More than a Pretty Picture:
Visual Thinking in Network Studies

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Introduction

We live in a connected world:

"To speak of social life is to speak of the association between people – their associating in work and in play, in love and in war, to trade or to worship, to help or to hinder. It is in the social relations men establish that their interests find expression and their desires become realized."

Peter M. Blau
Exchange and Power in Social Life, 1964

Introduction

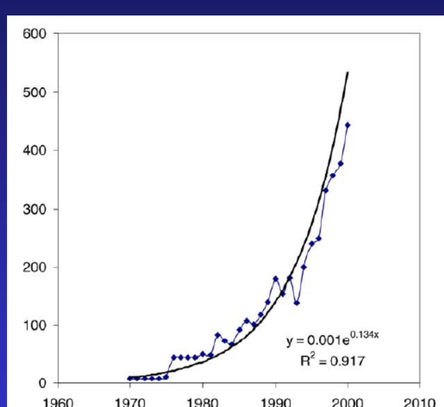
And yet, standard social science analysis methods do not take this space into account.

> "For the last thirty years, empirical social research has been dominated by the sample survey. But as usually practiced, …, the survey is a sociological meat grinder, tearing the individual from his social context and guaranteeing that nobody in the study interacts with anyone else in it."
>
> *Allen Barton, 1968 (Quoted in Freeman 2004)*

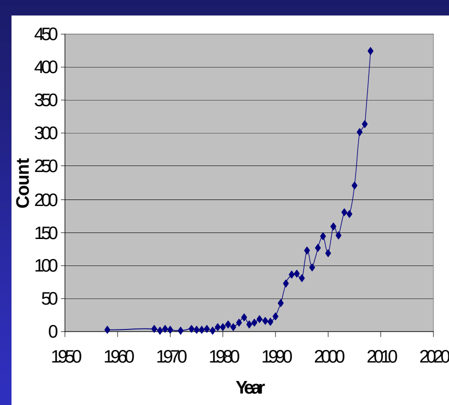
The study of social networks allows us to re-integrate our respondents in their social worlds.

Introduction

The recognition of the potential for Social Network Analysis is fast-growing:



Sociological Abstracts



Web of Science

Introduction

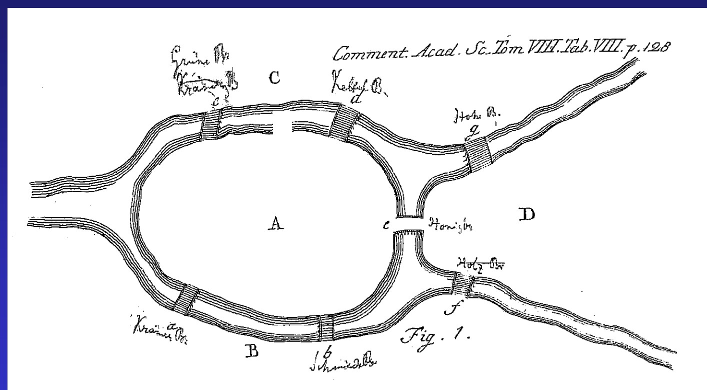
***From the beginning*, network science has been a *visual* science, rich with strange images purporting to illuminate our understanding of the world.**

Network Thinking Outline

1) Introduction
2) A Little History….
3) Why visualize networks at all?
4) What makes a good (*scientific?)* visualization
5) Two challenges to help us think
    1) Dynamics of Diffusion
    2) Political Polarization: Dense & Dynamic
6) Developing a visual network language
    (nouns: easy, rhetoric: moderate, verbs: hard)
7) Conclusion

A Little network Visualization History
Promising Foundations

The study of networks has depended on a visual thinking since the beginning:



Euler, 1741

Euler's treatment of the "Seven Bridges of Kronigsberg" problem is one of the first moments of graph theory, where he contrasted the observed map….

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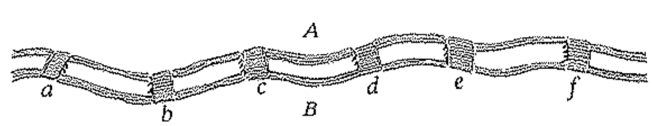

FIG. 1.3.

Euler, 1741

… to an alternative to help think through what would became the first theorem in graph theory, and the development of elements (land masses/vertices) linked as pairs (edges/bridges)

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Promising Foundations

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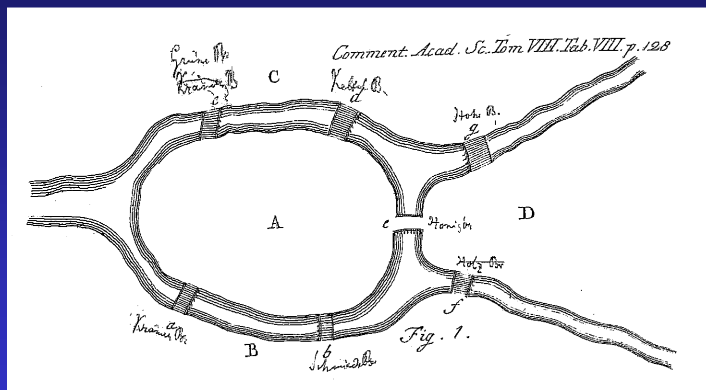


… and abstracted from the observed elements (land masses/bridges) to abstract connections (Vertices/edges)

A Little network Visualization History
Promising Foundations

The study of networks has depended on a visual thinking since the beginning:

Early kinship diagrams by Morgan (1871)

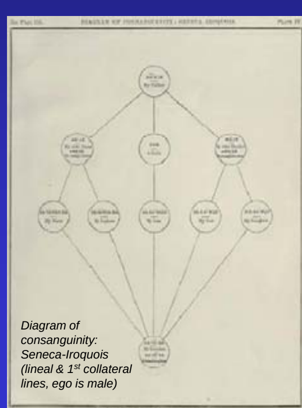
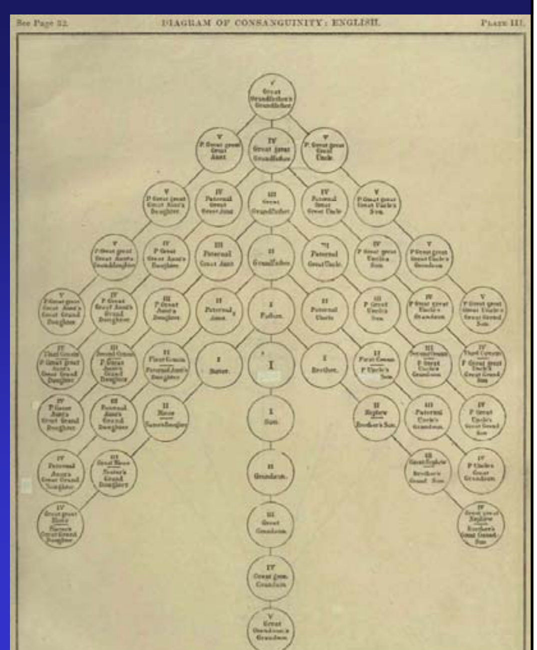


Diagram of consanguinity: Seneca-Iroquois (lineal & 1st collateral lines, ego is male)



