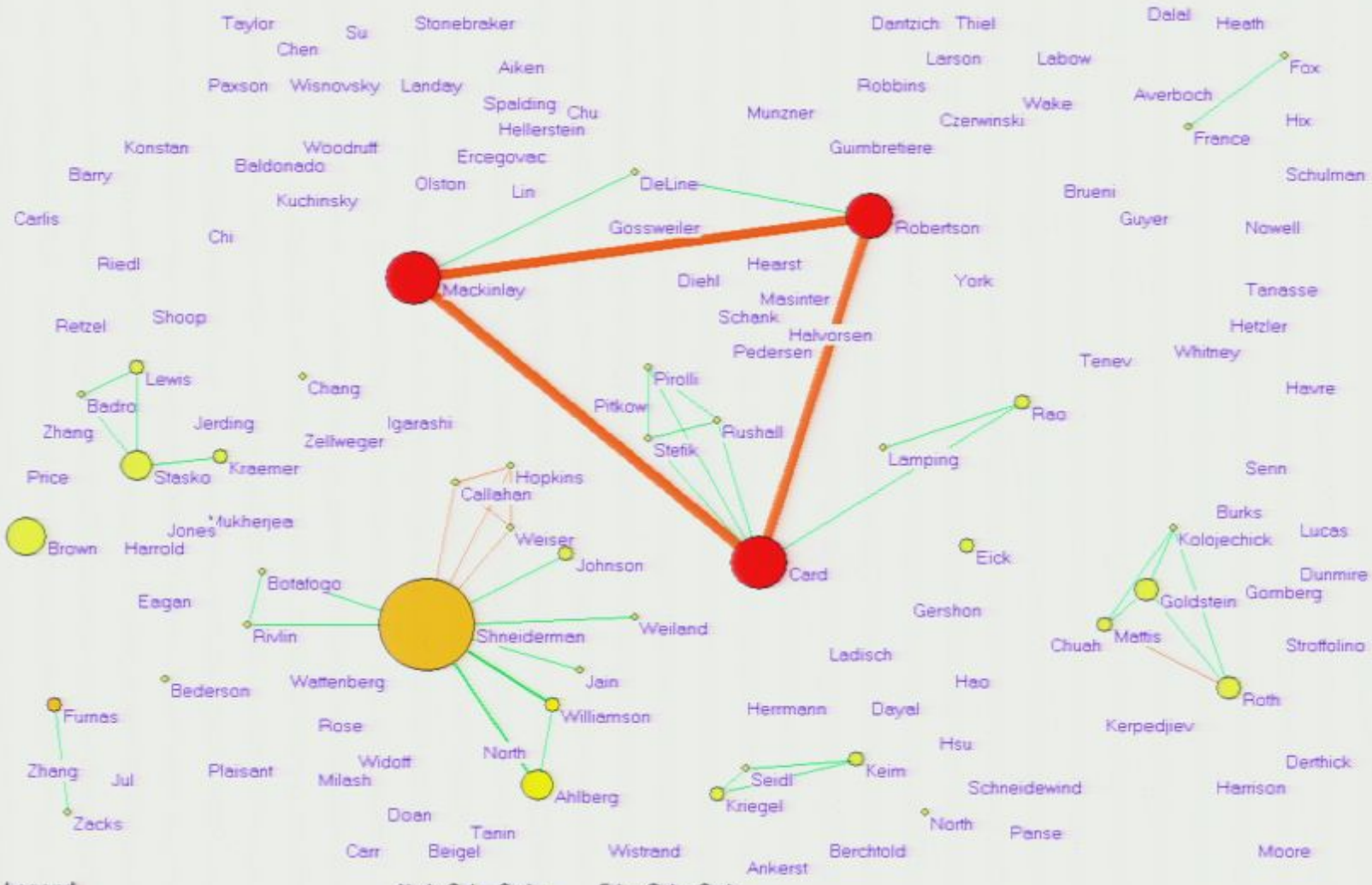

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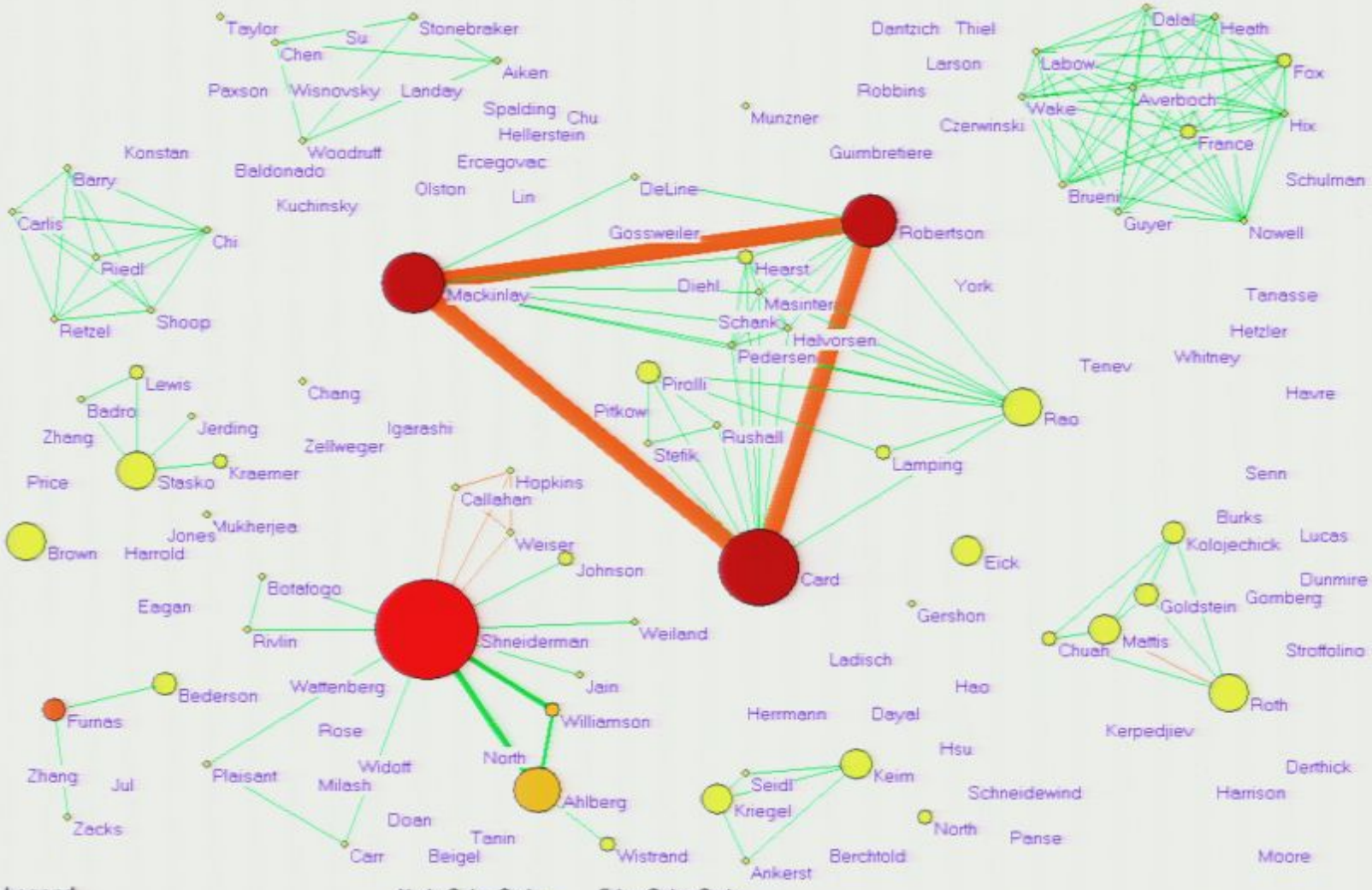

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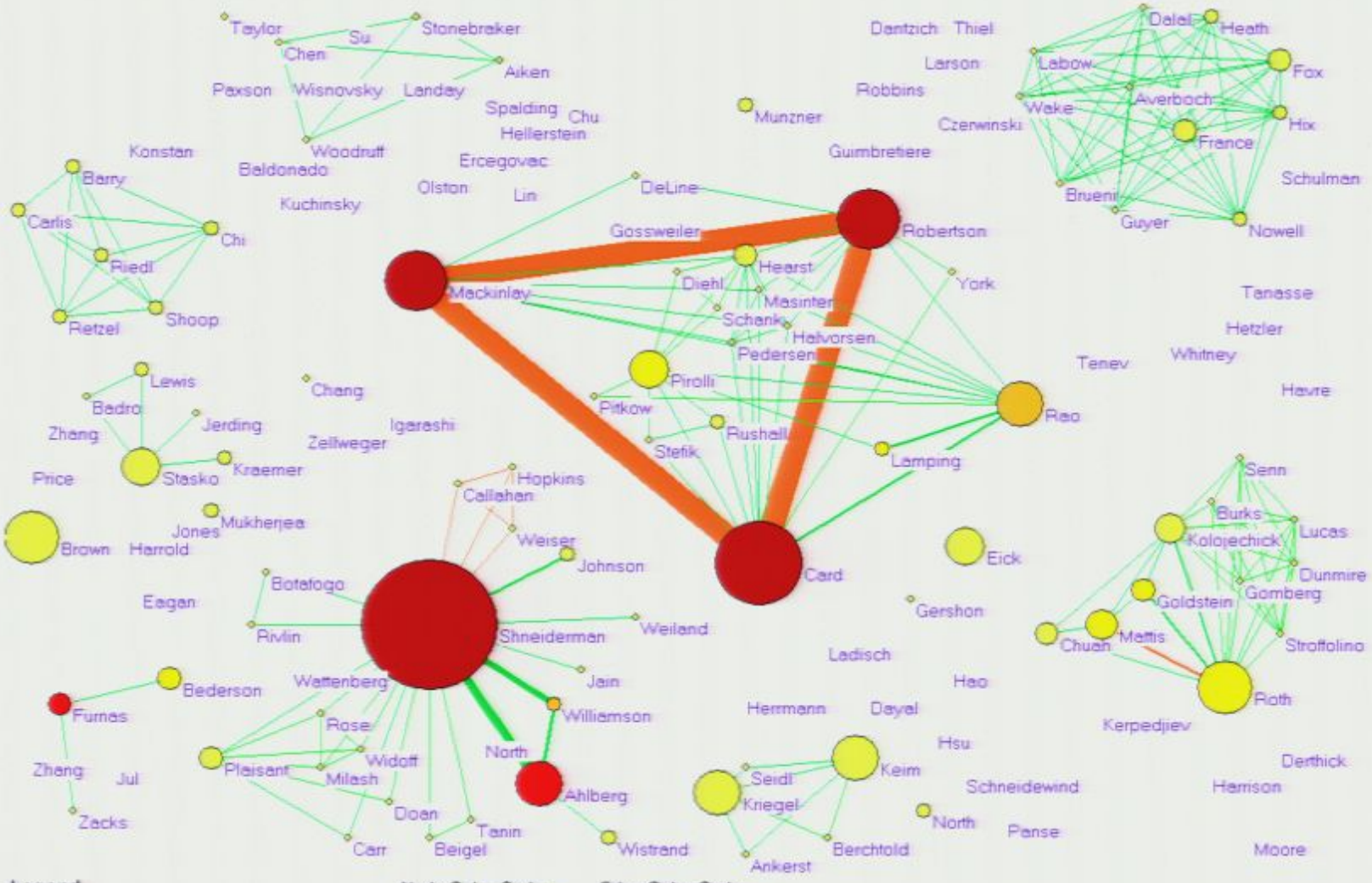

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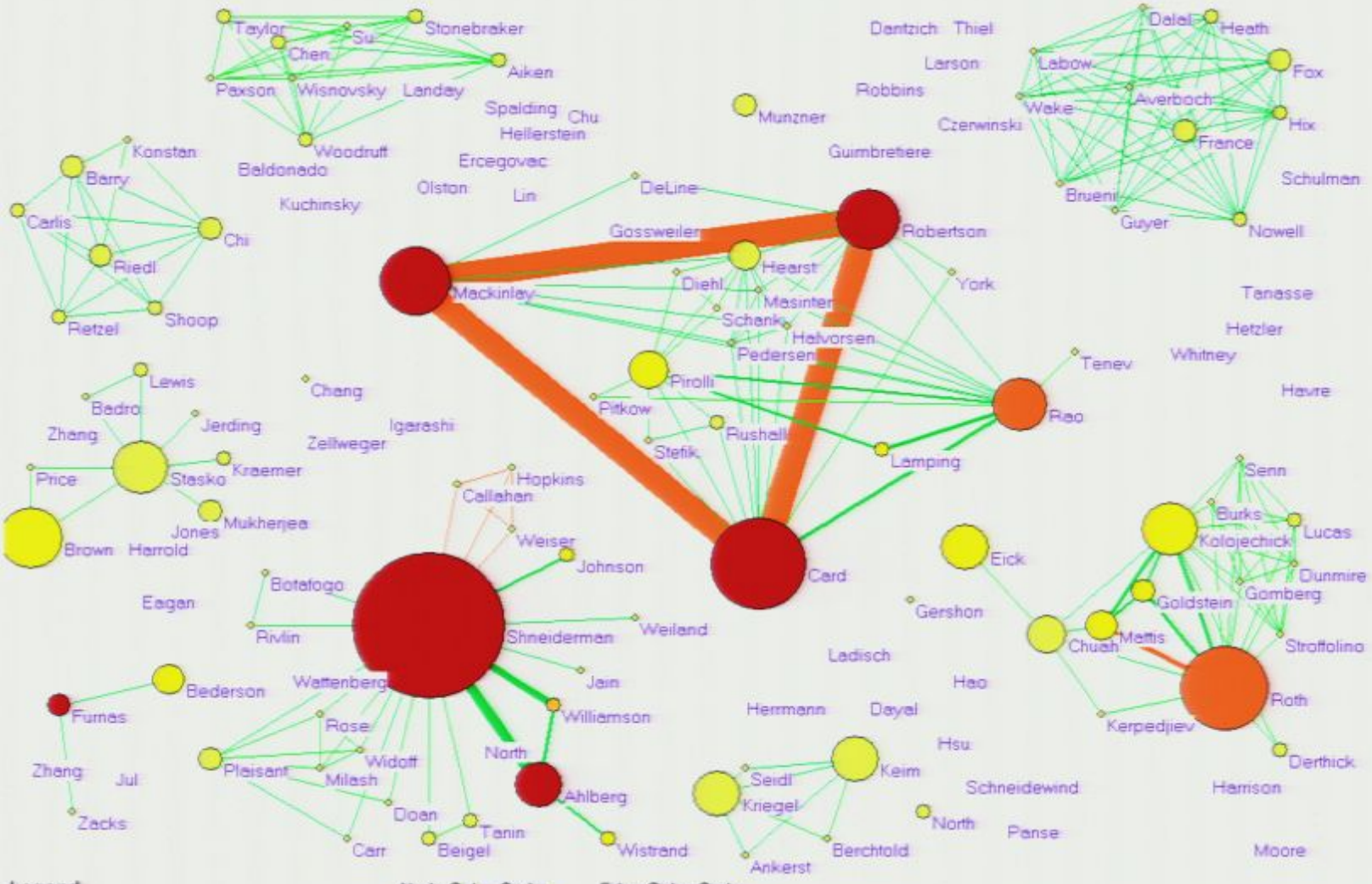

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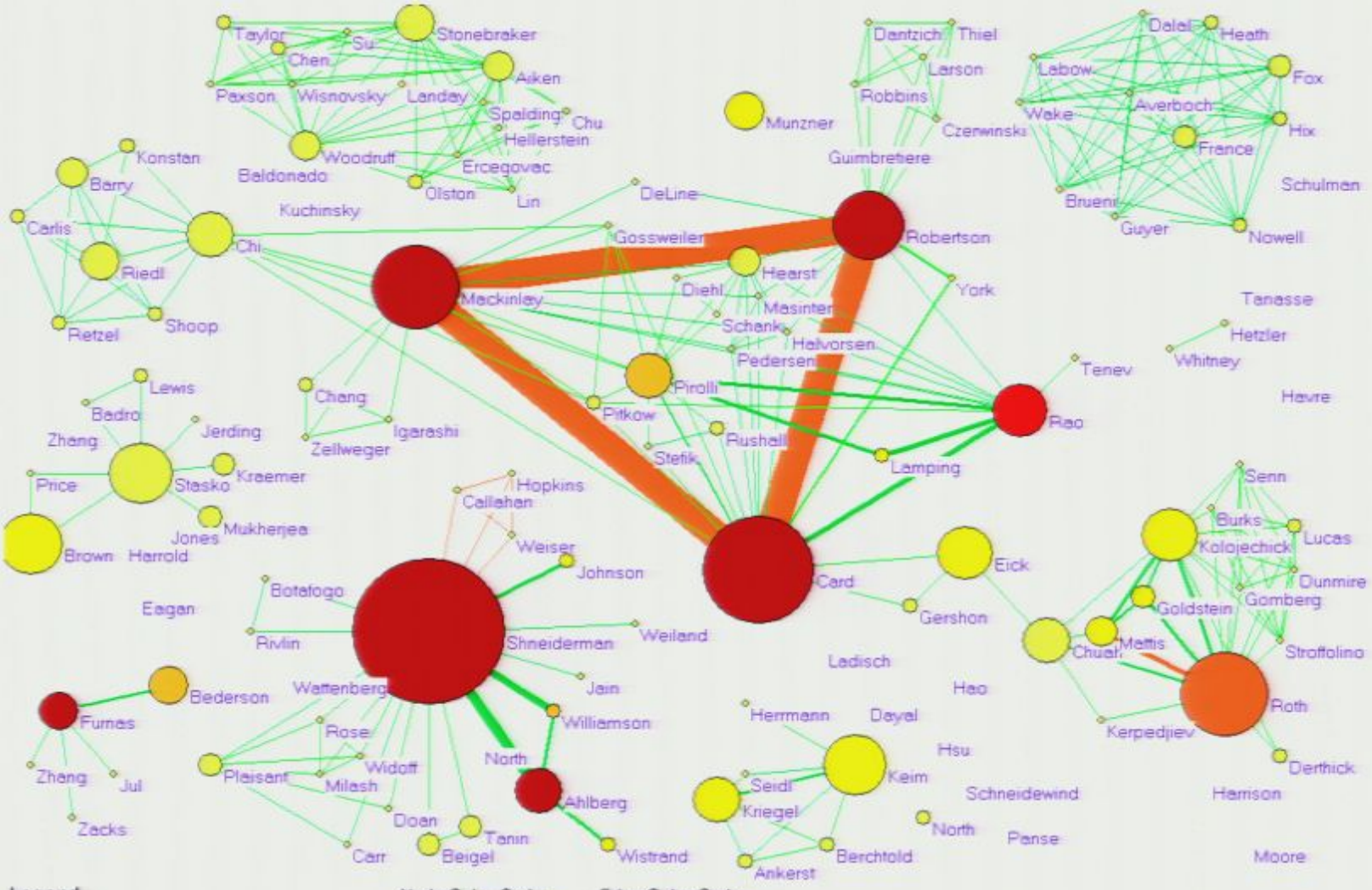

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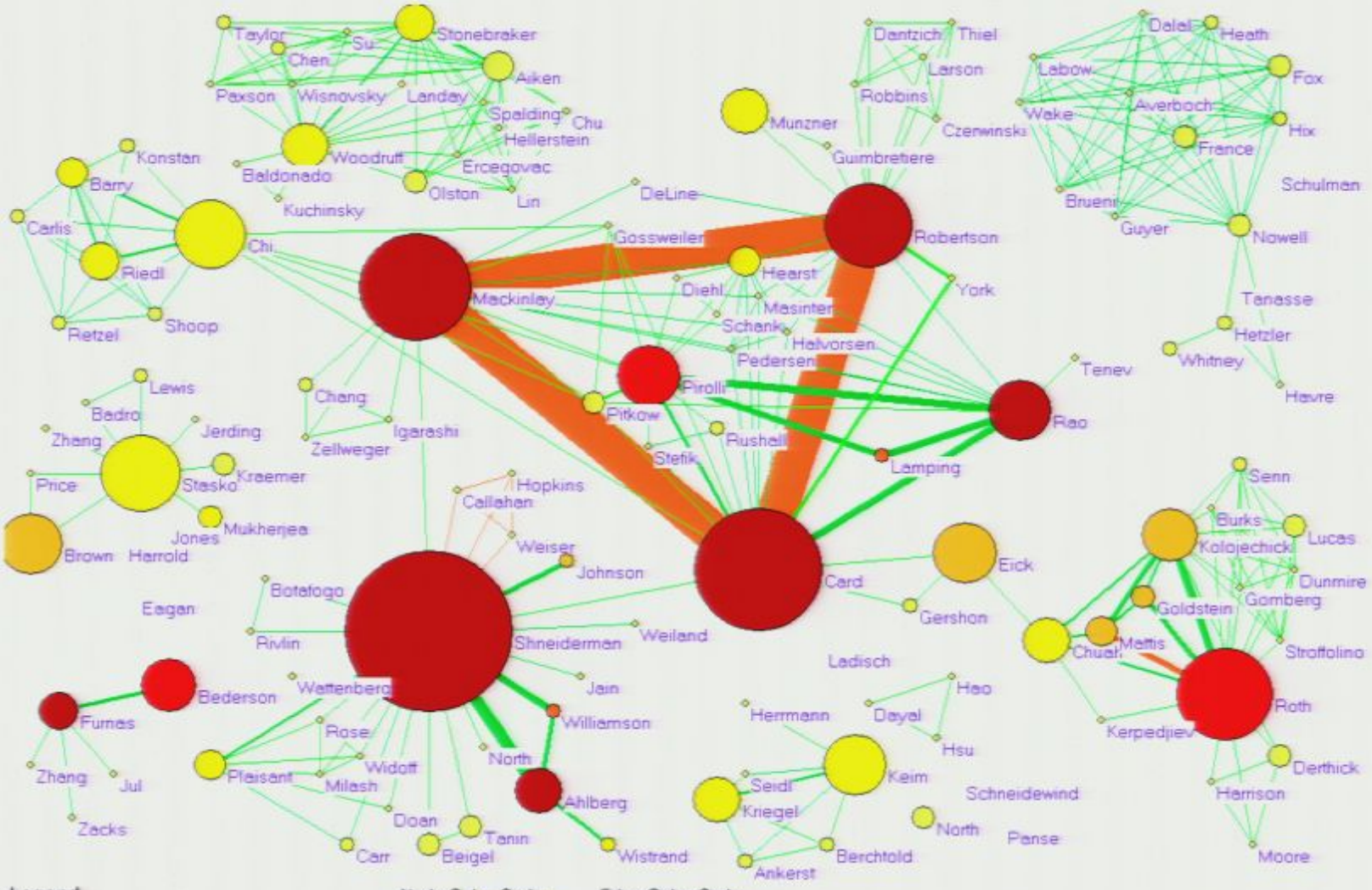

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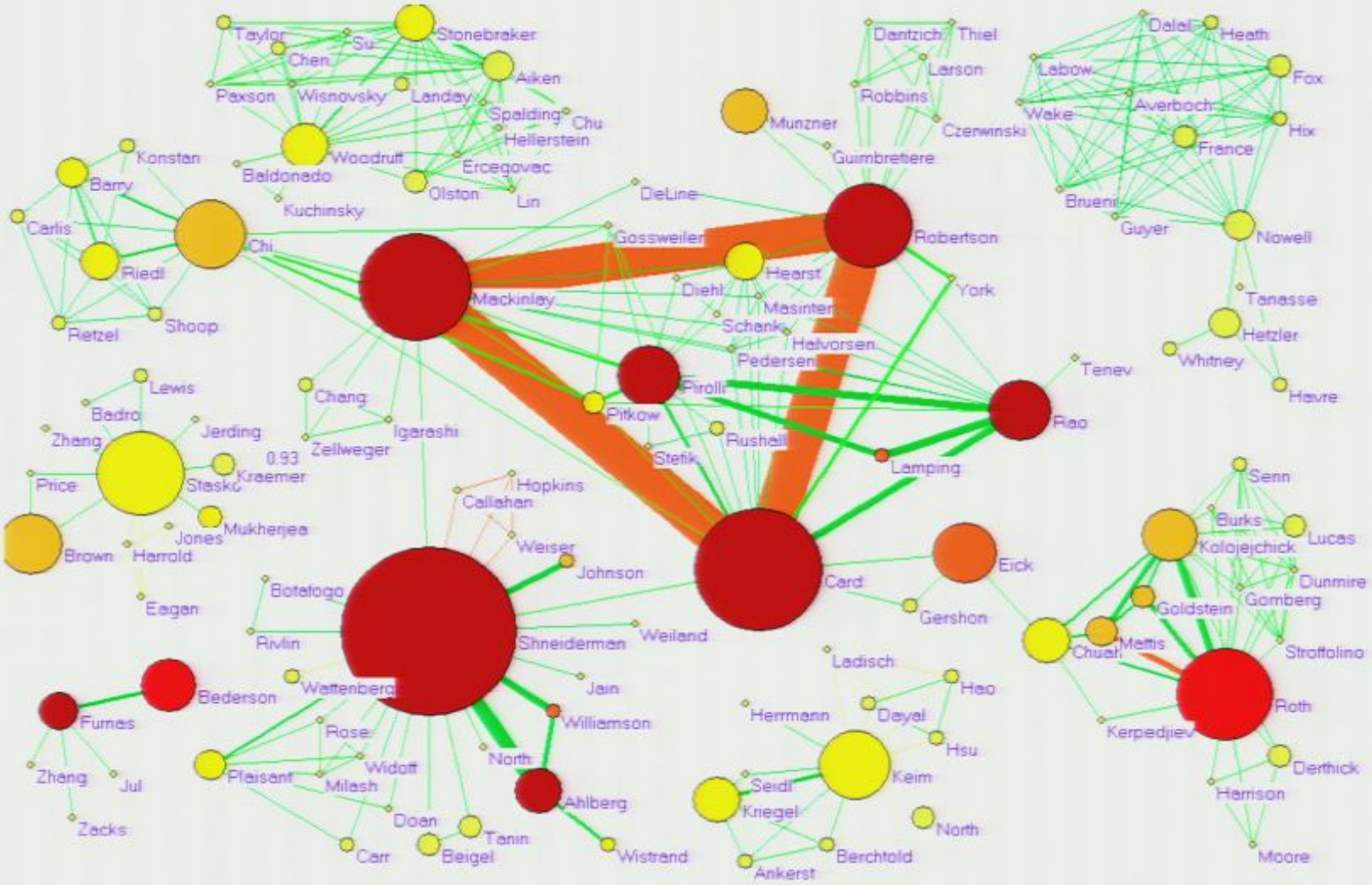

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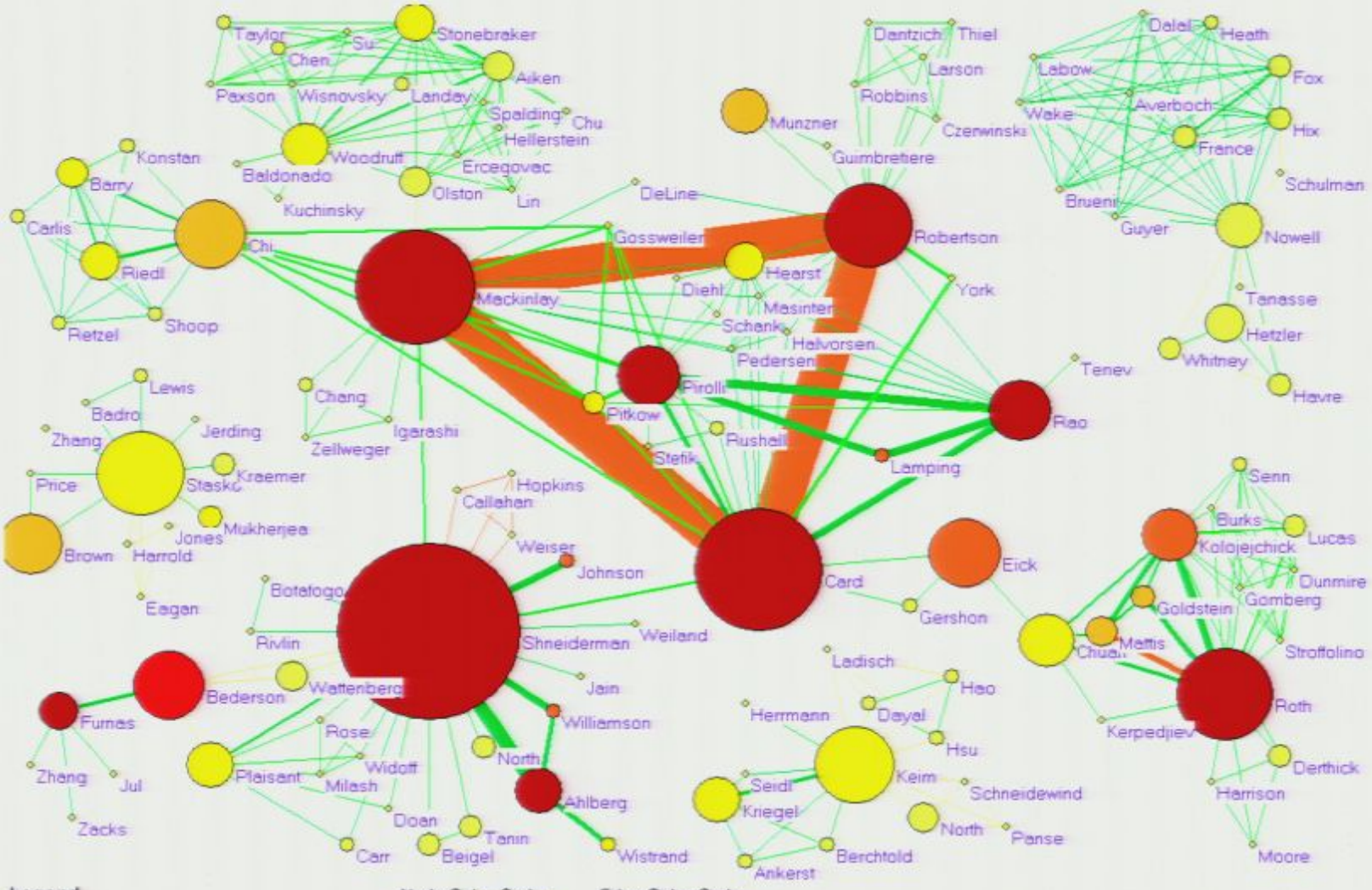

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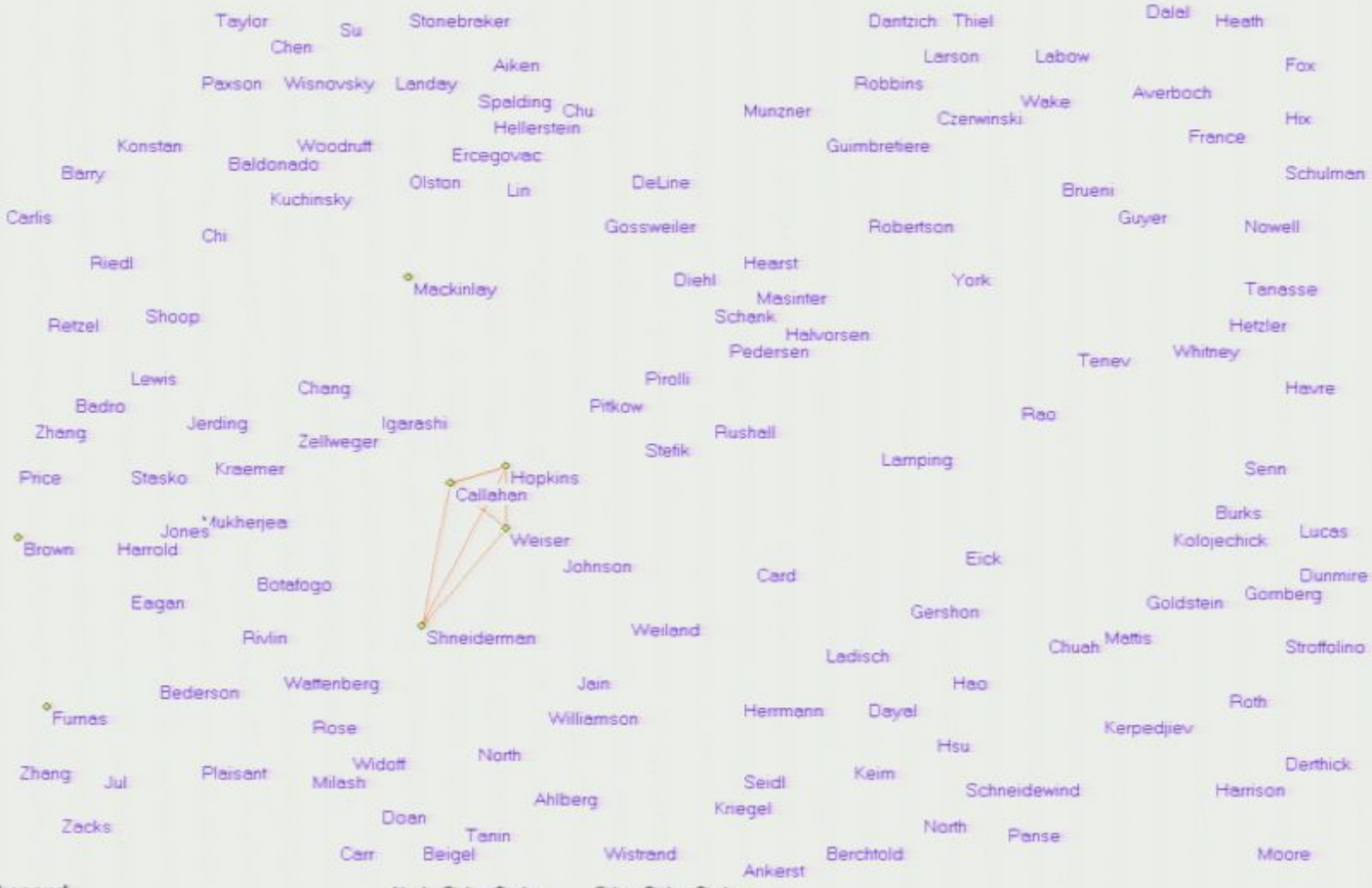

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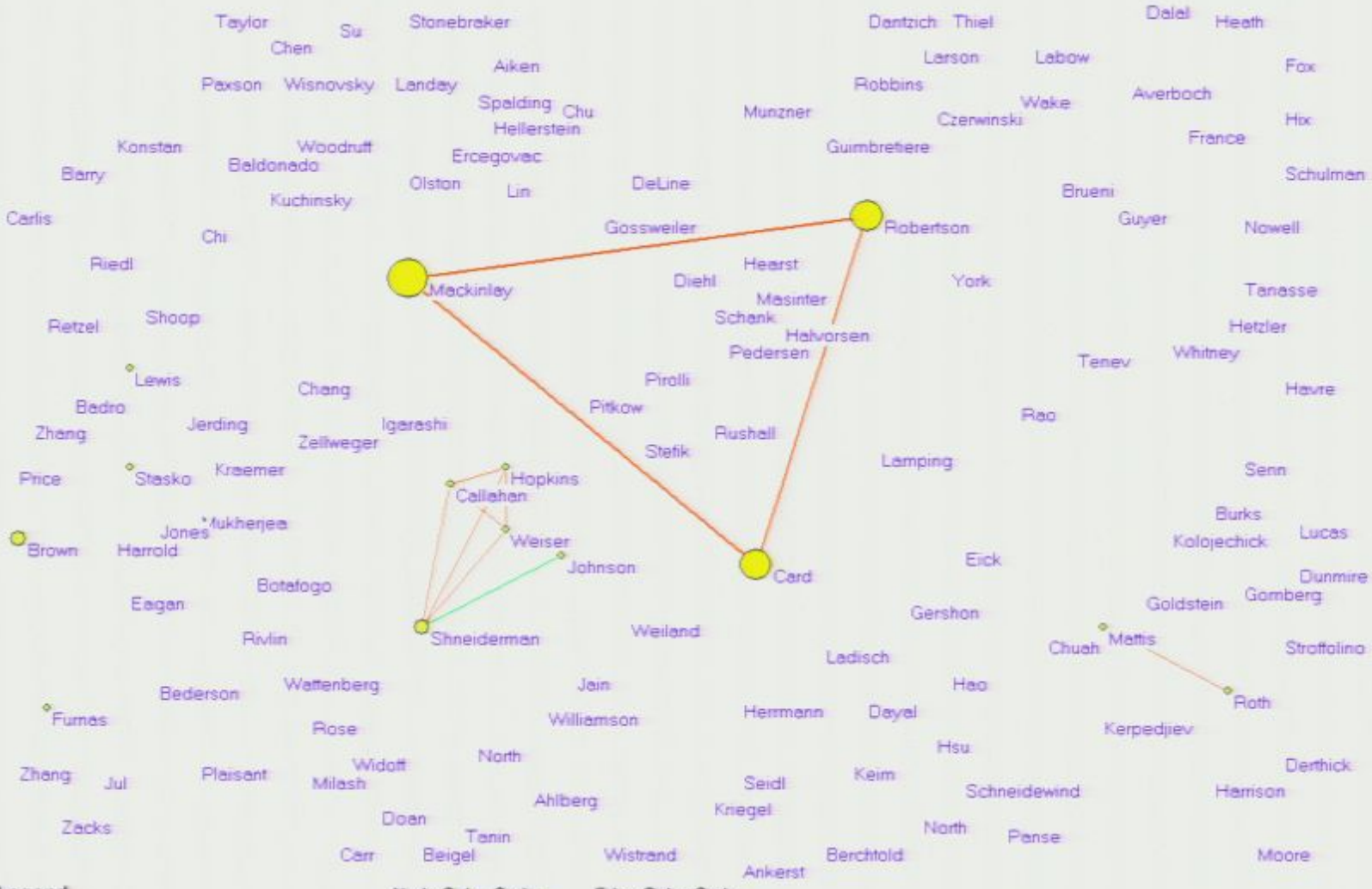

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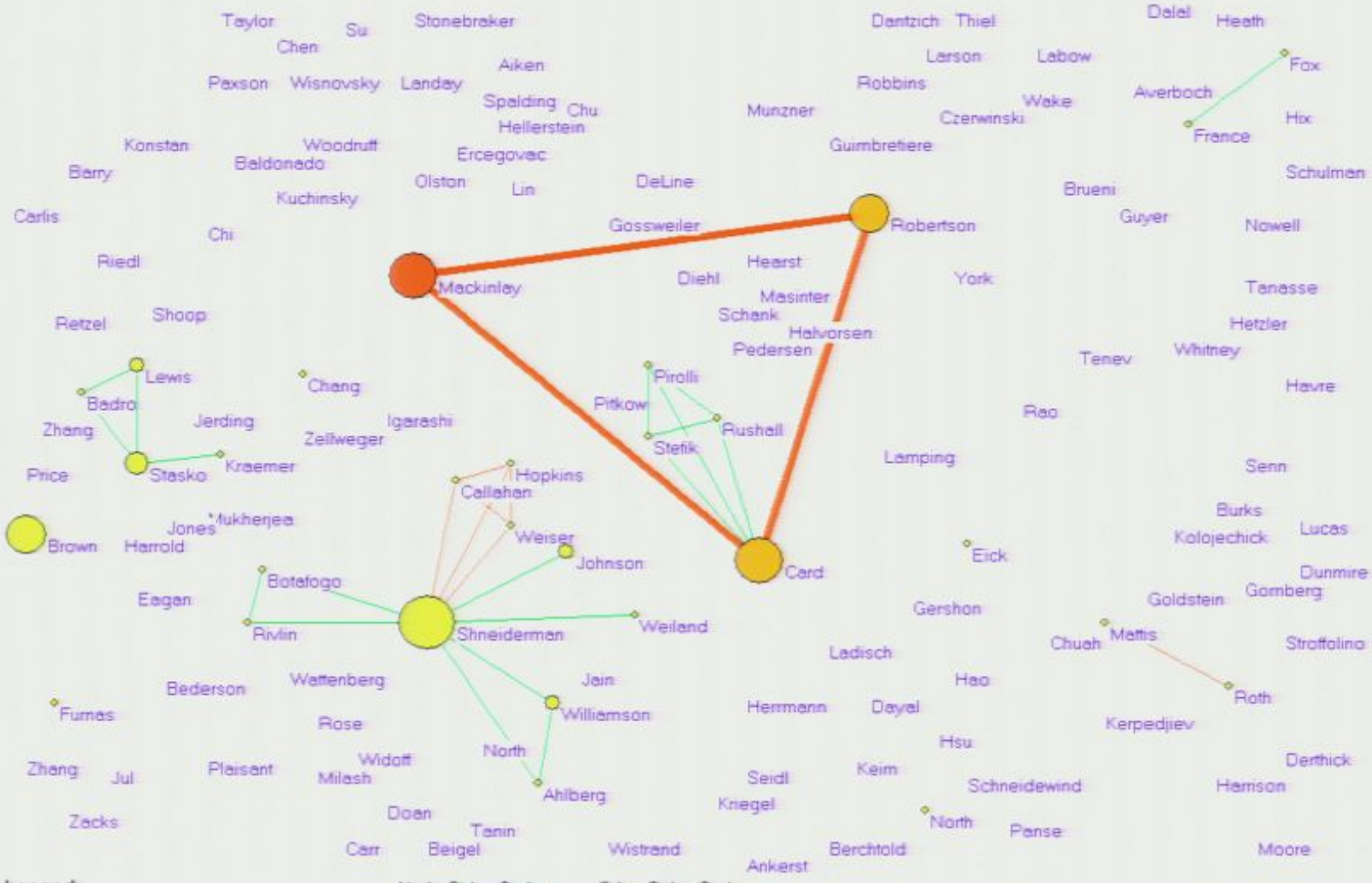