A Little network Visualization History
Promising Foundations

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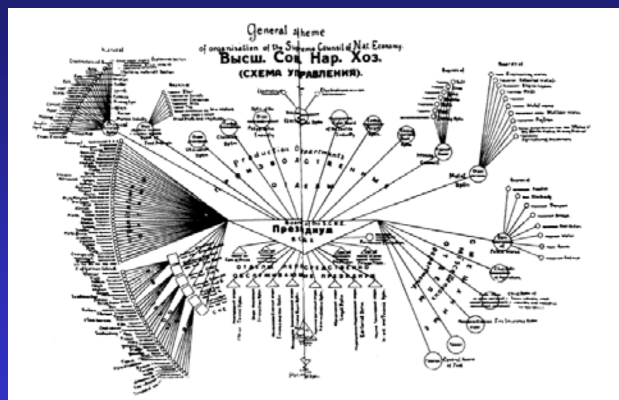
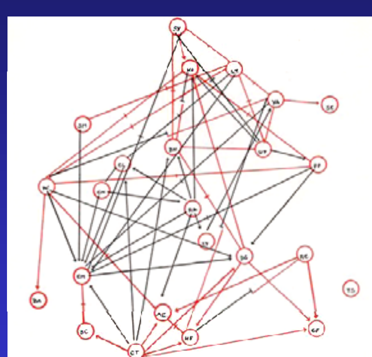


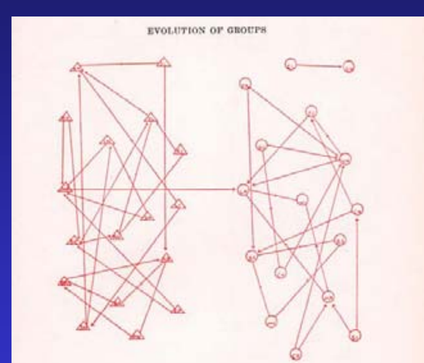
FIG. 3.—General scheme of organization of the Supreme Council of National Economy. From *The Russian Economist*, January 1921.

Or early representations of organizational relations (1921)

A Little network Visualization History
Promising Foundations

The study of networks has depended on a visual thinking since the beginning:





..but Moreno's sociograms from *Who Shall Survive* (1934) were something special. They ignited a wave of research that was to fundamentally transform social science.

A Little network Visualization History

Promising Foundations

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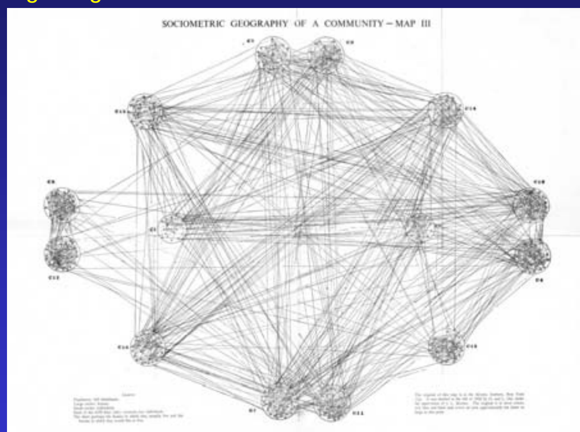
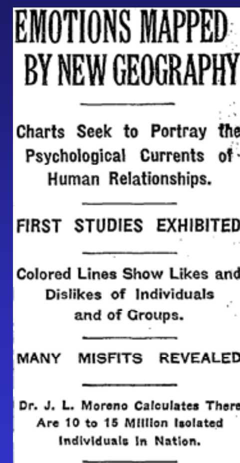




EMOTIONS MAPPED BY NEW GEOGRAPHY

Charts Seek to Portray the Psychological Currents of Human Relationships.

FIRST STUDIES EXHIBITED

Colored Lines Show Likes and Dislikes of Individuals and of Groups.

MANY MISFITS REVEALED

Dr. J. L. Moreno Calculates There Are 10 to 15 Million Isolated Individuals In Nation.

With a full write-up of the 1934 medical conference in the *New York Times**, his work sparked wide interest….

*He claims it was covered in "all the major papers" but I can't find any other clips…

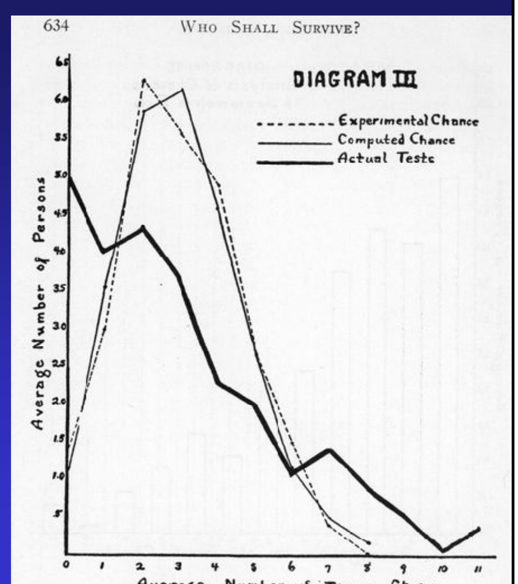
A Little network Visualization History

Promising Foundations

The study of networks has depended on a visual thinking since the beginning:

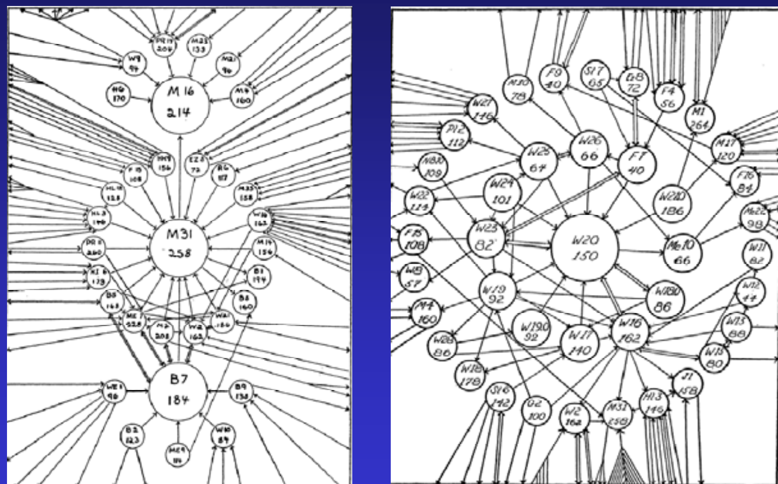
The first power-law?

The book includes this clear demonstration that the degree distribution differed from random expectation.



A Little network Visualization History
Promising Foundations

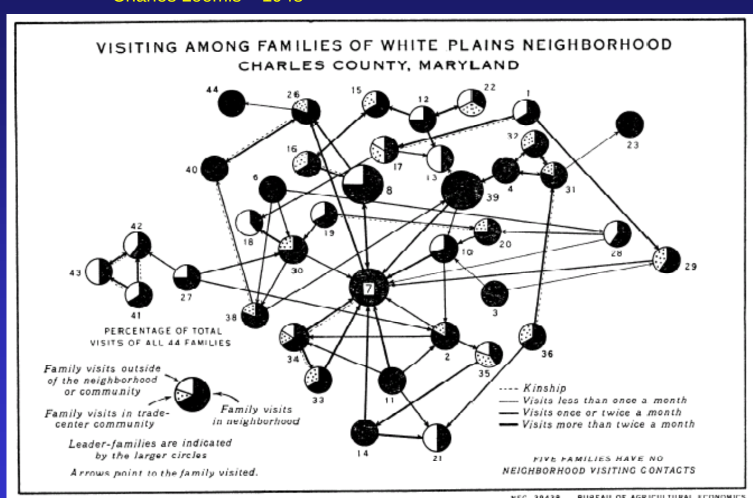
Lundberg & Steel 1938 – Using a "Social Atom" representation



Moreno's idea was quickly taken up in community studies, as the social analog to "atoms" in physics….

A Little network Visualization History
Promising Foundations

Charles Loomis – 1948



The sophistication included layering of information…here using size, position, and a pie-chart to tap multiple variables in addition to network structure.

A Little network Visualization History
From Art to Science…

Northaway's – "Target Sociograms"

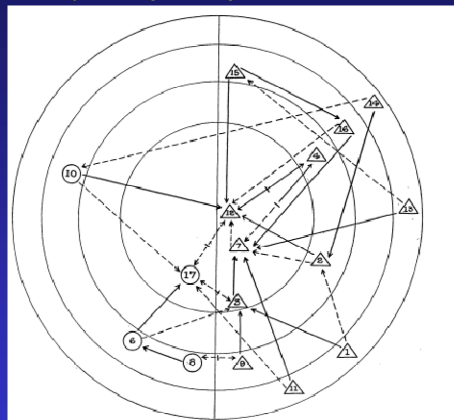


FIG. B.—SOCIOGRAM

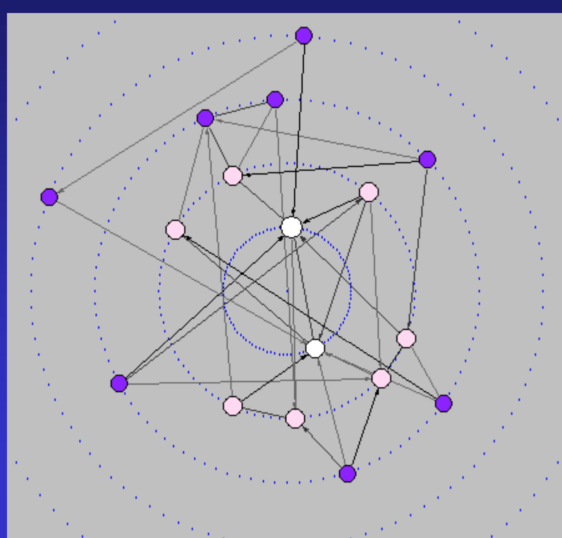
For a Third Grade Group

Criterion: Luncheon preference

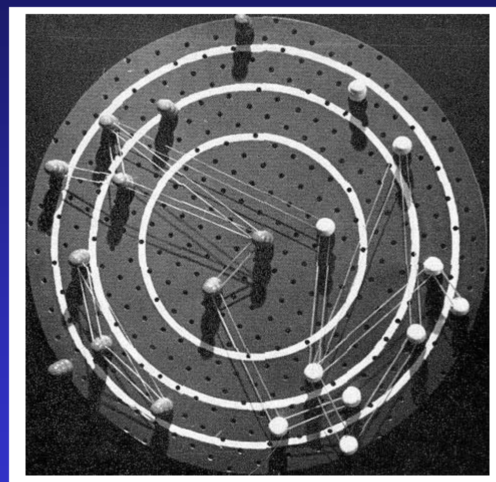
Researchers increasingly sought ways move from artistic production to science -- The "target" sociogram was an early example.

A Little network Visualization History
From Art to Science…

What's old is new? Pajek's fixed circular grid layout:



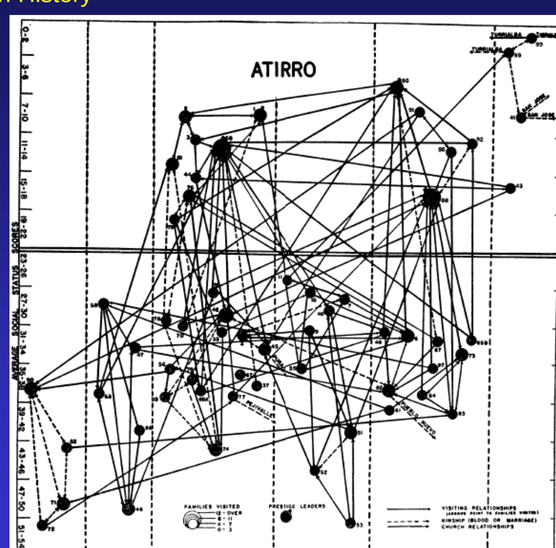
A Little network Visualization History
From Art to Science…



..complete with “hardware” to help in the construction!

A Little network Visualization History
From Art to Science…

Another attempt at regularization: add meaning to the y and x axes (here social status and “group” respectively).

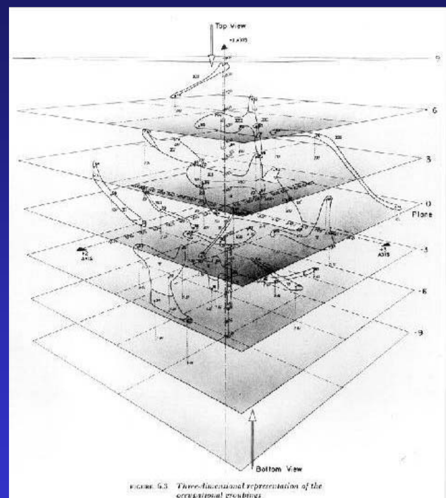


Loomis & McKinney, 1956, AJS

Attempts at generalizing dimensional meaning start to get muddy as the figures no longer carry an intuitive connectivity pattern.

A Little network Visualization History
From Art to Science…

But these attempts quickly become challenges to parsimony, as we move beyond 2 dimensions…

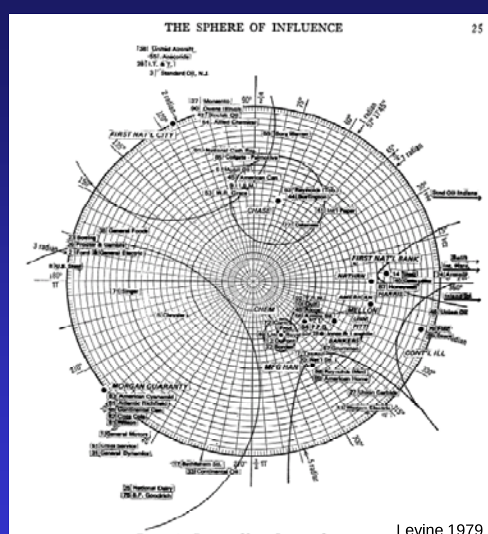


Lauman & Guttman, 1968

Attempts were also made to expand the number of dimensions, building on the development of multiple approaches to dimension reduction.

A Little network Visualization History
From Art to Science…

…and moves out of simple Cartesian space.



Levine 1979

The flow of images continued over time, marking a wide range of potential styles….

A Little network Visualization History

The space-bending challenge is made clear in modern attempts at mapping large-scale networks…

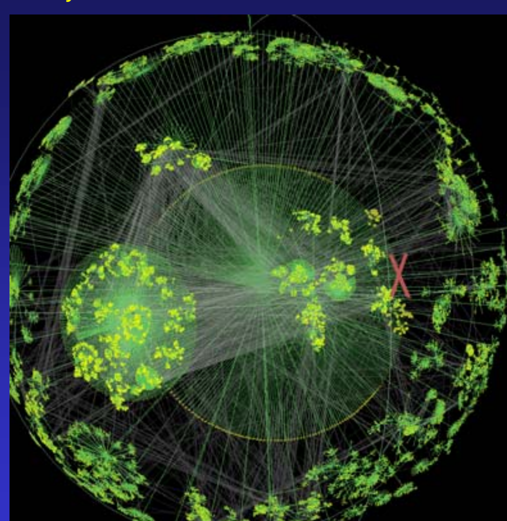
Credit: Matthew Hurst

The flow of images continued over time, marking a wide range of potential styles.