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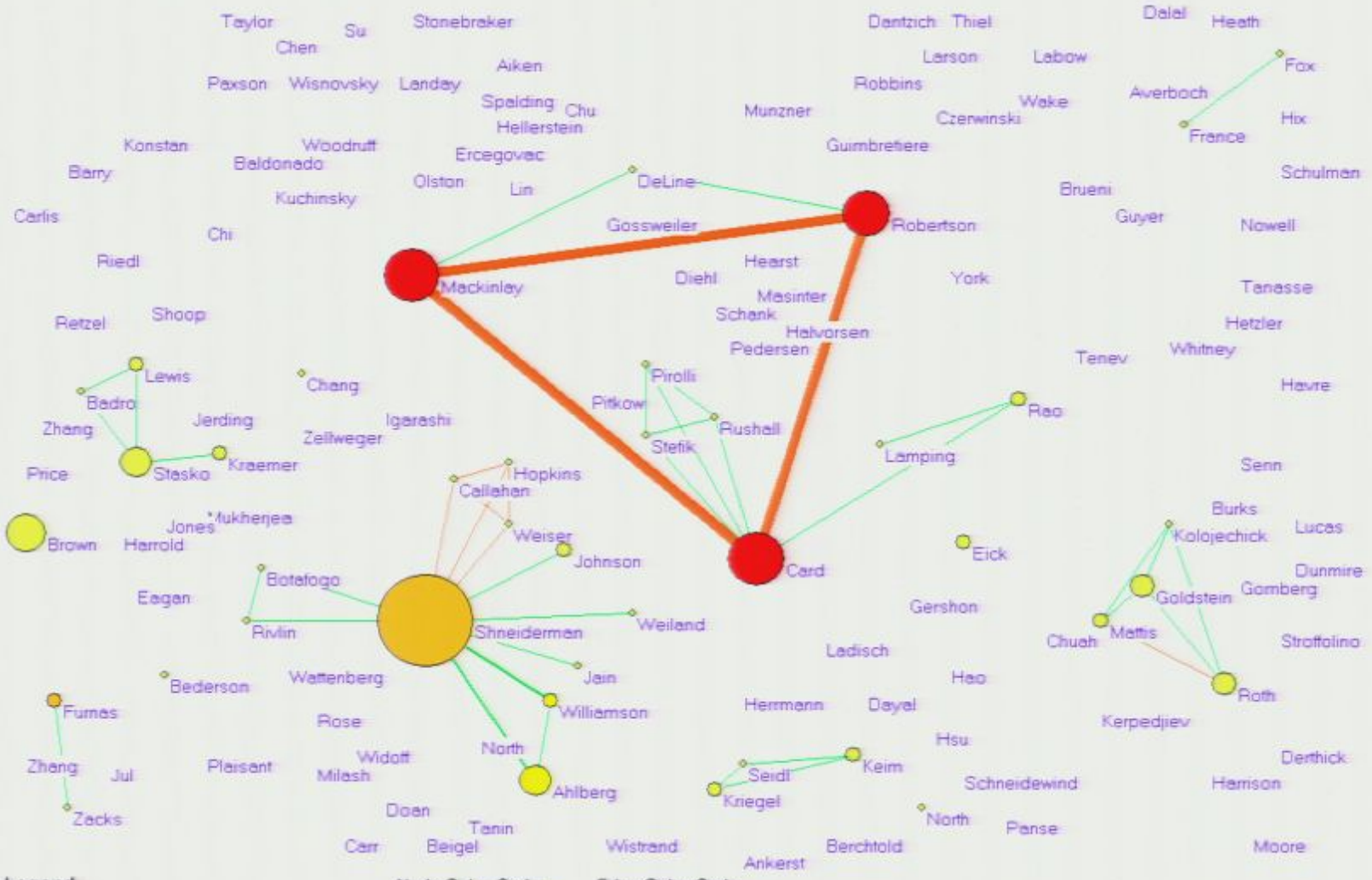

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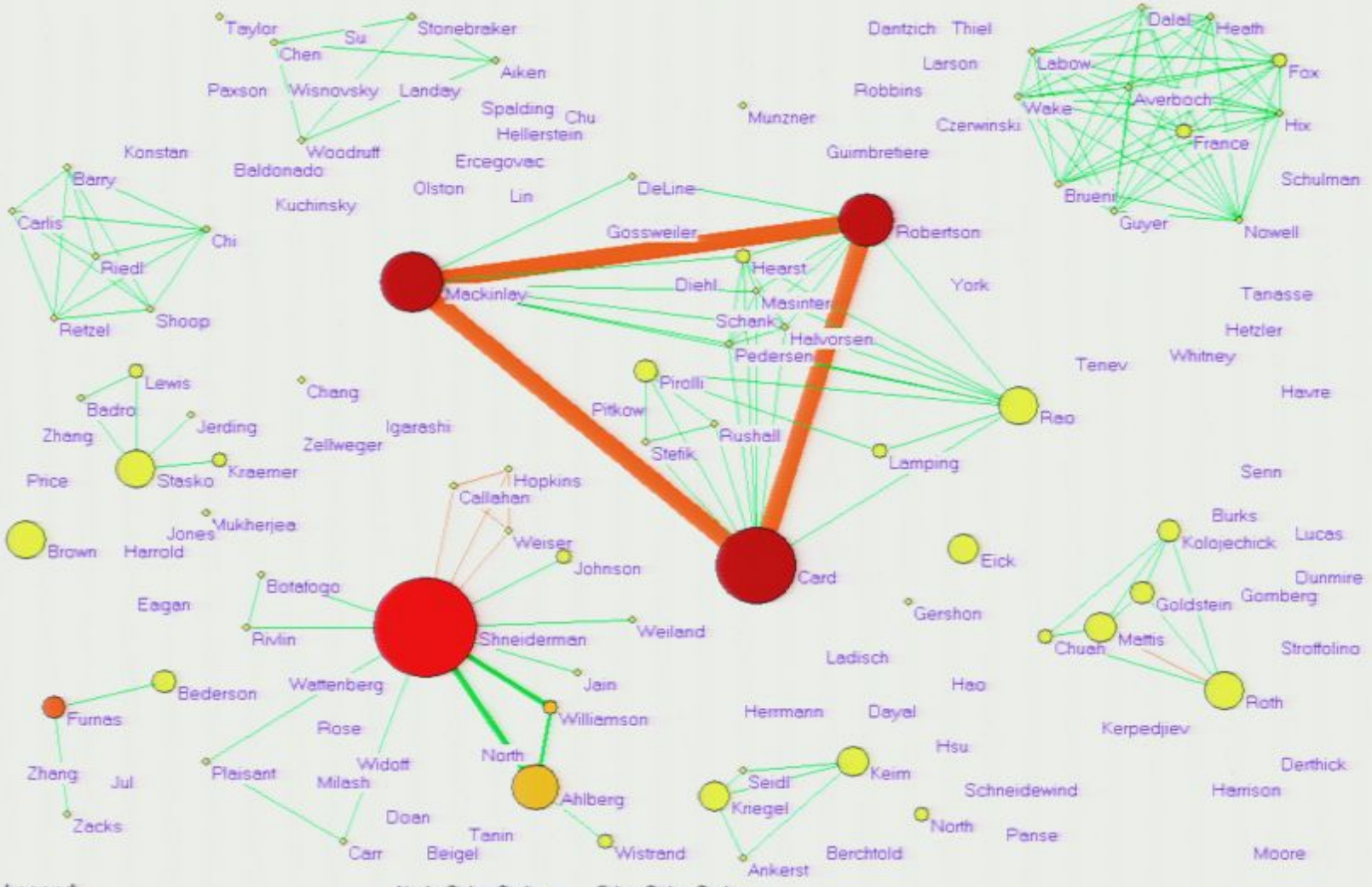

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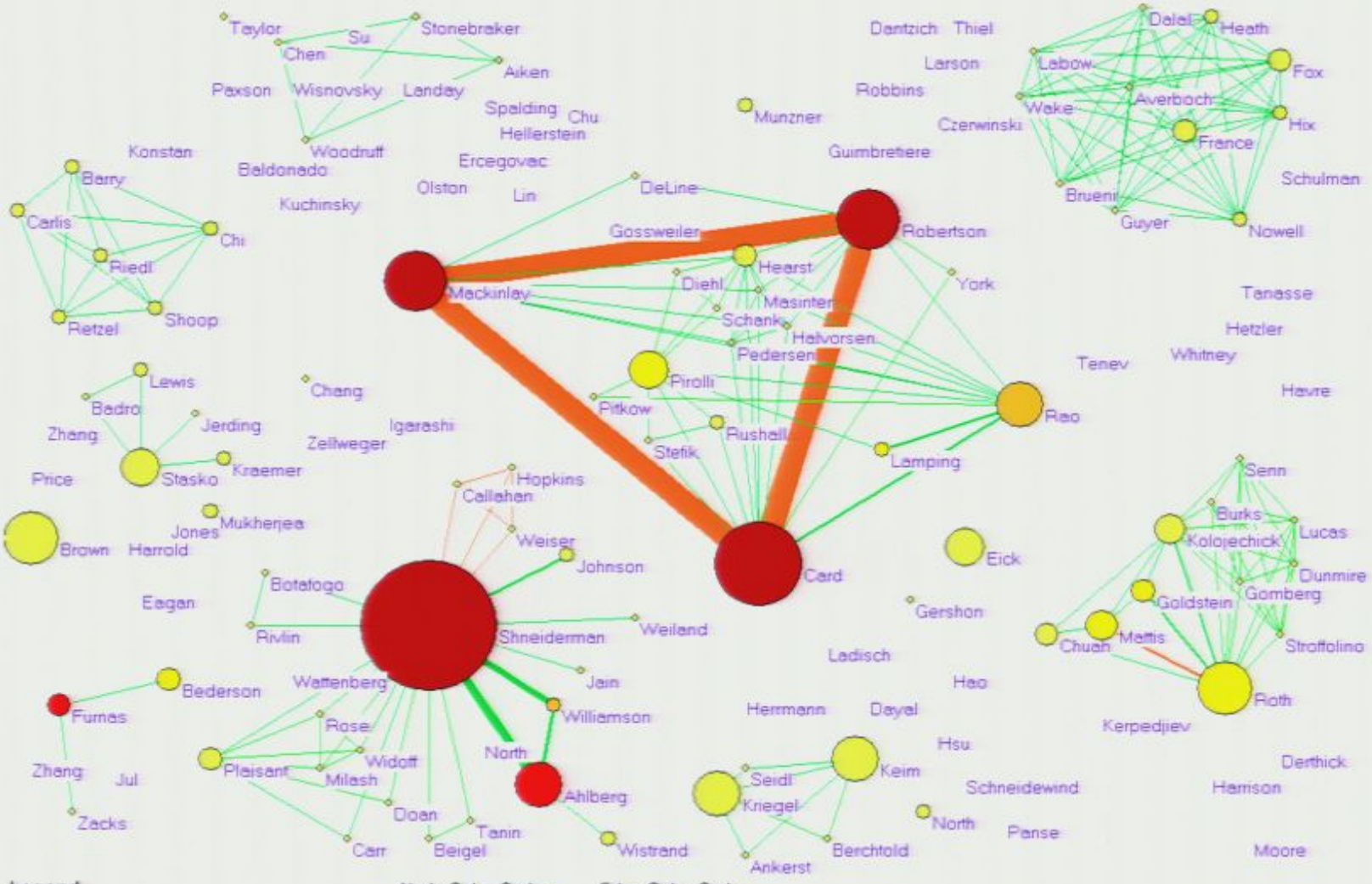

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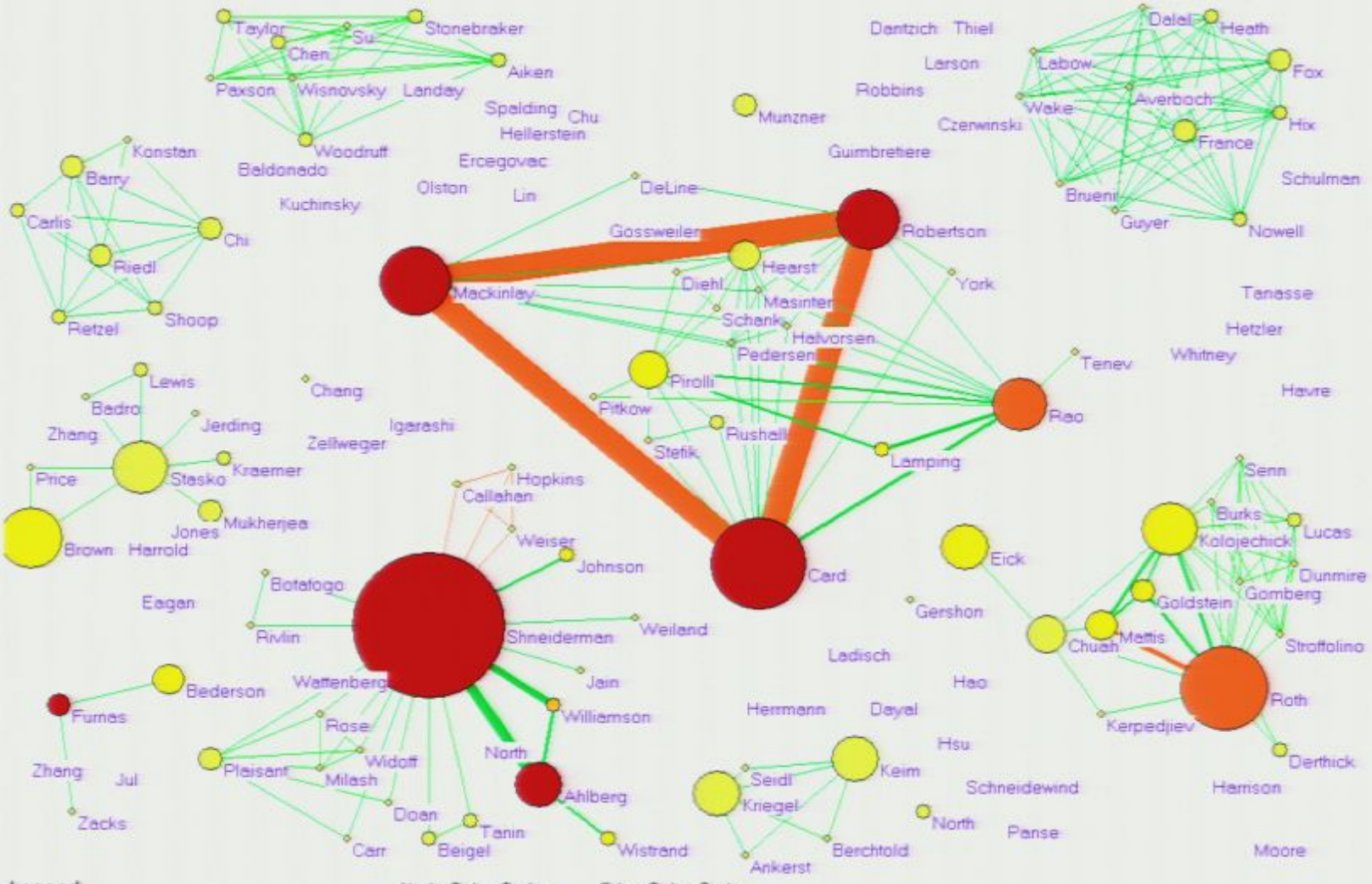

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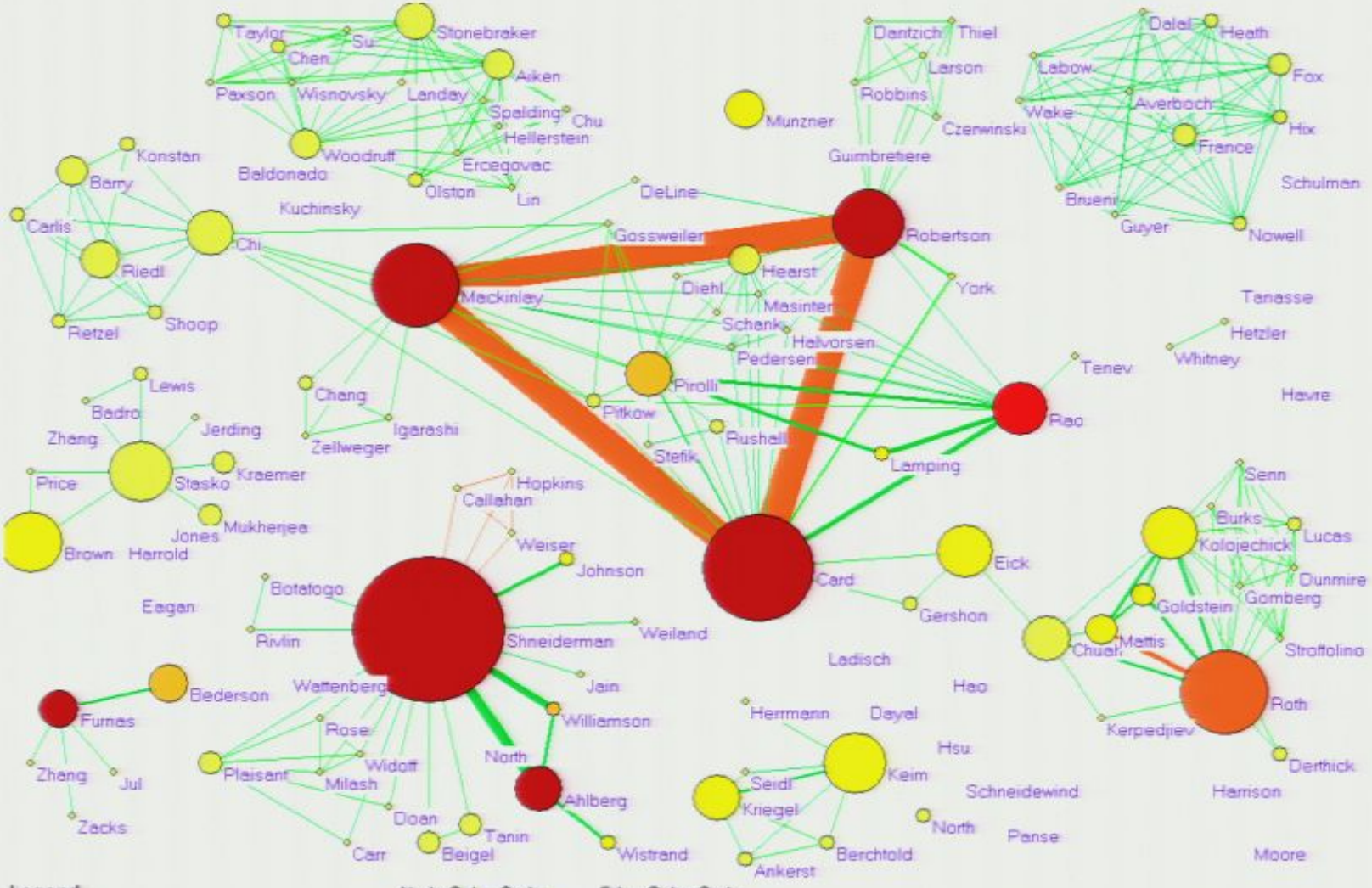

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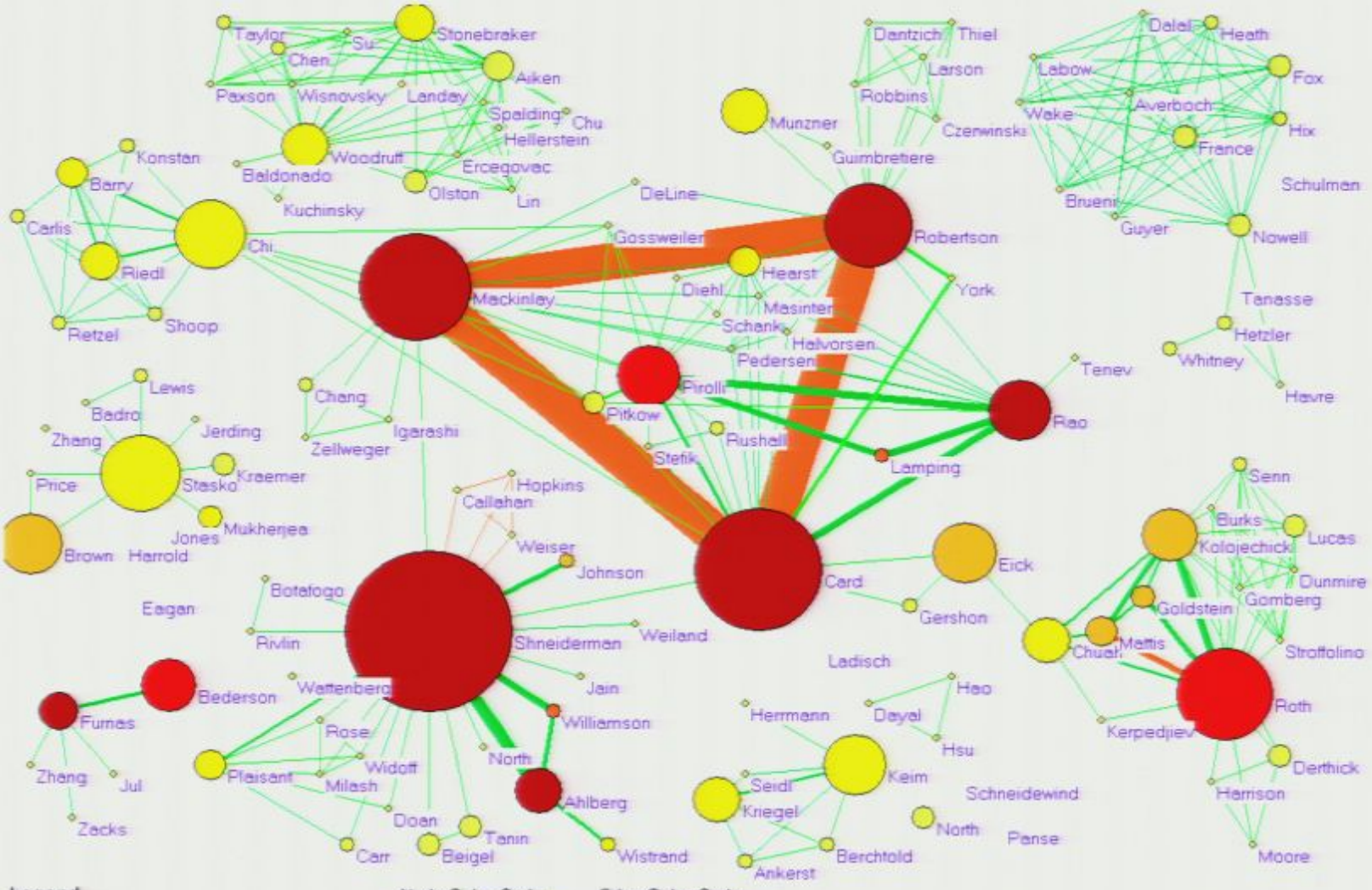

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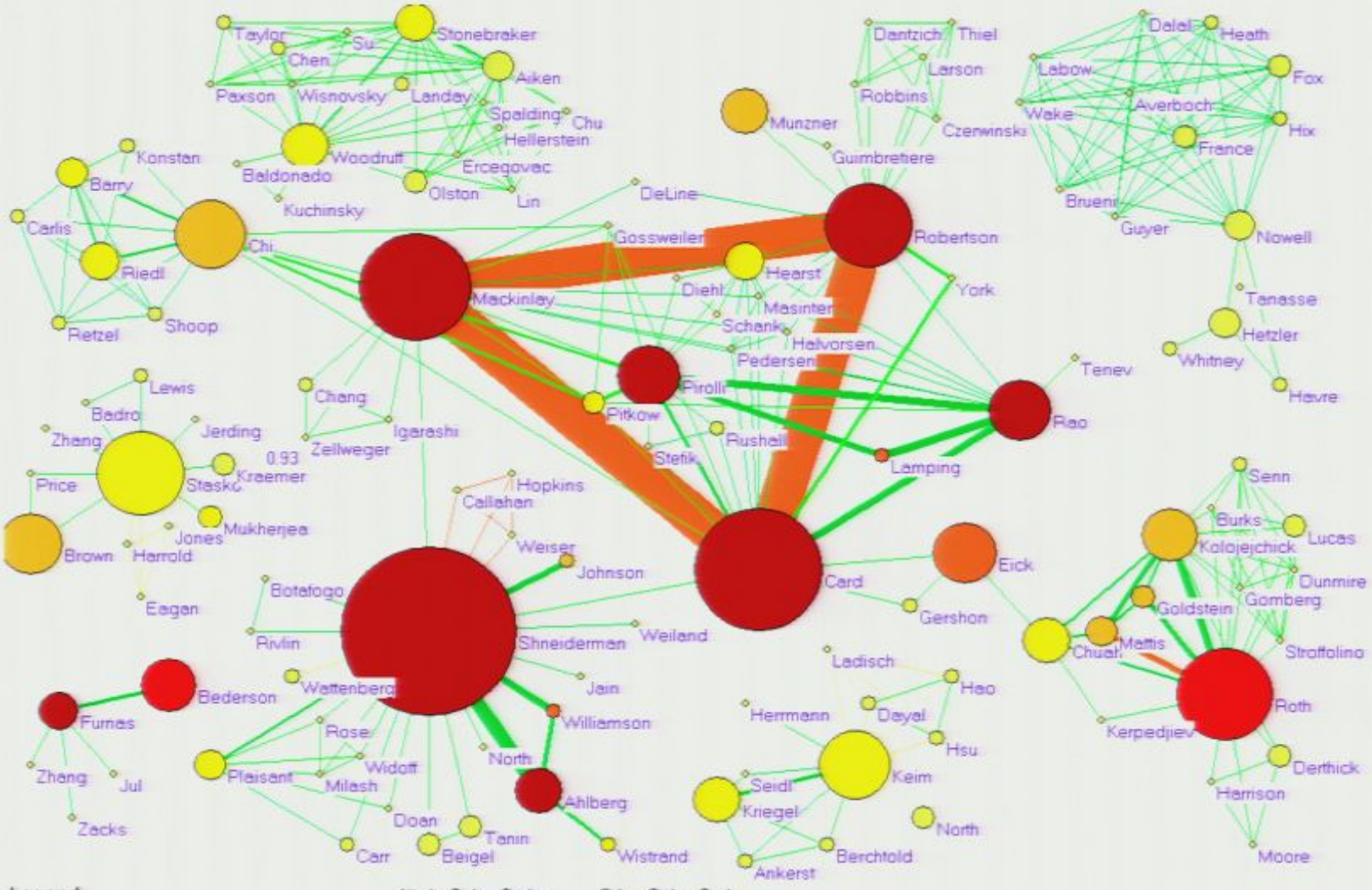

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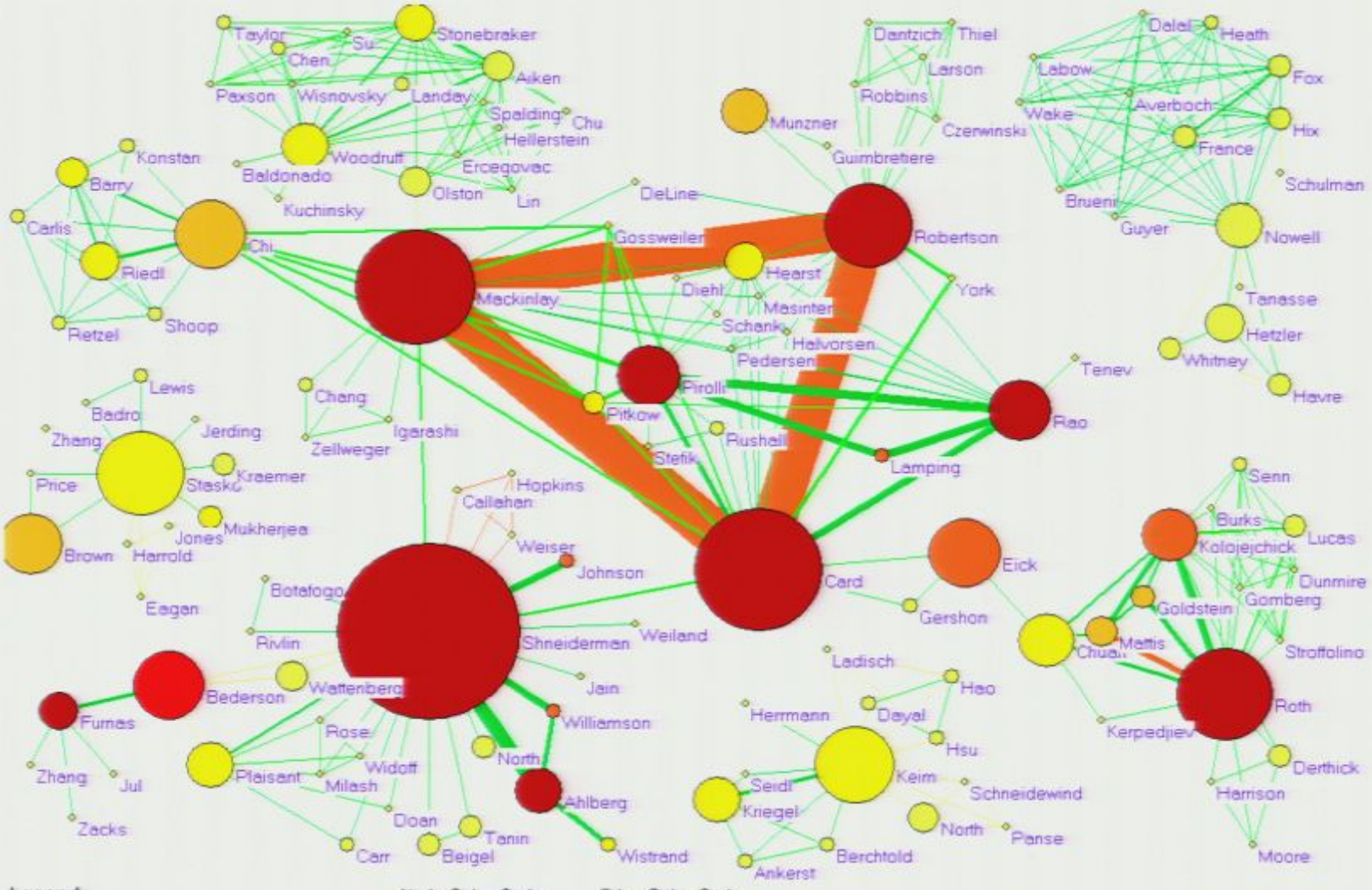

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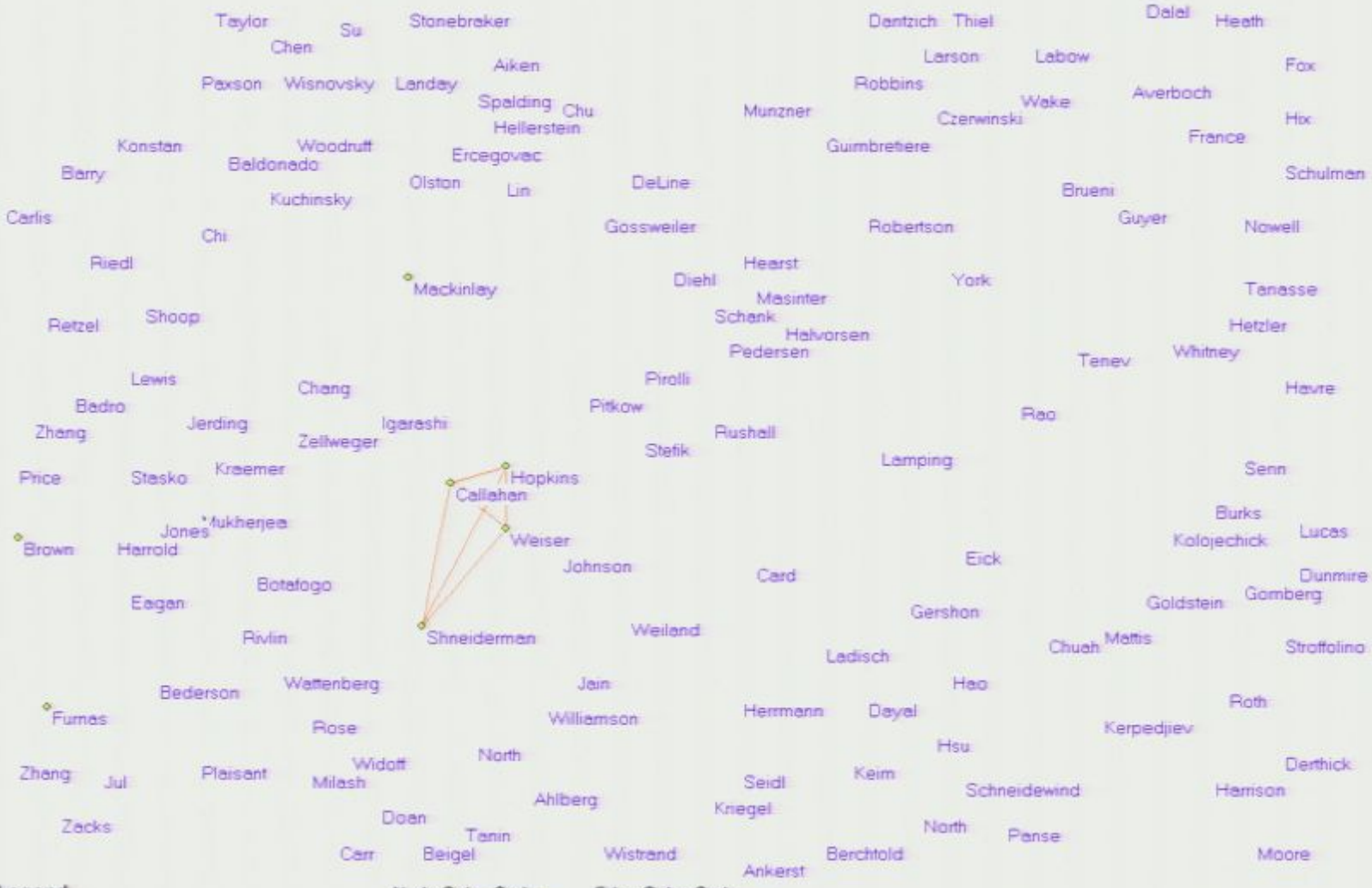

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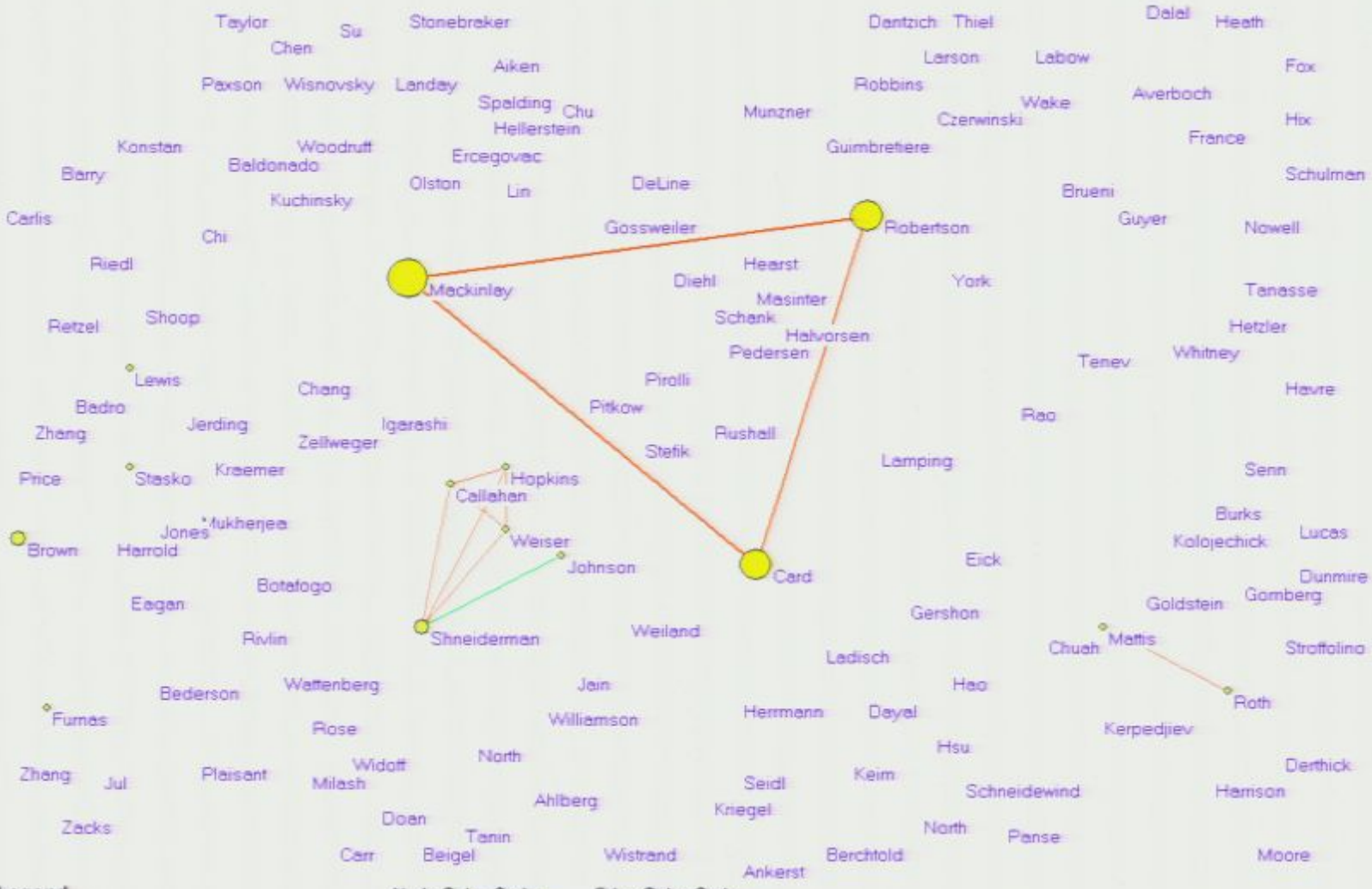

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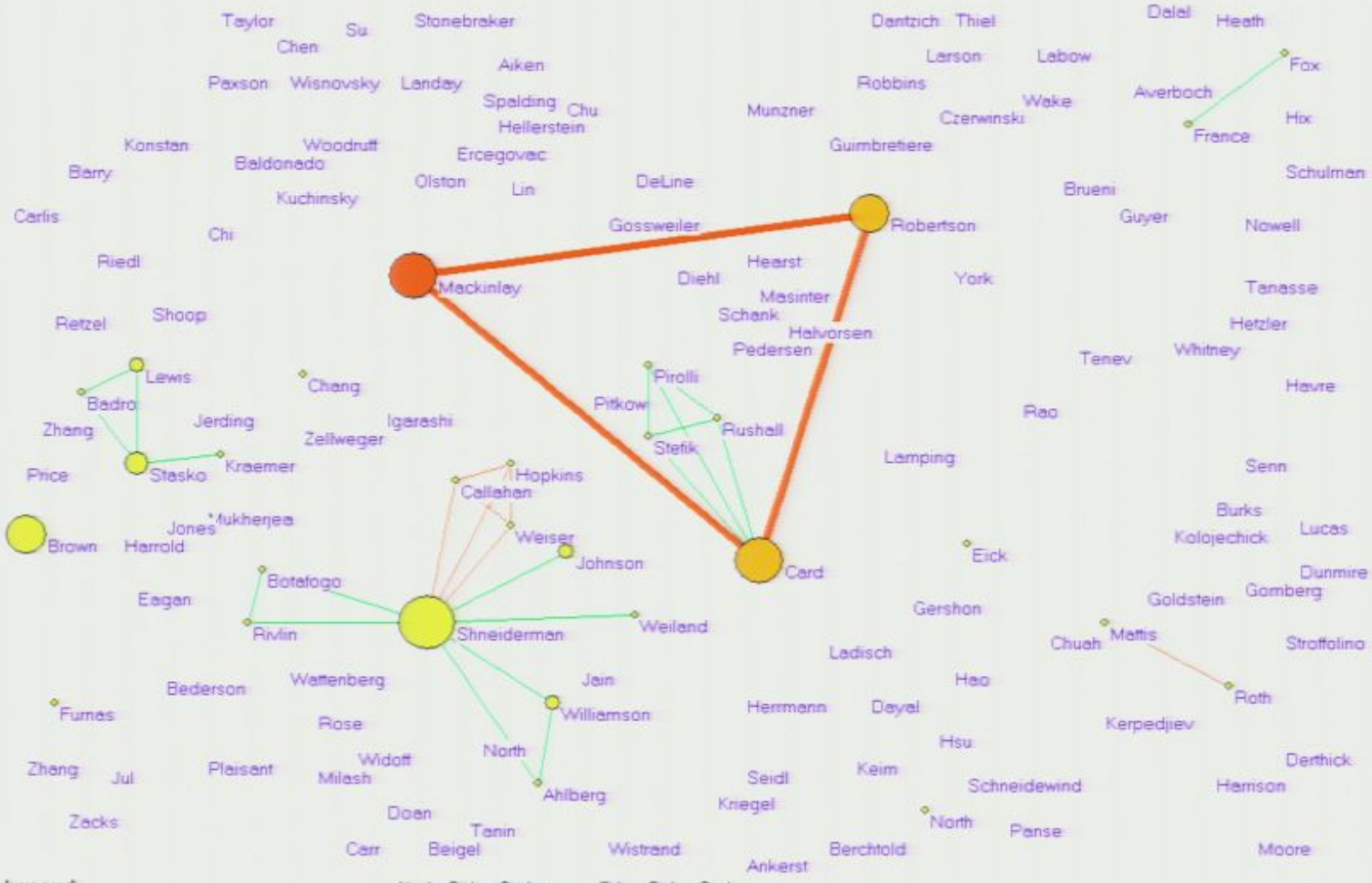