A Little network Visualization History

From Art to Science…

The space-bending challenge is made clear in modern attempts at mapping large-scale networks…



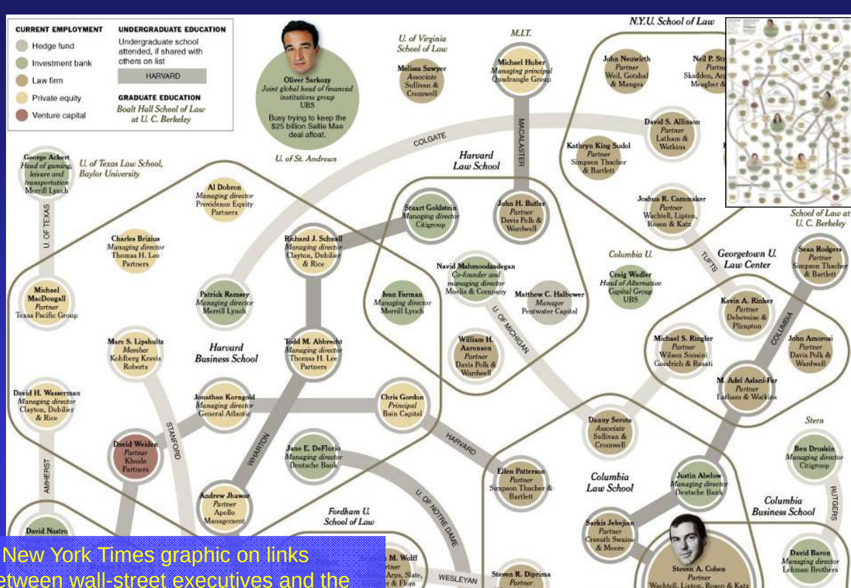
Walrus
(Tamara Munzer & Caida)

The flow of images continued over time, marking a wide range of potential styles.

A Little network Visualization History
From Science to Silly…

Sadly, we are now starting to see caricatures of “network” images everywhere:

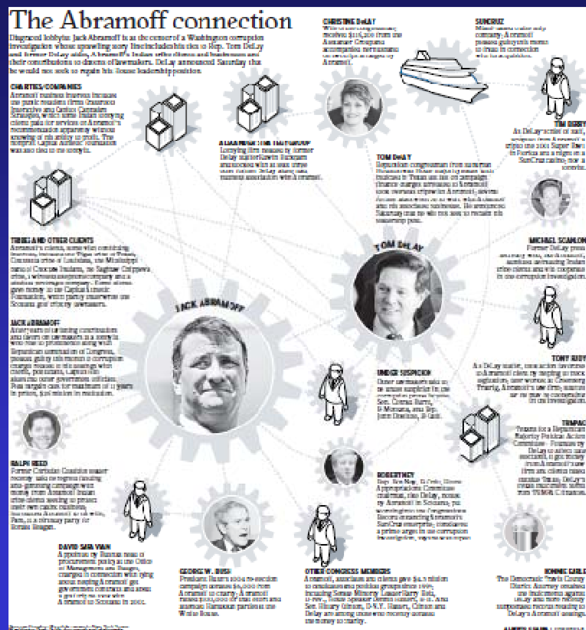
A Little network Visualization History
From Science to Silly…



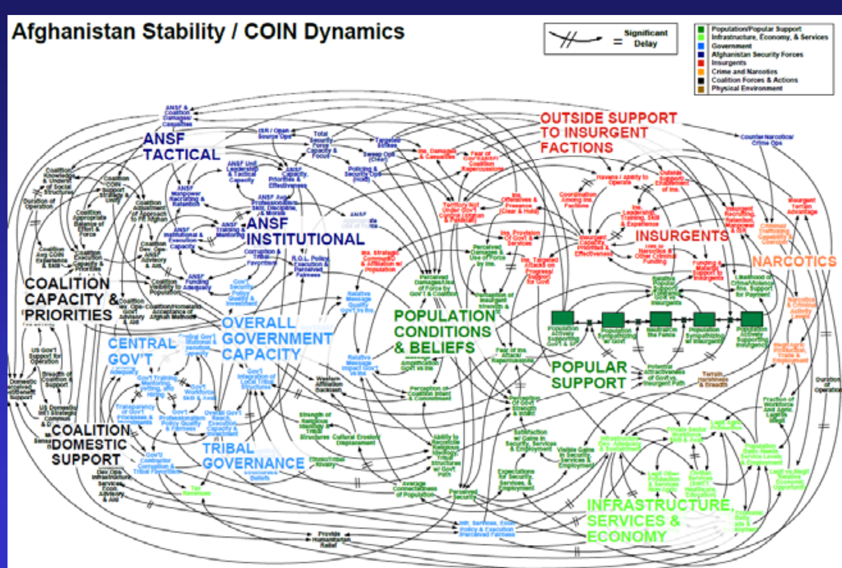
A New York Times graphic on links between wall-street executives and the business school they attended…

A Little network Visualization History
From Science to Silly…

…Or conspiracy models for disgraced politicians…



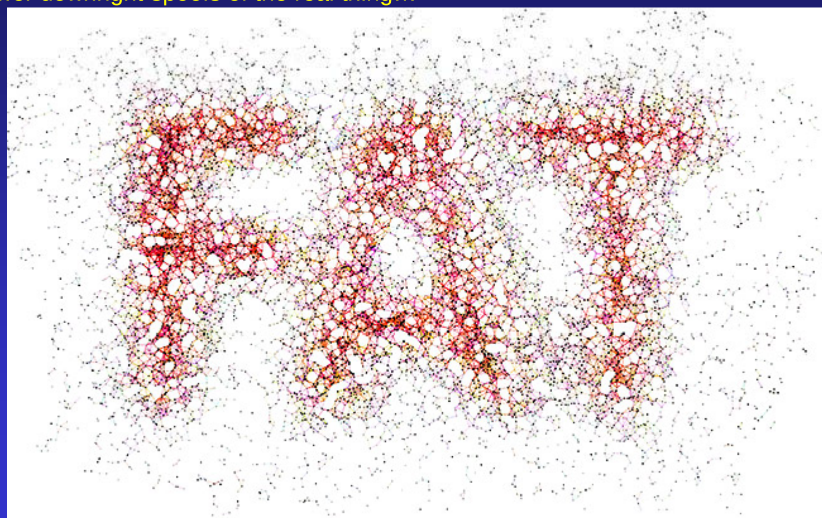
A Little network Visualization History
From Science to Silly…



From silly, to dangerous: the "causal model" network for the Afghan conflict

A Little network Visualization History
From Science to Silly…

…or downright spoofs of the real thing…



A Little network Visualization History
From Science to Silly…

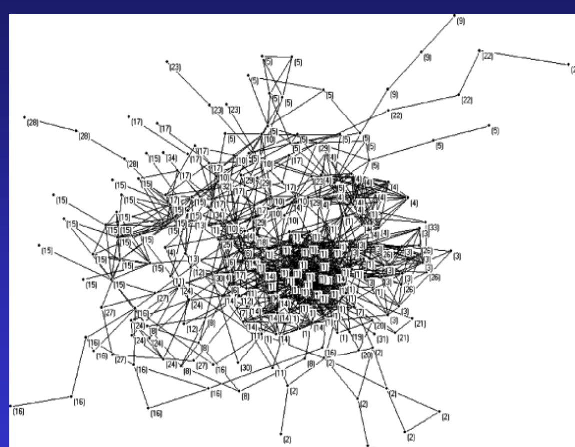
Lest we think only journalist do things with marginal scientific / information value….many (most?) published network images are information thin.

Such images often provide extremely little information; and the information one can derive from the image is often wrongly-weighted.

Our challenge today is two-fold:

a) What is it about visual representations that seem so important to network studies?
b) How do we do it well?

Science, Art or Craft?



A Little network Visualization History
Lessons from history?

The historic reliance on imagery is clear in Moreno's work:

"If we ever get to the point of charting a whole city or a whole nation, we would have … a picture of a vast solar system of intangible structures, powerfully influencing conduct, as gravitation does in space. Such an invisible structure underlies society and has its influence in determining the conduct of society as a whole."
J.L. Moreno, *New York Times*, April 13, 1933

We literally make the invisible visible. Part of the captivation of network science is the ability to see into a world that is otherwise extremely difficult to wrap our heads around.

A Little network Visualization History
Lessons from history?

Seeing is believing….

A Little network Visualization History
Lessons from history?

…but our eyes can be deceived!


Communication Challenges in Network Visualization
Types of problems

So what distinguishes a scientifically *effective* visualization?

•*Basic quantitative visualization craft:* ("style" or "rhetoric")

•Simple principles of graphic design as per Tufte:

-Clarity, scaling, layering of information, avoiding "chartjunk", effective use of color, and so forth.

- Challenge here mirrors cartography: how much information can one effectively *layer* into a network diagram?

This is hard to do well, and even harder to automate, and thus requires an active craft hand in graphic production.

Communication Challenges in Network Visualization

Types of problems

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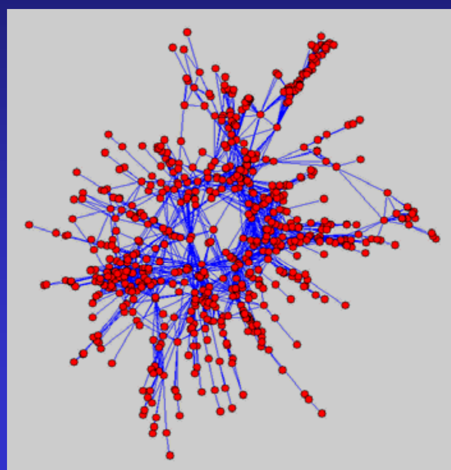
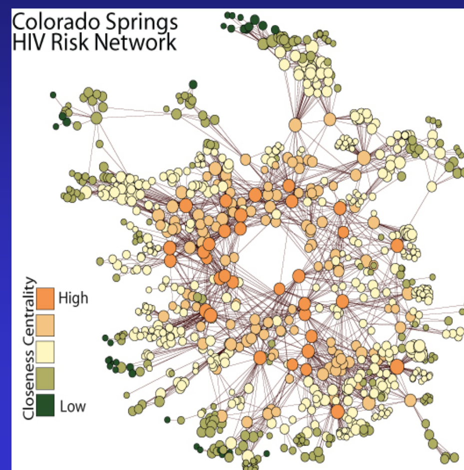


Before



After

Communication Challenges in Network Visualization

Types of problems

So what distinguishes a scientifically *effective* visualization?

•*Network Specific graphic problem:* Which social space?

•Example:

Networks to represent social space, but:

•Simple space is rarely accurate, so *how best to distort?*

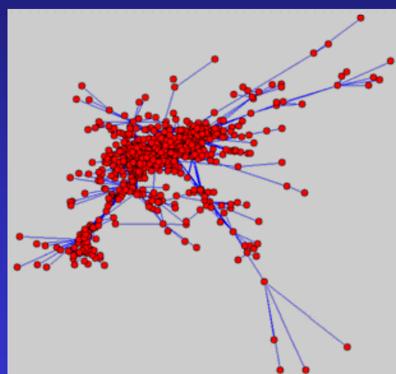
•How many dimensions are relevant?

•Do the dimensions *mean* anything?

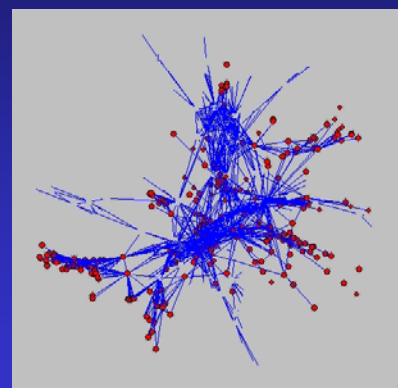
Communication Challenges in Network Visualization
Types of problems

So what distinguishes a scientifically *effective* visualization?

Network specific graphic problem: which social space?



First two eigenvectors



3d force-directed

Communication Challenges in Network Visualization
Types of problems

So what distinguishes a scientifically *effective* visualization?

•*Network Specific graphic problem:* Multidimensional data structure requires element selection.

•For example:

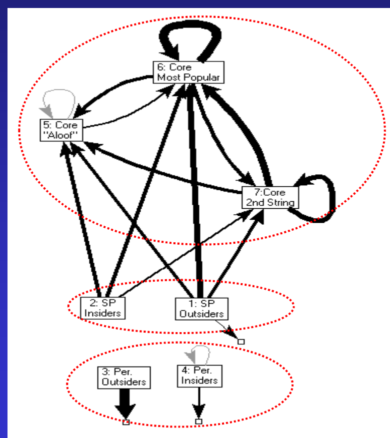
Global patterns or local positions

- •Are we trying to show the distinctiveness of nodes or the general topology of the network?

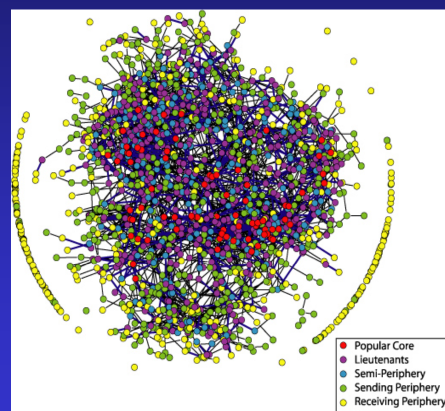
Communication Challenges in Network Visualization
Lessons from history?

So what distinguishes a scientifically *effective* visualization?

•*Network specific graphic problem:* Local or Global?



Reduced Block-Model

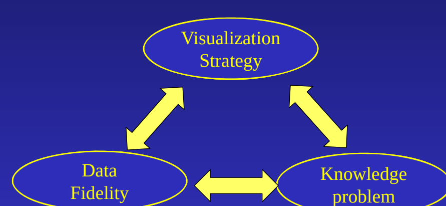


Labeled Sociogram

Communication Challenges in Network Visualization
Types of problems

So what distinguishes a scientifically *effective* visualization?

•*Network Specific graphic problems:*
- •*Model for social space*
- •*Resolution (local or global)*
- •*Multiple relations*
- •*Dynamics*
- •*Density*
- •*Node-level attributes*
- •*Edge-level attributes*
- •*Hierarchical ordering*
- •*Diffusion Potential*
- •*Exploration or communication*



There is a set of basic tradeoffs made with every visualization between data, the research problem, and the final image, which can challenge our basic instincts as scientists, *since we may have to make stuff up or throw away data.*

What makes a good visualization?

The simplest answer is that an image should *clearly* communicate something that we would have difficulty knowing any other way:

This includes:

Information & Communication:

- Helping *build intuition* about the social process generating the network
- Succinctly capturing *high-dimensional* properties of the network
- Being *worth the space*– the information content of the image needs to reward deeper inspection
- *Beauty* – powerful graphs are mesmerizing

What makes a good visualization?

The simplest answer is that an image should *clearly* communicate something that we would have difficulty knowing any other way:

This includes:

Science:

- Ability to *replicate* results – same data should produce same picture
- *Quantification* – most features evident from a graph should be translatable to a measurement of the graph (though this may not be initially evident)
- *Theory-relevant*: either gives us something new to theorize about or is useful as a theory-building device itself.

This probably implies a move toward problem-specific families of visualizations.

Why Visualize Network at all?

Insights from scatter plots

While the history is deeply rooted in visual analysis, why bother? If we have good metrics, why not use them instead?

X	y1	y2	y3
4	4.26	3.1	5.39
5	5.68	4.74	5.73
6	7.24	6.13	6.08
7	4.82	7.26	6.42
8	6.95	8.14	6.77
9	8.81	8.77	7.11
10	8.04	9.14	7.46
11	8.33	9.26	7.81
12	10.84	9.13	8.15
13	7.58	8.74	12.74
14	9.96	8.1	8.84

These 3 series seem very similar, when viewed statistically:

N=11
Mean of Y = 7.5
Regression Equation: Y = 3 + .5(X)
SE of slope estimate: 0.118, T=4.24
Sum of Squares $(X-\bar{X})$: 110
Regression SS: 27.5
Correlation Coeff: 0.82

Why Visualize Network at all?