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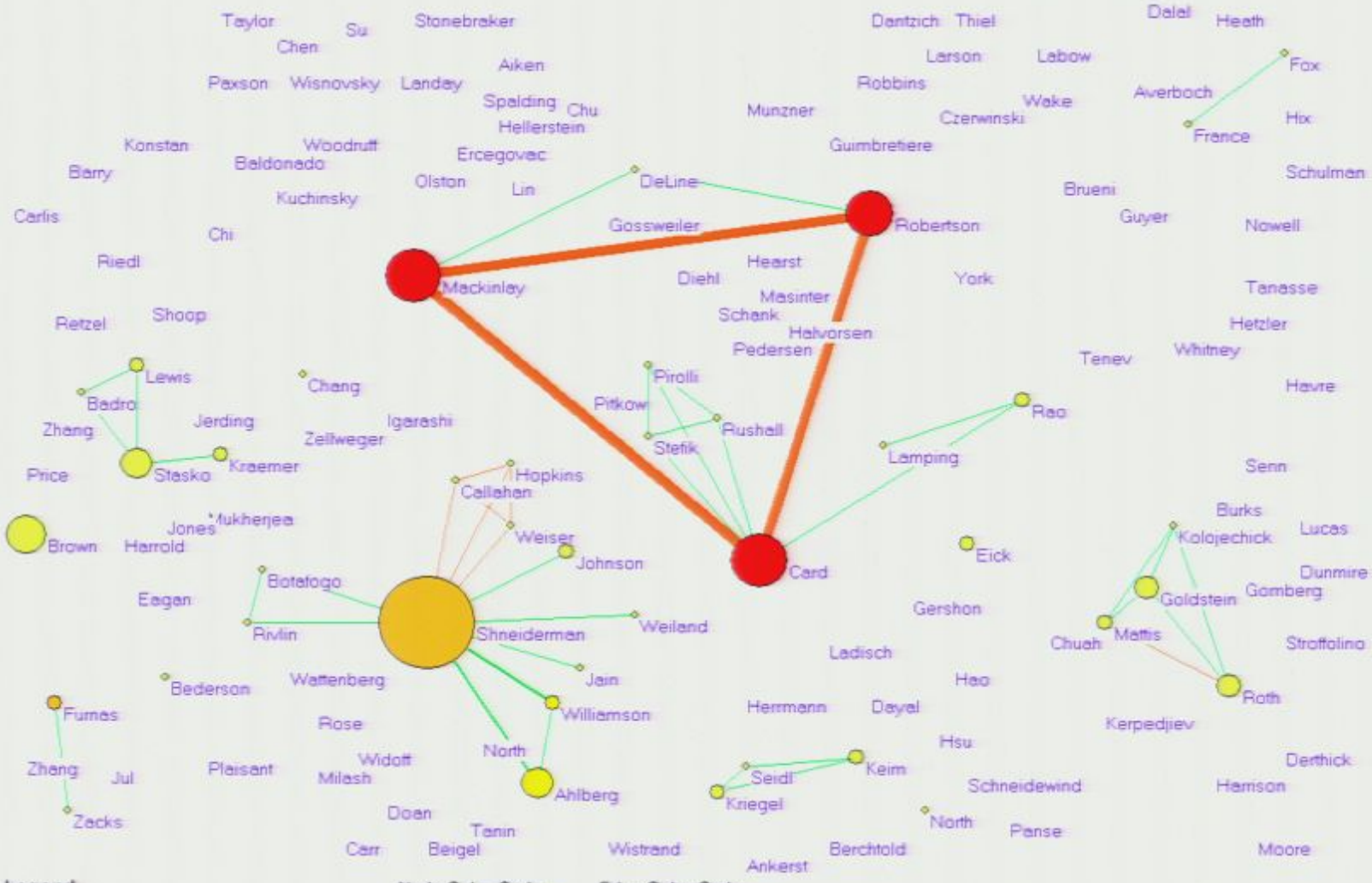

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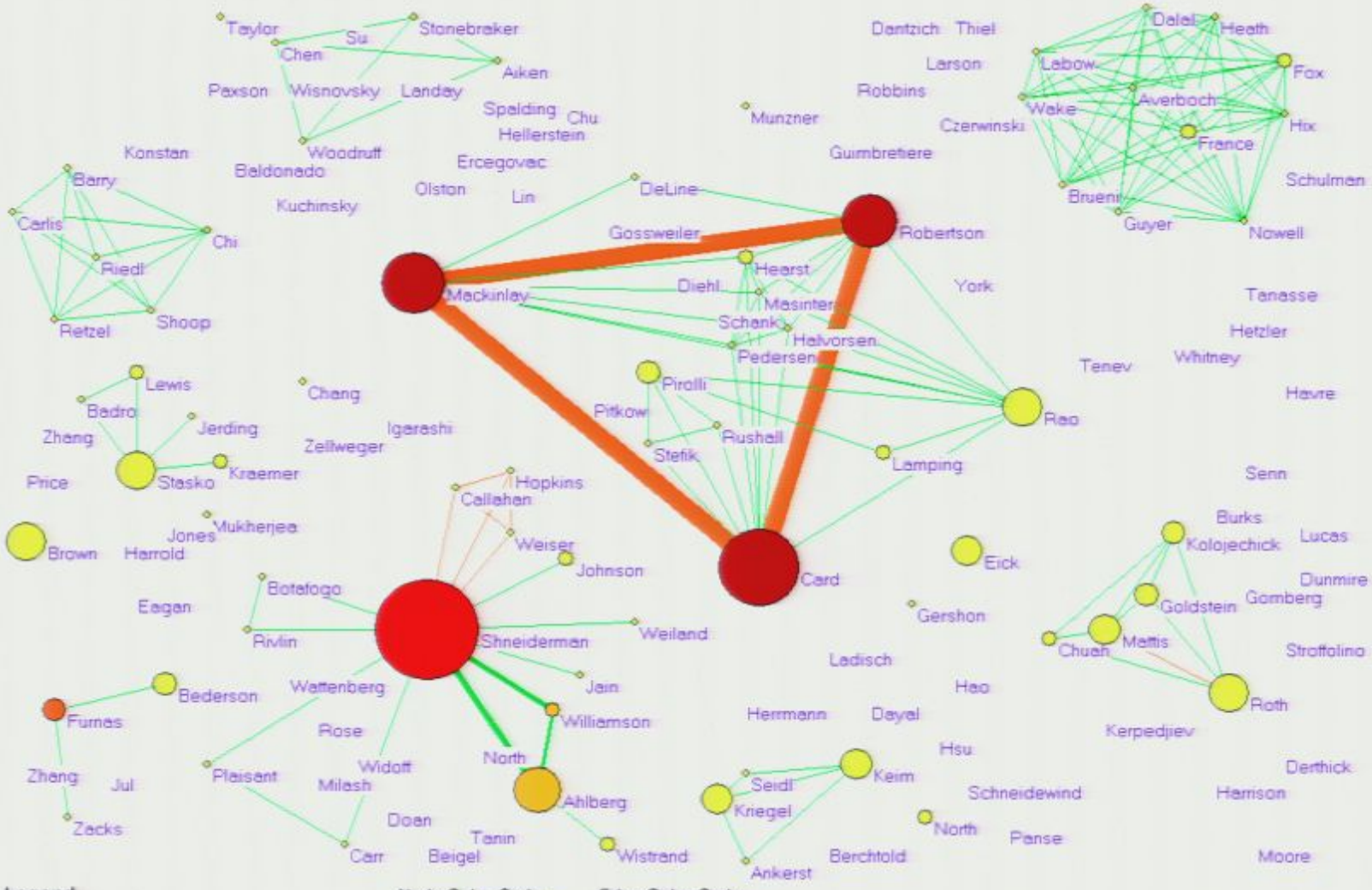

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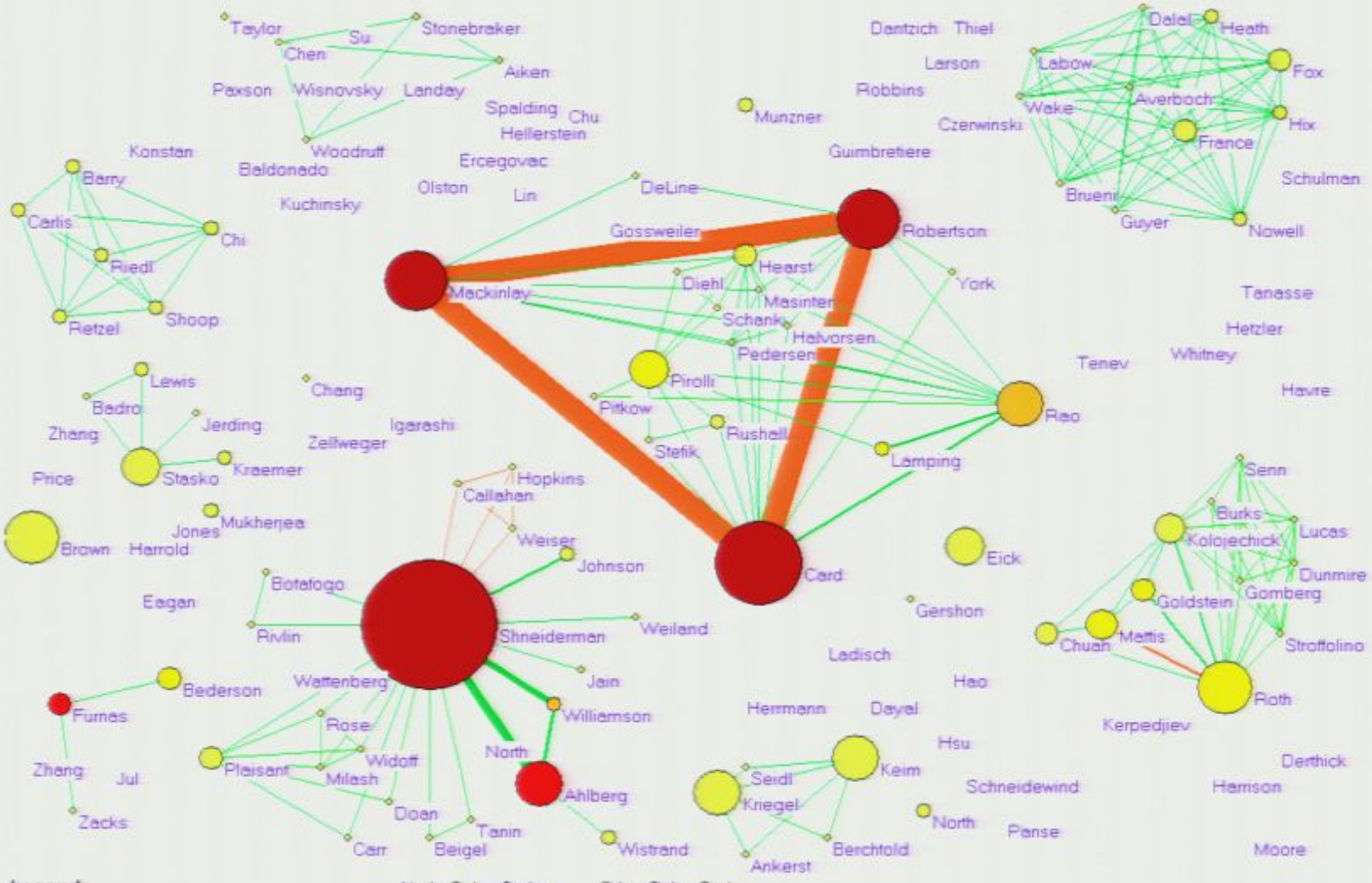

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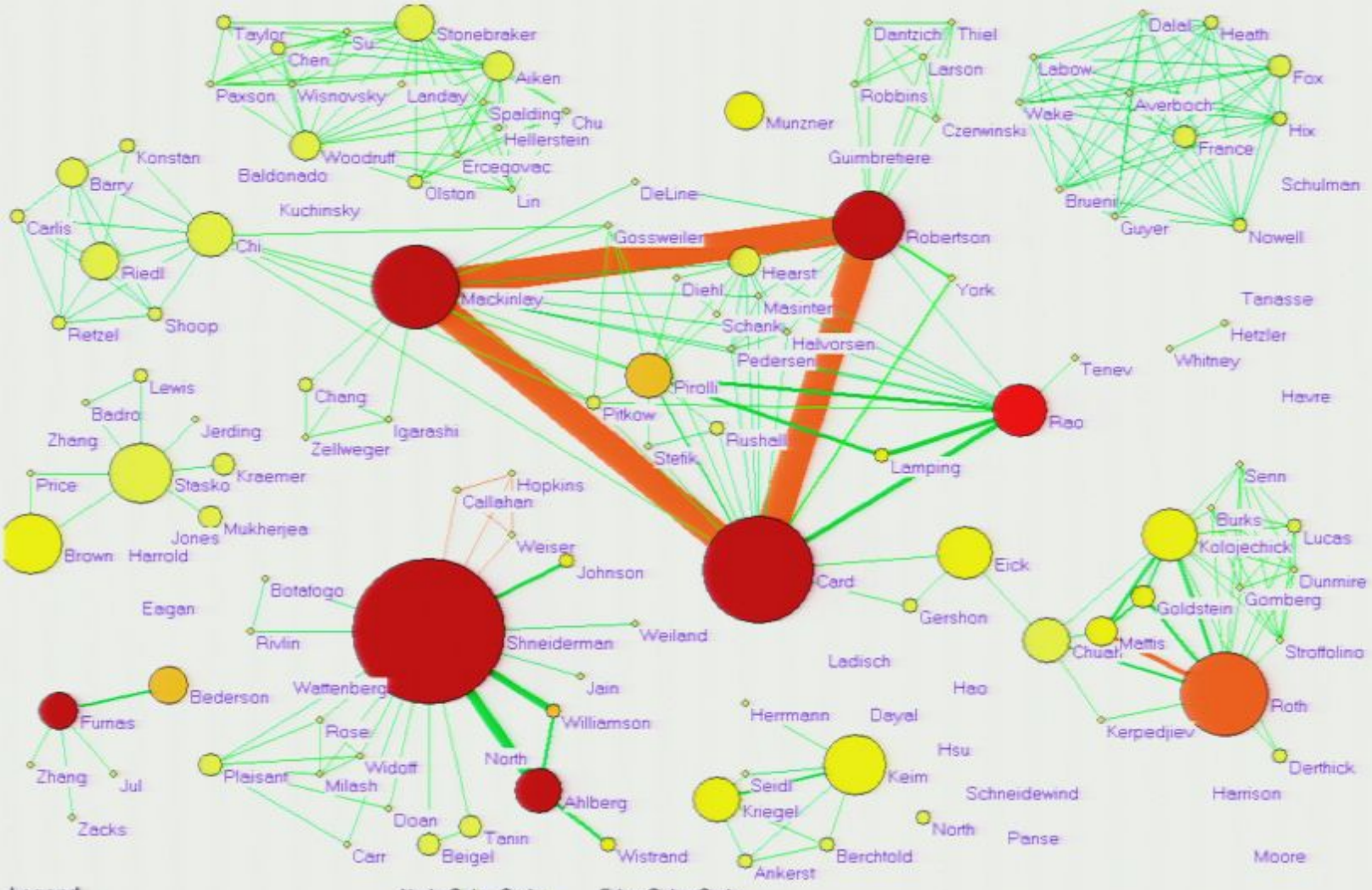

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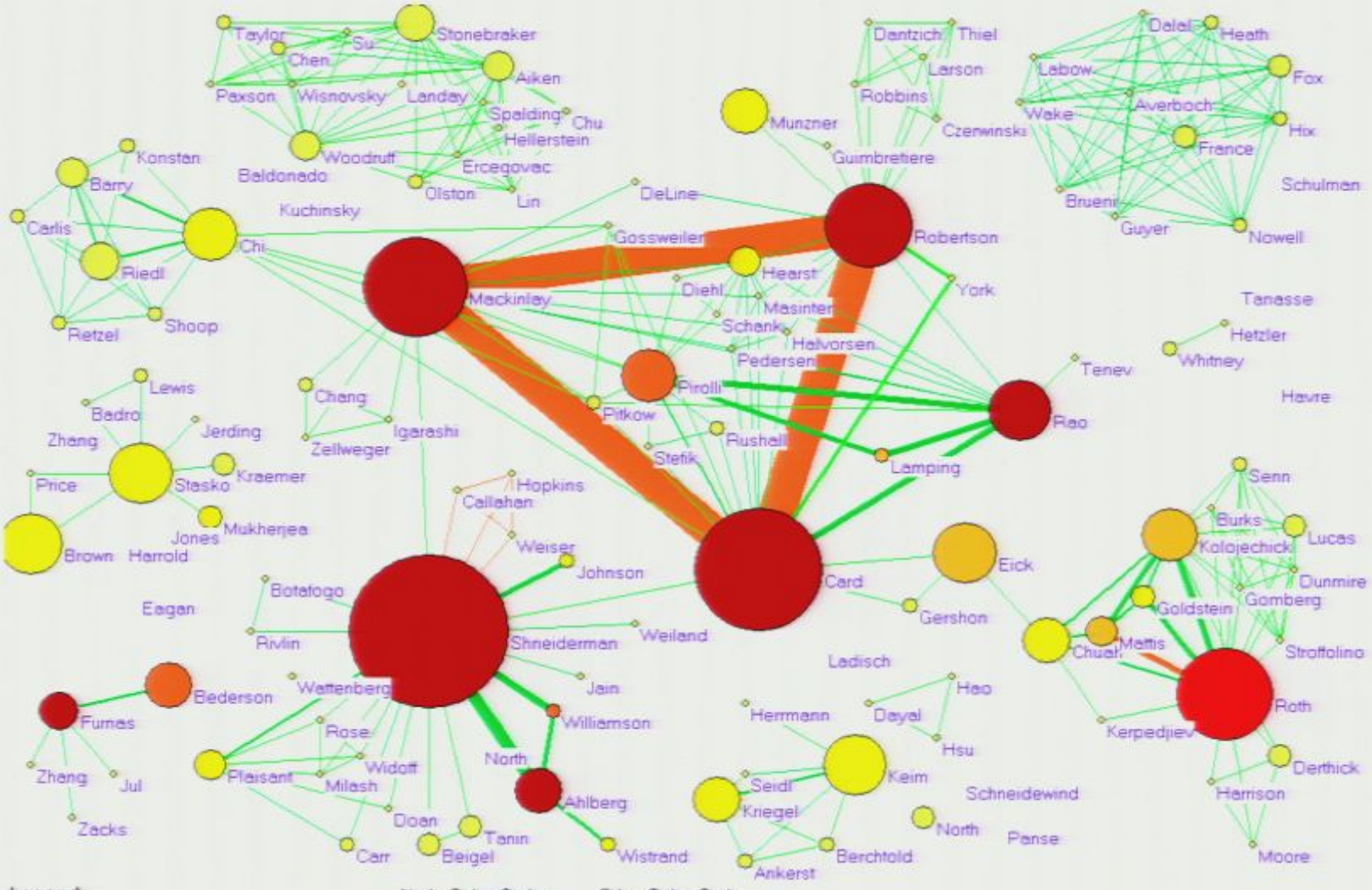

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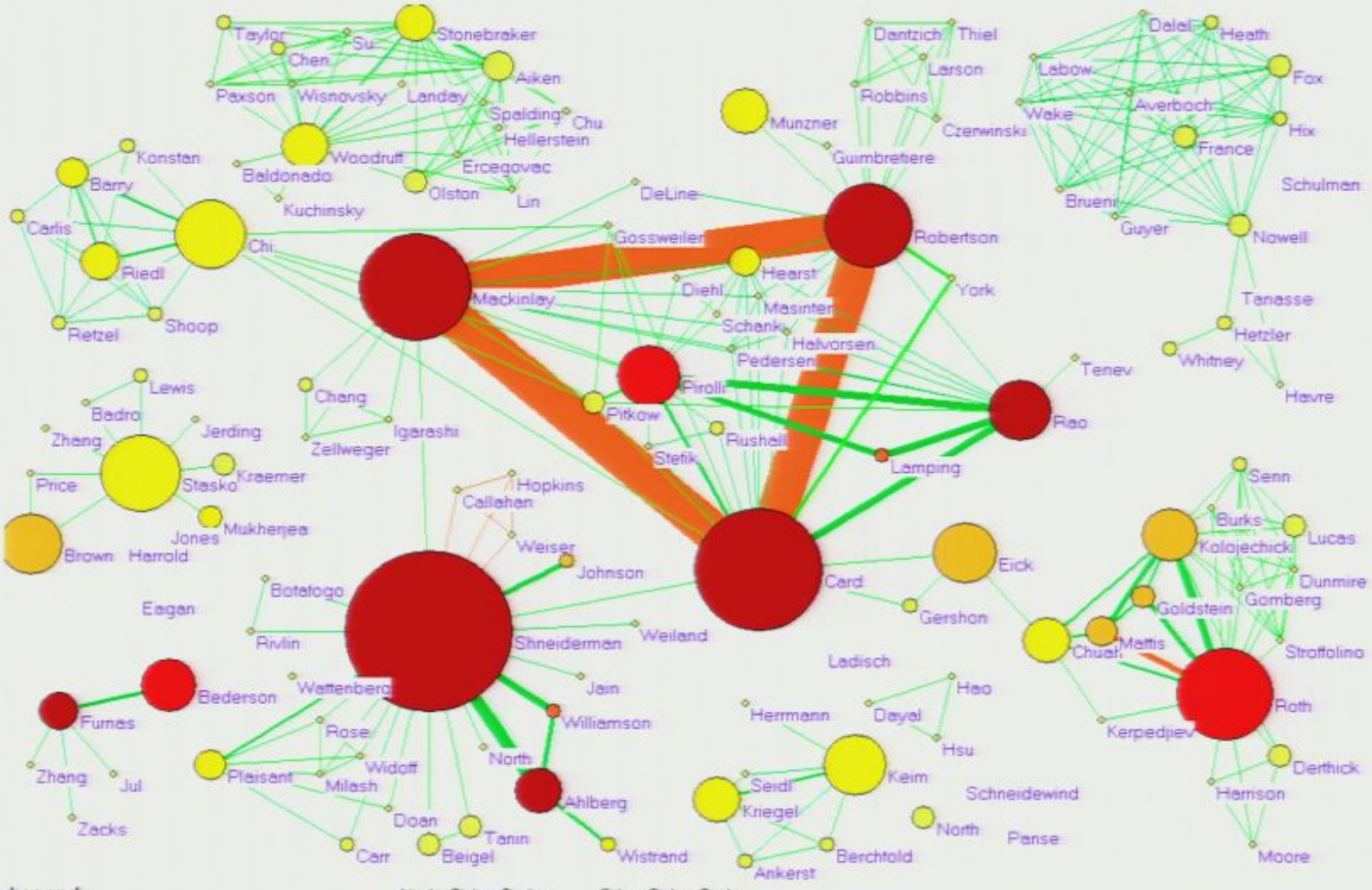

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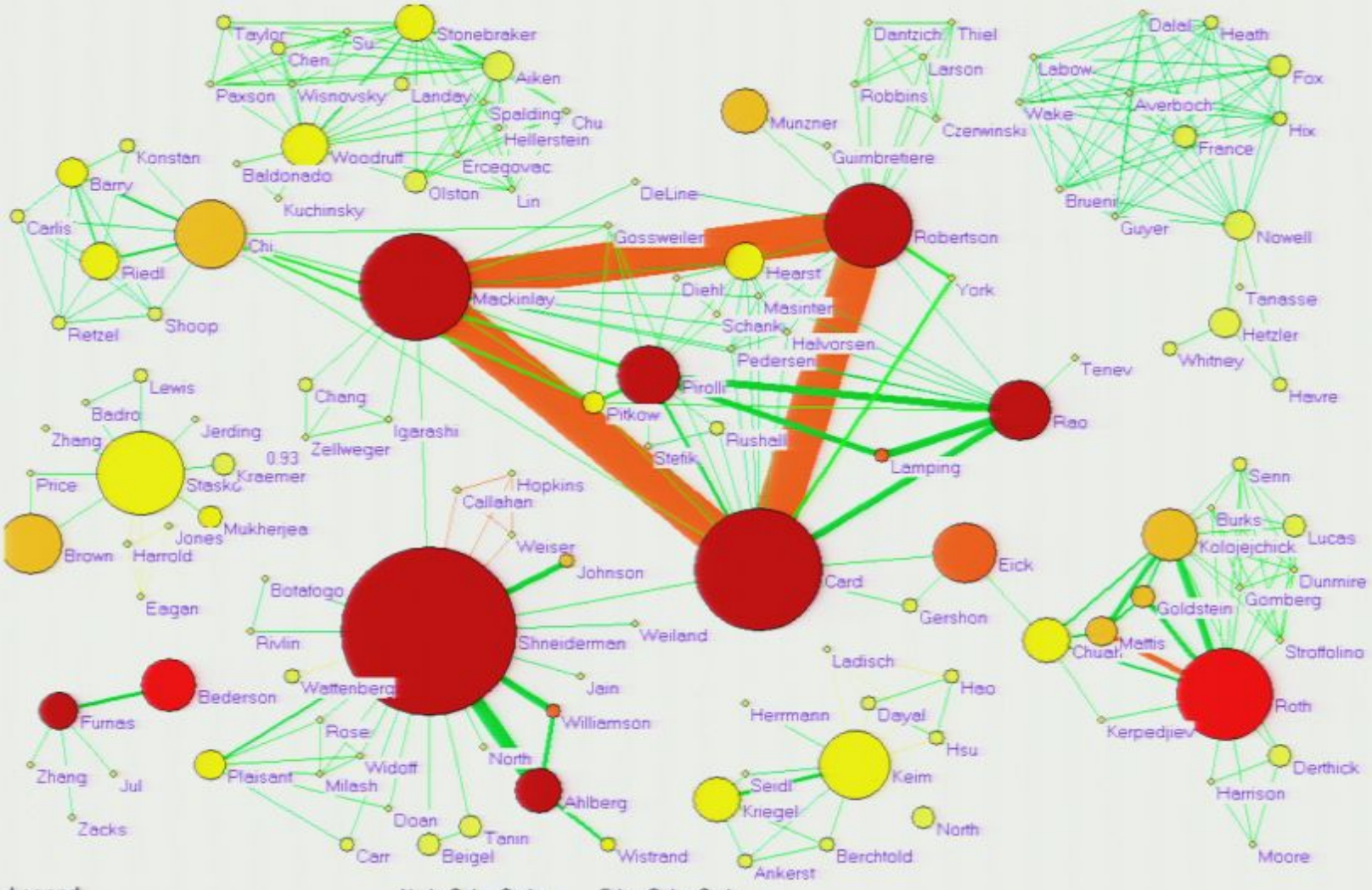

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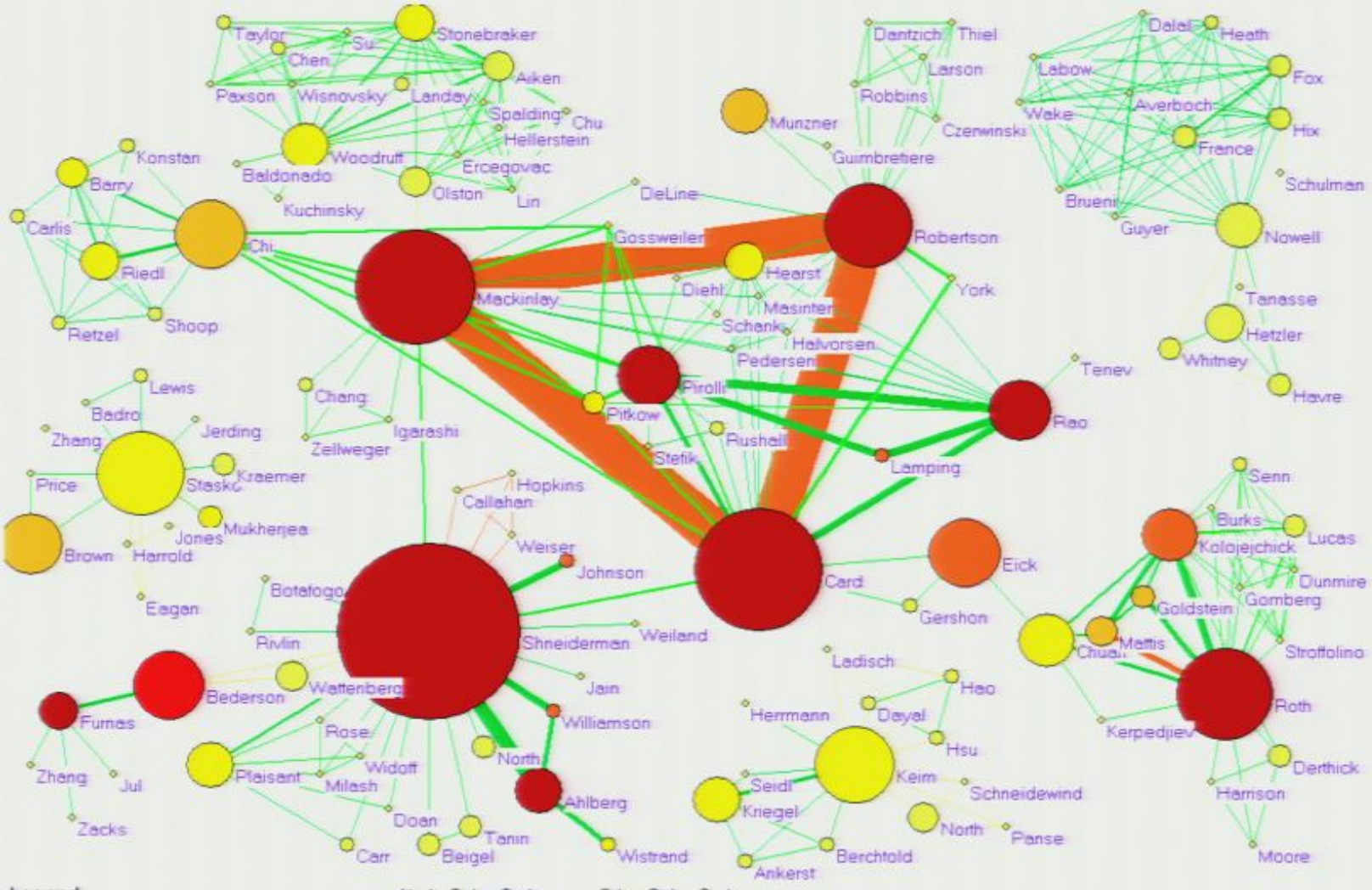

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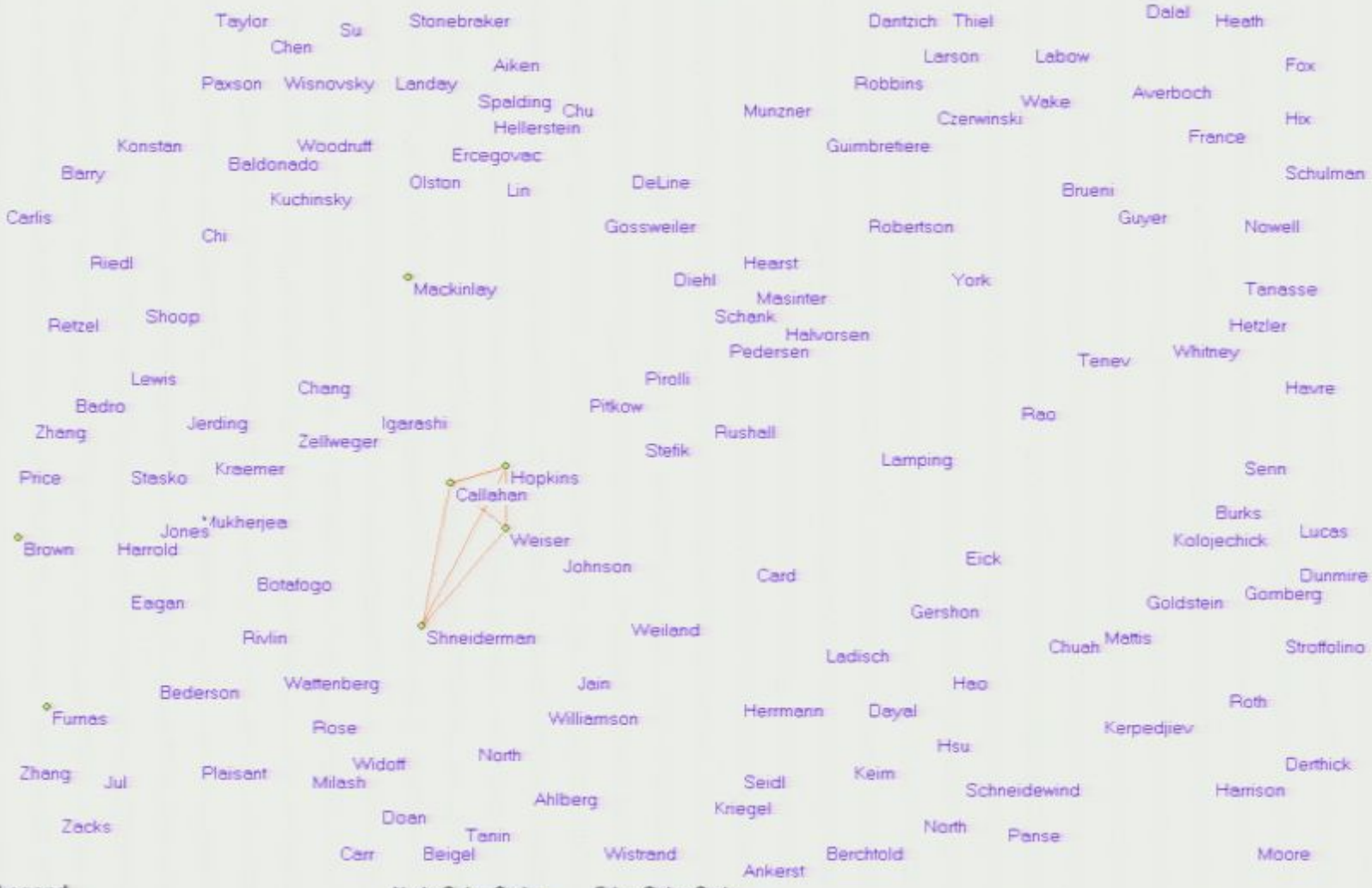

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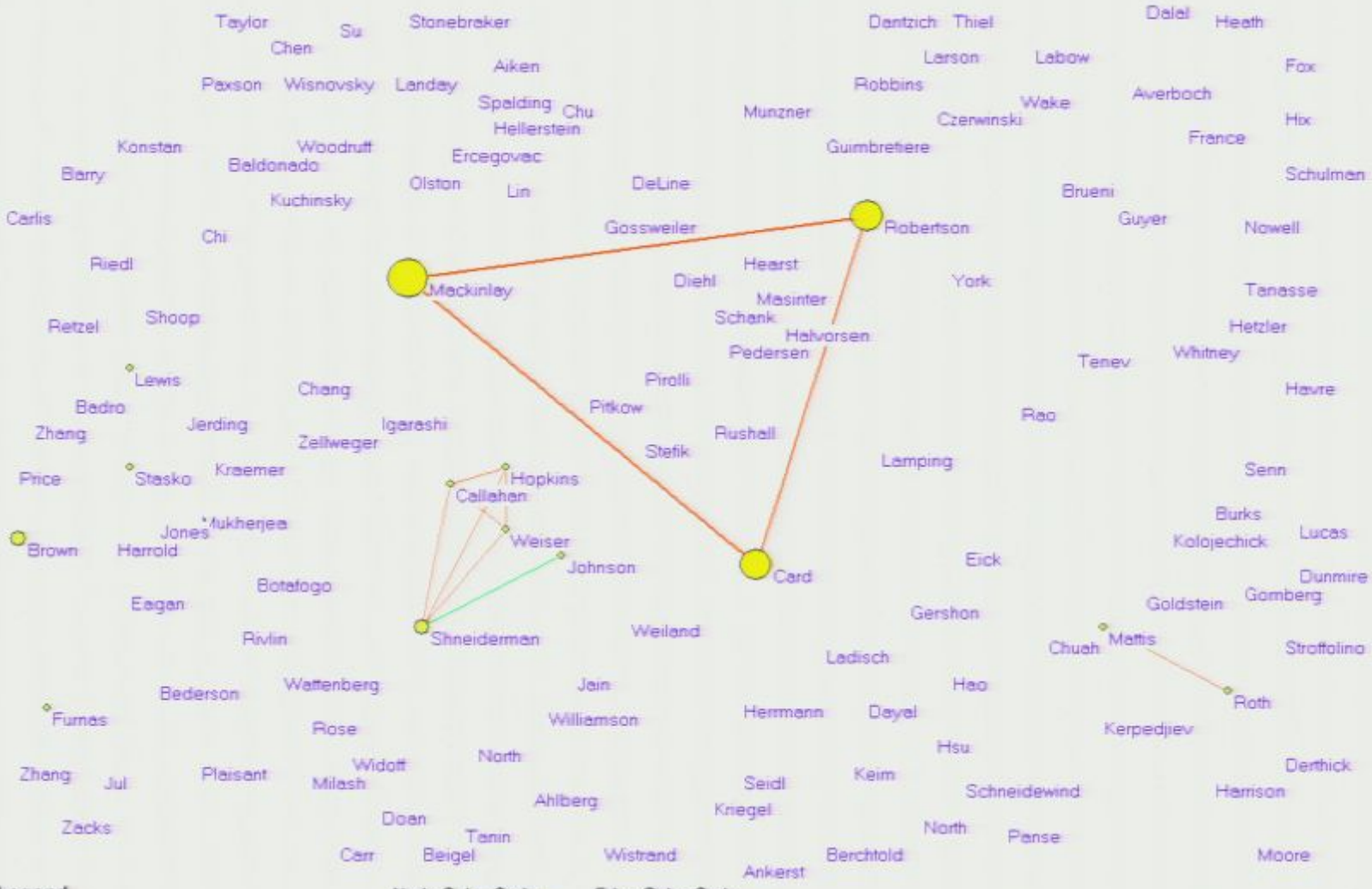

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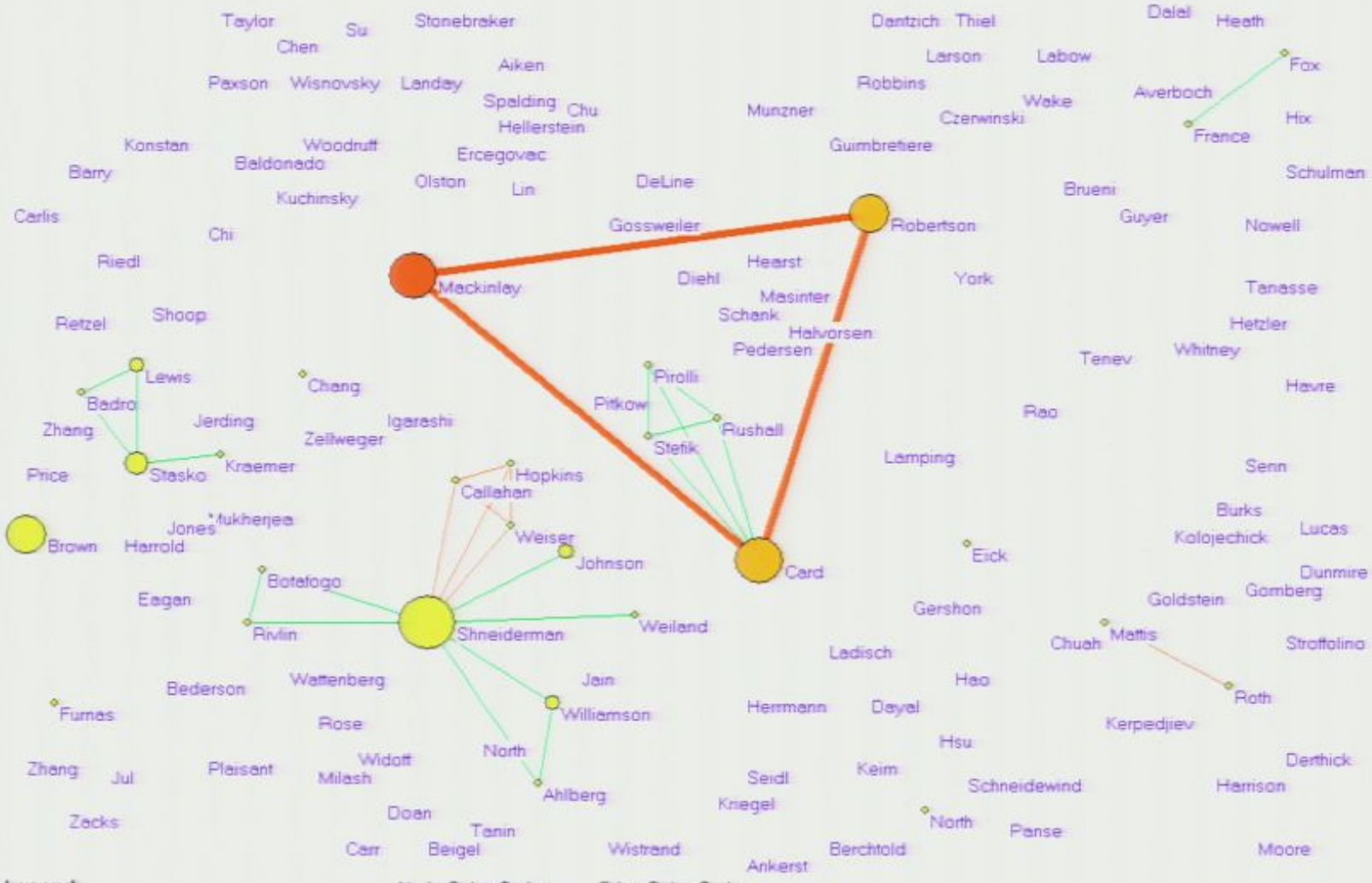