Insights from scatter plots

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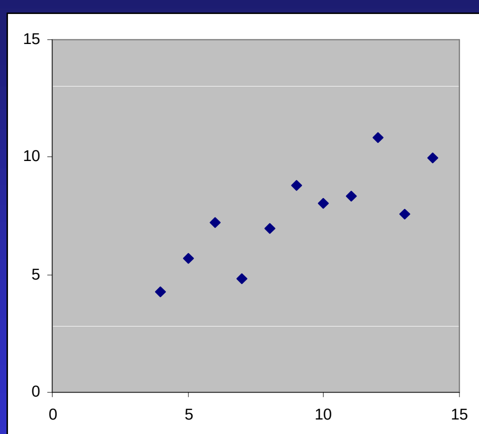
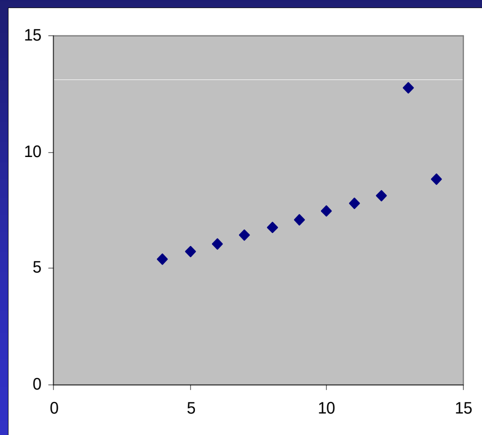


And given these statistics, we expect a relation something like this – a strong correlation with "random" error.

Why Visualize Network at all?
Insights from scatter plots

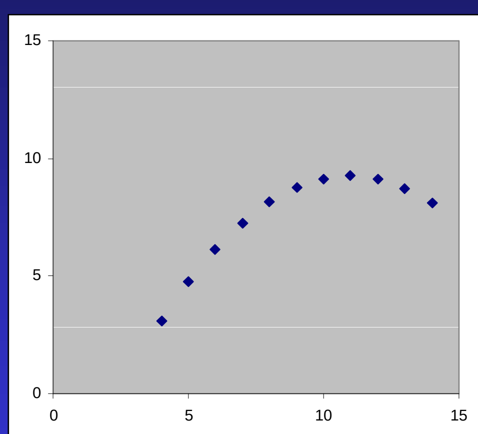
While the history is deeply rooted in visual analysis, why bother? If we have good metrics, why not use them instead?



..but this would also fit…

Why Visualize Network at all?
Insights from scatter plots

While the history is deeply rooted in visual analysis, why bother? If we have good metrics, why not use them instead?

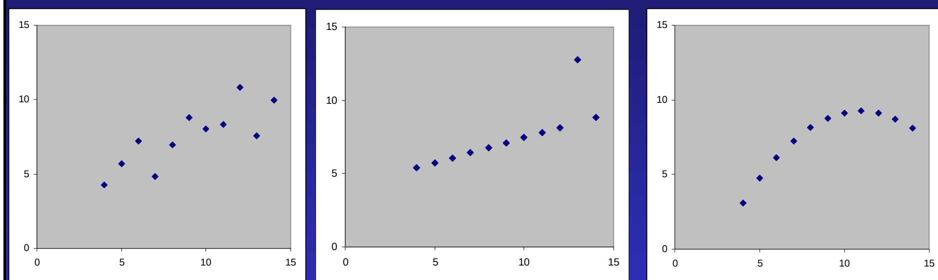


…or this…

Or many more.

Why Visualize Network at all?
Insights from scatter plots

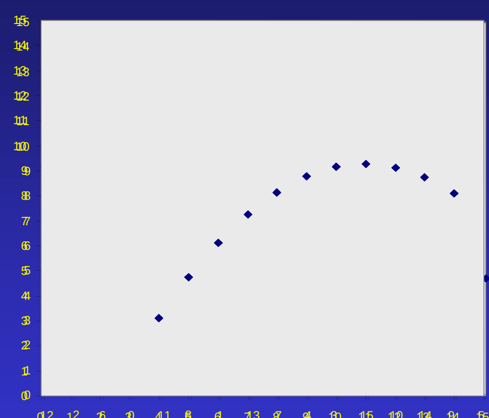
While the history is deeply rooted in visual analysis, why bother? If we have good metrics, why not use them instead?



Visualization allows you to see the relations among elements "in the whole" – a complete macro-vision of your data in ways that summary statistics cannot. This is largely because a good summary statistic captures a single dimension, while visualization allows us to layer dimensionality and relations among them.

Why Visualize Network at all?
Insights from scatter plots

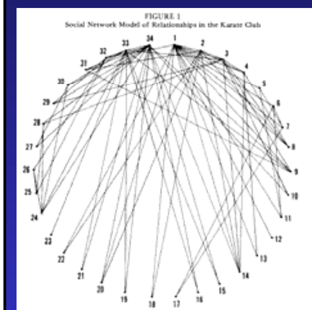
But consider changing a key assumption of the scatter-plot: the scaled ordering of the axes.



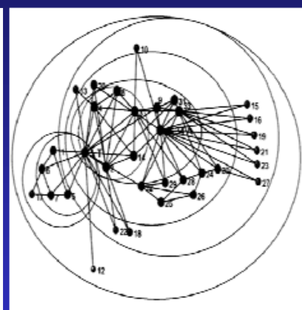
Technically, all the information is retained - one could reconstruct the data pairs from both images – but the re-ordered panel provides no *additional* information.

Why Visualize Network at all?
Insights from scatter plots

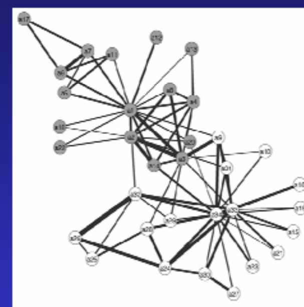
3 representations of the same data



Original



White & Harary, 2001



Kolaczyk, Eric D., Chua, David B., Barthélemy, Marc (2009)

The exact same data, presented *in press* in distinct ways. We'd never see this with a scatter plot.

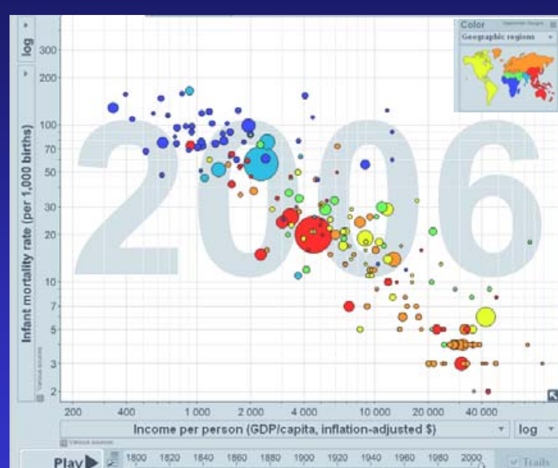
Why Visualize Network at all?
Insights from scatter plots

Scatter plots are good models for network imagery:

- Multiple dimensions
- Layered information
- Global patterns with local detail
- Shape matters

Fails as a model in a key respect: *The coordinate space is rigid.*

The reason to visualize is that we discover elements we didn't already know, and can communicate it effectively.



Gapminder

Why Visualize Network at all?
Problem summary

Benefits to network graphics
- Make visible the invisible
  - → give a sense of reality to unobserved features
  - → Can be truly beautiful (when well done), capturing audience imaginations
  - → Can communicate complex features quickly
- provide multi-dimensional insights into setting processes
  - → Metrics capture a single dimension
  - → We care about the *shape* of related entities
  - → Help us contextualize and make sense of the metrics we calculate
- Help us think by organizing, arranging and abstracting generals from particulars
  - → Networks are *already* massive abstractions – removing qualitative micro-detail to capture interconnectivity
  - → ..but we often need to abstract further to identify elements we care about.

Why Visualize Network at all?
Problem summary

Challenges:
- No consistent or obvious display frame
  - → Arrangement guided by heuristic principles, which may not be consistent with each other
  - → an inability to judge the “fit” of an image to the data and small hopes of replication
- Too much information
  - → We have multiple levels (node, edge, community, network) and multiple characteristics at each level → necessitates “denying the data” in favor of insights, *building the theory into the image*
- Scale:
  - → “Magnitude” – Size of the network makes standard approaches slow, and likely not useful even when fast
  - → “Temporal Scale” – how to bind discrete occurrences to generate a structure from particulars

What makes a good visualization?
Solutions

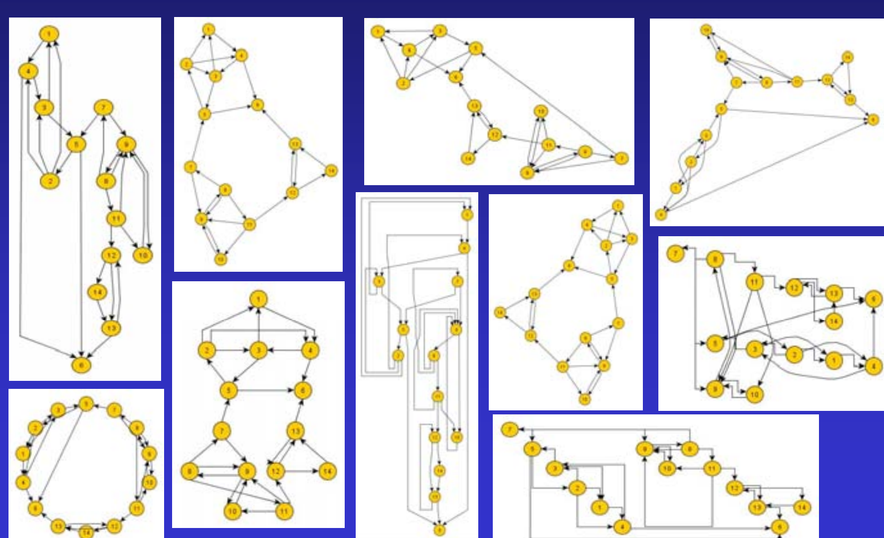
These problems feed an entire field of graph-visualization heuristics; guides to tell computers how "best" to arrange points, which focus on:

- Even node distribution
- Consistent edge lengths
- Avoid line crossing
- Emphasize symmetry
- Maximize edge-edge angles
- Avoid lines passing over nodes
- Avoid node overlaps
- And many many more…

Auto layouts have two conflicting problems to solve:
(a) finding a good layout and
(b) finding it quickly.

What makes a good visualization?

Unlike a scatter-plot, the default layout styles of most off-the-shelf programs will lead to very different layouts:



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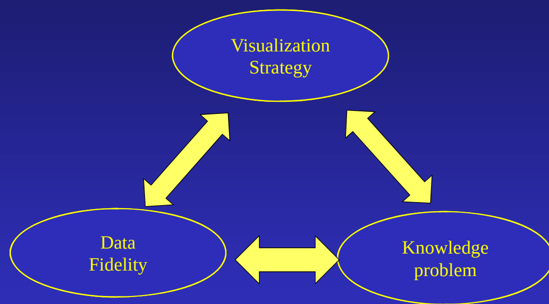


Visualization as craft: My instinct is that hard-and-fast rules will be difficult to find, craft production is thus a better model than either art (too expressive) or technical drawing (too rigid).

Let's work through some exemplars and see how they balanced these trades

Build theory into the visualization

The scientists first rule is to never interfere with data – but this is probably exactly what is needed for (social?) network science.

Consider as a good example, Ken Frank's drawing program:

The "raw" network is distorted by emphasizing within-group ties. This is then highlighted by edge-patterns (solid or dotted) and group boundaries.

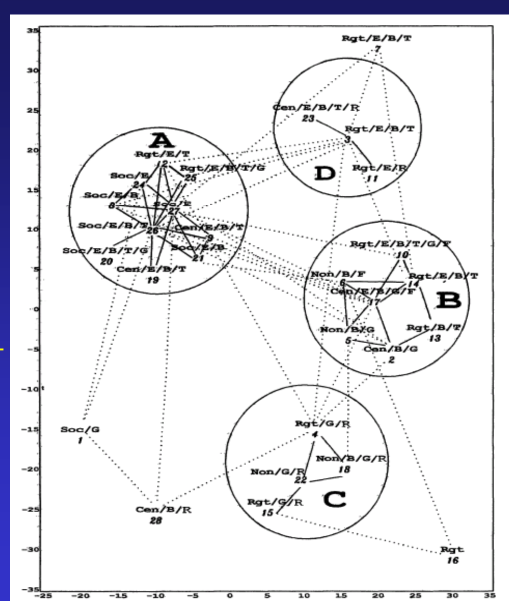


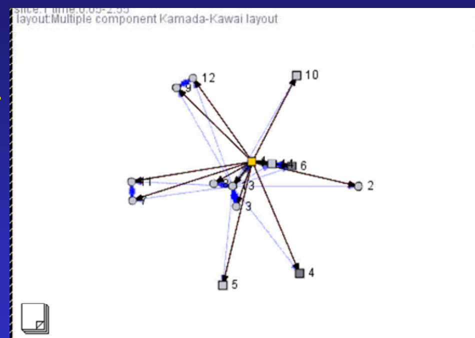
FIG. 1.—Crystallized sociogram: friendships among the French financial elite

Group-weighted MDS

Build theory into the visualization

The scientists first rule is to never interfere with data – but this is probably exactly what is needed for (social?) network science.

Or the dynamic visualizations of McFarland's school classrooms.



Black ties: Teaching relevant communication
Blue ties: Positive social communications
Red ties: Negative social communication

Source: Moody, James, Daniel A. McFarland and Skye Bender-DeMoll (2005) "Dynamic Network Visualization: Methods for Meaning with Longitudinal Network Movies" *American Journal of Sociology* 110:1206-1241

Build theory into the visualization

The same data produce different impressions if you change the observation window.

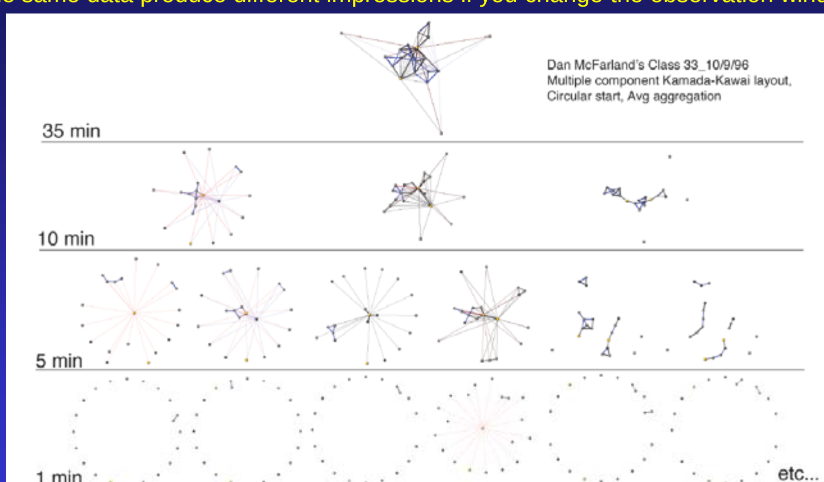


Figure 1. Interaction data from McFarland's classroom observations viewed at various levels of time aggregation from 35 minutes (one entire class period) to 1 minute (two to three turns of interaction).