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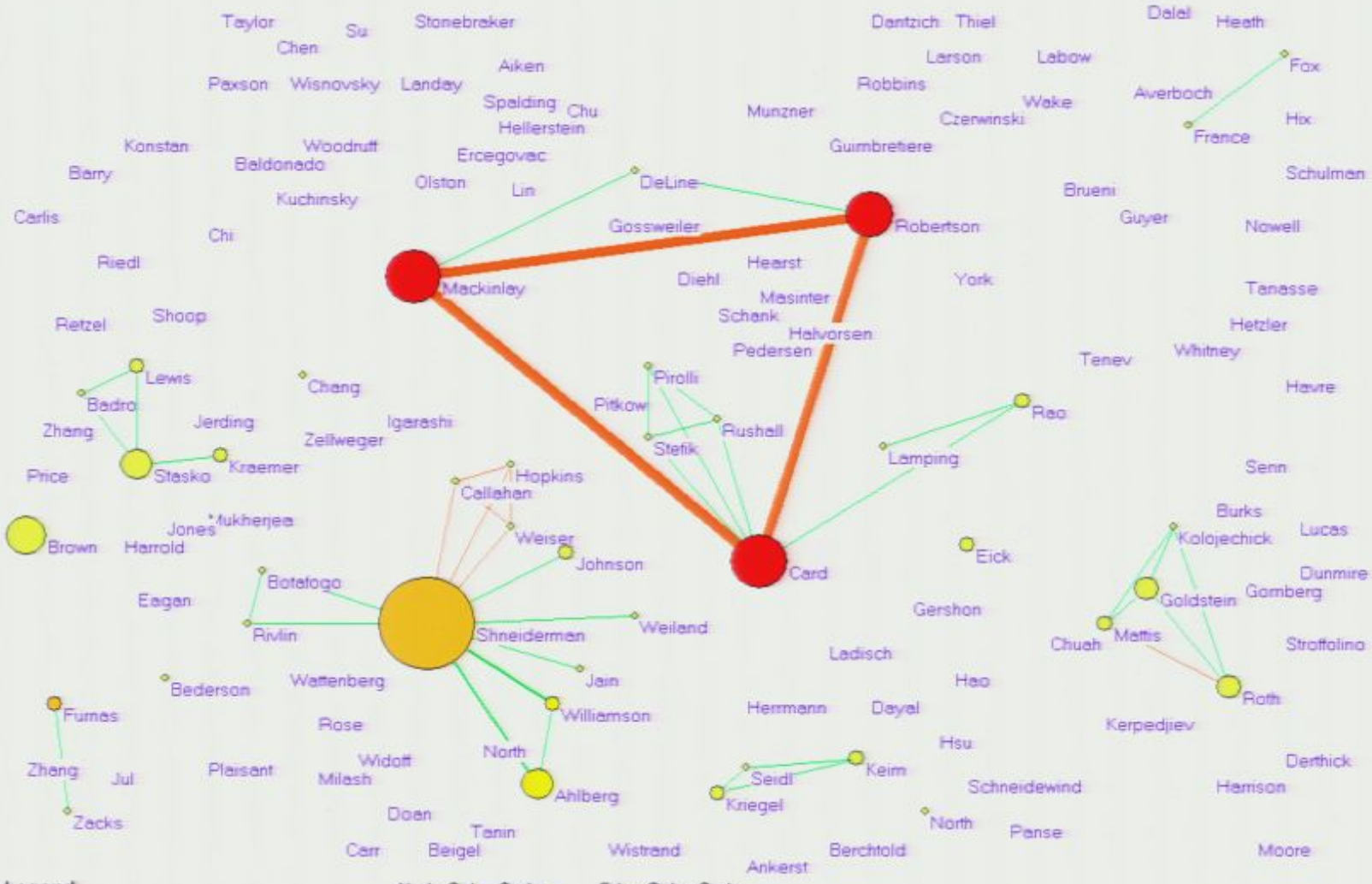

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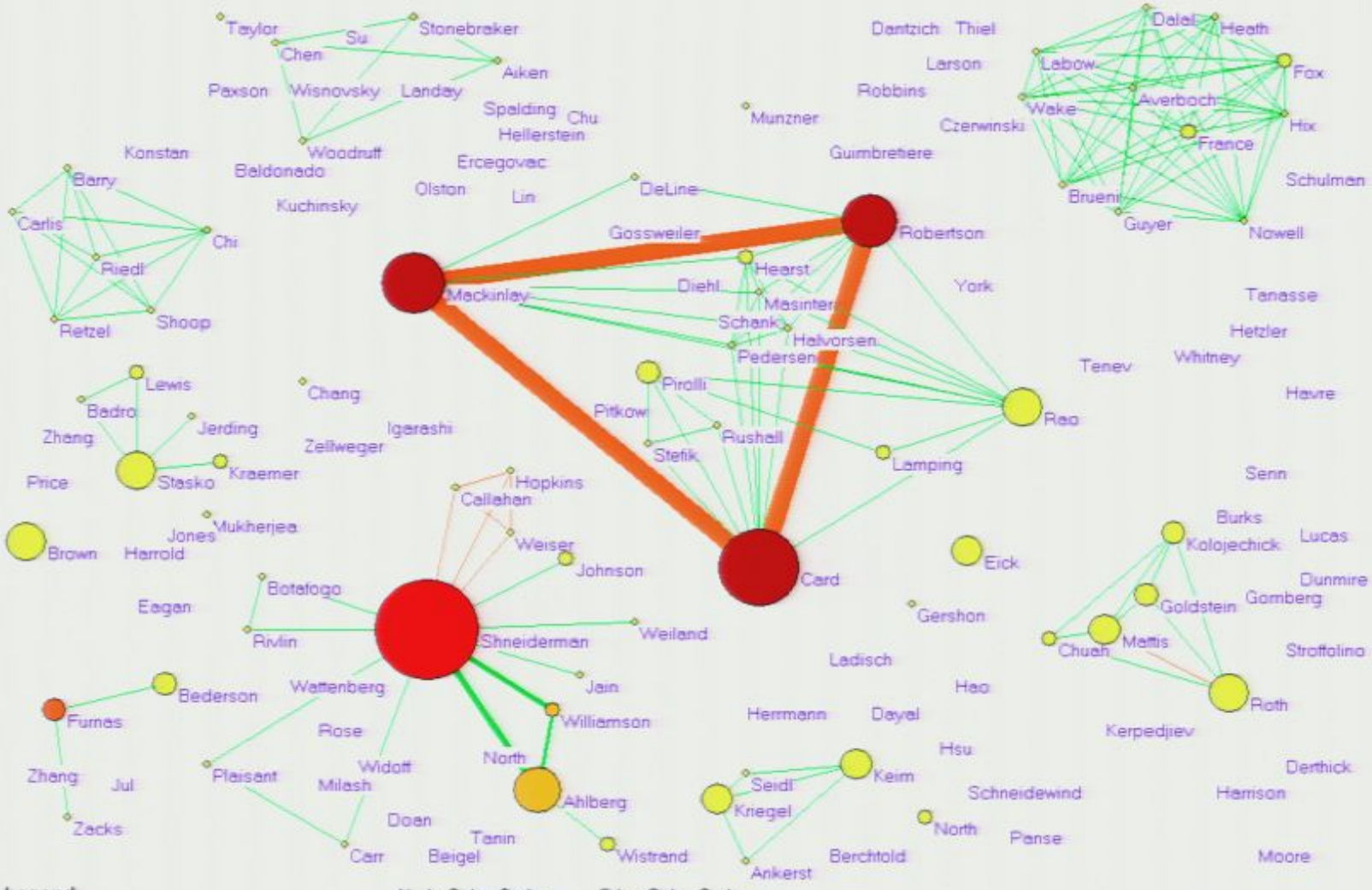

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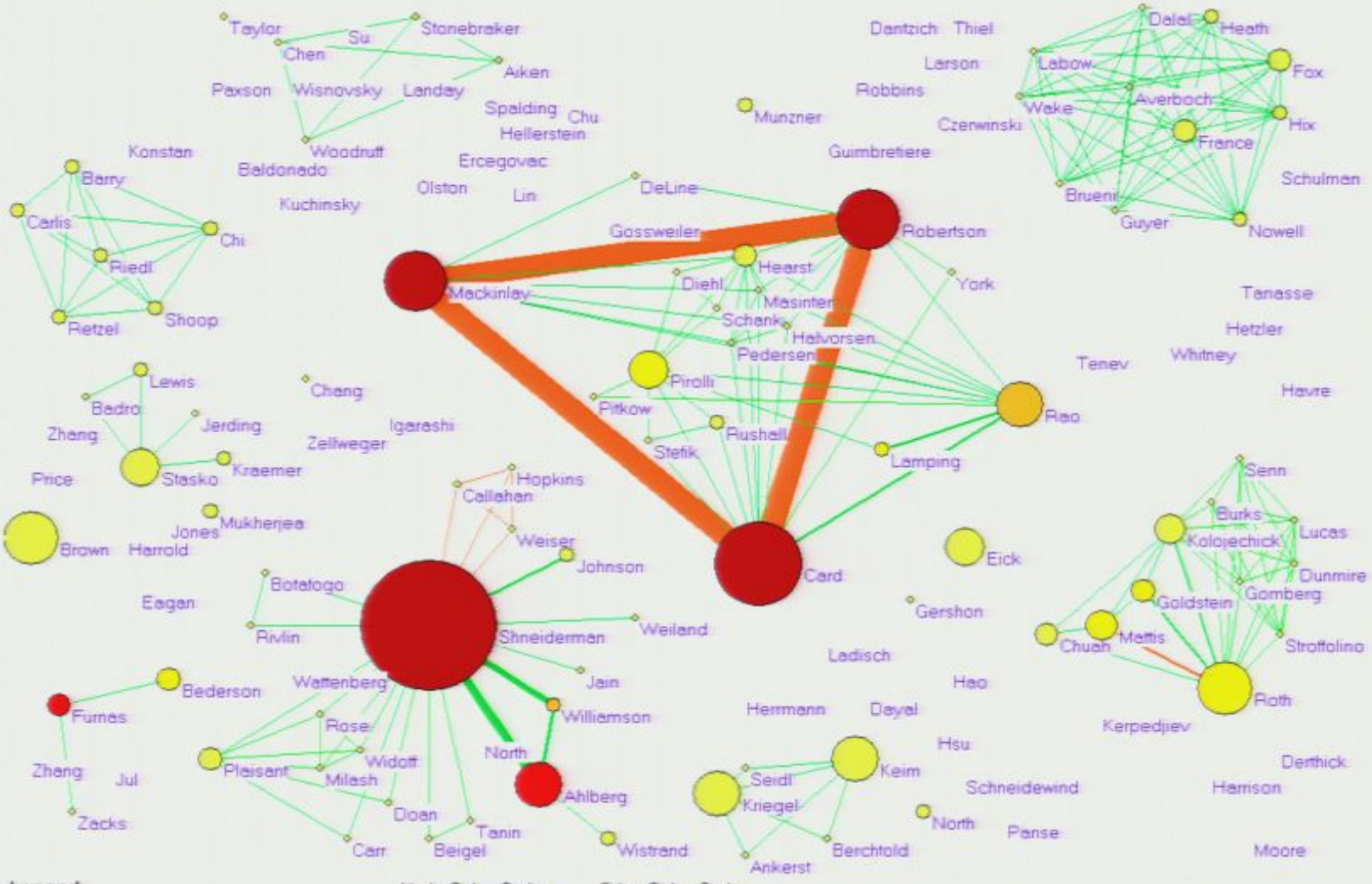

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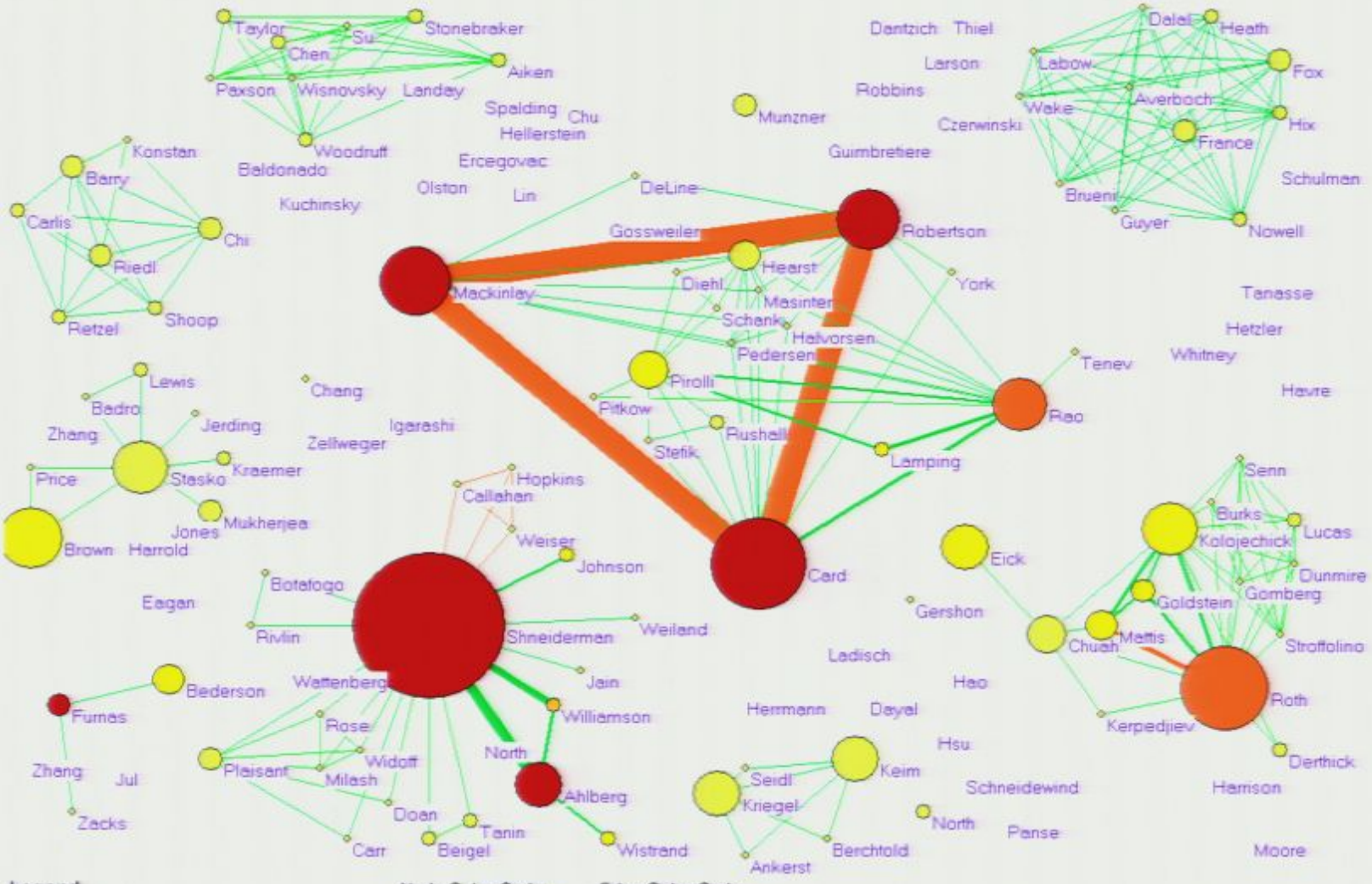

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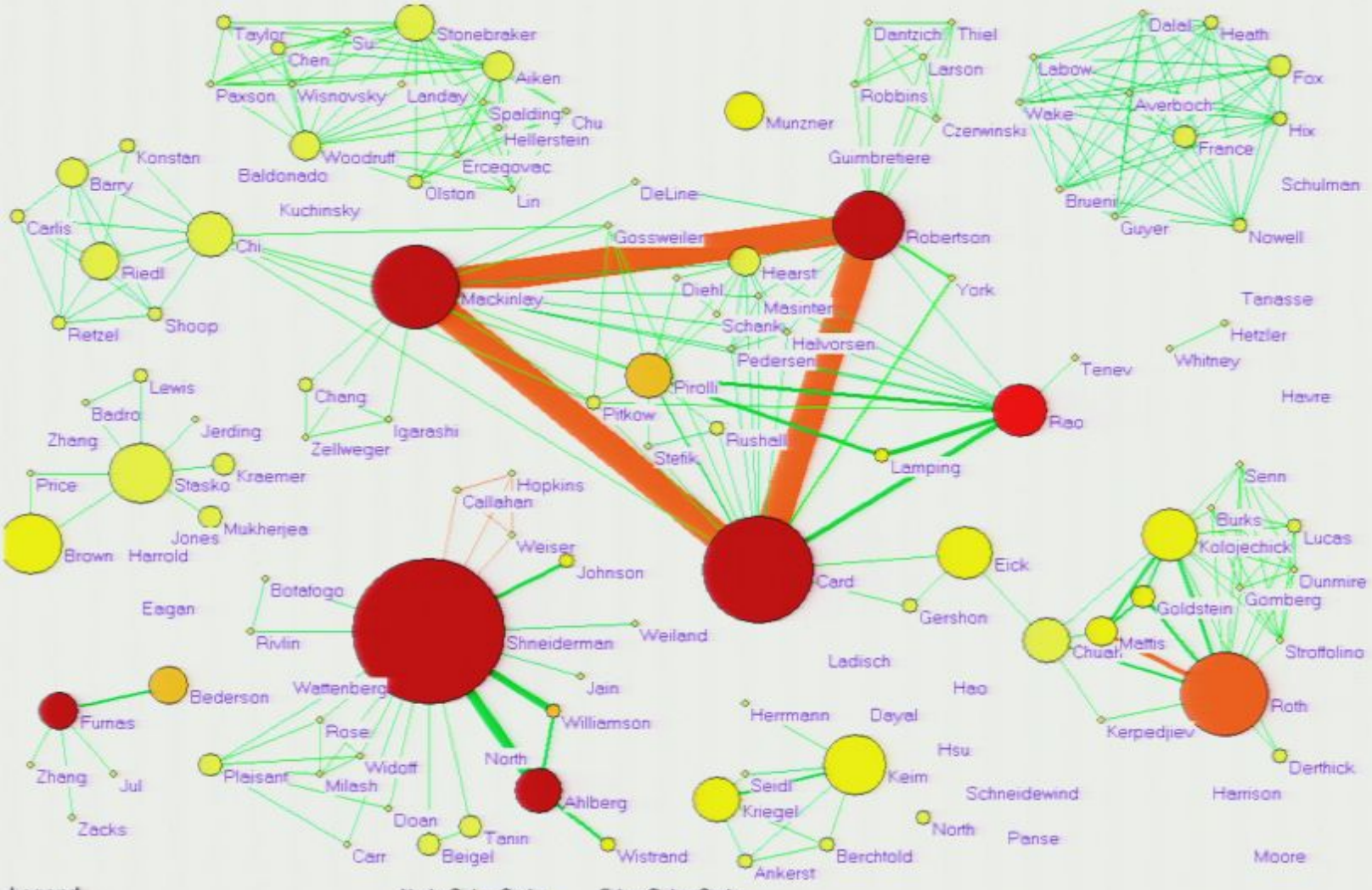

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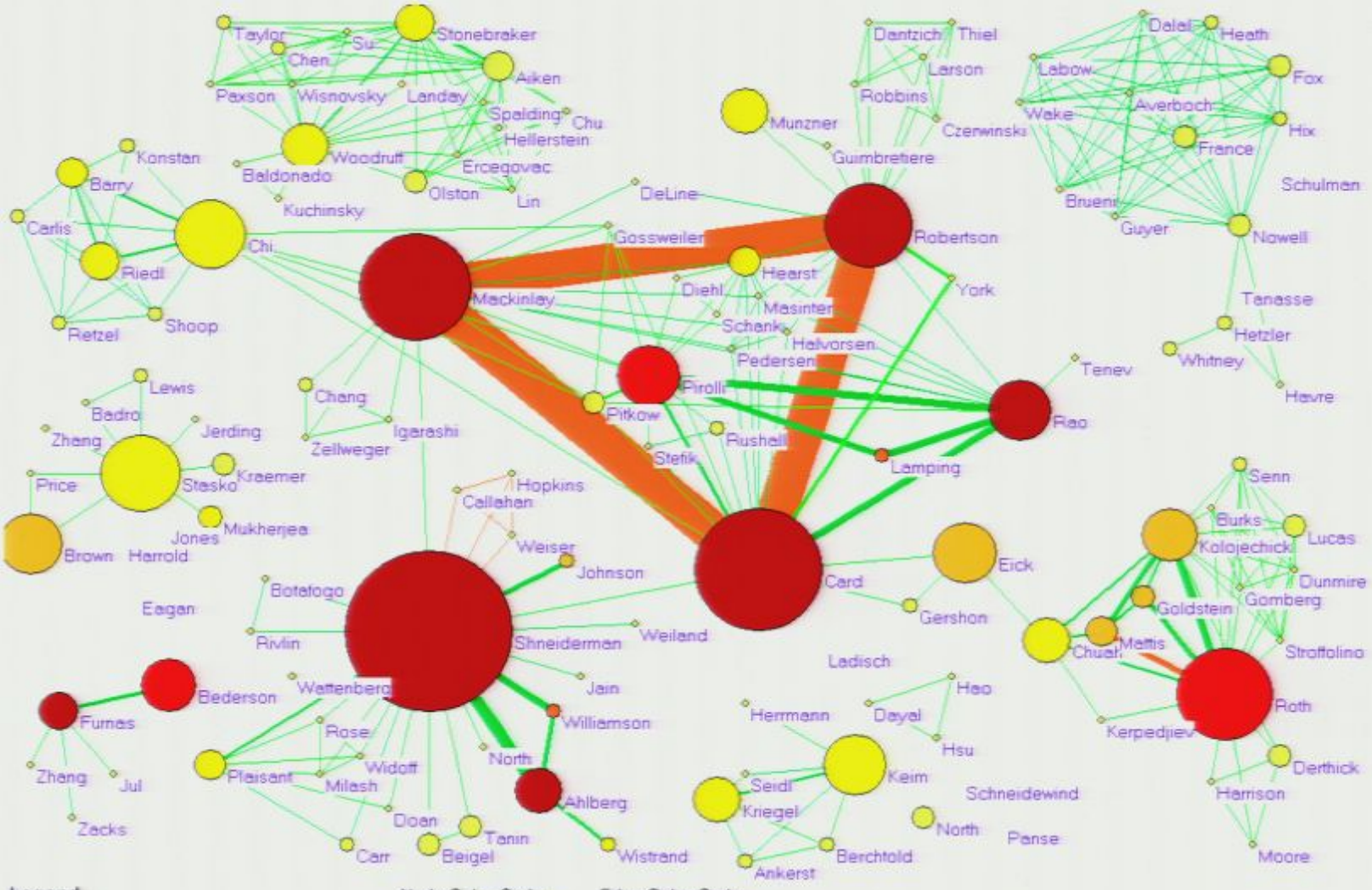

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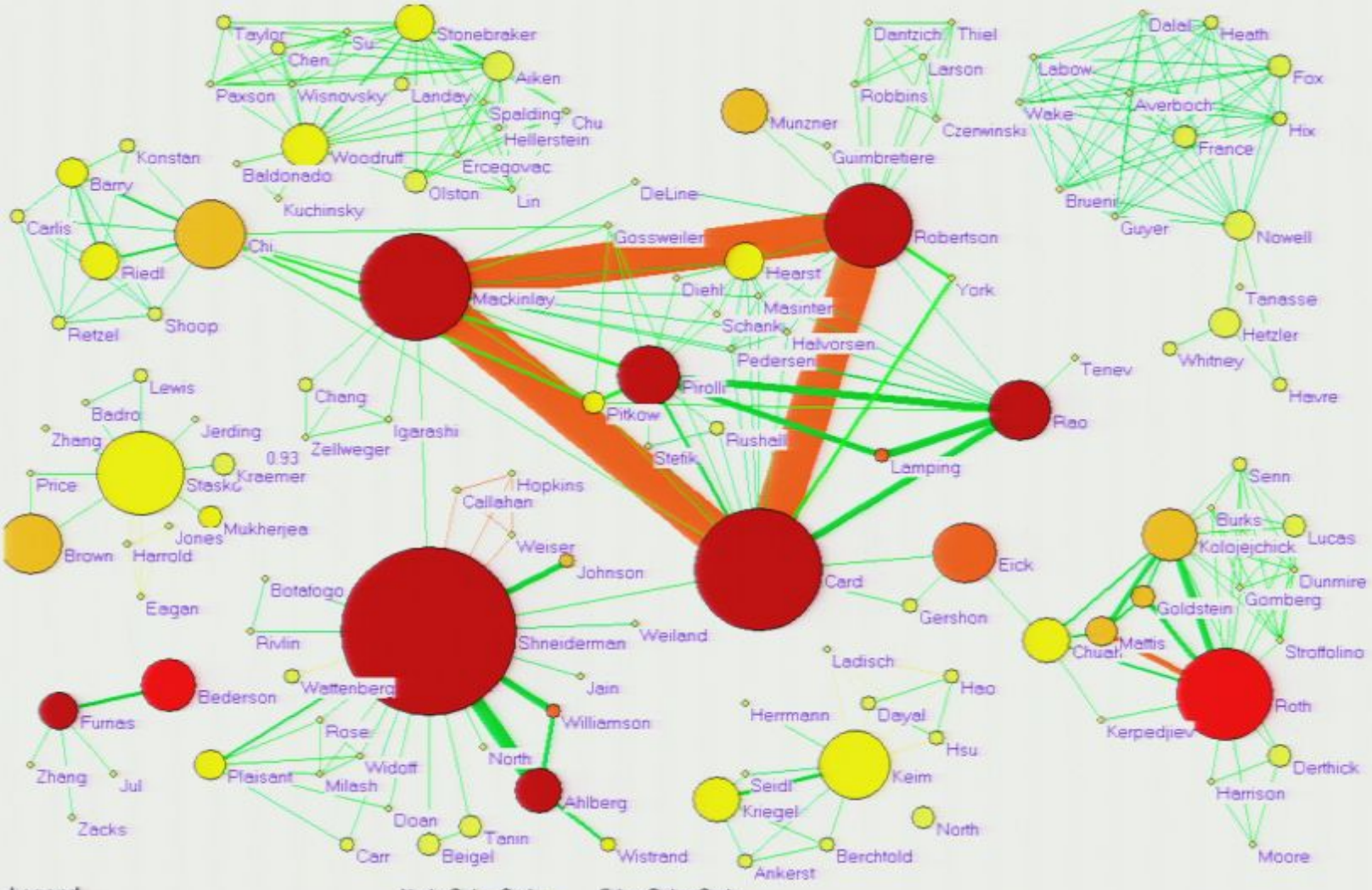

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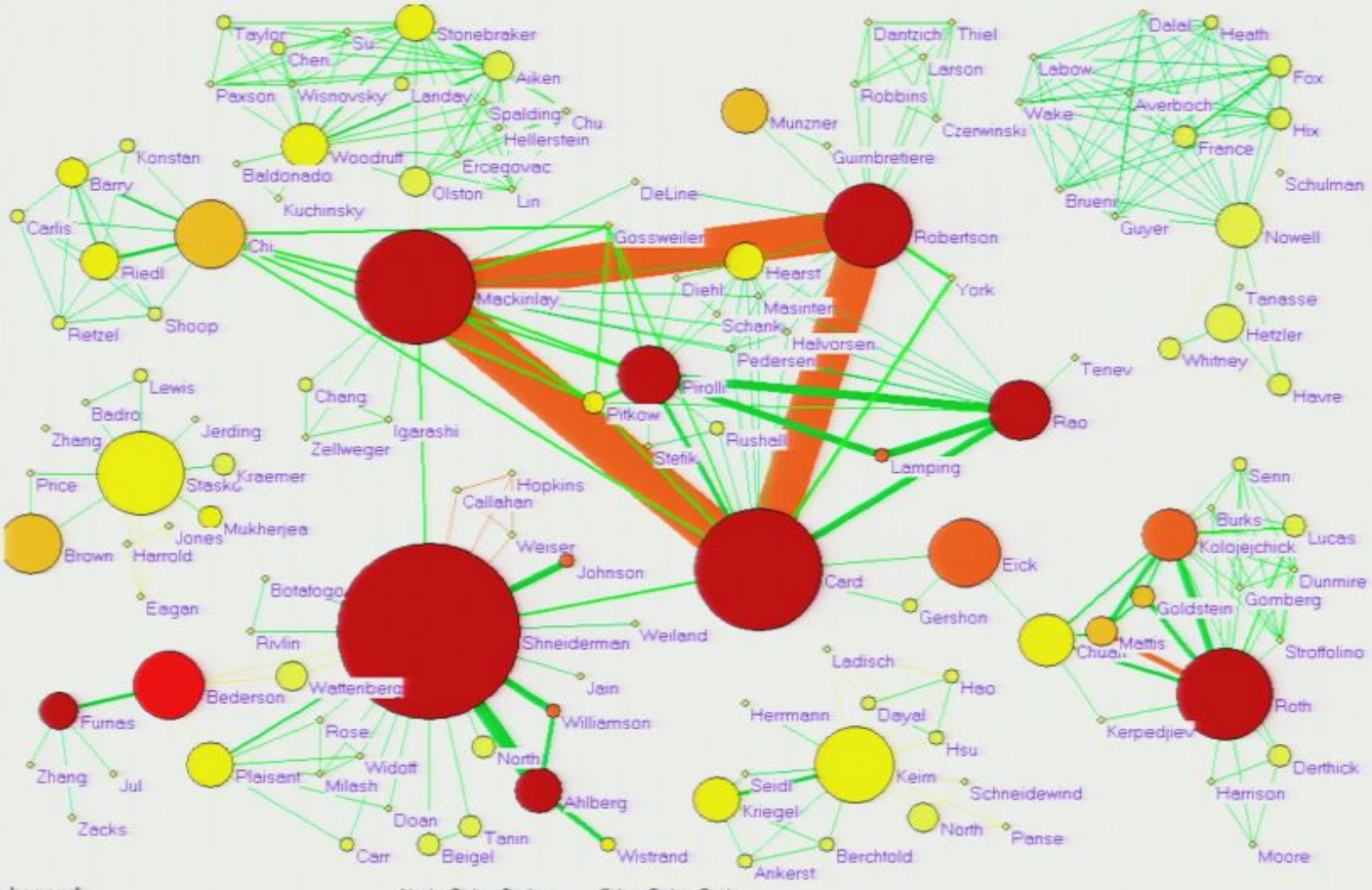

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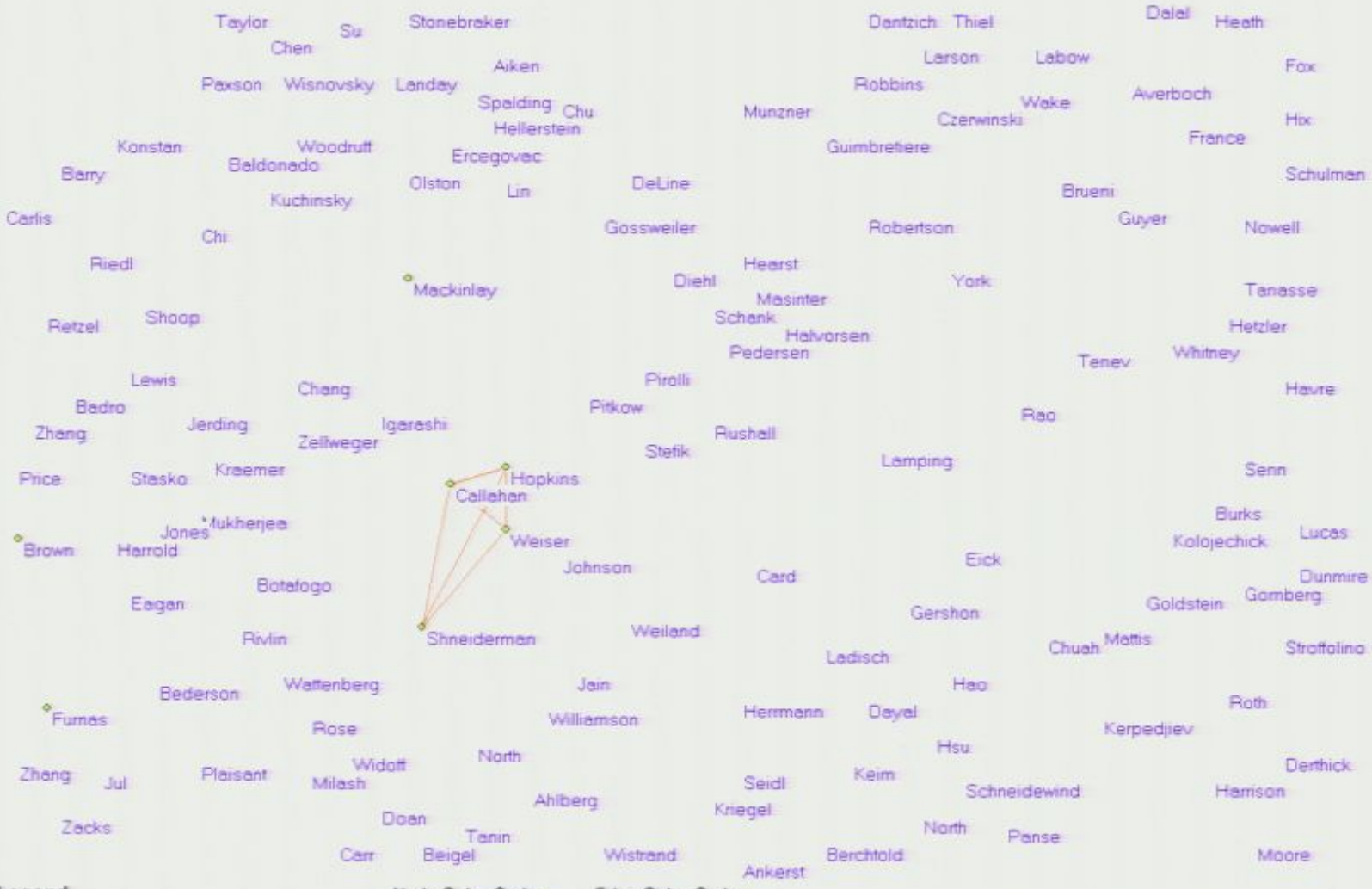

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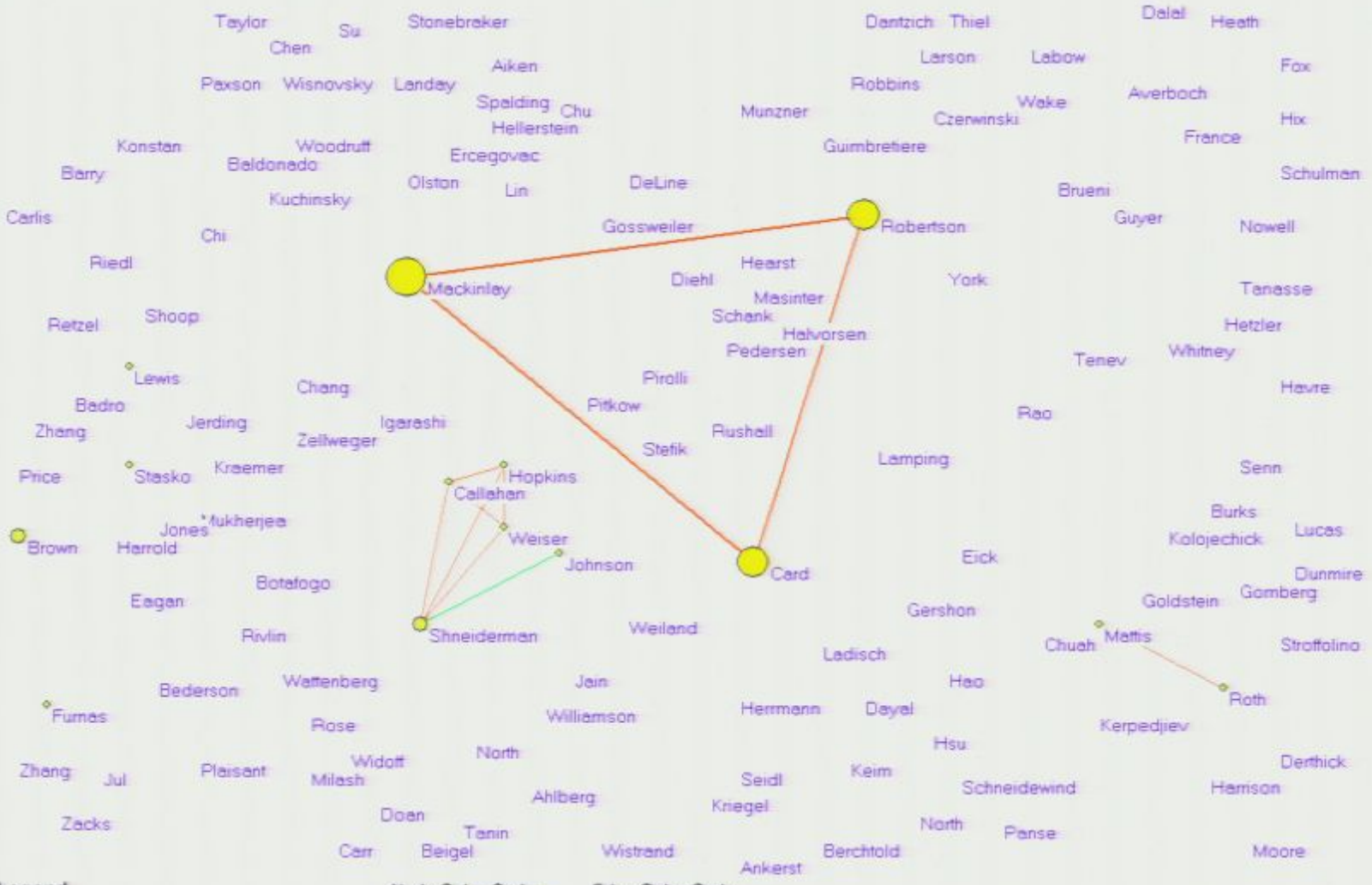

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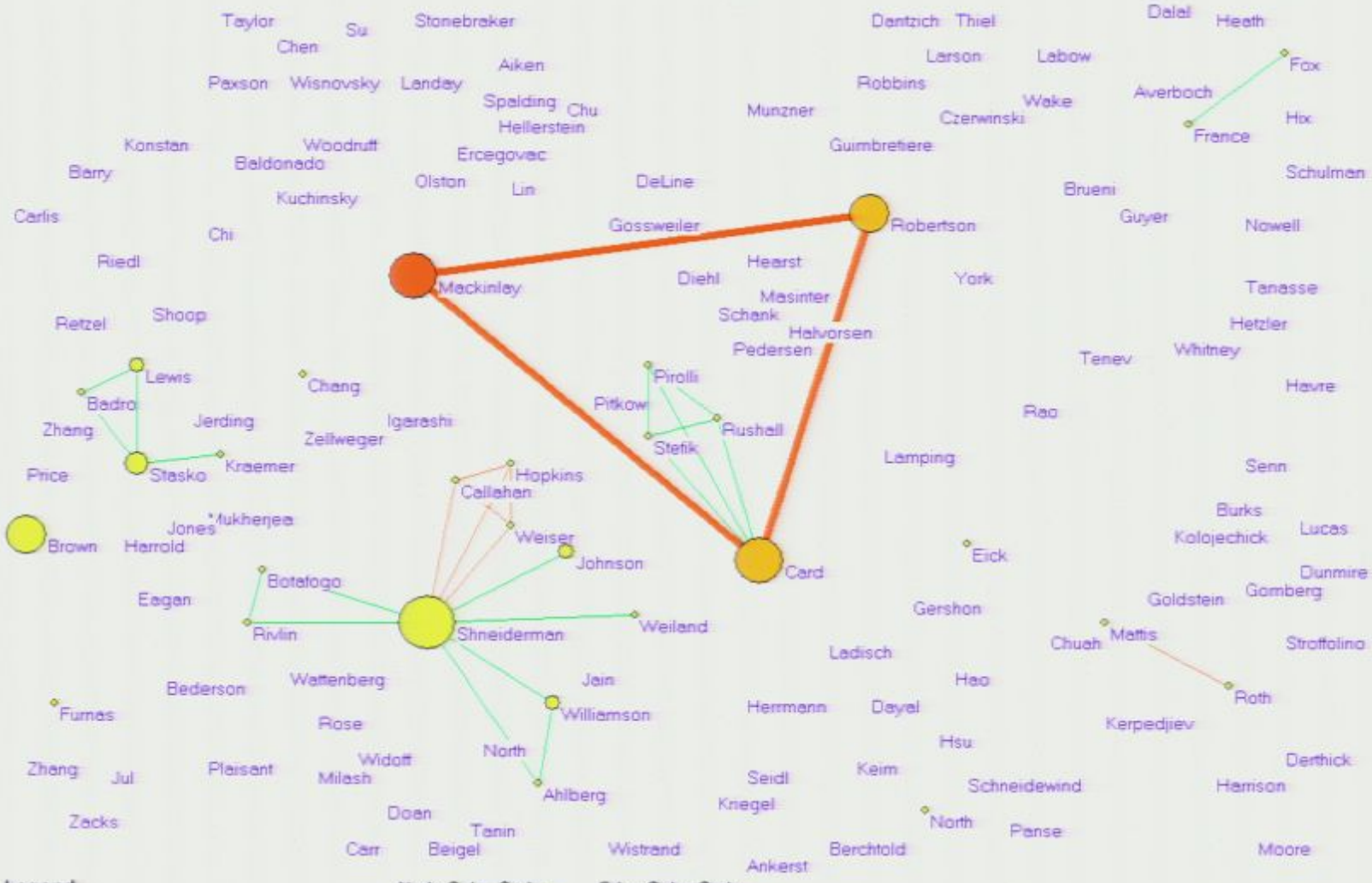

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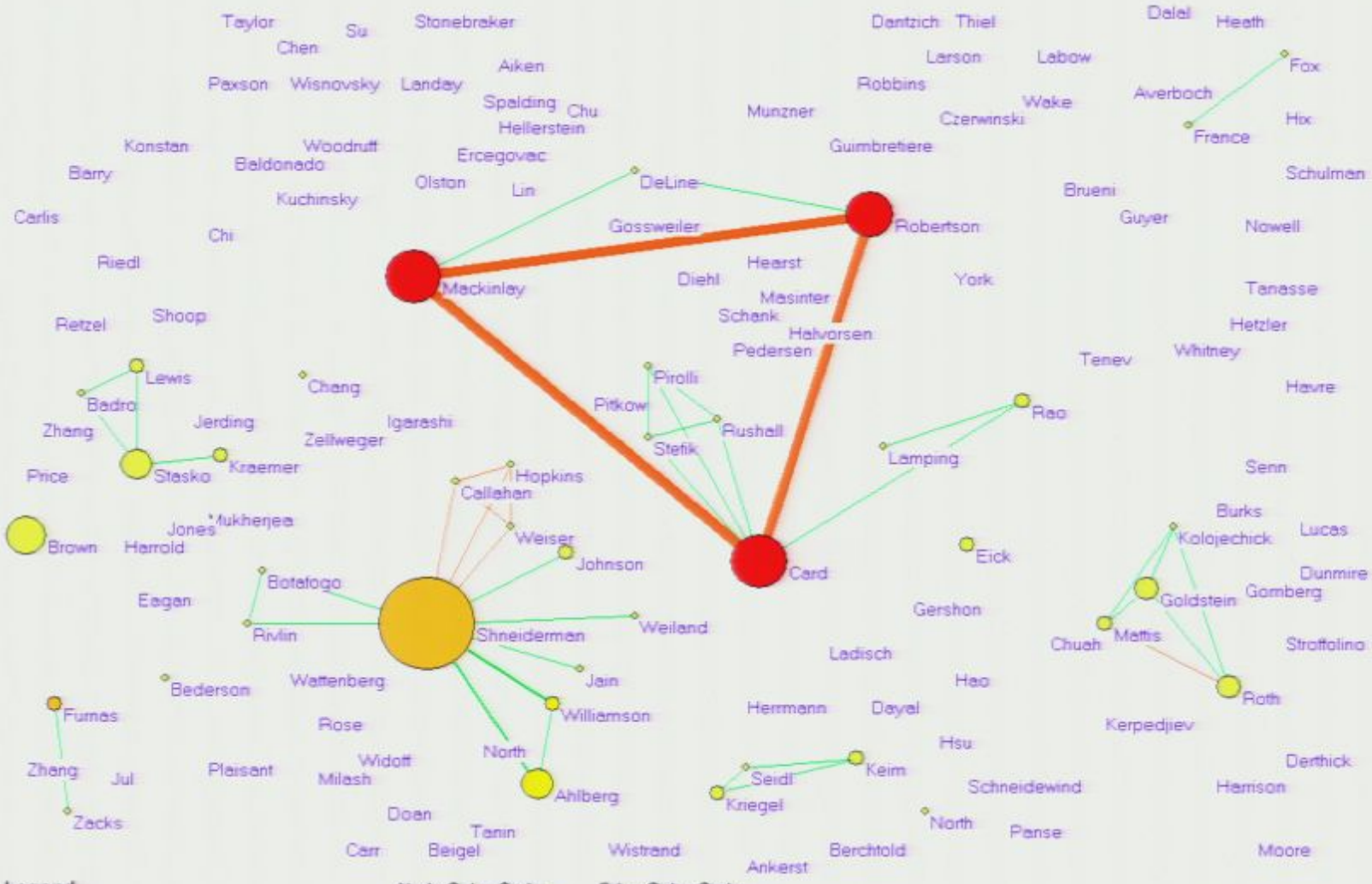

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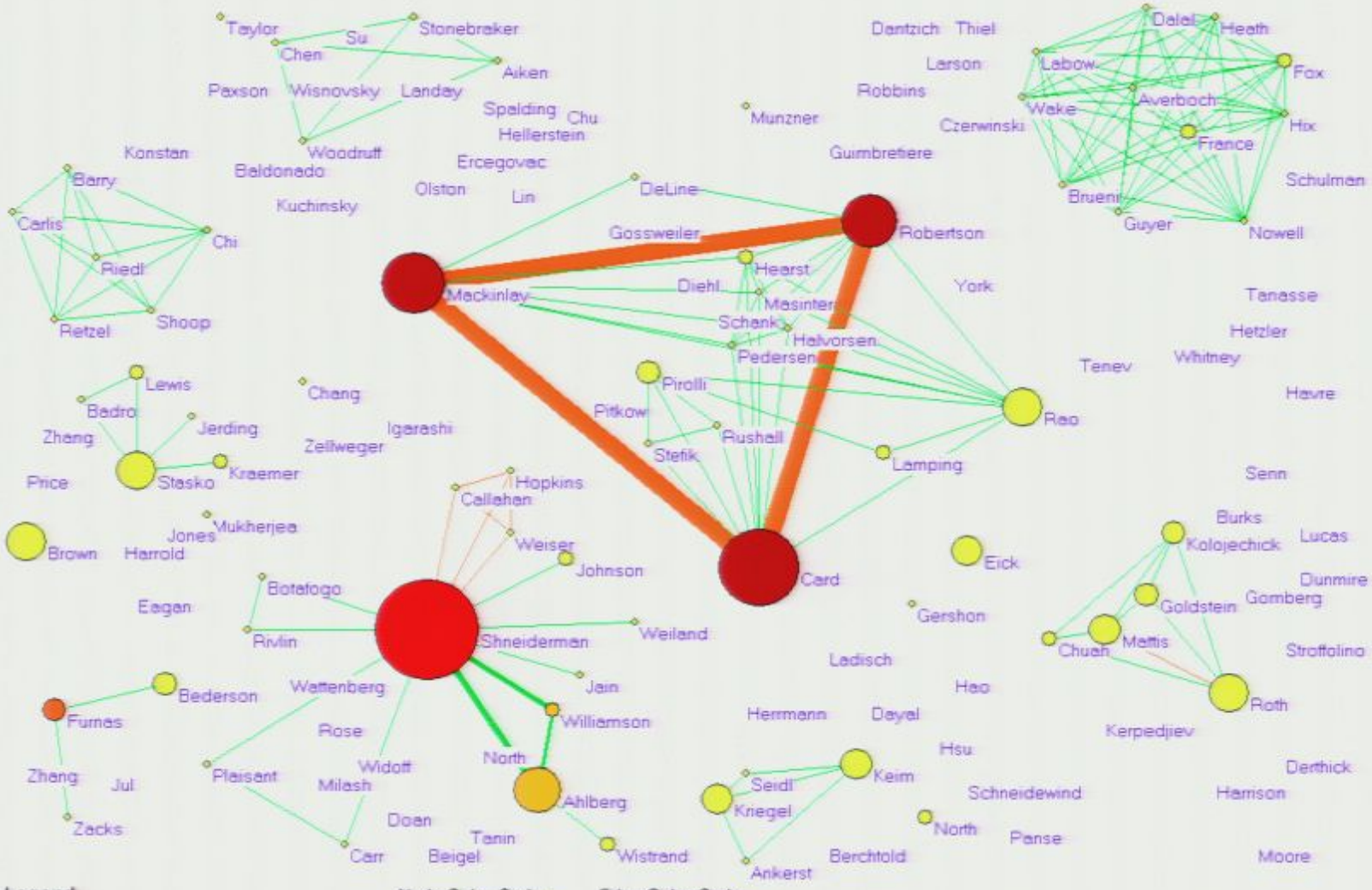

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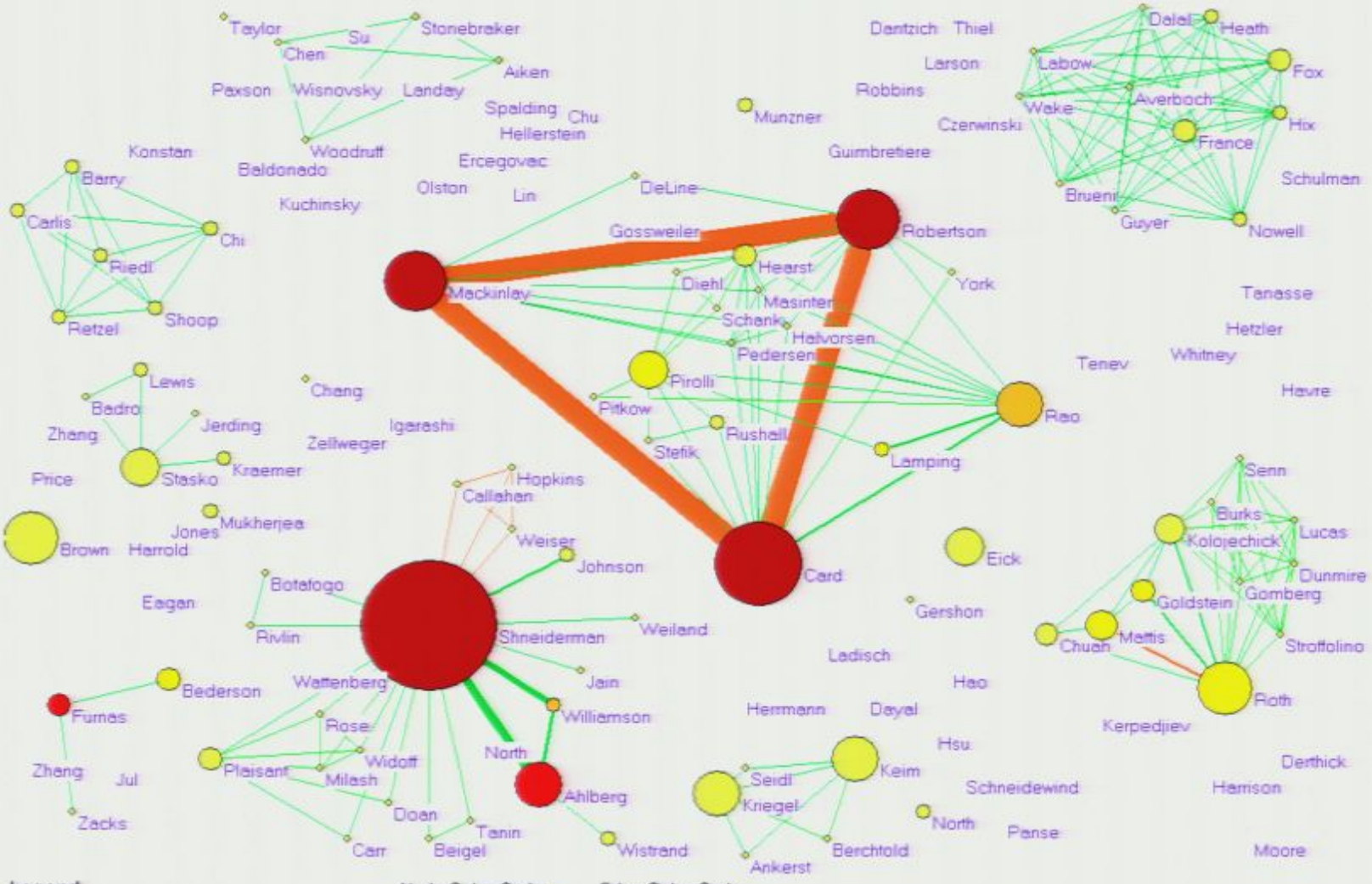

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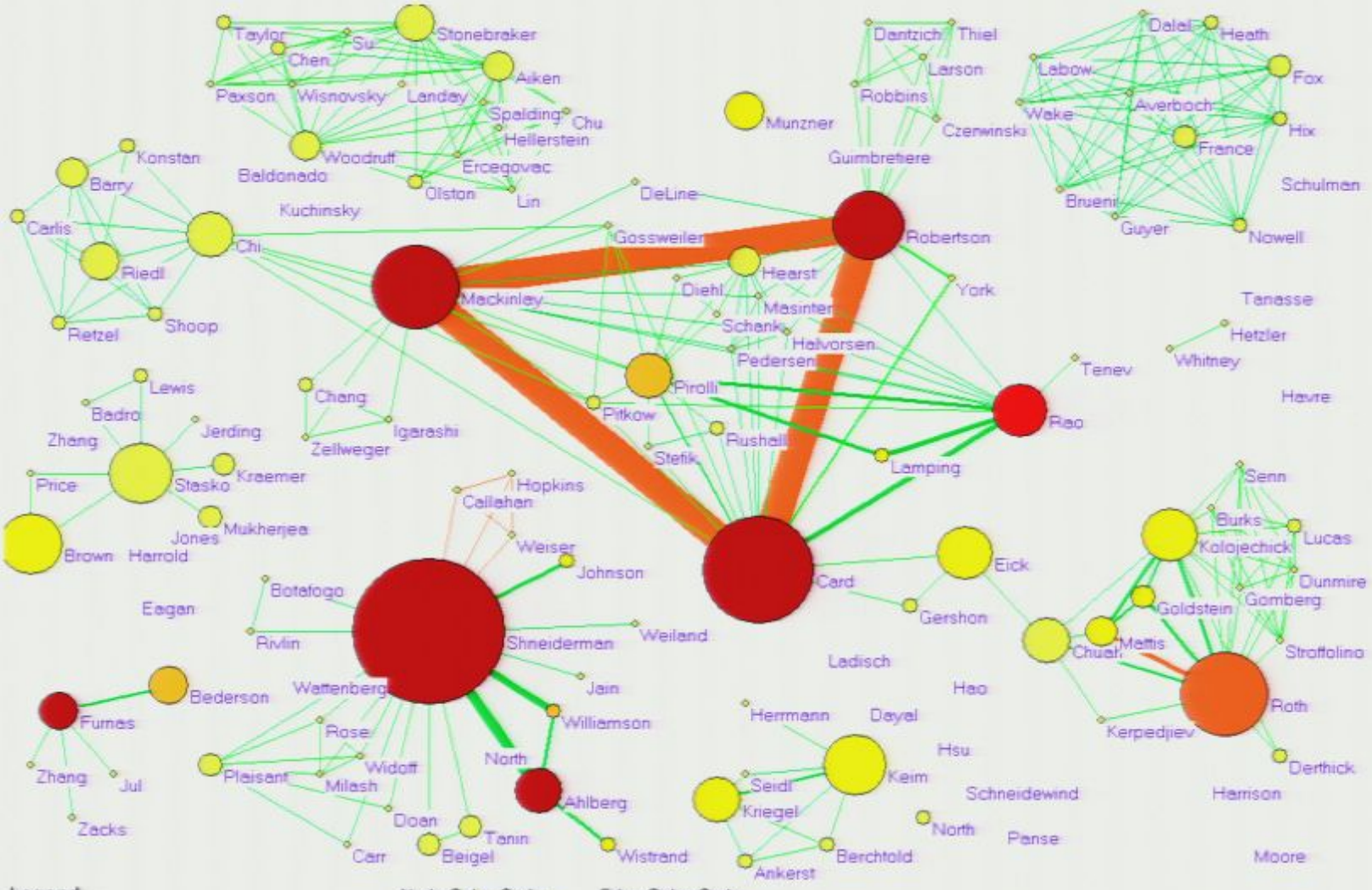

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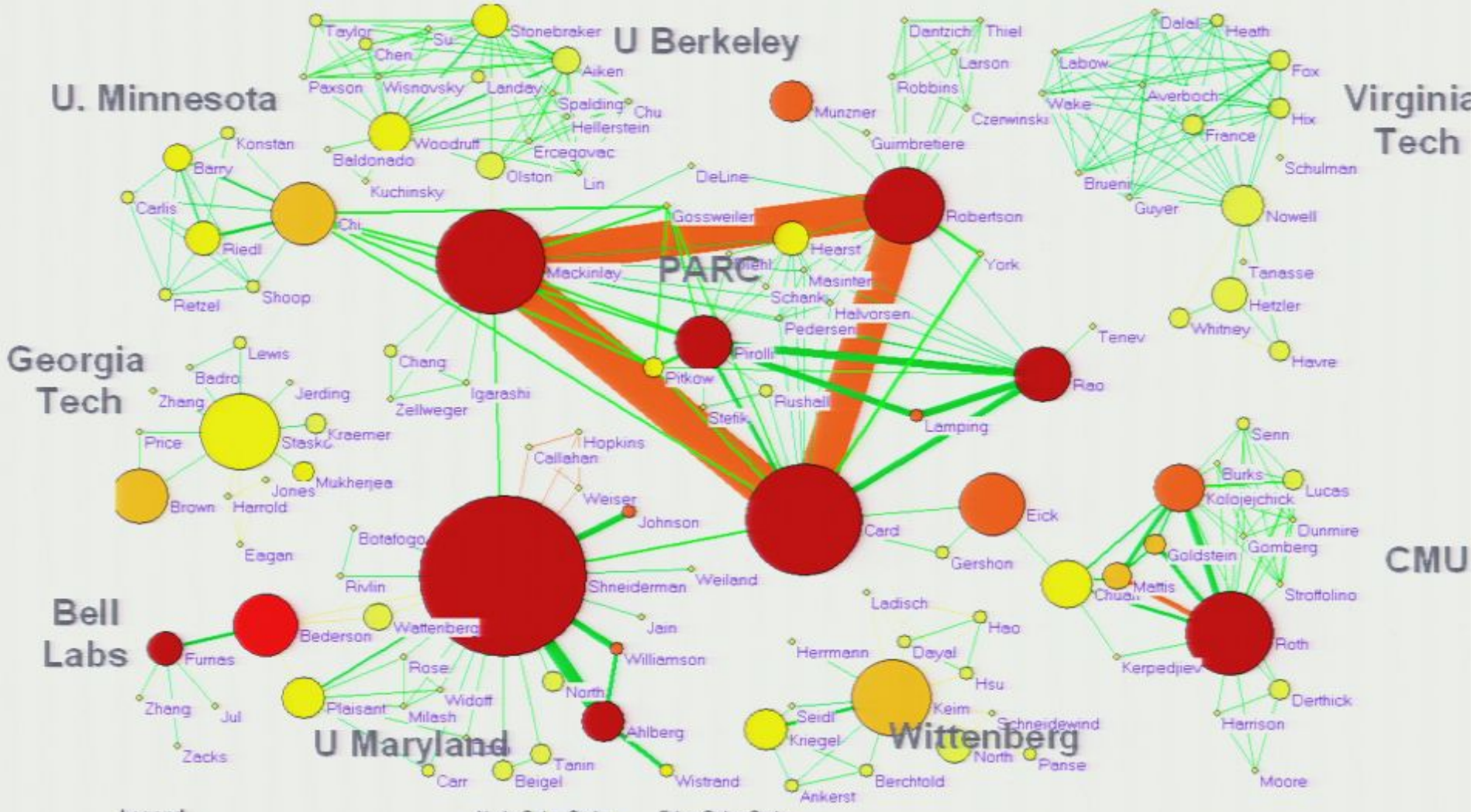
Weimao Ke, Lalitha Visvanath & Katy Borner
InfoVis Lab @ Indiana
2004

Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Borner, (2004) Won 1st price at the IEEE InfoVis Contest.



Legend

Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Number of citations

Edges ~ Co-authorship relations
Edge color ~ Year of first co-authorship

Node Color Code

0 - 9
10 - 19
20 - 29
30 - 39
40 - 49
50 -

Edge Color Code

86 - 90
91 - 95
96 - 00
01 -

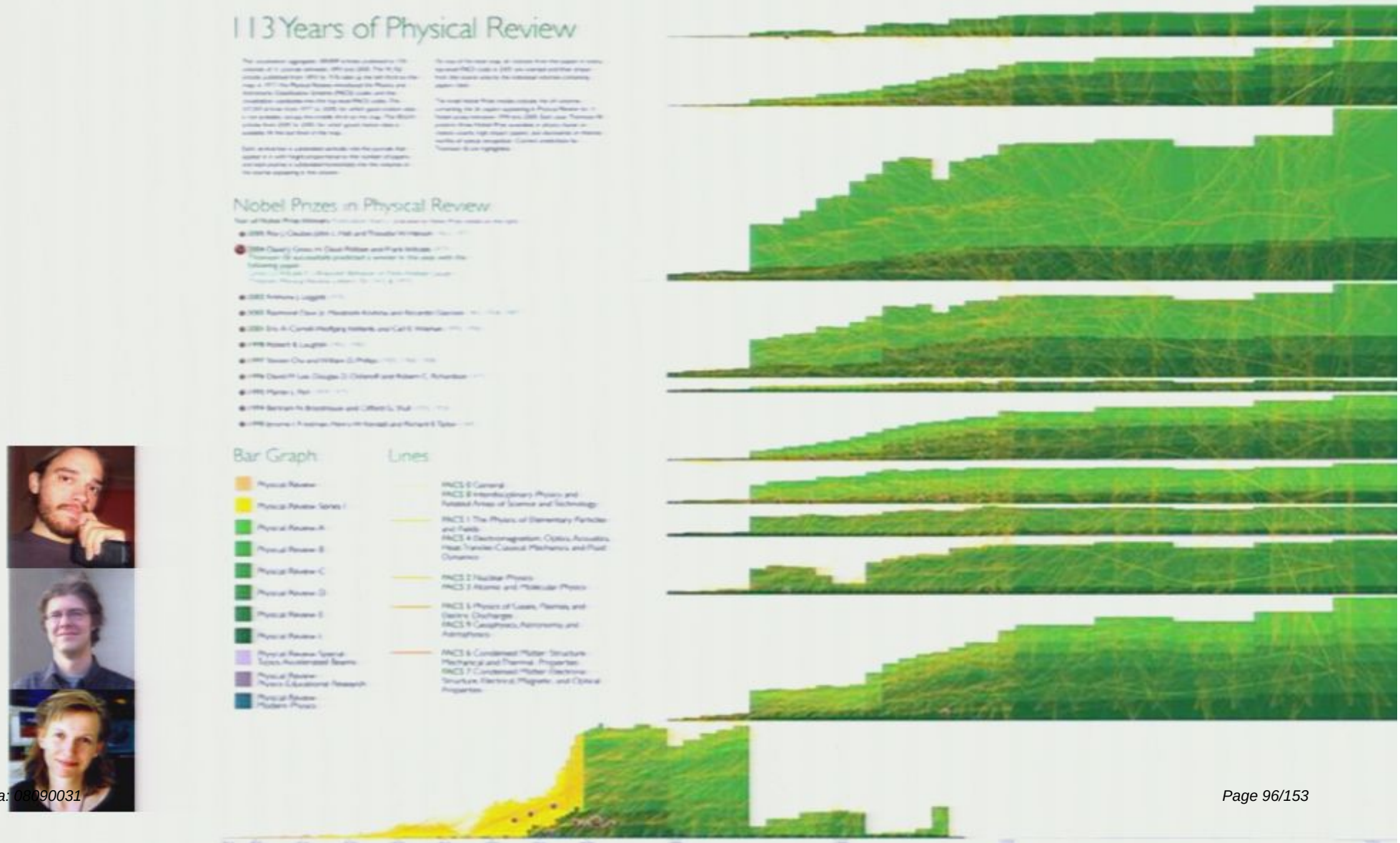
Displayed Year: 2004

Mapping the Evolution of Co-Authorship Networks
Weimao Ke, Lalitha Visvanath & Katy Borner
InfoVis Lab @ Indiana
2004

113 Years of Physical Review

http://scimaps.org/dev/map_detail.php?map_id=171

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

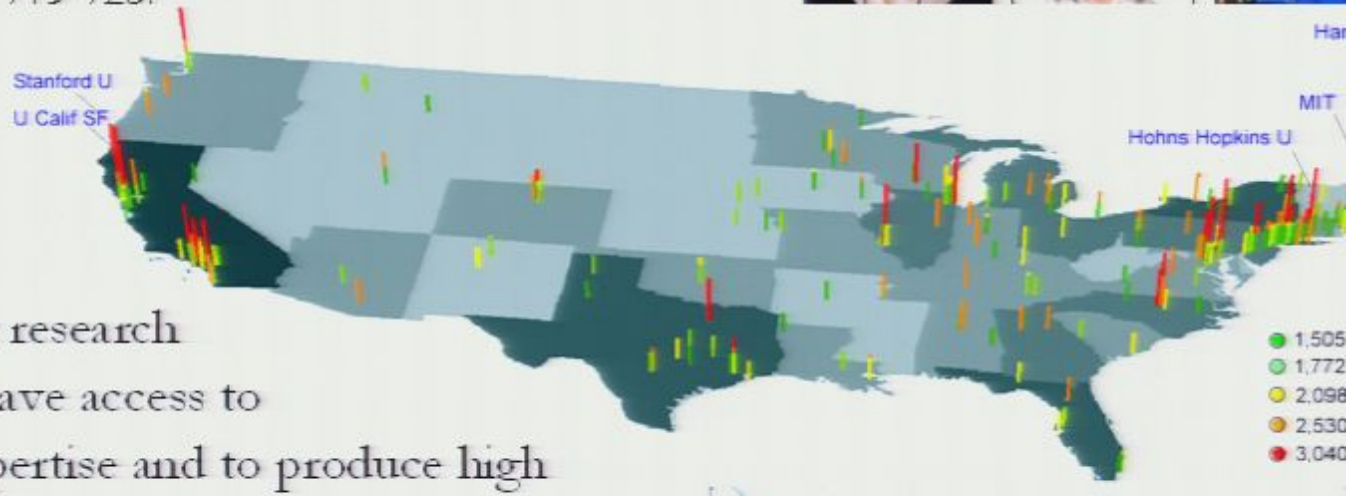


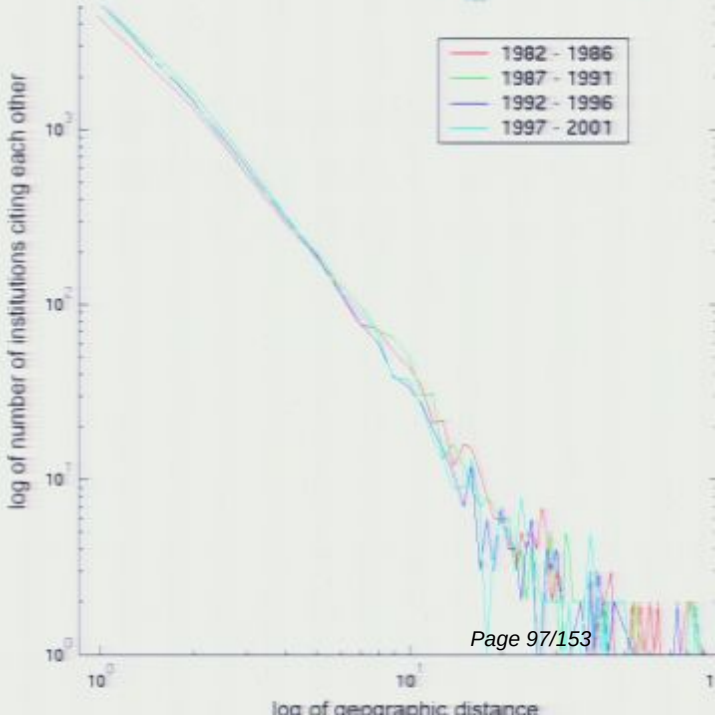
Spatio-Temporal Information Production and Consumption of Major U.S. Research Institutions

Börner, Katy, Penumarthy, Shashikant, Meiss, Mark and Ke, Weimao. (2006) Mapping the Diffusion of Scholarly Knowledge Among Major U.S. Research Institutions. Scientometrics. 68(3), pp. 415-426.

Research questions:

1. Does space still matter in the Internet age?
2. Does one still have to study and work at major research institutions in order to have access to high quality data and expertise and to produce high quality research?
3. Does the Internet lead to more global citation patterns, i.e., more citation links between papers produced at geographically distant research instructions?





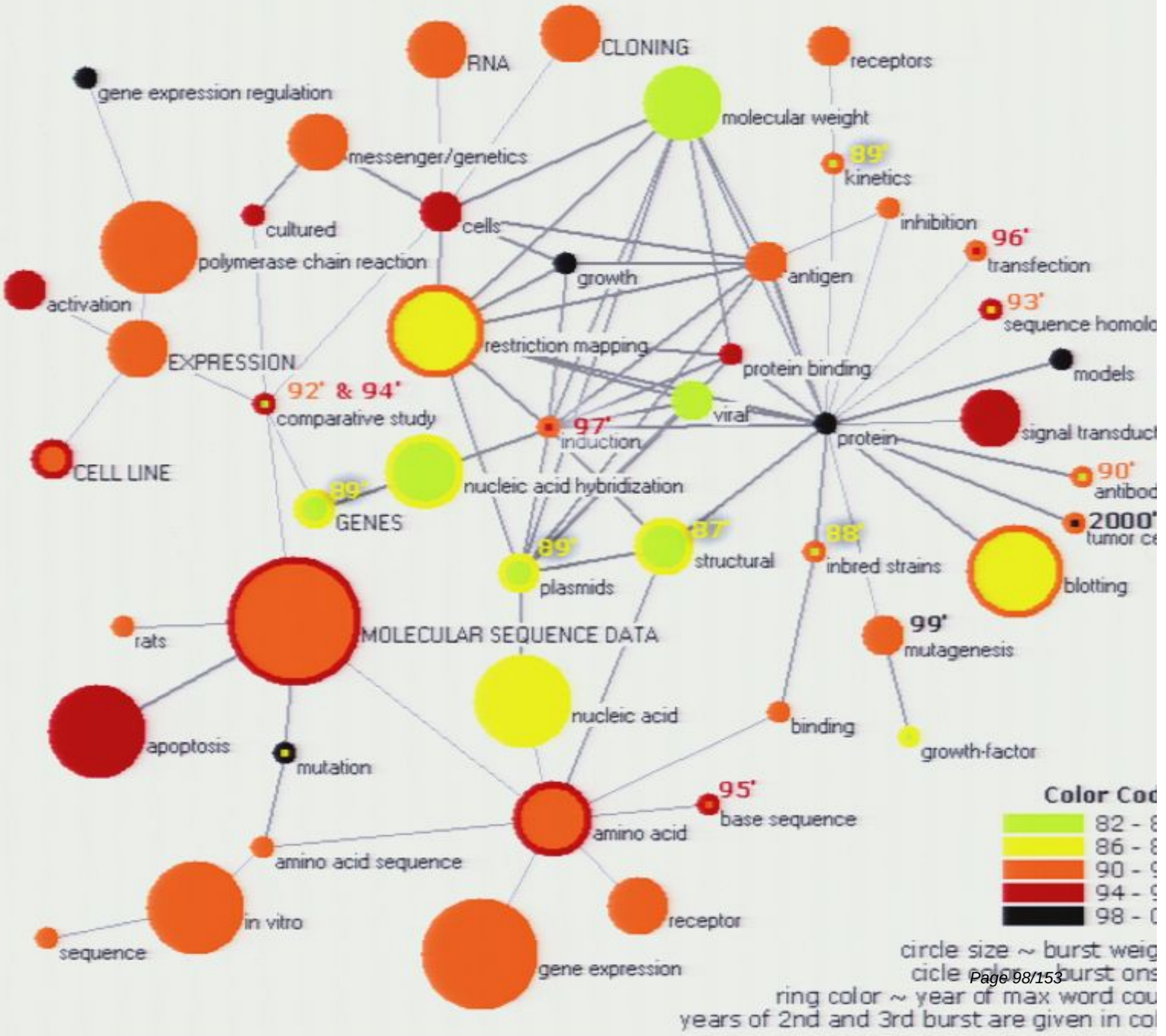
Contributions:

- Answer to Qs 1 + 2 is YES.
- Answer to Qs 3 is NO.
- Novel approach to analyzing the dual role of institutions as information producers and consumers and to study and visualize the diffusion of information among them.

Mapping Topic Bursts

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.

Mane & Borner. (2004) PNAS. 101(Suppl. 1): 5287-5290.



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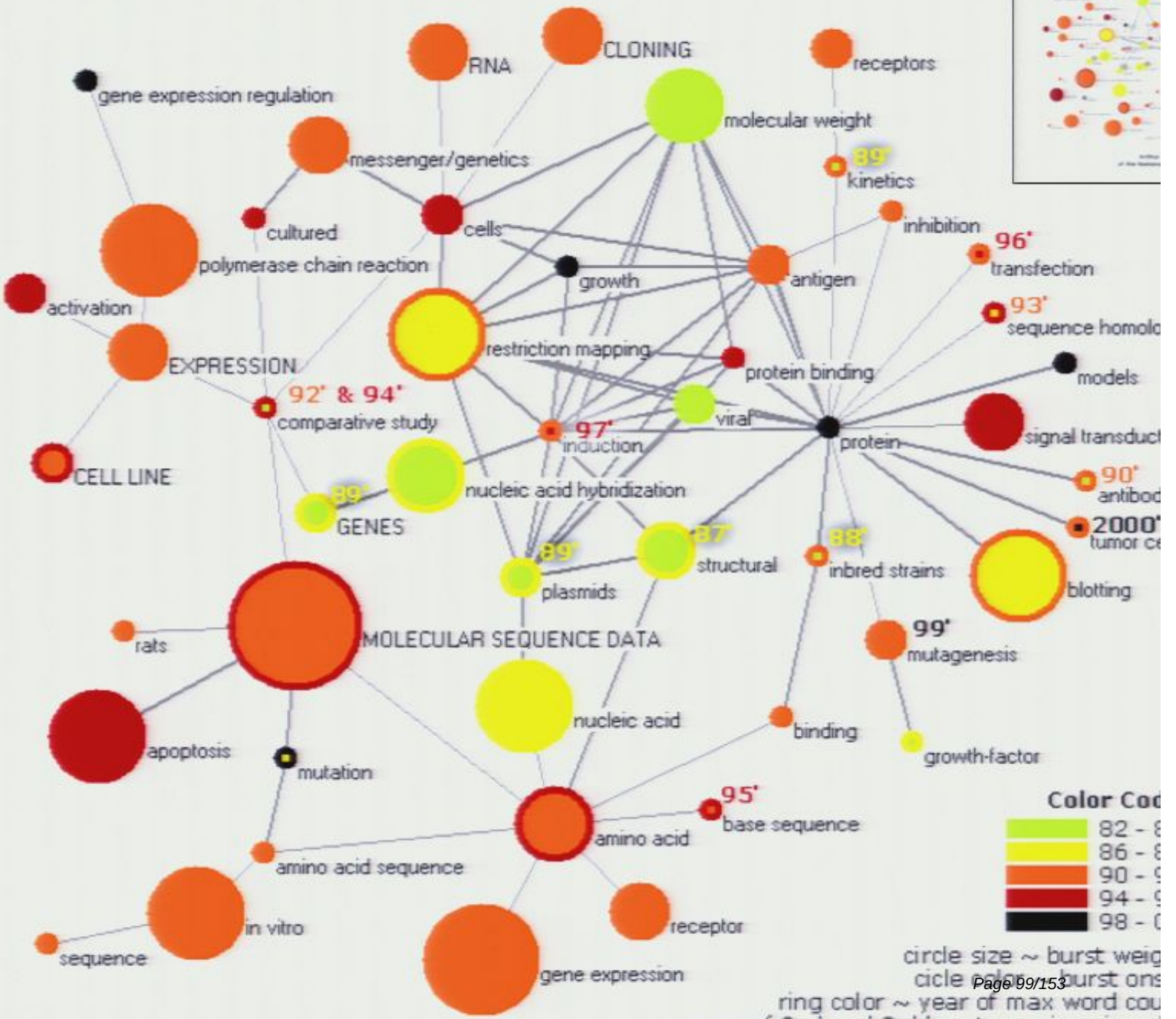
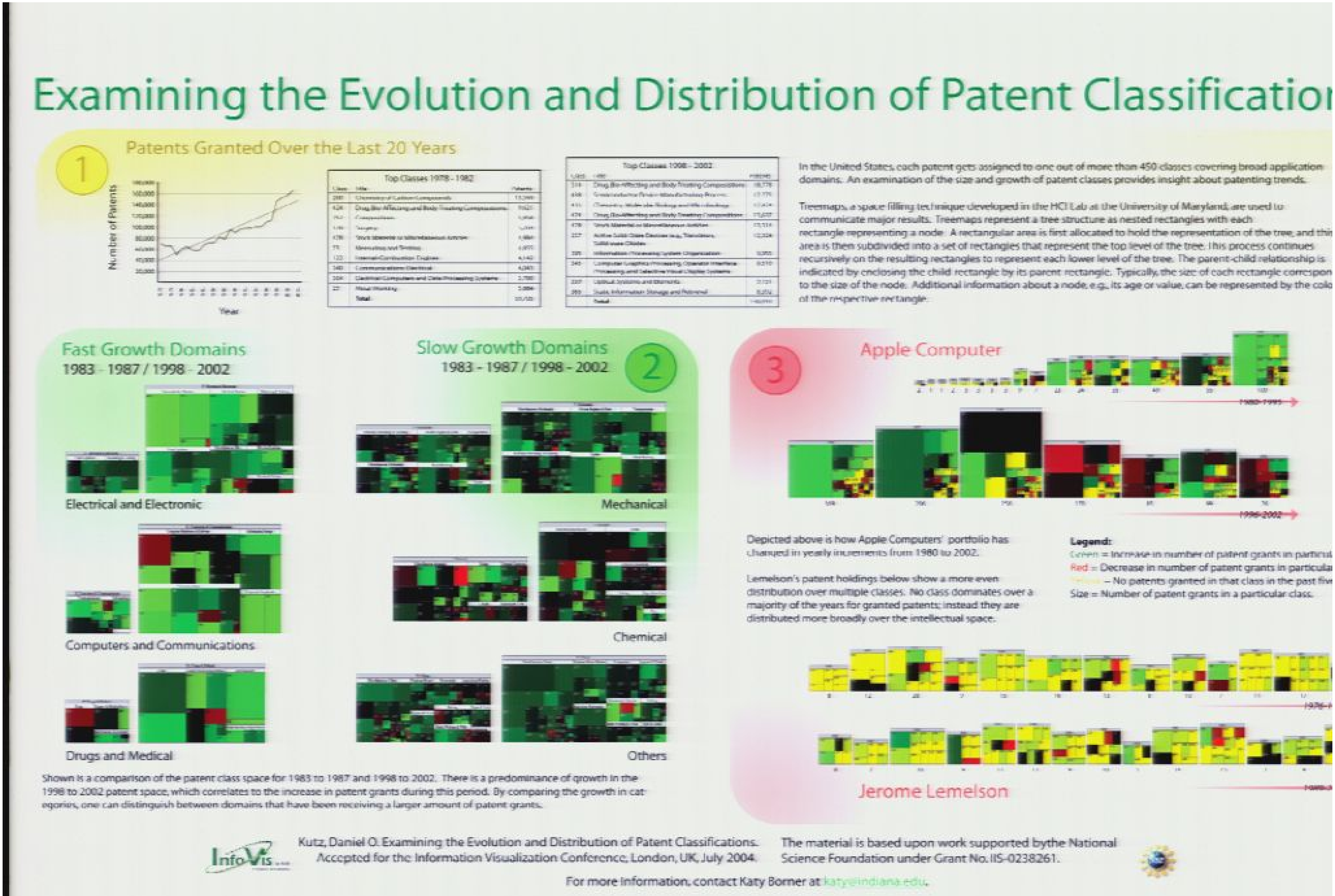
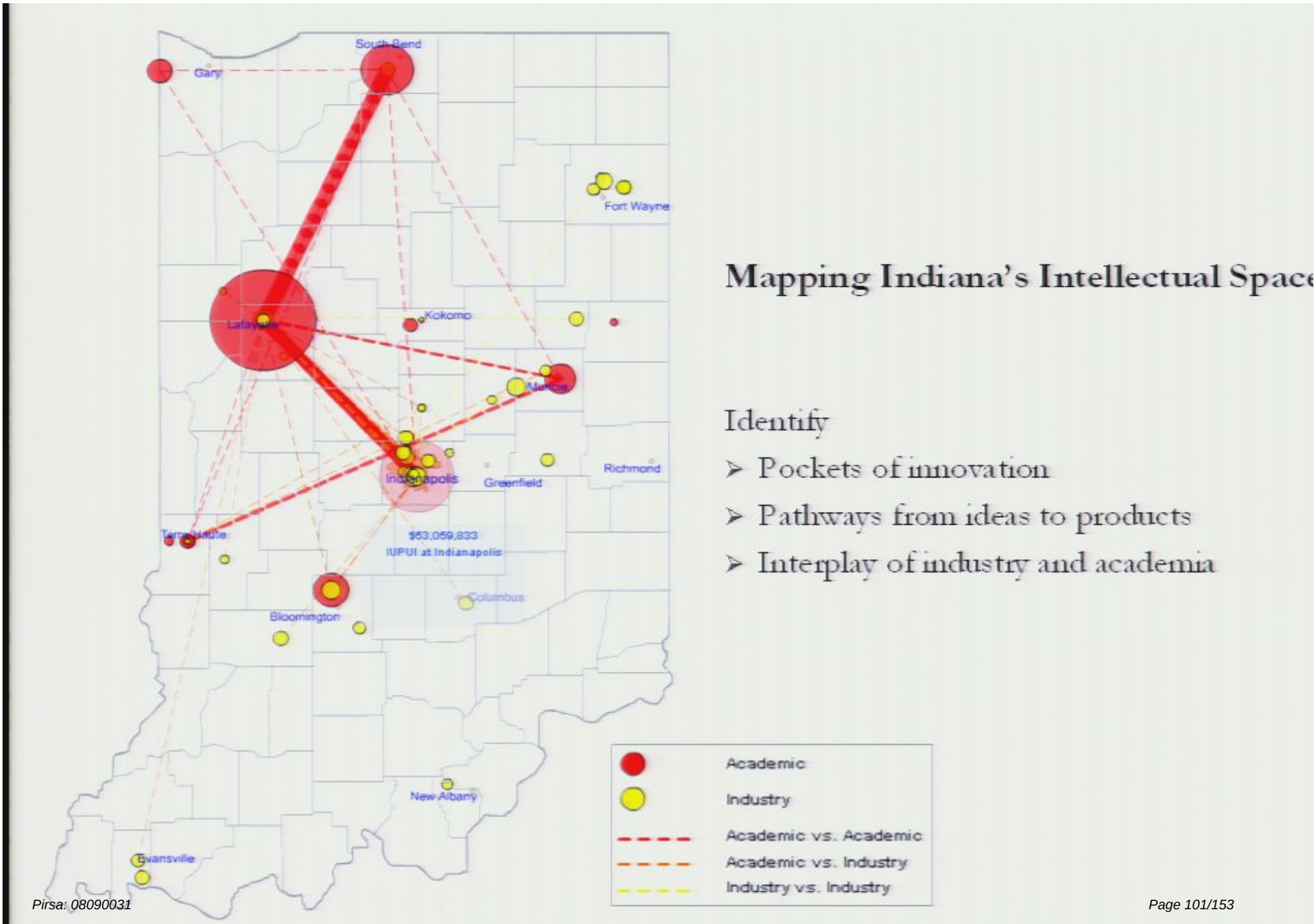



Examining the Evolution and Distribution of Patent Classificatio
1
Patents Granted Over the Last 20 Years
Number of Patents
Year
Top Classes 1978 - 1982
Top Classes 1998 - 2002
In the United States, each patent gets assigned to one out of more than 450 classes covering broad application domains. An examination of the size and growth of patent classes provides insight about patenting trends.
Treemaps, a space filling technique developed in the HCI Lab at the University of Maryland, are used to communicate major results. Treemaps represent a tree structure as nested rectangles with each rectangle representing a node. A rectangular area is first allocated to hold the representation of the tree, and thi area is then subdivided into a set of rectangles that represent the top level of the tree. This process continues recursively on the resulting rectangles to represent each lower level of the tree. The parent-child relationship is indicated by enclosing the child rectangle by its parent rectangle. Typically, the size of each rectangle correspon to the size of the node. Additional information about a node, e.g., its age or value, can be represented by the colo of the respective rectangle.
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
Shown is a comparison of the patent class space for 1983 to 1987 and 1998 to 2002. There is a predominance of growth in the 1998 to 2002 patent space, which correlates to the increase in patent grants during this period. By comparing the growth in categories, one can distinguish between domains that have been receiving a larger amount of patent grants.
3
Apple Computer
1998-2002
Depicted above is how Apple Computers' portfolio has changed in yearly increments from 1980 to 2002.
Lemelson's patent holdings below show a more even distribution over multiple classes. No class dominates over a majority of the years for granted patents; instead they are distributed more broadly over the intellectual space.
Legend:
Green = Increase in number of patent grants in particul
Red = Decrease in number of patent grants in particula
– No patents granted in that class in the past fiv
Size = Number of patent grants in a particular class.
Jerome Lemelson
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.



Mapping Indiana's Intellectual Space

Identify

- Pockets of innovation
- Pathways from ideas to products
- Interplay of industry and academia

Wikipedian Activity

Studying large scale social networks such as Wikipedia

Vizzards 2007 Entry

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

Rendered as Google Map:
http://scimaps.org/maps/wikipedia

Jan 8th, 2008 Data Version on Gigapan:
http://gigapan.org/viewGigapan.php?id=5042

Second sight

Image: Bruce W. Herr and Todd M.

Power struggle

How do you keep track of the bubbling mass of information that is Wikipedia? This chaotic-looking mosaic is one attempt to show which topics are contained in the online encyclopedia, and those most hotly contested.

It's a mind-boggling task. About 4 million "Wikipedians" have made over 130 million edits, and the English-language version alone contains 1.7 million articles. Every second a new edit is made, and every day 2000 new articles spring up.

To make sense of it all, Bruce Herr and Todd Holloway of Indiana University, Bloomington, created clusters of 300 or so articles that touch on a related topic, such as a religion or a famous person. For each cluster they took one picture from the most popular article and laid them out in a circular grid.

Atop the grid are coloured dots showing how often and how recently each article has been edited. The larger, darker dots mean more intense activity. The list of blitzed articles reveals the idiosyncratic priorities of Wikipedians: Jesus, Adolf Hitler, Nintendo, Hurricane Katrina, Britney Spears and Albert Einstein.

Updating the image in real time would allow Wikipedia's administrators to spot where arguments are taking place, Herr suggests. If rival contributors are repeatedly changing each other's entries, for example, a page could be locked until the mood cools (locked pages at the time of writing include entries on Sheffield Wednesday football club, Mikhail Gorbachev and pigs).

The mosaic has been commended in a competition for images that visualise network dynamics, coinciding with this week's International Workshop and Conference on Network Science in Bloomington.

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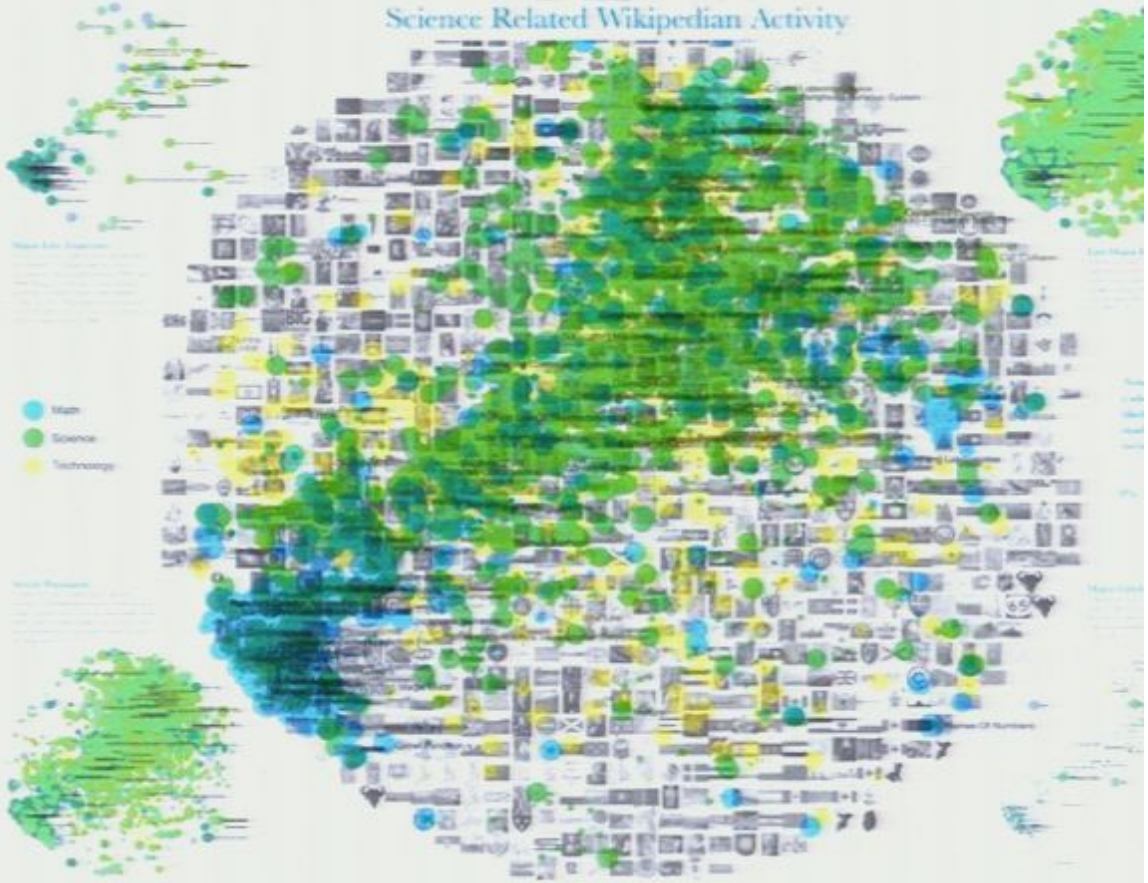
Science Related Wikipedian Activity

http://scimaps.org/dev/map_detail.php?map_id=165

Same base map.

Overlaid are 3,599 math (blue), 6,474 science (green), and 3,164 technology relevant articles (yellow).
All other articles are given in grey.

Corners show articles size coded according to
-article edit activity (top left),
- number of major edits (top right),
- number of bursts in edit activity (bottom, right)
- indegree (bottom left).



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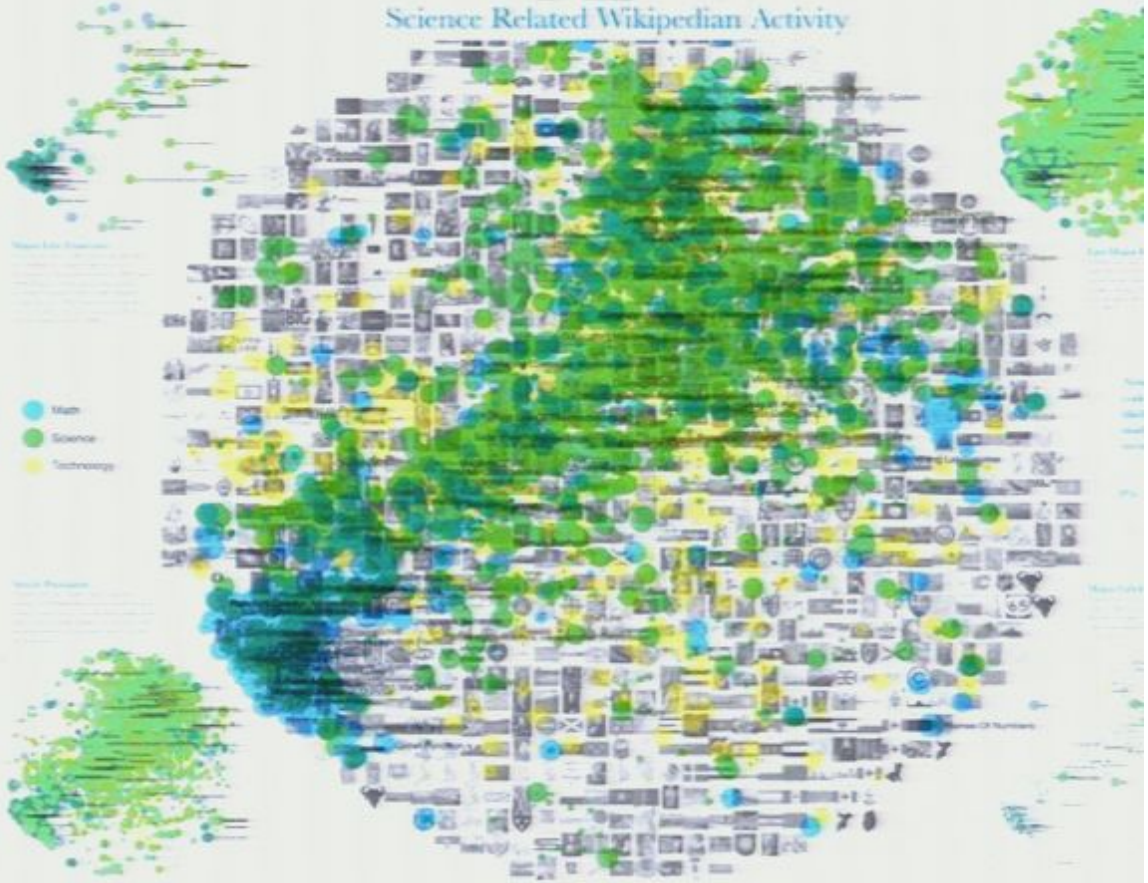

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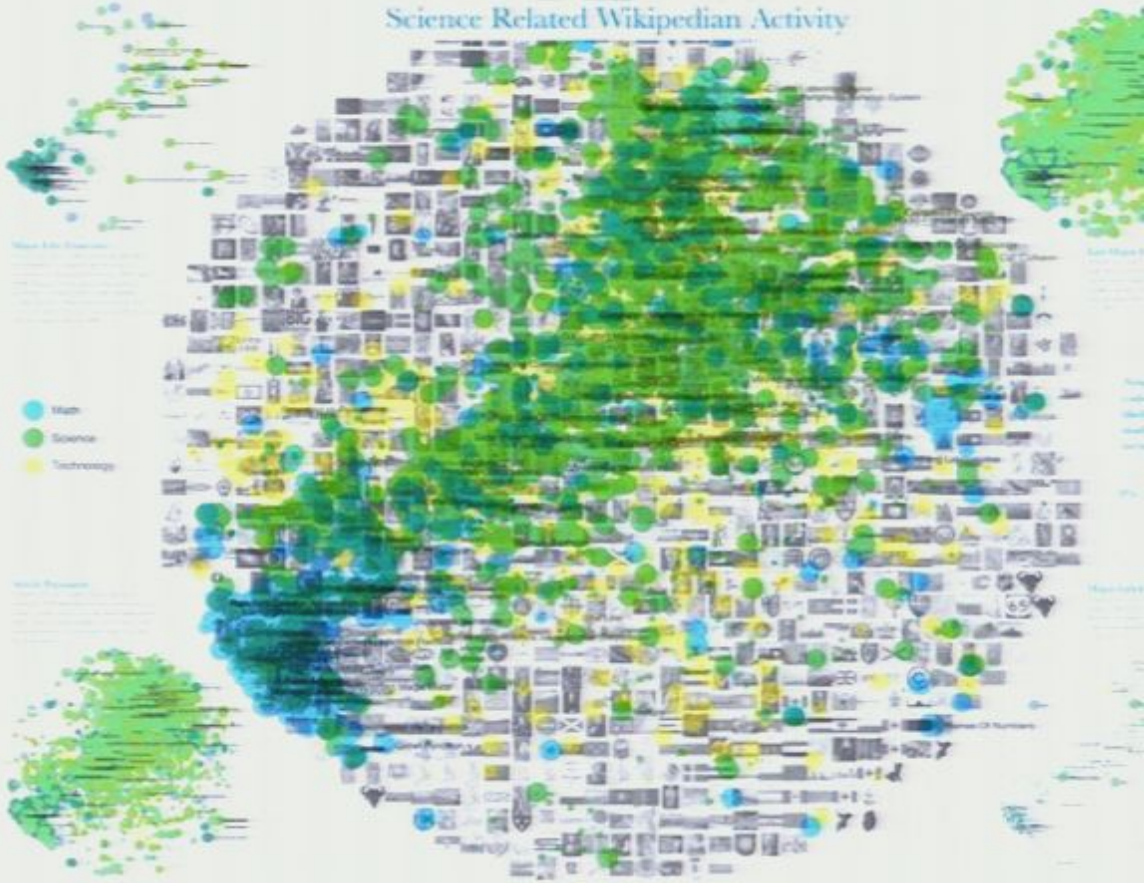
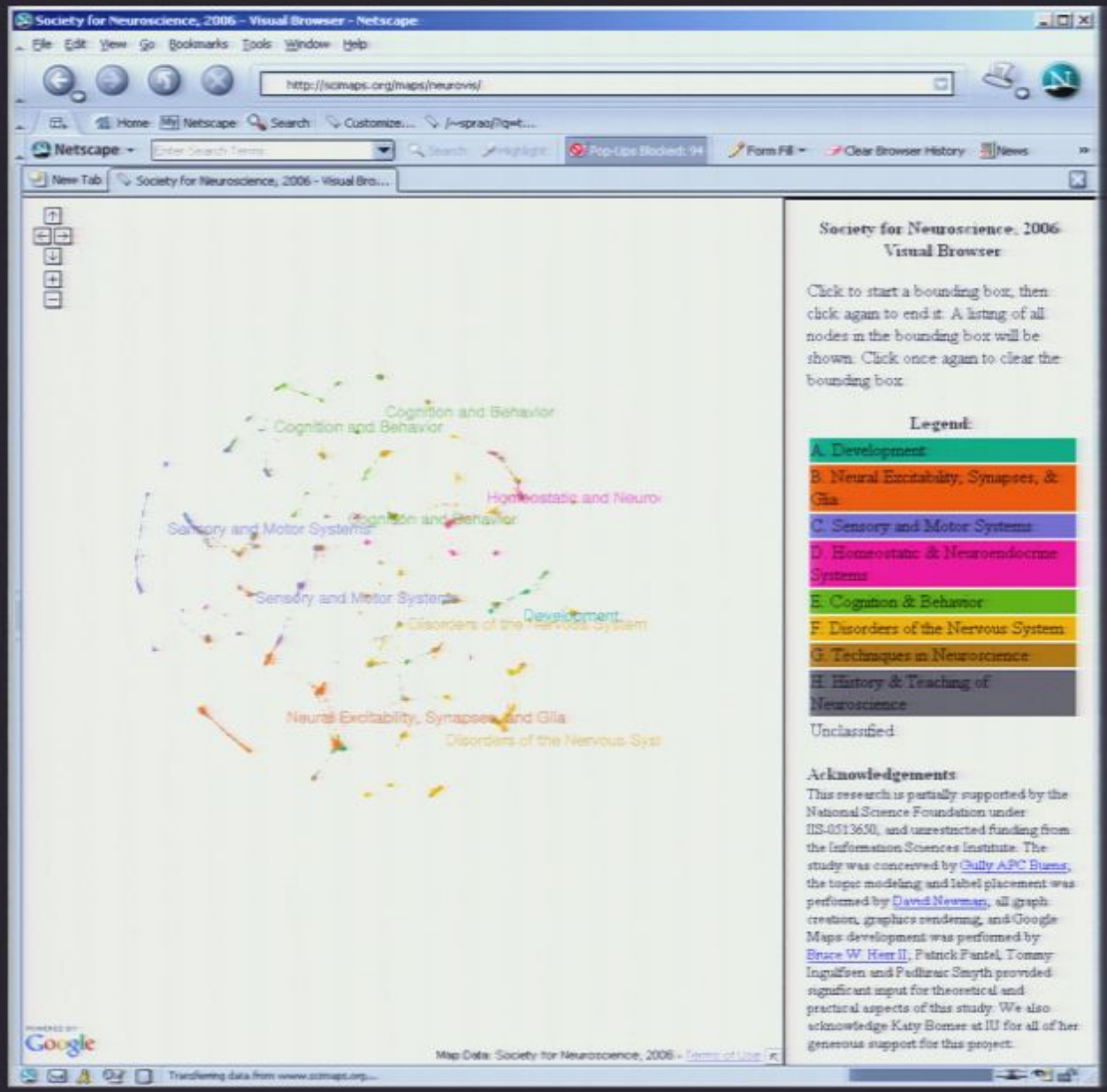
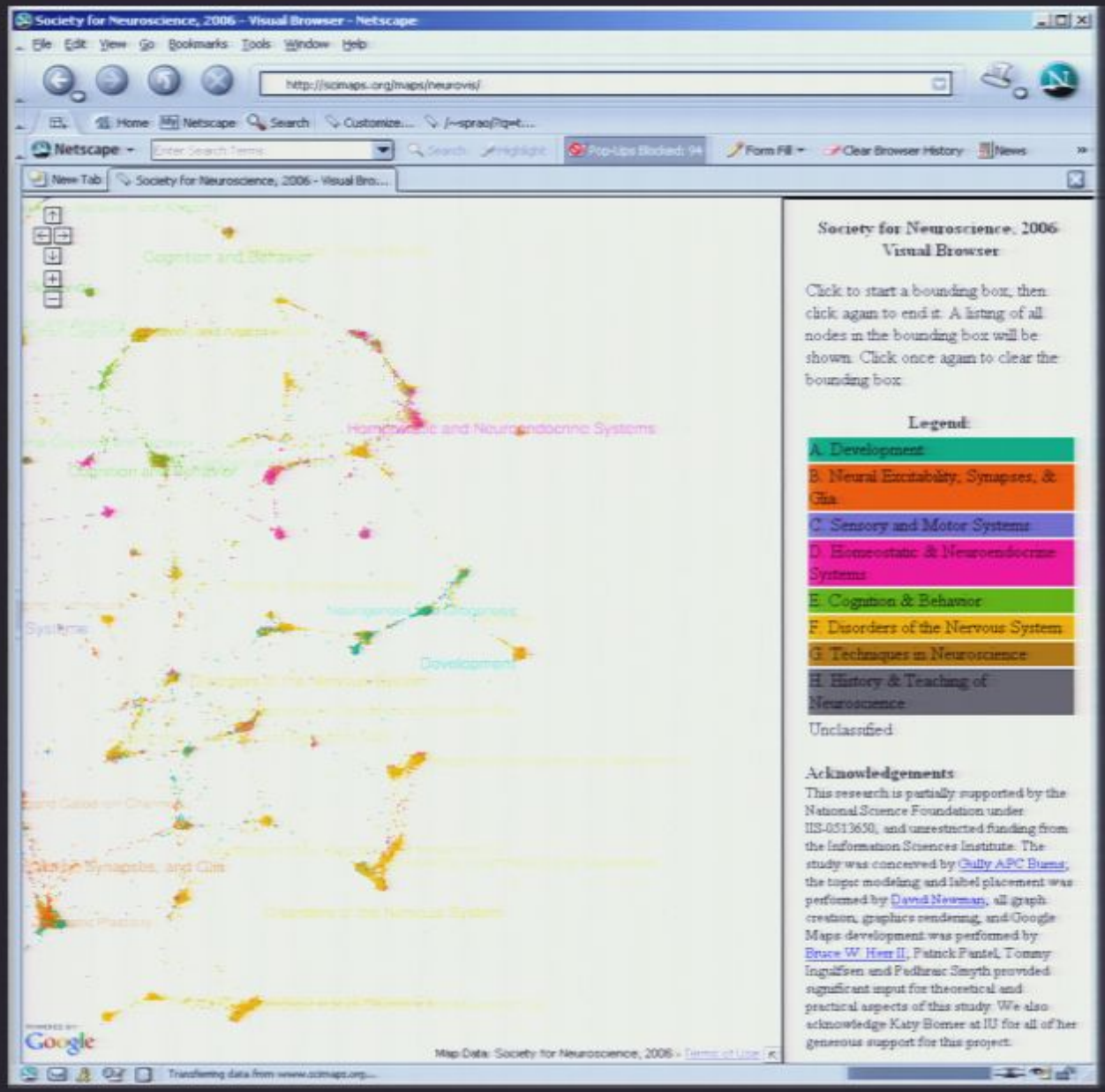




Bruce W. Herr II, Gully Burns (USC), David Newman (UCI), Society for Neuroscience, 2006 Visual Browser, 2007, http://scimaps.org/maps/neurovis/



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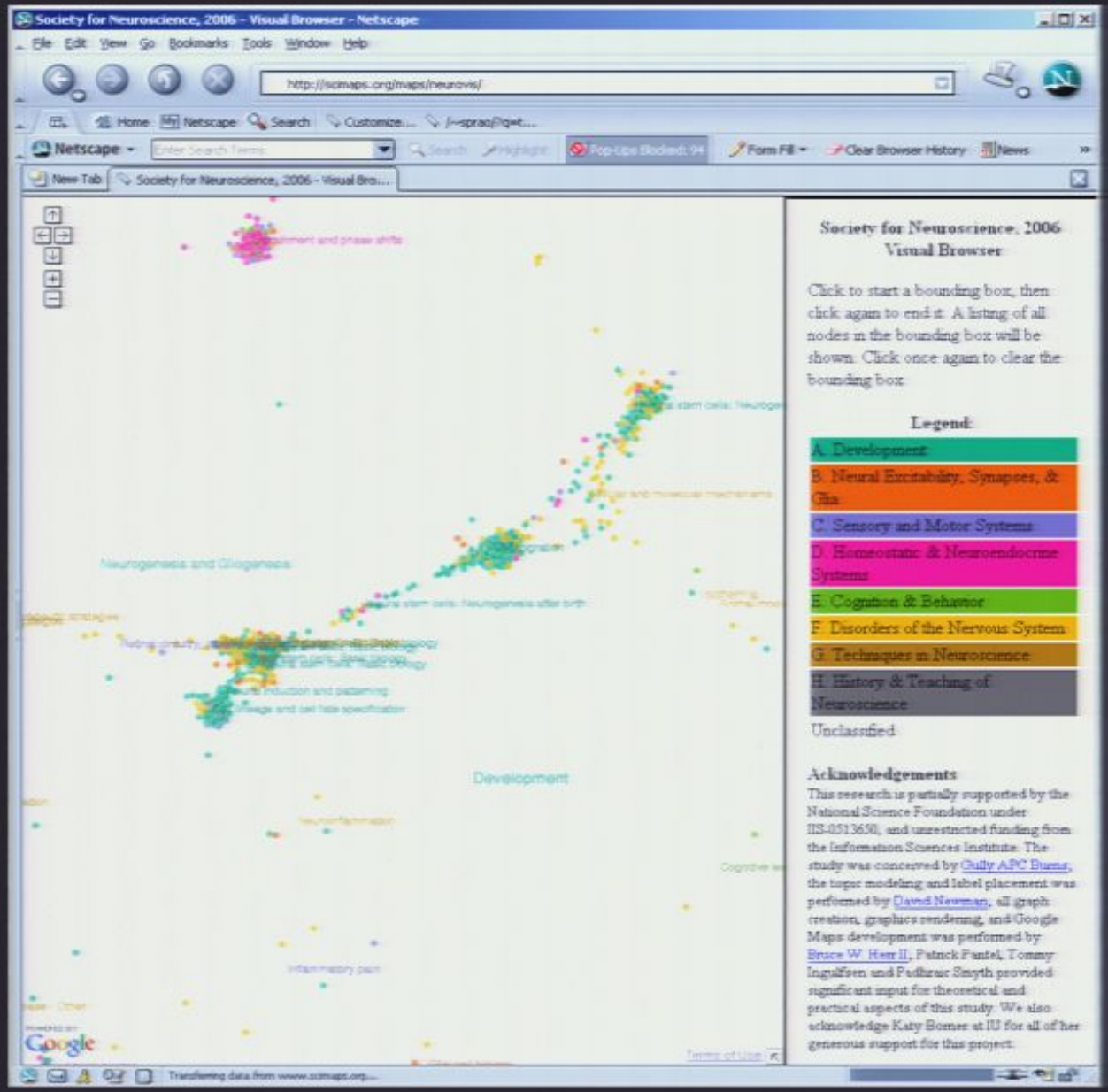

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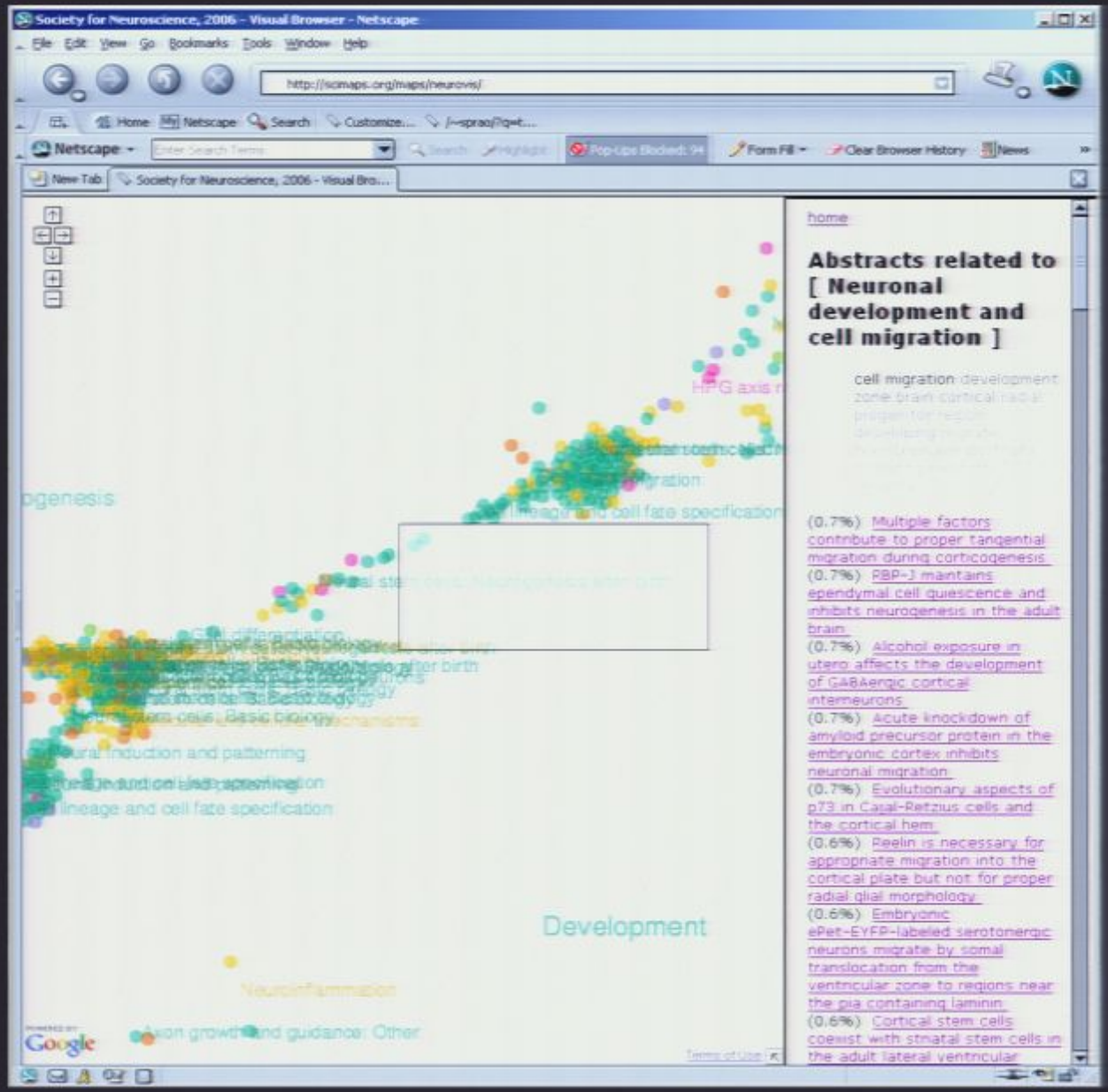

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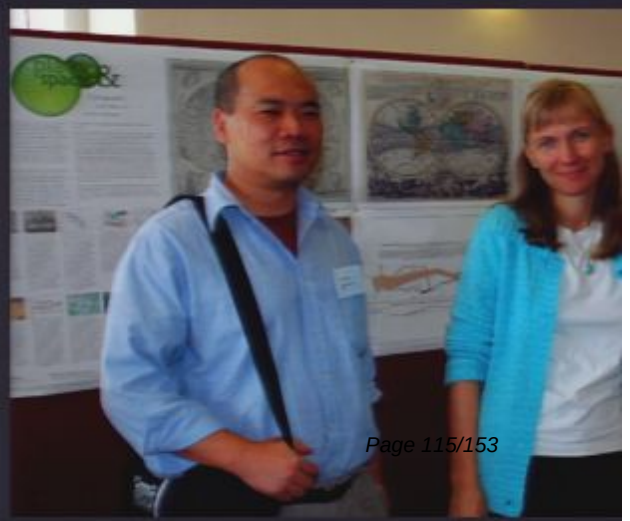
Mapping Science Exhibit

Places & Spaces: Mapping Science

a science exhibit that introdu people to maps of sciences, their makers and users.

http://scimaps.org

Exhibit Curators: Dr. Kat Börner & Elisha F. Hardy



Mapping Science Exhibit – 10 Iterations in 10 years

The Power of Maps (2005)

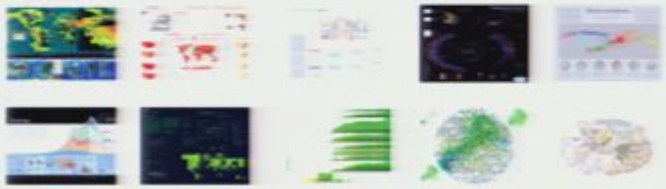
Science Maps for Economic Decision Makers (2008)

The Power of Reference Systems (2006)

Science Maps for Science Policy Makers (2009)
Science Maps for Scholars (2010)
Science Maps as Visual Interfaces to Digital Libraries (201
Science Maps for Kids (2012)
Science Forecasts (2013)

How to Lie with Science Maps (2014)

The Power of Forecasts (2007)



scimaps.org

Illuminated Diagram Display

W. Bradford Paley, Kevin W. Boyack, Richard Kalvans, and Katy Borner (2007) Mapping, Illuminating, and Interacting with Science. SIGGRAPH 2007, San Diego, CA.

You may run your finger over each of these maps to control the lighting on the other: touching a place on the world map will light up topics studied in that place; touching a paradigm on the topic map will light up the places that study that topic.

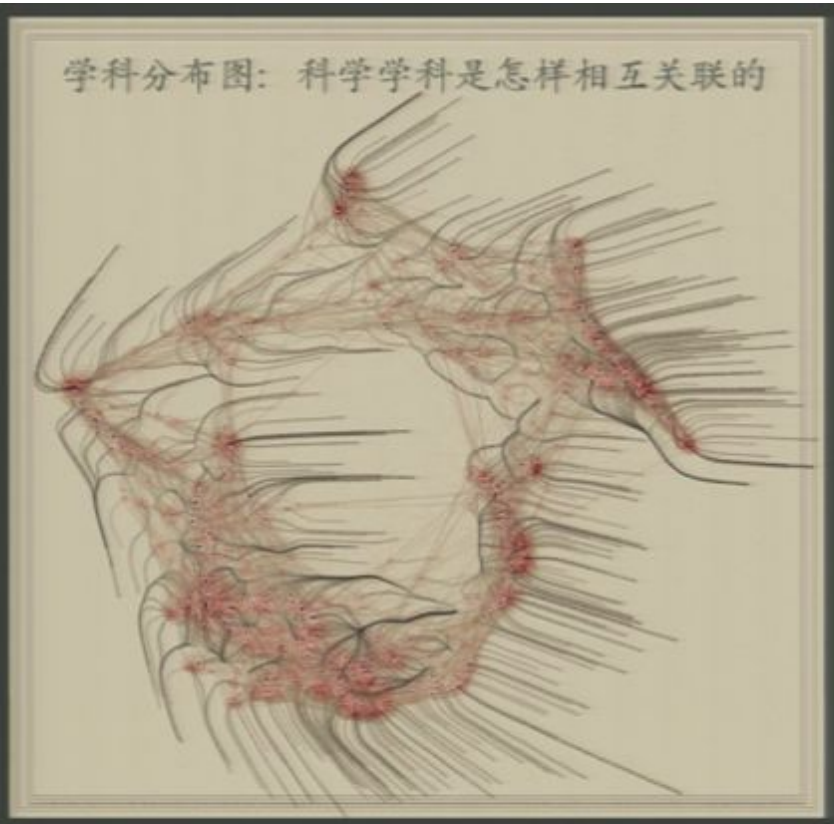
Nanotechnology

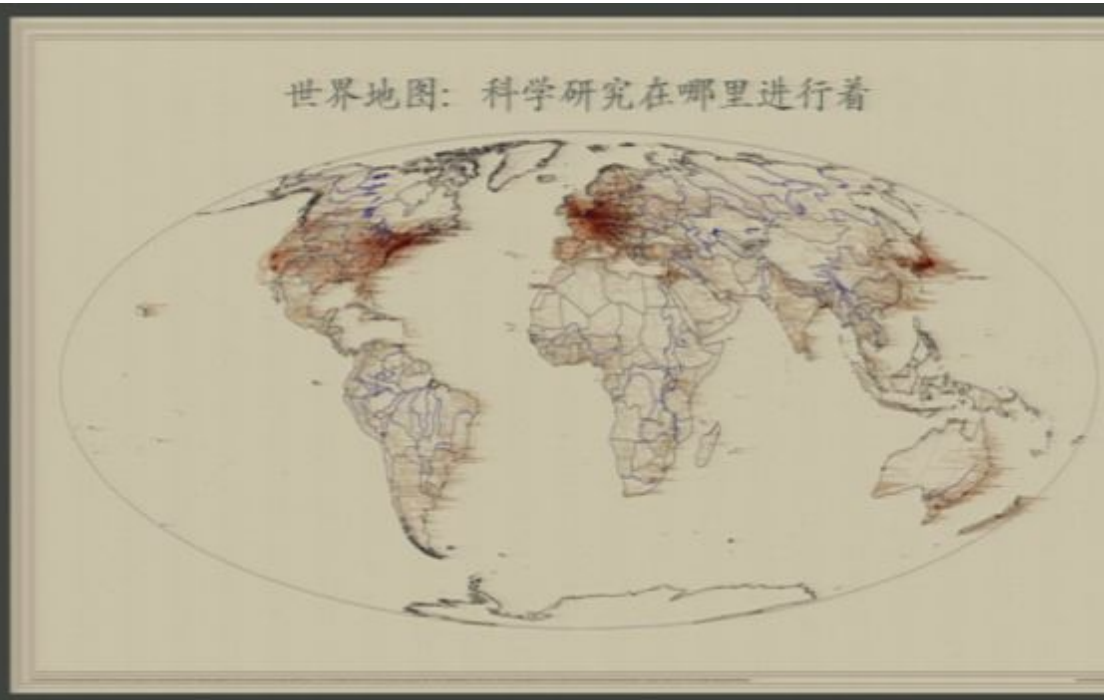
This overlay shows the distribution of nanotechnology within the paradigms of science. The majority of current work in nanotechnology takes places in physics, chemistry, and materials science, at the upper right portion of the map. However, an increasing amount of nanotechnology is being applied in the biological and medical sciences, at the lower right.

All Topics *Sweep through all 776 scientific paradigms*	**Nanotechnology** *Science on the tiny scale of molecules*	**Francis H. C. CRICK** *Co-discovered DNA's double helix*	**Albert EINSTEIN** *Revitalized physics with Relativity theories*	**Michael E. FISHER** *Models critical phase transitions of matter*	**Susan T. FISKE** *Connects perceptio and stereotypes*
Sustainability *The science behind our long-term hopes*	**Biology & Chemistry** *The interface between these two vital fields*	**Joshua LEDERBERG** *Pioneer in bacterial genetic mechanisms*	**Derek J. de Solla PRICE** *Known as the "Father of Scientometrics"*	**Richard N. ZARE** *Uses laser chemistry in molecular dynamics*	**About this display** *People & organizat that helped create*

We sweep slowly through adjoining related topics, lighting up the places in the world that study each topic. You may select a subset of the topics that deal with these three interesting subjects by touching it.

A single person's spreading influence is shown as a series of four snapshots. First, we light only topics places relating to that person's papers—papers that are still highly cited today. The second lights ev thing that cites that original work. Note that this first-generation impact more topics did the original work. The third shapshot lights science that cites the second; and the fourth lights s that cites the third.





你可以通过触摸屏点地图上随意指点来改变所到之处的光亮强度。当你触摸世界地图的某一点时，在那个地
位置上的所有研究机构会被点亮。同时在这些研究机构工作的学者的论文所属的学科会在学科分布图上被点
亮。而当你触摸学科分布图的某一点时，在那个位置上的科学学科会被点亮。同时以事这些学科研究的研究
构在世界地图上的分布会被点亮。

纳米技术

这里显示所有和纳米技术相关的科学学科。纳米技术和科学研究人类在无形的空间里改造世界的能力。这些空间存在于极其微小以至单个原子的结构中。目前大部分有关纳米的研究主要集中在物理、化学和材料科学领域。它们主要位于学科分布图上半部分的右面。不过，纳米技术在生物学和医药学研究里的应用也越来越多。生物学和医药学位于学科分布图下半部分的右面。

探索科学学科的相互关联性

所有科学学科 显示所有776种科学学科	纳米技术 有关微观粒子的科学
可持续性 一些与人类寄予长期希望相关的科学	化学和生物 化学和生物科学的交叉部分

无缝隙的扫过所有相互关联的科学学科，每一个学科以及从事这方面科学研究的研究机构在世界地图上的位置会被逐一点亮。首先，显示屏会点亮那些产出论文最多、最活跃的科学学科，然后那些小学科或冷门学科会被逐一点亮。

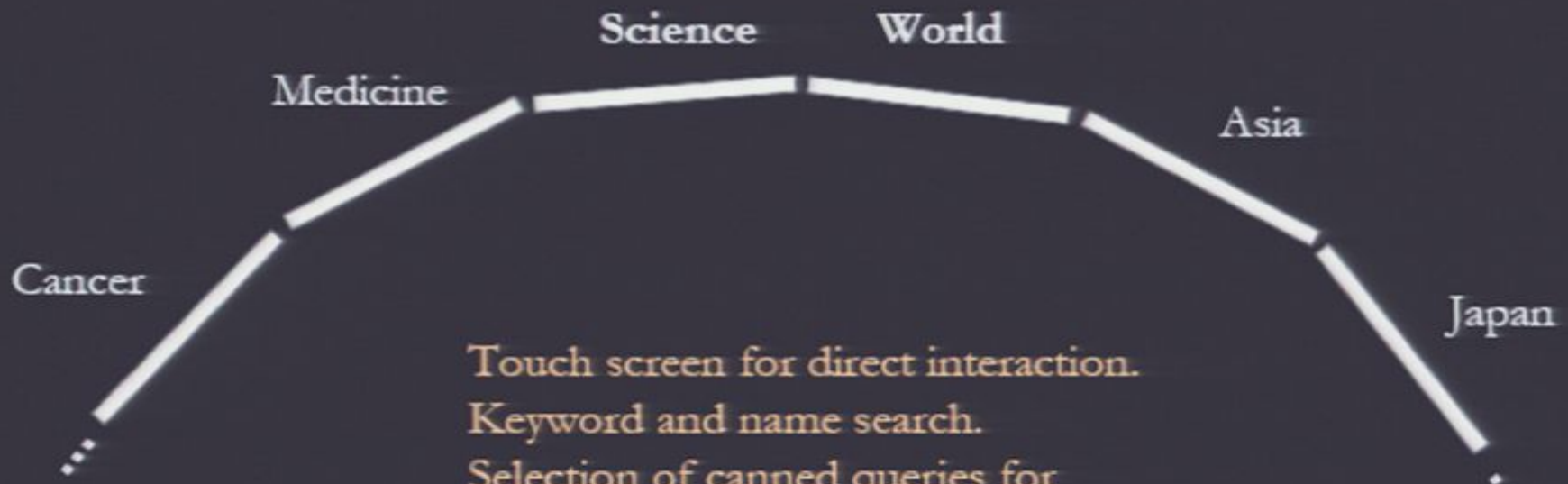
探索某个学者的科学著作的影响力的传播

弗郎西.科里克 DNA双螺旋状的发现者之一	阿尔伯特.爱因斯坦 用相对论重新激活了物理学	迈克尔.费舍尔 发现了物质转变模式的关键步骤	苏珊.费斯克 研究人的认知是如何产生偏见的
约舒亚.雷德伯格 细菌遗传机制研究的先驱	德里克.德索拉.普里斯 著名的“科学计量学之父”	理查德.扎尔 采用激光化学技术研究分子动态分布	关于本次展览与此展览相关人员机构

显示屏通过四步来展示某个学者对科学的贡献以及影响力的传播。首先，显示屏点亮该学者
表的论文所属的学科在学科分布图上的位置以及该学者从事这项研究时所在的研究机构在世
地图上的位置。到目前为止，所有这些论文的引用率仍然很高。第二步，显示屏点亮所有引用
一步中被点亮的原始论文的论文在学科分布图上的位置以及它们在
位置。第三
显示屏点亮所有引用了在第二步中被点亮的论文的学科在学科分布图上的位置以及它们在世
地图上的位置。第四步，显示屏点亮所有引用了在第三步中被点亮的论文的学科在学科分布

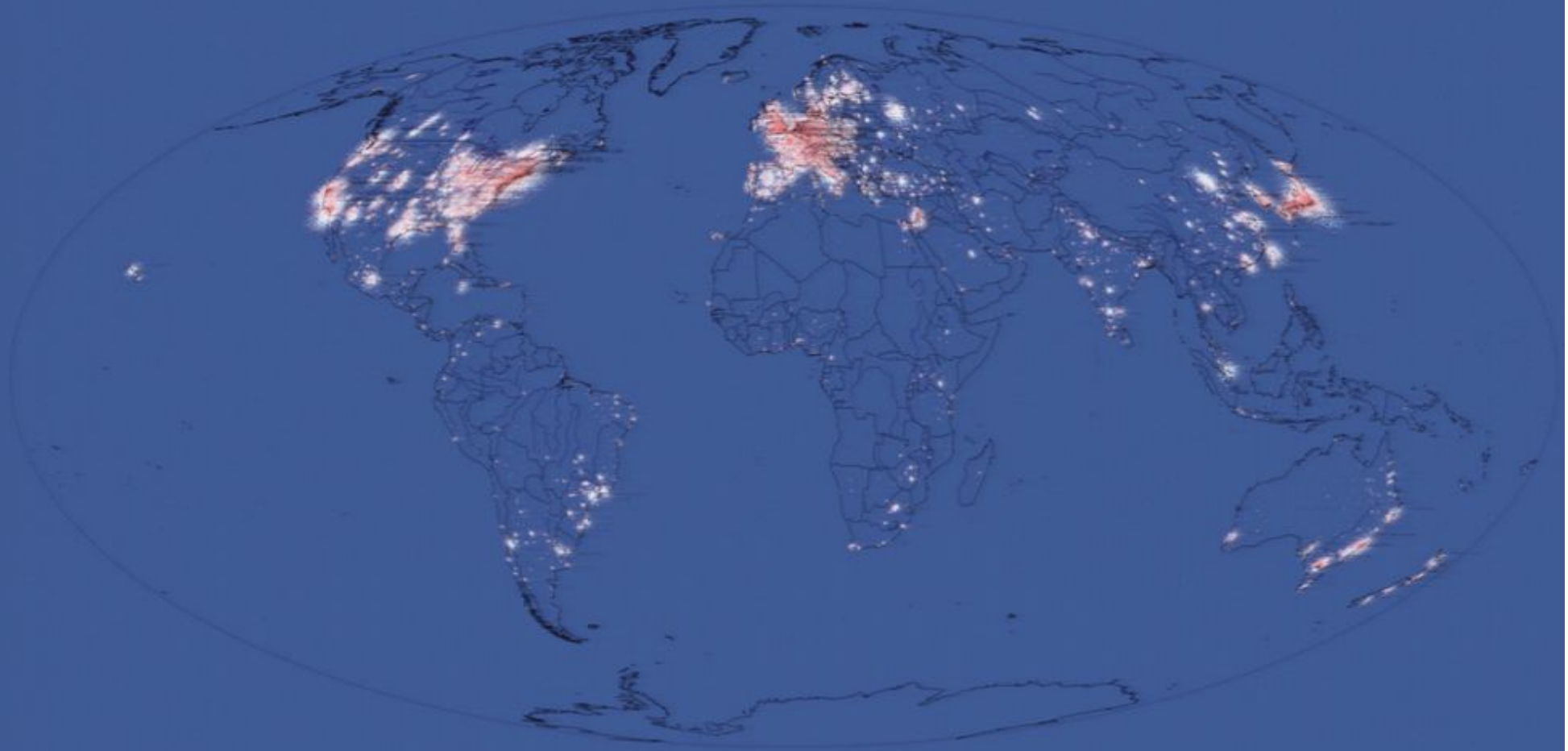
Re-implementation of Illuminated Diagram Software
by Advanced Visualization Lab, Indiana University

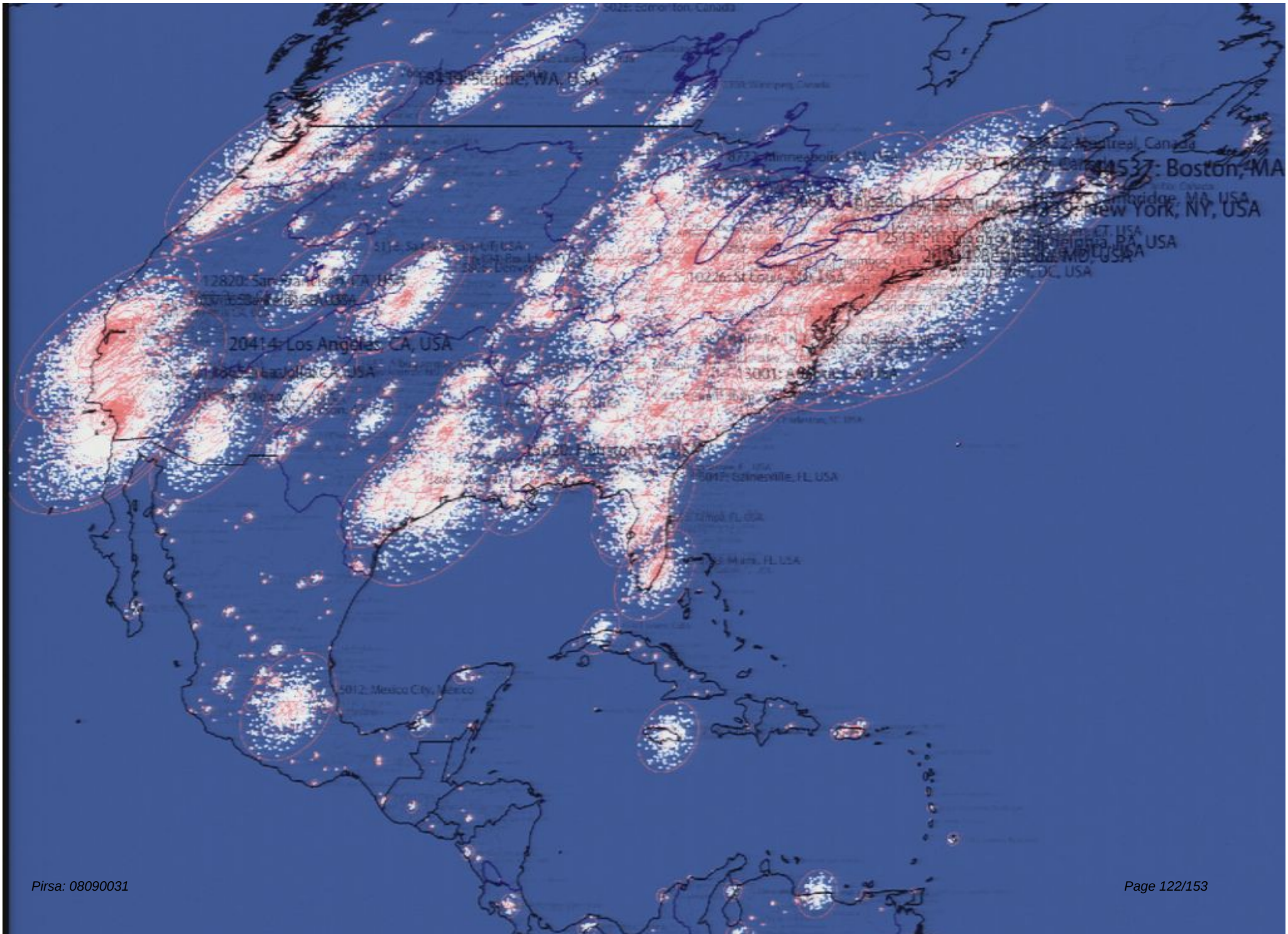
Drives unlimited number of ID screens.

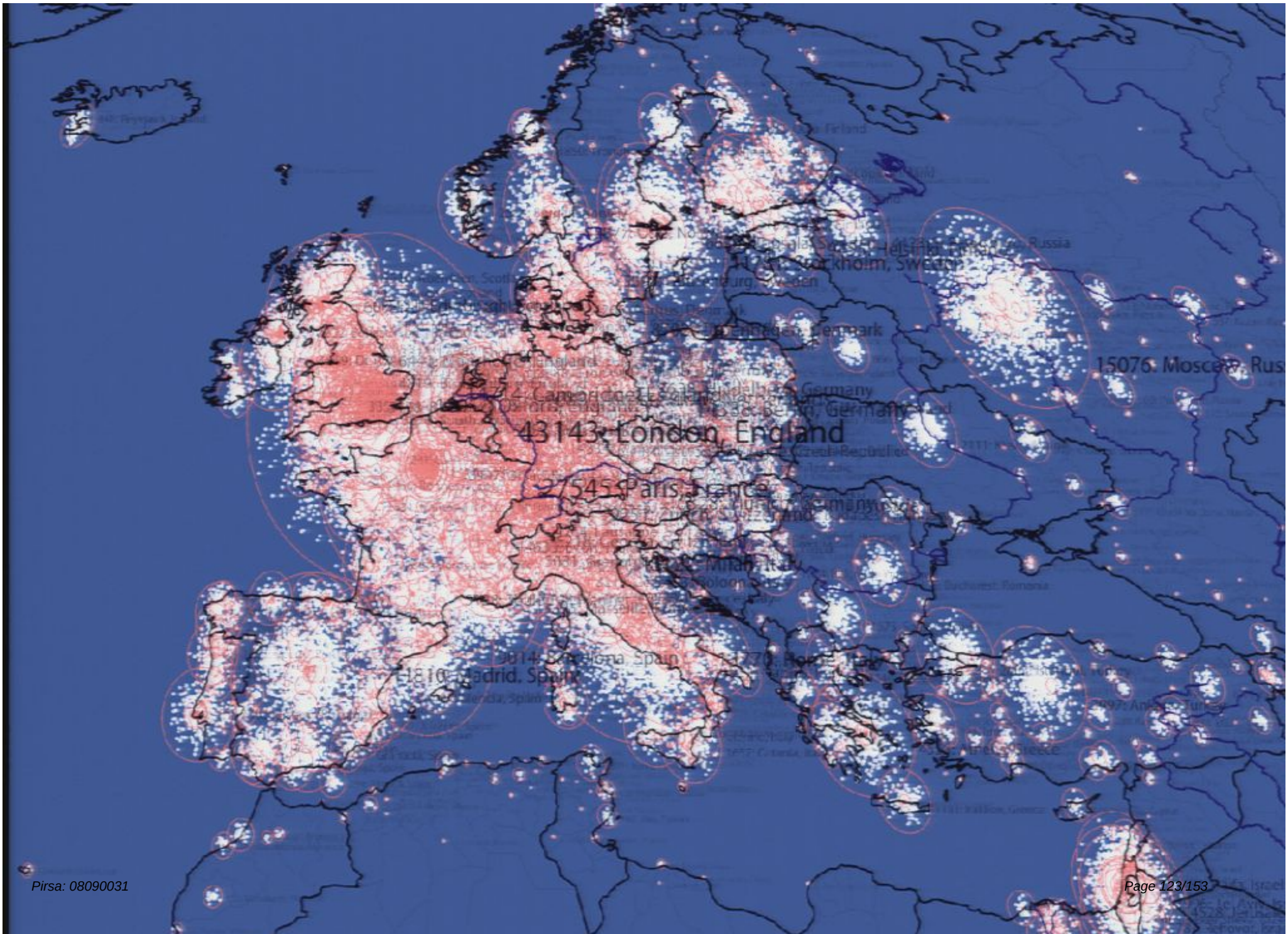


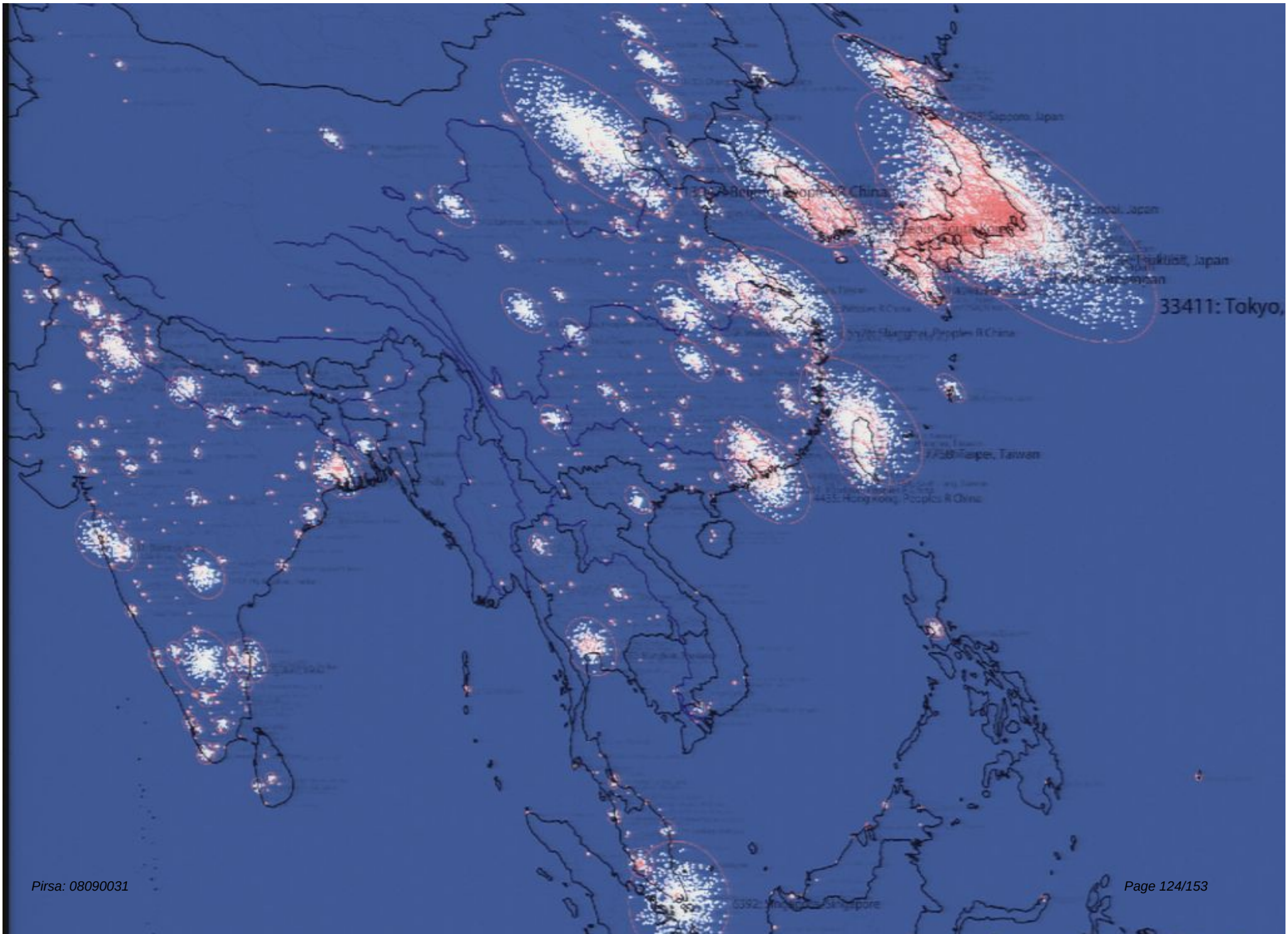
Touch screen for direct interaction.
Keyword and name search.
Selection of canned queries for
- interdisciplinary research areas
- famous people
- activity patterns, e.g., bursts, trends, etc.

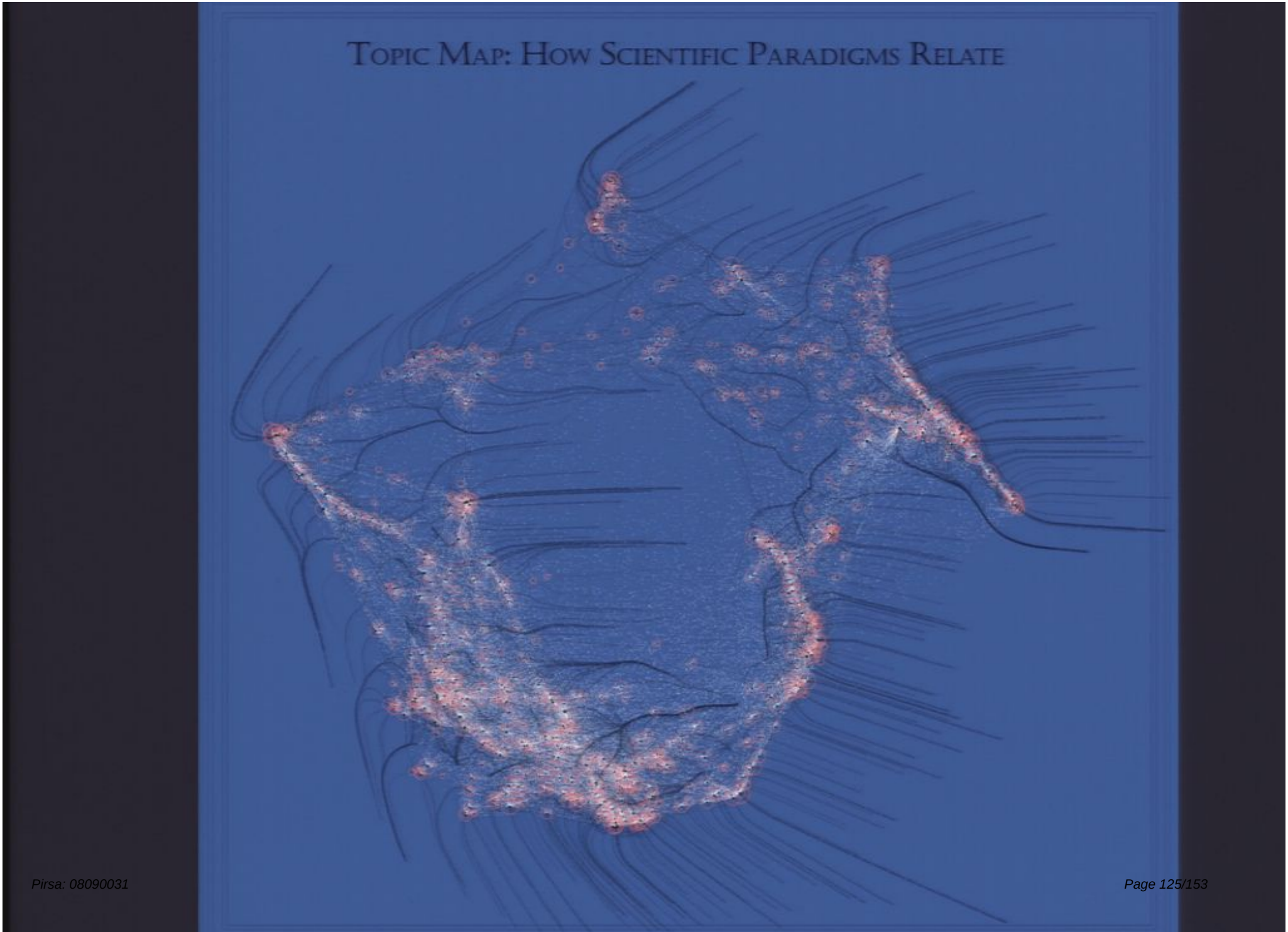
Geographic Map: Where Science Gets Done

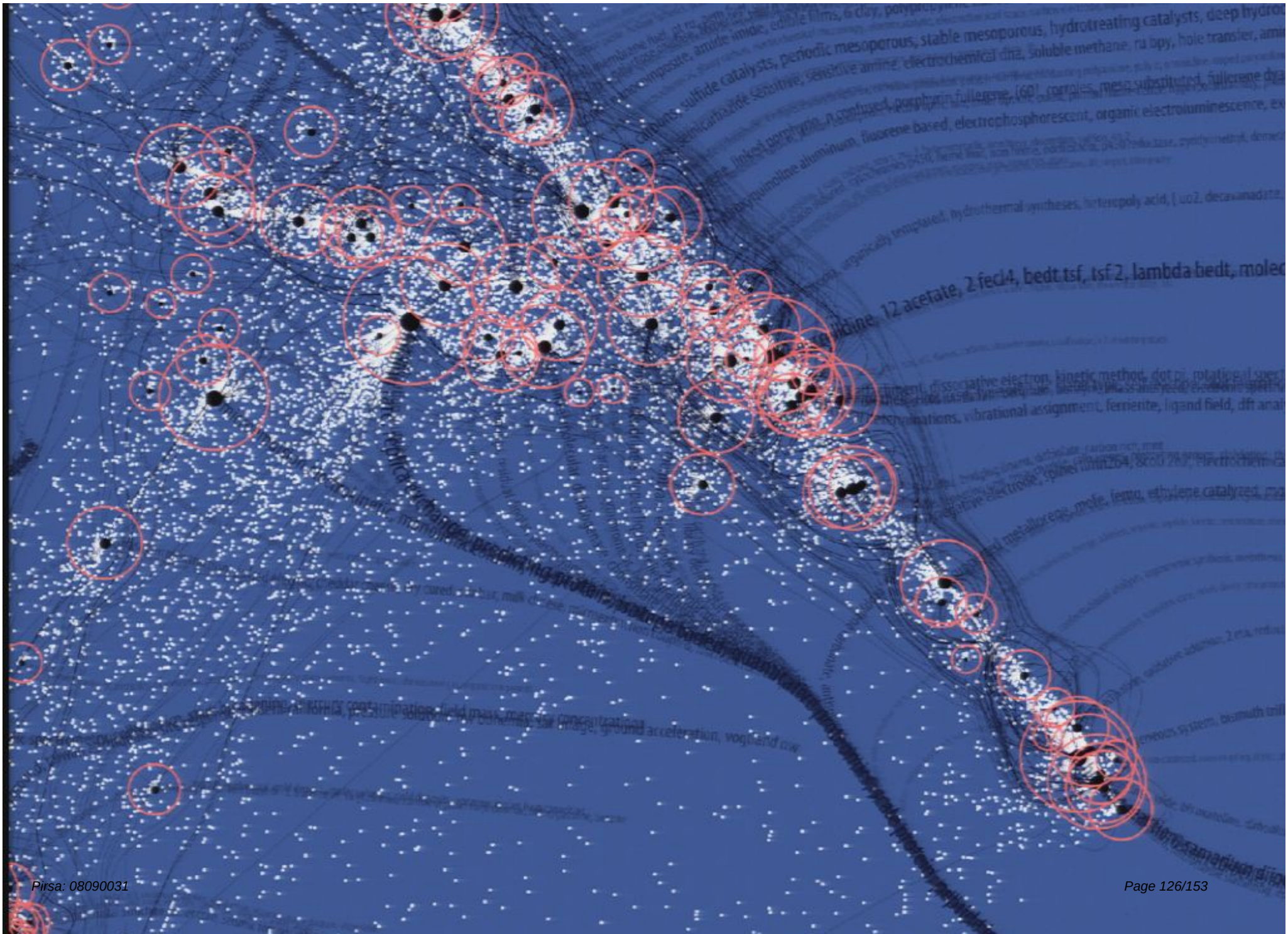



Seattle, WA, USA
Boston, MA
New York, NY, USA
Los Angeles, CA, USA
Mexico City, Mexico


43143: London, England
27545: Paris, France
15076: Moscow, Russia

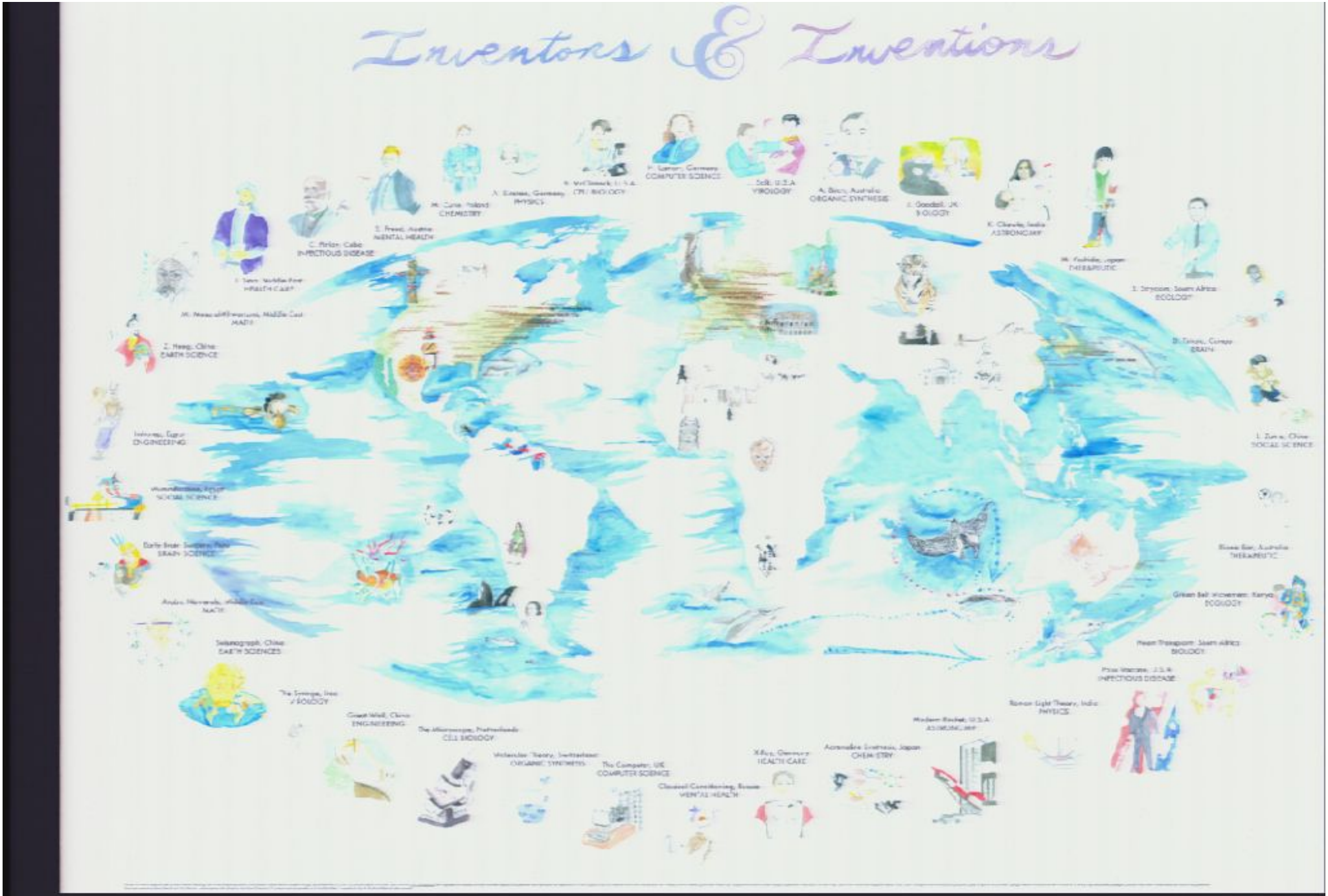

33411: Tokyo,


Topic Map: How Scientific Paradigms Relate

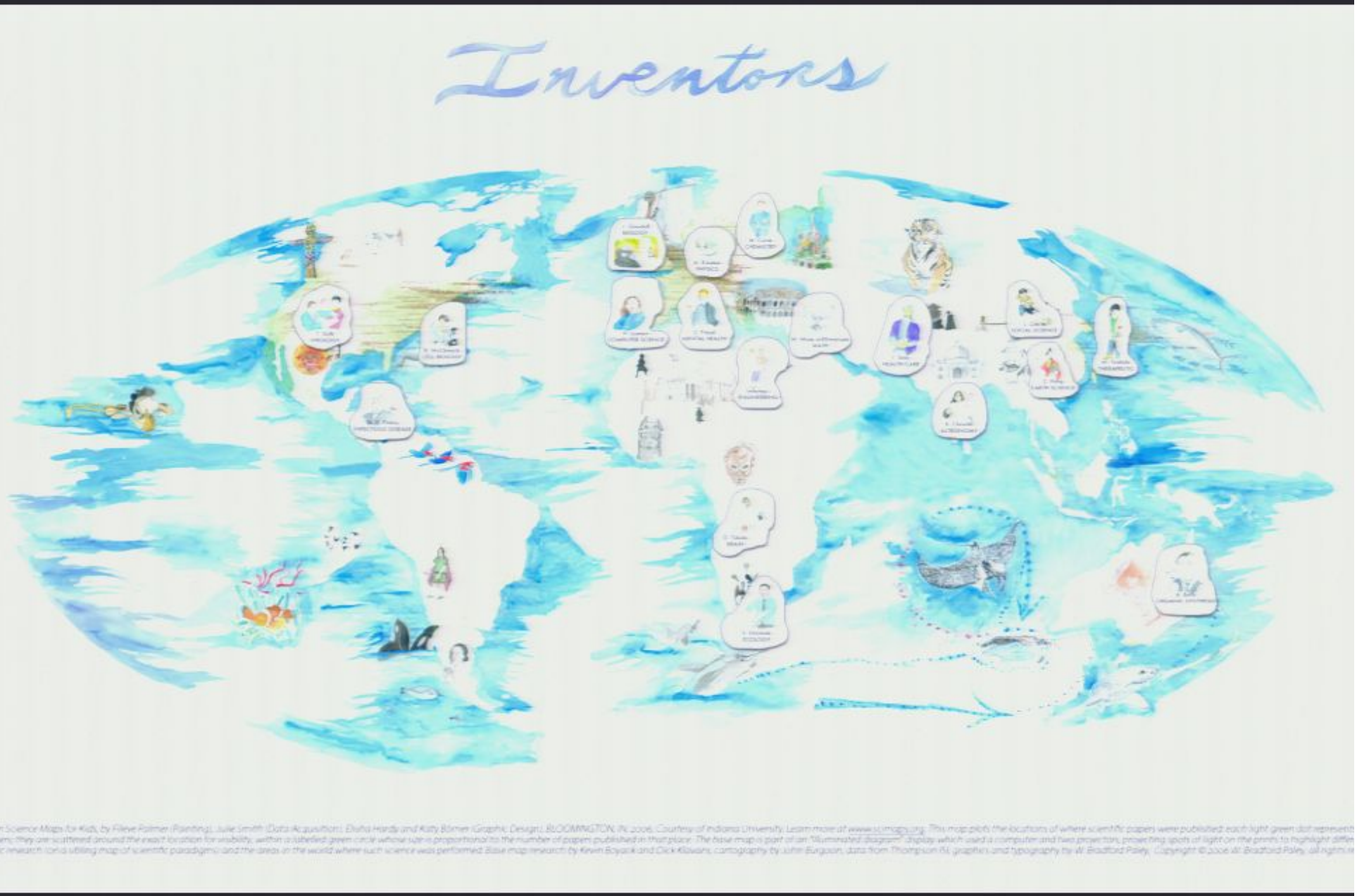


Hands-On Science Maps for Kids, by Fiona Fisher (Painting), Julie Smith (Data Acquisition), Elvita Hardy and Kelly Bonner (Graphic Design), BLOOMINGTON, IN, 2006. Courtesy of Indiana University. Learn more at www.scimaps.org. This map plots the locations of


Inventors
ASTRONOMY
PHYSICS
ENGINEERING
COMPUTER SCIENCE
MATH
SOCIAL SCIENCE
PHYSICAL CHEMISTRY
BRAIN
MENTAL HEALTH
EARTH SCIENCES
ORGANIC THEORY
ECOLOGY
HEALTH CARE
BIOLOGY
THERAPEUTIC RESEARCH
CELL BIOLOGY
VIRUSES
INFECTIOUS DISEASE



Science Puzzle Map for Kids by Fileve Palmer, Julie Smith, Elisha Hardy and Katy Börner, Indiana University, 2006.
(Base map taken from Illuminated Diagram display by Kevin Boyack, Richard Klavans, and W. Bradford Paley.)



Hands-On Science Maps for Kids, by Fleeve Palmer (Painting), Julie Smith (Data Acquisition), Elisha Hardy and Kelly Blomer (Graphic Design), BLOOMINGTON, IN, 2006. Courtesy of Indiana University. Learn more at www.scimaps.org. This map plots the locations of where scientific papers were published; each light green dot represents
fewer papers; they are scattered around the exact location for visibility, within a labelled green circle whose size is proportional to the number of papers published in that place. The base map is part of an "Illuminated Diagram" display, which used a computer and two projectors, projecting spots of light on the prints to highlight diffe
of scientific research, on a utilitarian map of scientific paradigms and the areas on the world where such science was performed. Base map research by Kevin Boyack and Dick Klavans, cartography by John Burgoon, data from Thomson ISI, graphics and typography by W. Bradford Paley. Copyright © 2006 W. Bradford Paley, all rights re


54
SOCCER

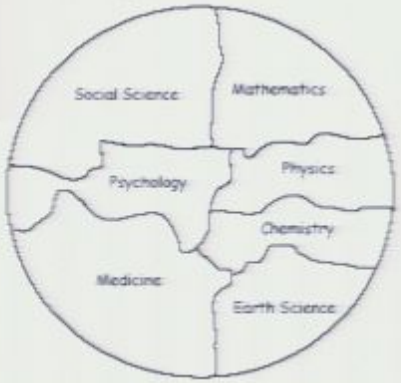
My Science Story

By _____

For more information about the map of science for kids or this exercise, please contact Katy Borner (katy@indiana.edu) or Nikki Roberg (nroberg@indiana.edu) at the School of Library and Information Science, Indiana University.

These materials were compiled by Nikki Roberg in 2006.

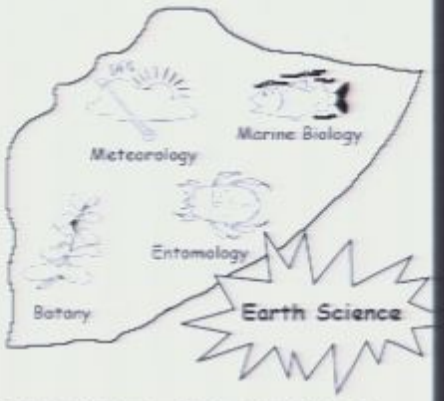
There are seven main fields of science. They are...



social science, mathematics, physics, chemistry, earth science, medicine, and psychology. I like to study earth science.

Color earth science green.

Earth scientists study the weather, plants and trees, marine life, insects, and much more.

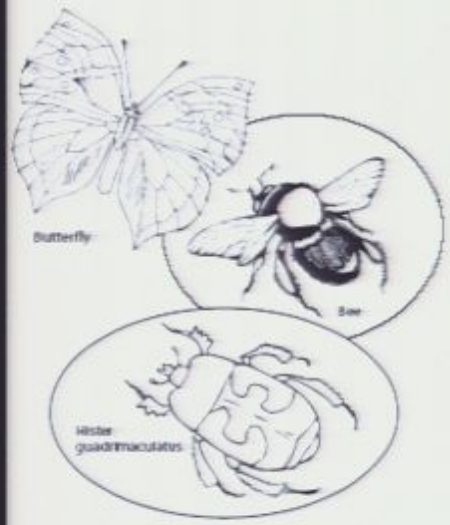


I like insects. They are interesting to look at and study.

Color in the insect.

Activities:

Solve the puzzle.
Navigate to 'Earth Science'.
Identify major inventions.
Place major inventors.
Find your dream job on the map.
Why is mathematics important?



There are many types of insects in the world. Bees, butterflies, and beetles are just a few.

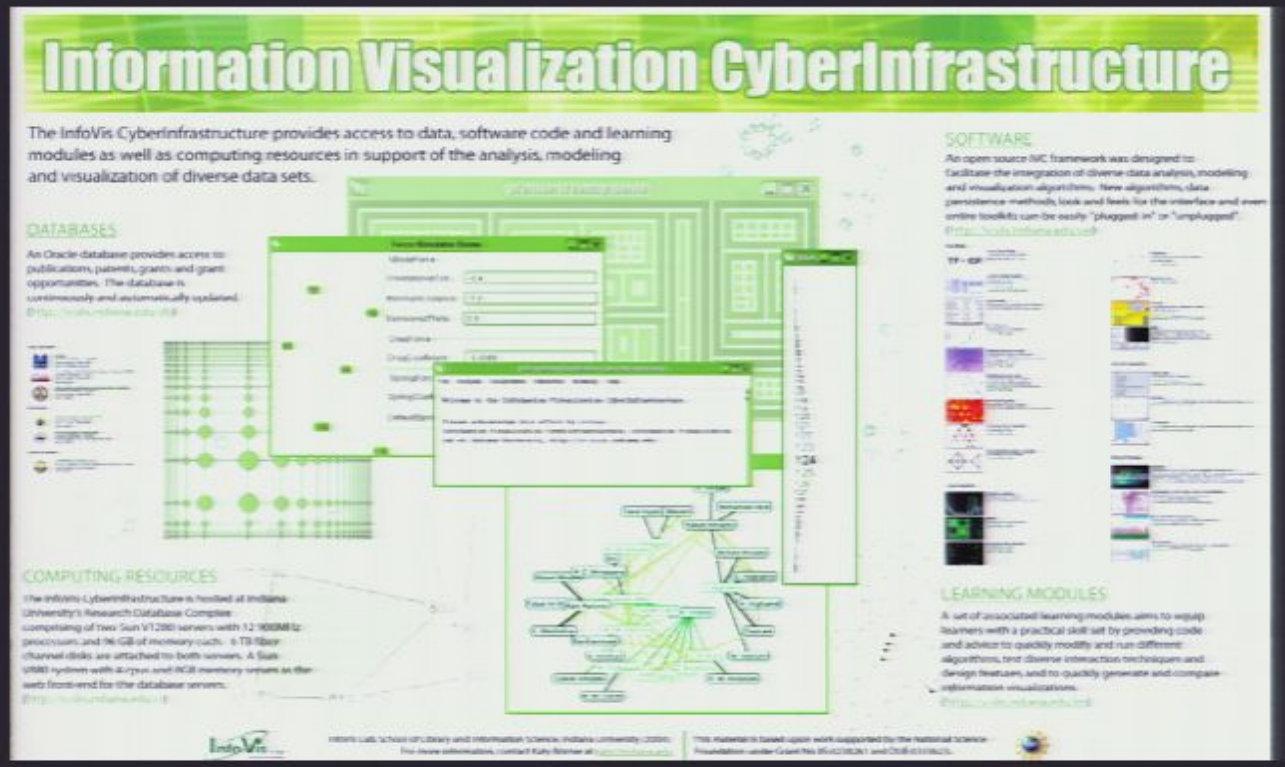
I want to be an **entomologist** wh
grow up. Then I can study insec
all the time.

Winners @ AMSE

JoHanna Sanders, age 12, a picture of someone enjoying nature and a theme that science is all around us.

Sascha Richey, age 8, drew a picture of her mother and

Science of Science Cyberinfrastructure



CAREER: Visualizing Knowledge Domains. NSF IIS-0238261 award (Katy Börner, $451,000) Sept. 03-Aug. 08.
http://ivl.slis.indiana.edu/

CIShell

SDB | SCHOLARLY DATABA

Scholarly Database
http://sdb.slis.indiana.edu

Network Workbench
A Workbench for Network Scientists

SEI: Network Workbench: A Large-Scale Network Analysis, Modeling and Visualization Toolkit for Biomedical, Social Science and Physics Research. NS IIS-0513650 award (Katy Börner, Albert-Laszlo Barabasi, Santiago Schnell Alessandro Vespignani & Stanley Wasserman, Eric Wernert (Senior Personn $1,120,926) Sept. 05 - Aug. 09. http://nwb.slis.indiana.edu

NSF SBC Sun microsystems HPNAP High Performance Network Applications Progr INDIANA 21st Century Research & Technology Fund

SDB | SCHOLARLY DATABASE

SCHOLARLY DATABASE

SEARCH INTERFACE: https://iv.slis.indiana.edu/db/
DOCUMENTATION: http://iv.slis.indiana.edu/db/

DB PROJECT LEAD
Gavin LaRowe
glarowe@indiana.edu

DB DEVELOPER
Sumeet Ambre
sambre@indiana.edu

PROJECT MANAGER
Katy Börner

STATUS
as of 06.08.28

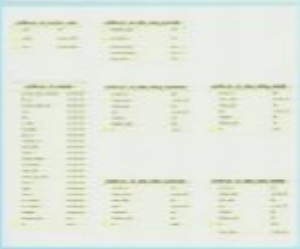
Information Visualization Laboratory
Cyberinfrastructure for Network Science Center
School of Library and Information Science
Indiana University
Bloomington, IN 47405, USA

PAPERS

SDB MEDLINE

SDB PHYSREV

SDB PNAS

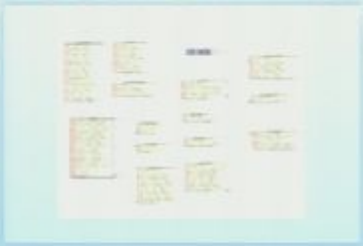


SDB JCR

PATENTS

SDB USPATENTS

DOCUMENT TABLE



KNOWLEDGE WEBS

SDB WIKI

GRANT AWARDS

SDB NSF

SDB NIH

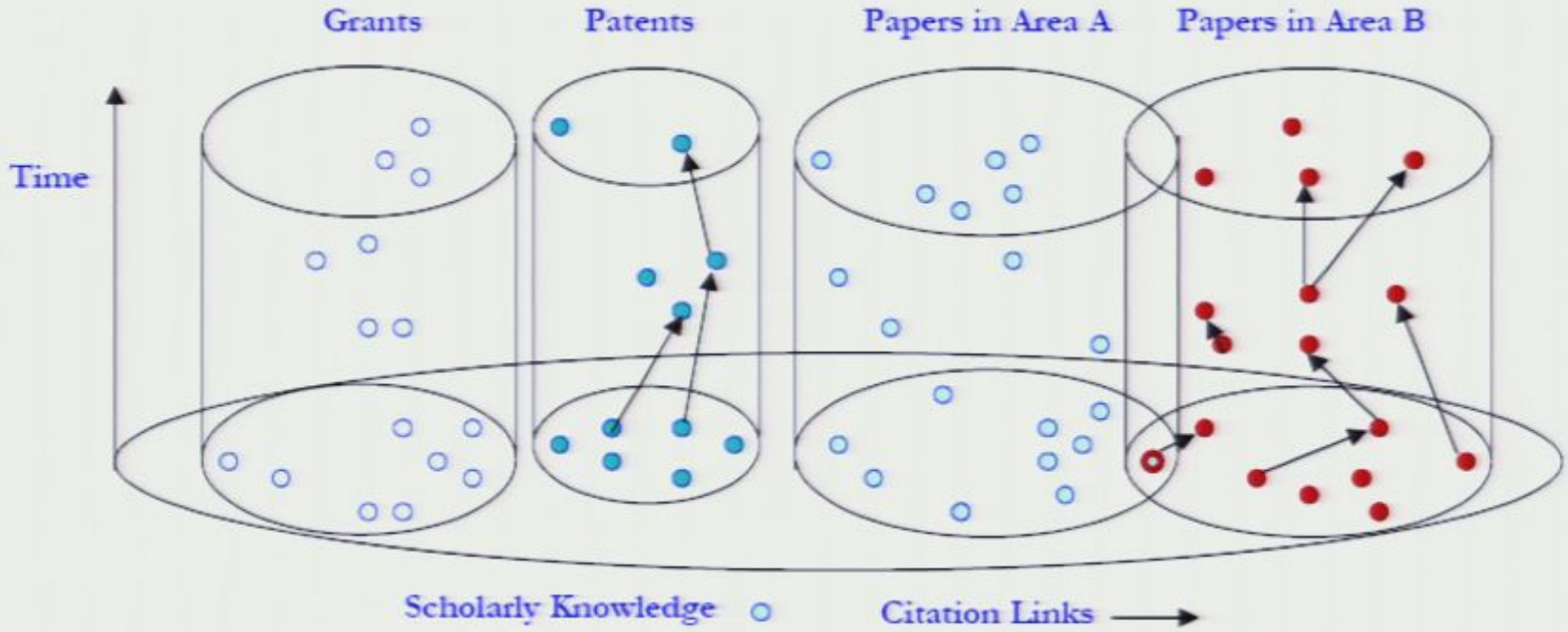
FUNDING OPPORTUNITIES

SDB COS

DESIGN BY ELISHA HARDY

SDB | SCHOLARLY DATABASE

Challenges - Interlink $ Input & Publication/Patent Citation Output



Need to interlink

- Grants and papers/patents.
- Grants/papers/patents and their PIs/authors/inventors, etc.

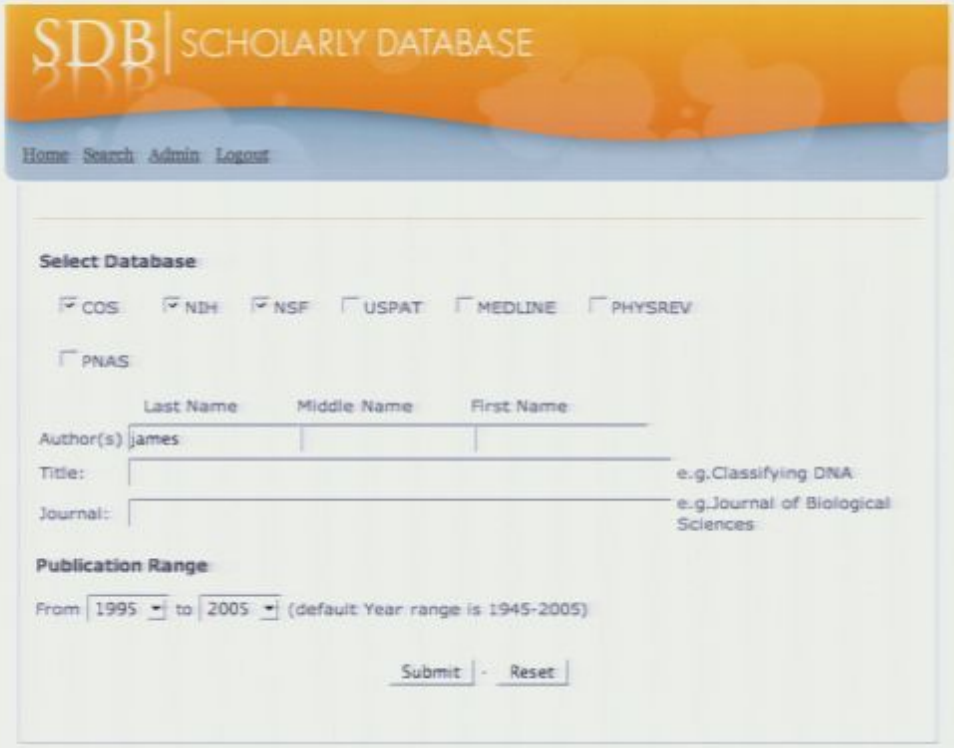
Use resulting networks to

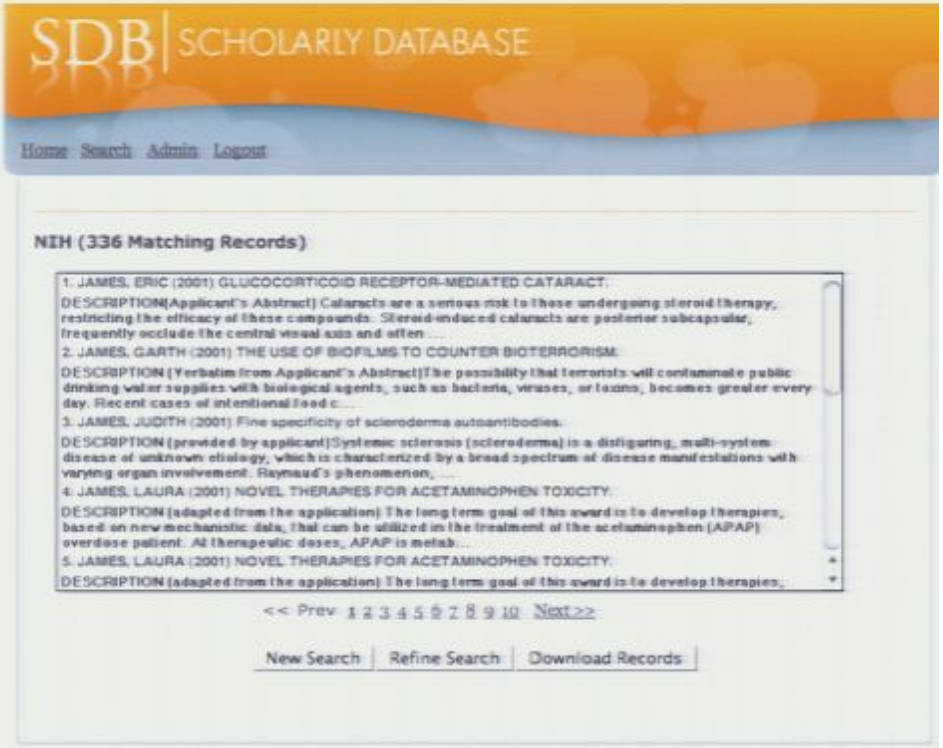
- Count #papers, #citations, etc.
- Determine strength of co-PI/author/inventor relations, etc.

Scholarly Database: Web Interface

Search across publications, patents, grants.

Download records and/or (evolving) co-author, paper-citation networks.





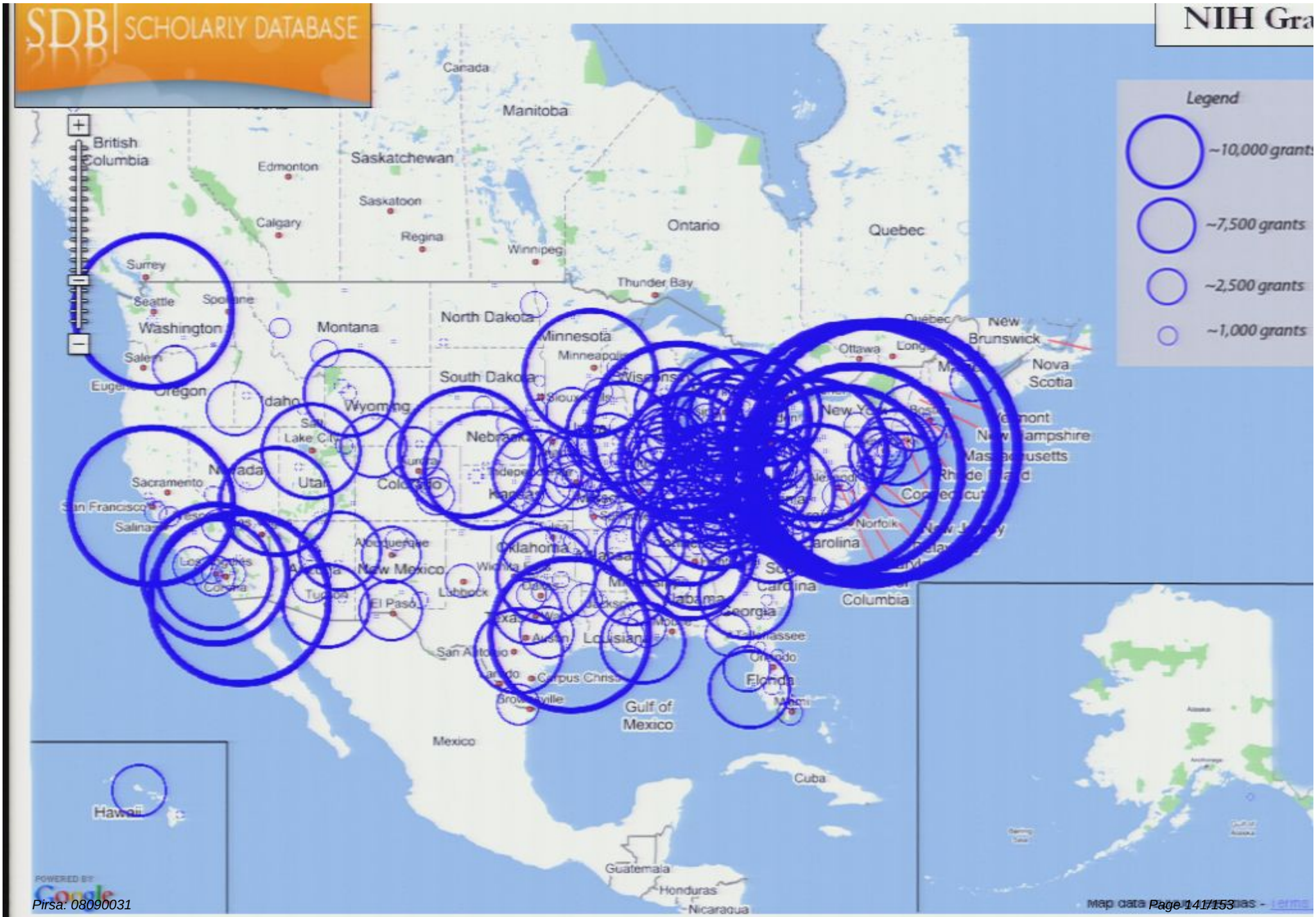
Register for free access at https://sdb.slis.indiana.edu.

Scholarly Database: # Records & Years Covered

Datasets available via the Scholarly Database (* future feature)

Dataset	# Records	Years Covered	Updated	Restricted Access
Medline	13,149,741	1965-2005	Yes	
PhysRev	398,005	1893-2006		Yes
PNAS	16,167	1997-2002		Yes
JCR	59,078	1974, 1979, 1984, 1989 1994-2004		Yes
USPTO	3,179,930	1976-2004	Yes*	
NSF	174,835	1985-2003	Yes*	
NIH	1,043,804	1972-2002	Yes*	
Total	**18,021,560**	**1893-2006**	**4**	**3**

Aim for comprehensive time, geospatial, and topic coverage.


SDB SCHOLARLY DATABASE
NIH Gra
Legend
~10,000 grants
~7,500 grants
~2,500 grants
~1,000 grants
Canada
Manitoba
Saskatchewan
Ontario
Quebec
British Columbia
Edmonton
Saskatoon
Calgary
Regina
Winnipeg
Thunder Bay
Surrey
Seattle
Washington
Montana
North Dakota
Minnesota
Minneapolis
South Dakota
Wyoming
Nebraska
Oregon
Idaho
Salem
Sacramento
San Francisco
Utah
Colorado
Nevada
Oklahoma
New Mexico
Albuquerque
El Paso
Lubbock
Austin
Louisiana
Alabama
Georgia
Florida
Carolina
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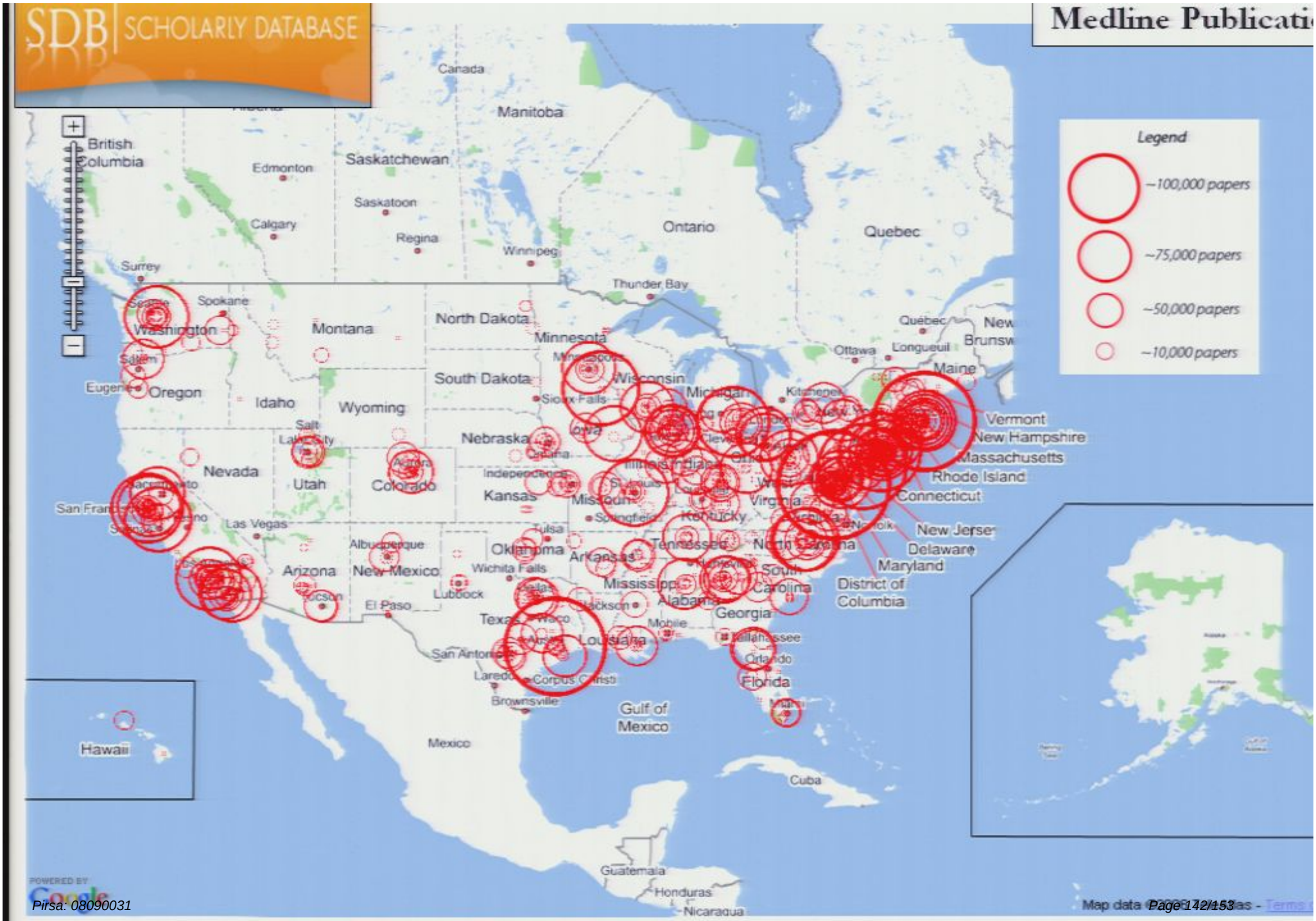
Nova Scotia
Norfolk
Gulf of Mexico
Mexico
Cuba
Hawaii
Guatemala
Honduras
Nicaragua
Map data


SDB SCHOLARLY DATABASE
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~100,000 papers
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South Dakota
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Missouri
Iowa
Illinois
Indiana
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Kentucky
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North Carolina
South Carolina
Georgia
Alabama
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Vermont
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Massachusetts
Rhode Island
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Delaware
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District of Columbia
Pennsylvania
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Longueuil
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San Antonio
Corpus Christi
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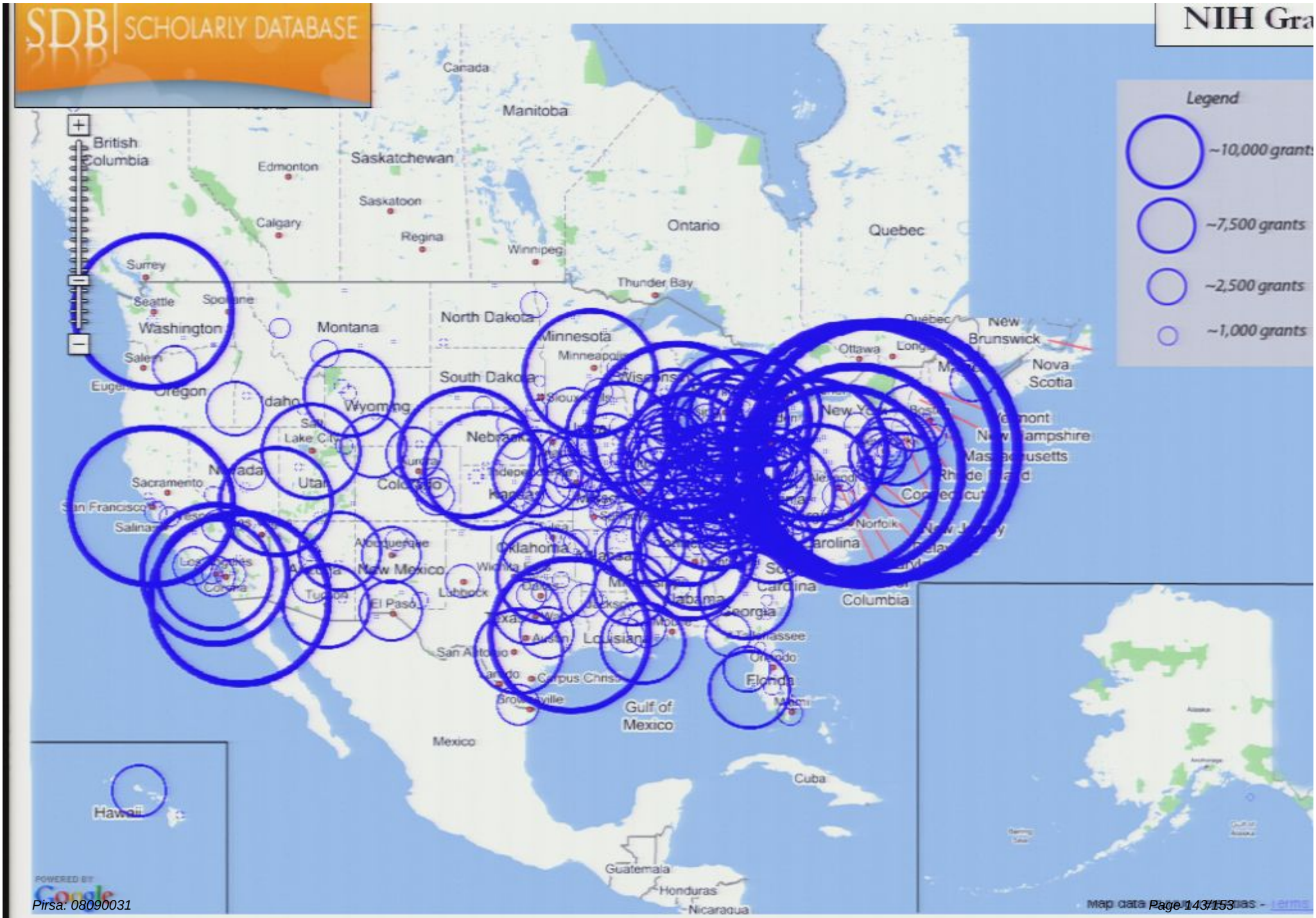
POWERED BY Google
Map data


SDB SCHOLARLY DATABASE
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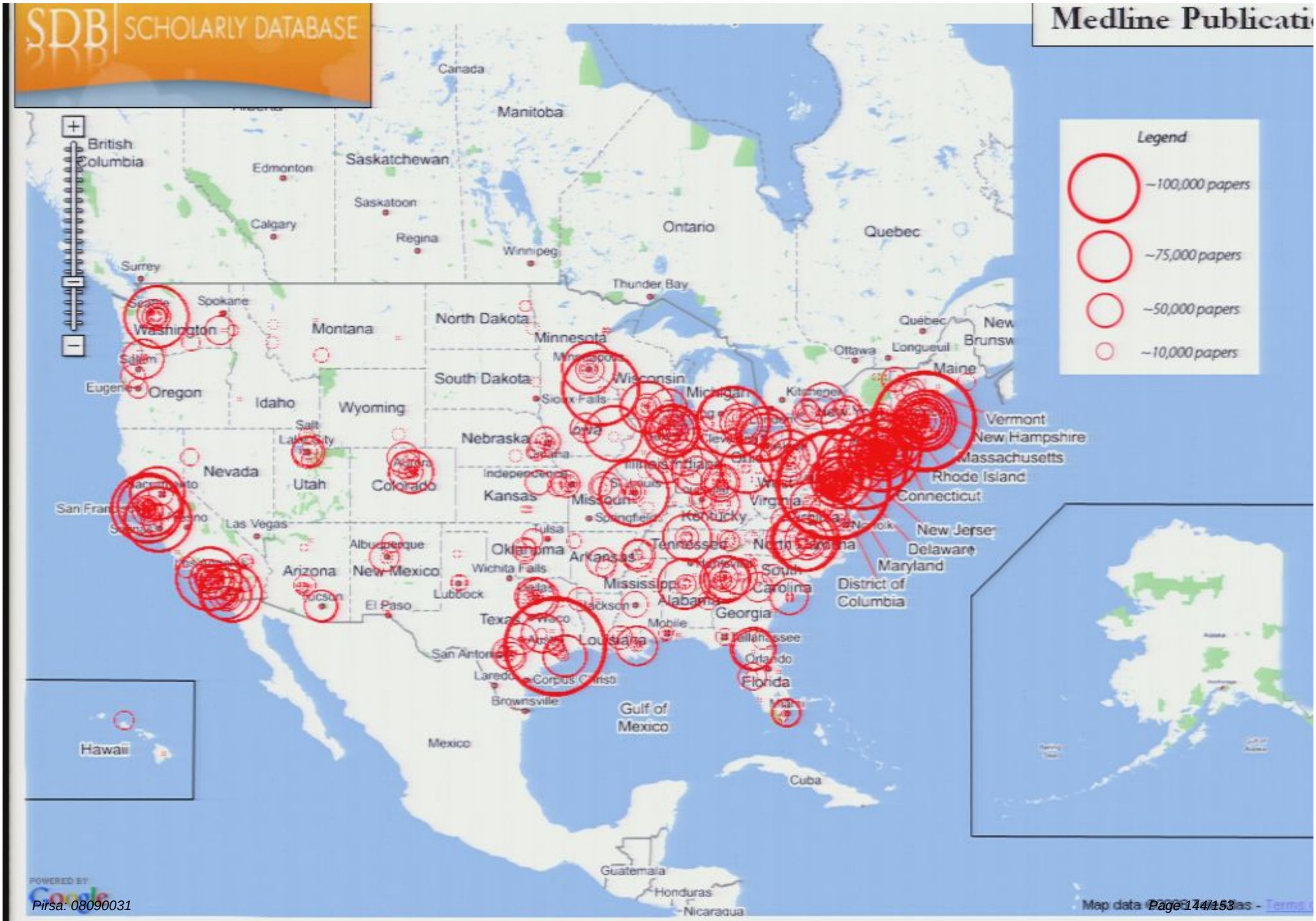
SDB SCHOLARLY DATABASE
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Wichita Falls
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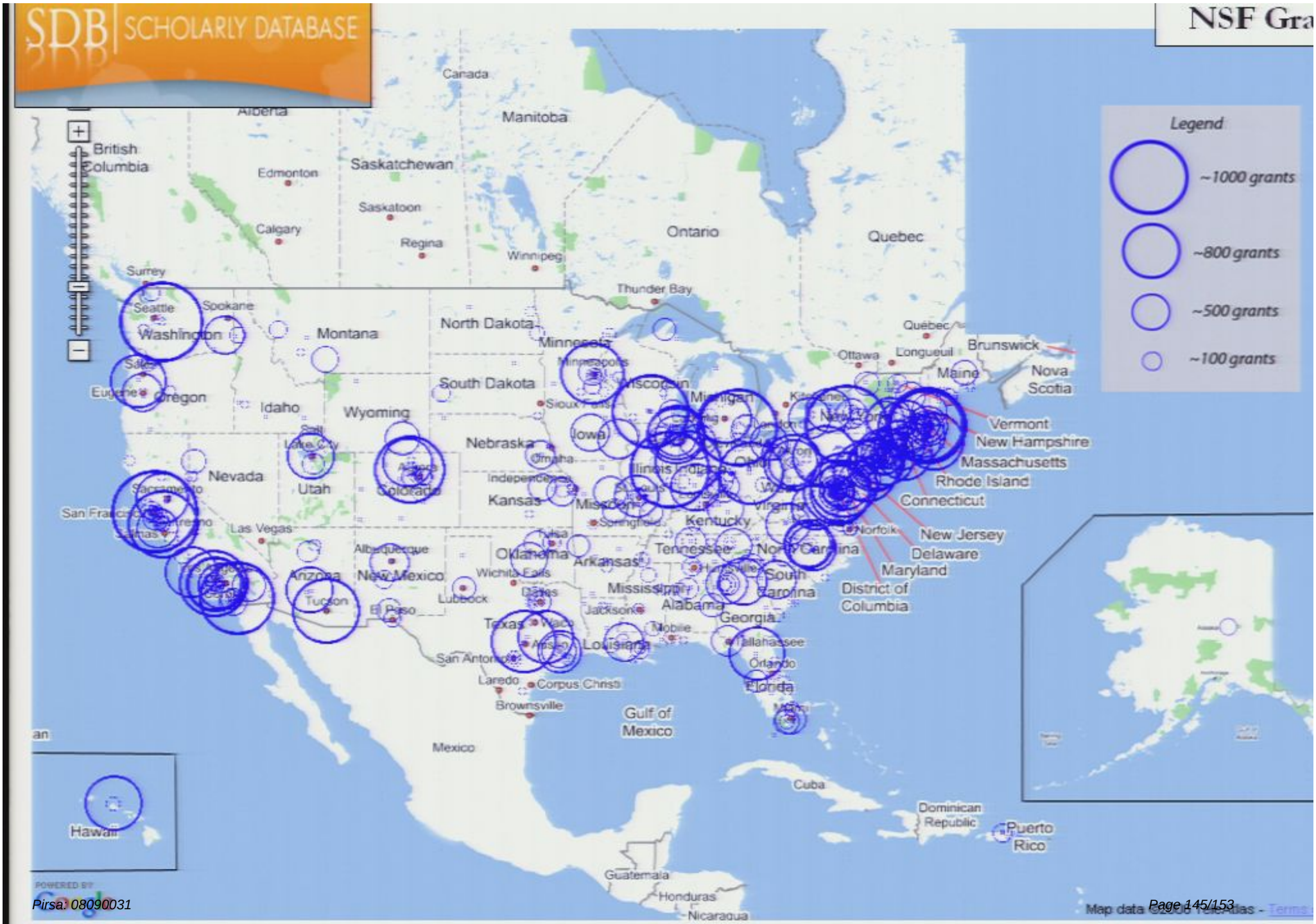
Map data


SDB SCHOLARLY DATABASE
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Iowa
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Kentucky
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Arkansas
Tennessee
North Carolina
South Carolina
Arizona
New Mexico
Wichita Falls
Lubbock
Dallas
Mississippi
Alabama
Georgia
Tucson
El Paso
Texas
Jackson
Mobile
Tallahassee
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San Antonio
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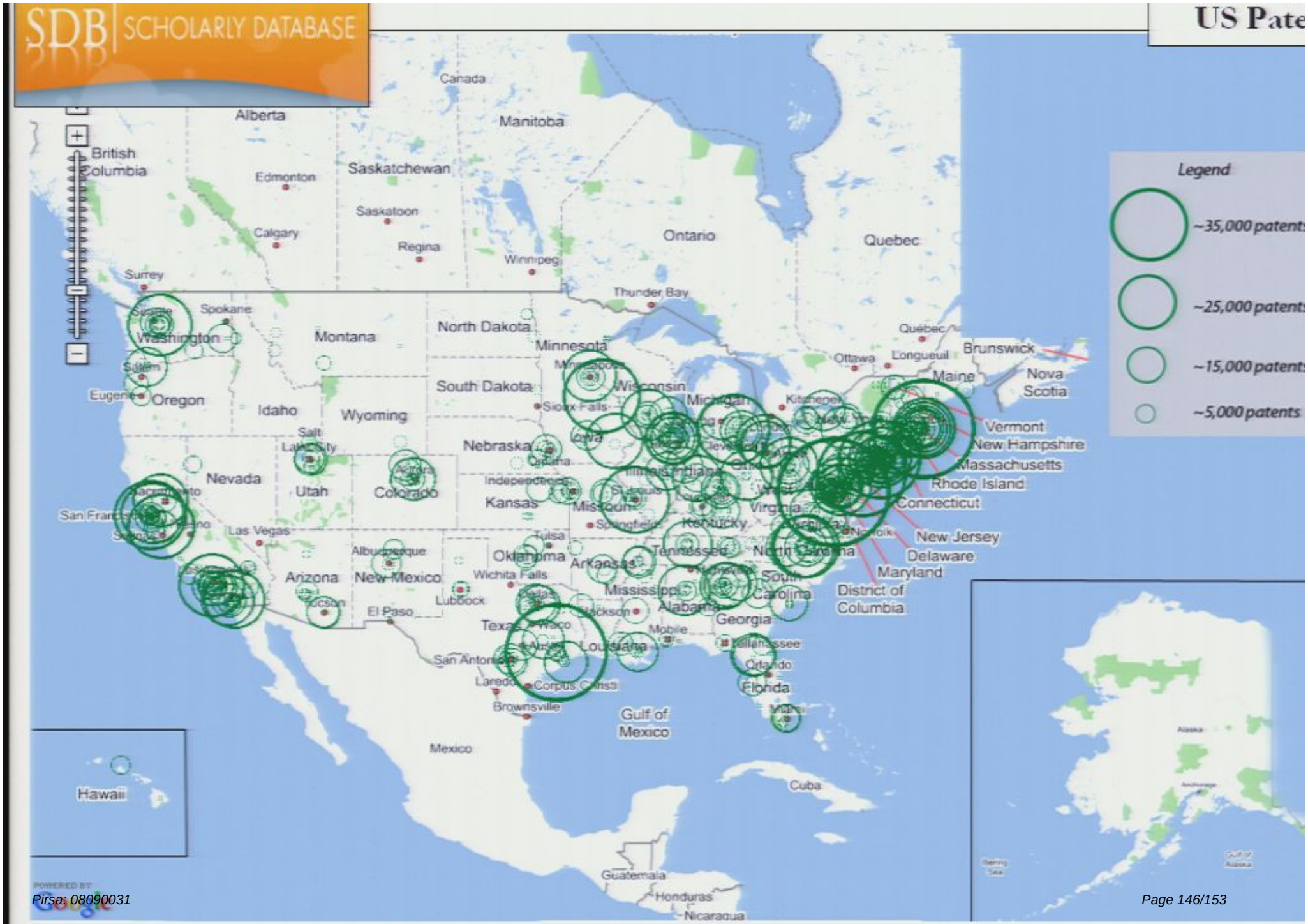


NetworkWorkbench

A Workbench for Network Scientists

LOGIN

Home | People | Research | Publications | Community | Download | Documentation | Dev Zone | About

Summary

Network Workbench: A Large-Scale Network Analysis, Modeling and Visualization Toolkit for Biomedical, Social Science and Physics Research.This project will design, evaluate, and operate a unique distributed, shared resources environment for large-scale network analysis, modeling, and visualization, named Network Workbench (NWB). The envisioned data-code-computing resources environment will provide ..

more

How to cite this project

News & Updates

- 2.26.08 NWB Tool 0.9.0 Release
- 1.30.08 NWB Tool pre 0.9.0 v5 Release
- 1.29.08 NWB Flyer Update (added supported file formats)
- 1.23.08 NWB at Sunbelt 08 (Poster)
- 1.22.08 NWB Flyer Update (now two-sided!)
- 1.22.08 New Tutorials
- 1.22.08 NWB Basic Tutorial: Getting Started

Download Latest Release

Note: save the download as .jar

Select Your Operating System

Windows XP

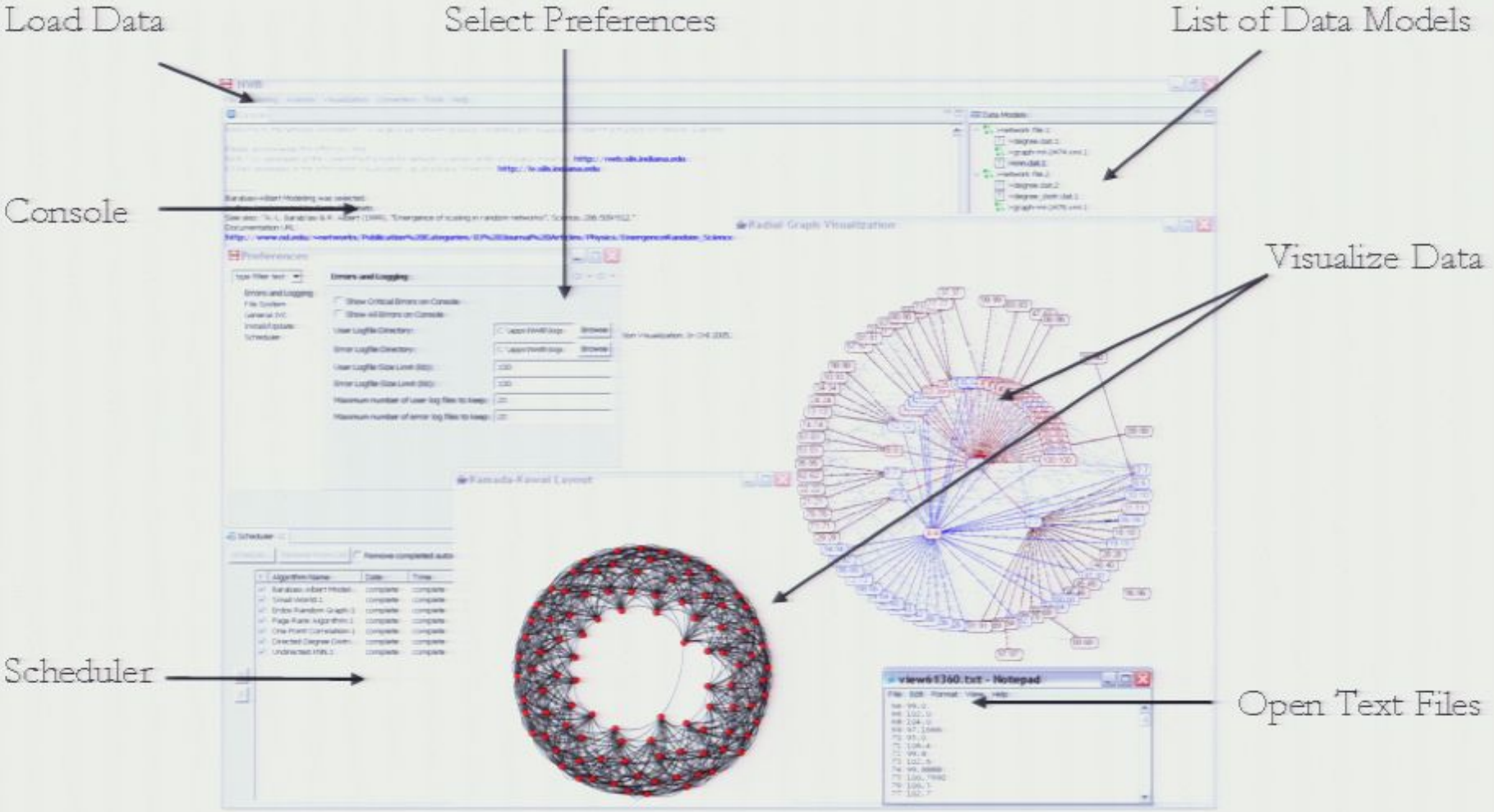
DOWNLOAD

Get Involved

- Sign up for NWB mailing lists
- Bug Tracking System

NWB Tool: Interface Elements

http://nwb.slis.indiana.edu



Algorithms Currently Available

See https://nwb.slis.indiana.edu/community/?n=Algorithms.HomePage

July 1st, 20

Preprocessing Edit

Remove Nodes
- Extract Top Nodes
- Extract Nodes Above or Below Val
- Delete High Degree Nodes
- Delete Random Nodes
- Delete Isolates

Remove Edges
- Extract Top Edges
- Extract Edges Above or Below Val
- Remove Self Loops
- Trim By Degree[2]
- Pathfinder Network Scaling

Sampling
- Snowball Sampling (n nodes)
- Node Sampling
- Edge Sampling

Transformations
- Symmetrize
- Dichotomize
- Multipartite Joining

Modeling Edit

General
- Random Graph
- Watts-Strogatz Small World
- Barabási-Albert Scale-Free

Structured
- CAN
- Chord

Unstructured
- Hypergrid
- PRU

Other
- TARL
- Discrete Network Dynamics

Analysis Edit

General Purpose
- Network Analysis Toolkit[2]

Unweighted & Undirected

Based on degree/
- Node Degree
- Node Distribution

Based on clustering
- k-Nearest Neighbor
- Watts Strogatz Clustering Coefficient
- Watts Strogatz Clustering Coefficient

Based on path
- Diameter
- Average Shortest Path
- Shortest Path Distribution
- Node Betweenness Centrality

Based on components
- Connected Components
- Weak Component Clustering

K-Core
- Extract K-Core[2]
- Annotate K-Coreness[2]

Unweighted & Directed

Based on degree
- Node Indegree
- Node Outdegree
- Indegree Distribution
- Outdegree Distribution

Based on local graph structure
- k-Nearest Neighbor
- Single Node In-Out Degree Correlati

Unnamed Category?
- Page Rank

Based on local graph structure #:
- Dyad Reciprocity[2]
- Arc Reciprocity[2]
- Adjacency Transitivity[2]

Based on components
- Weak Component Clustering

Visualization Edit

Tools
- GUESS
- GnuPlot[2]

Predefined Positions Layout
- DrL (VxOrd)
- Pre-defined Positions (prefuse beta)[2]

Move
- Circular

Tree Layouts
- Radial Tree (prefuse alpha)
- Radial Tree with Annotations (prefuse beta)[2]
- Tree Map
- Tree View
- Balloon Graph (prefuse alpha)[2]

Network Layouts
- Force Directed with Annotation (prefuse beta
- Kamada-Kawai (JUNG)
- Fruchterman-Reingold (JUNG)
- Fruchterman-Reingold with Annotation (prefu
- Spring (JUNG)
- Small World (prefuse alpha)

Other Layouts
- Parallel Coordinates (demo)[2]
- LaNet (k-Core Decomposition)

Scientometrics Edit

Extract Network From Table
- Extract Co-Authorship Network
- Extract Co-Occurrence Network From Table[2]
- Extract Directed Network From Table[2]

Extract Network From Another Network
- Extract Bibliographic Coupling Similarity Netw
- Extract Co-Citation Similarity Network[2]

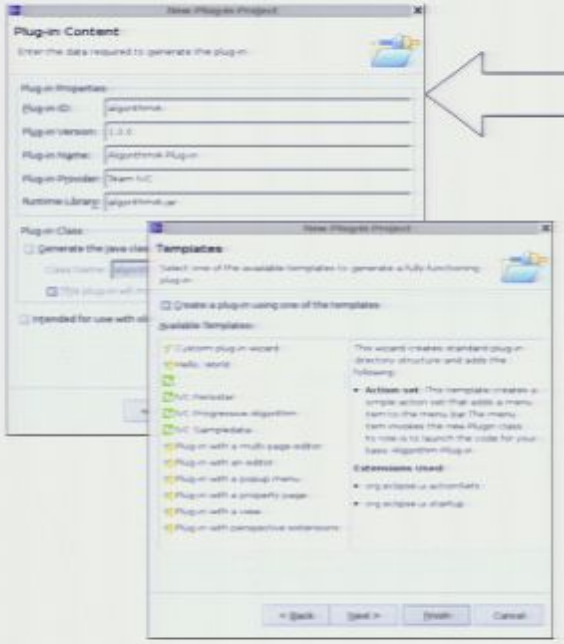
Cleaning
- Remove ISI Duplicate Records
- Detect Duplicate Nodes
- Remove Rows With Multitudinous Fields[2]

CIShell – Serving Non-CS Algorithm Developers & User

Developers

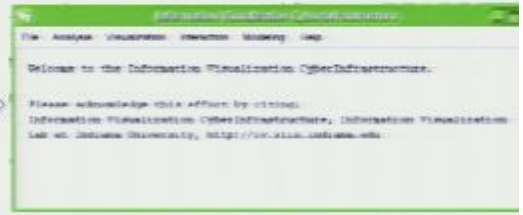
Users

CIShell Wizards



CIShell

IVC Interface



NWB Interface

CIShell – Builds on OSGi Industry Standard

CIShell is built upon the Open Services Gateway Initiative (OSGi) Framework.

OSGi (http://www.osgi.org) is

- A standardized, component oriented, computing environment for networked services.
- Successfully used in the industry from high-end servers to embedded mobile devices since 8 years.
- Alliance members include IBM (Eclipse), Sun, Intel, Oracle, Motorola, NEC and many others.
- Widely adopted in open source realm, especially since Eclipse 3.0 that uses OSGi R4 for its plugin model.

Advantages of Using OSGi

- Any CIShell algorithm is a service that can be used in any OSGi-framework based system.
- Using OSGi, running CIShells/tools can connected via RPC/RMI supporting peer-to-peer sharing of data, algorithms, and computing power.

Ideally, CIShell becomes a standard for creating OSGi Services for algorithms.

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