Source: Bender-deMoll & McFarland "The Art and Science of Dynamic Network Visualization" JoSS *2006*

Build theory into the visualization

The scientists second rule has to be to look for regularity and exploit that for theory. Consider as a good example, Harrison White's Kinship model:

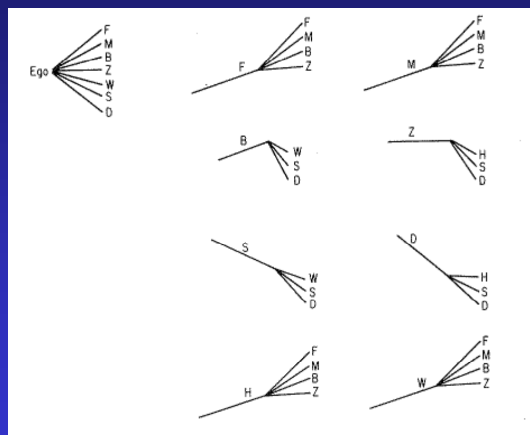


Fig. 1.1. Branching rules for a tree of kin roles familiar to Western minds.

Build theory into the visualization

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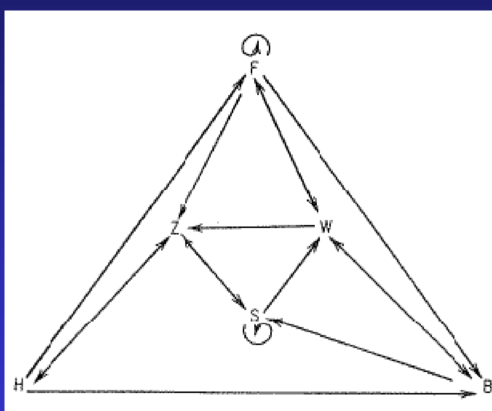
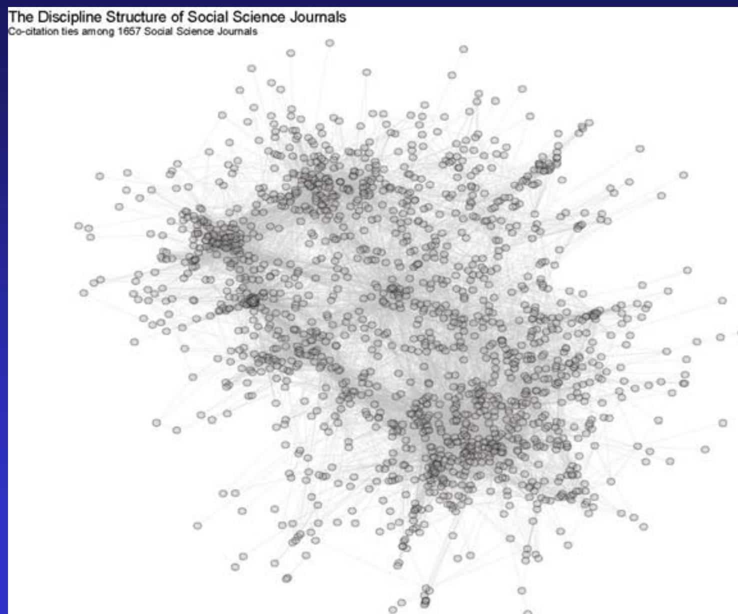


Fig. 1.2. Structure diagram for kinship role tree.

A powerful reduction of complexity; but at the cost of a particular perspective: Mom = Father's Wife, for example.

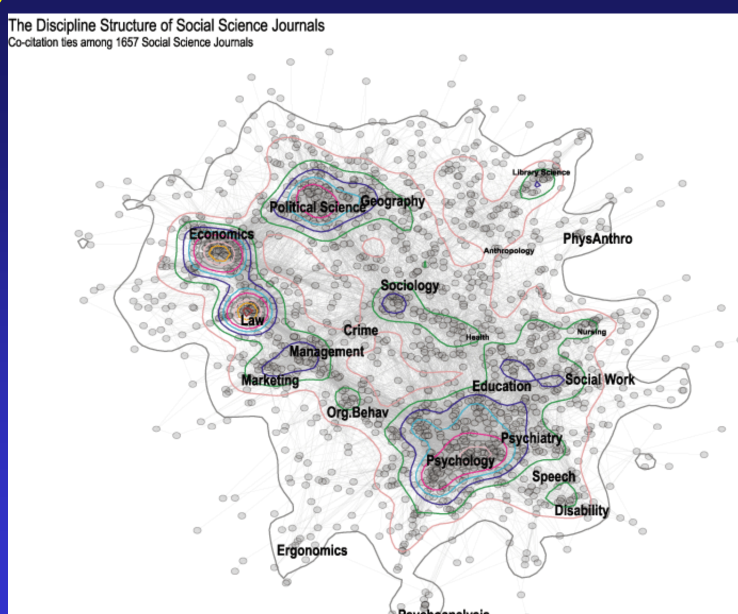
Build theory into the visualization

Abstraction helps – consider larger networks



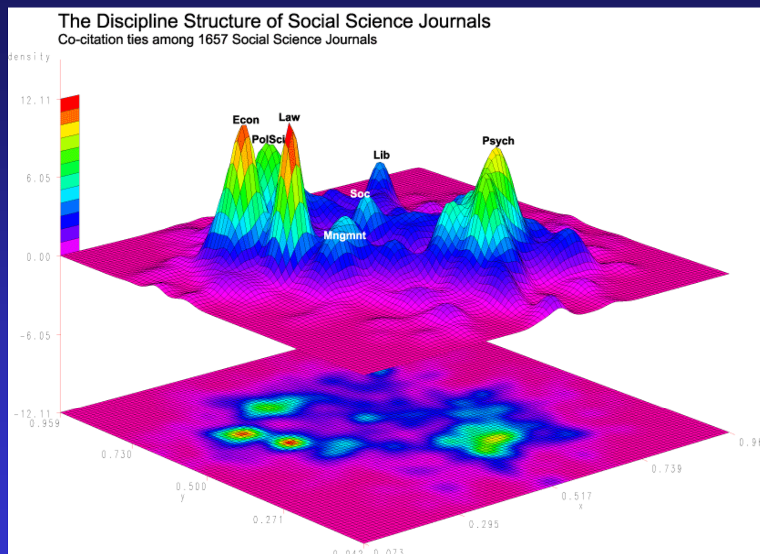
Building theory into the visualization

Abstraction helps – consider larger networks



Build theory into the visualization

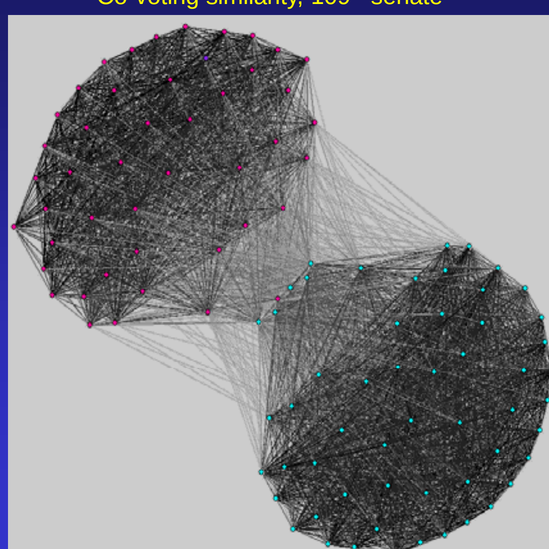
Abstraction helps – consider larger networks



Building theory into the visualization

Abstraction helps – consider dense networks

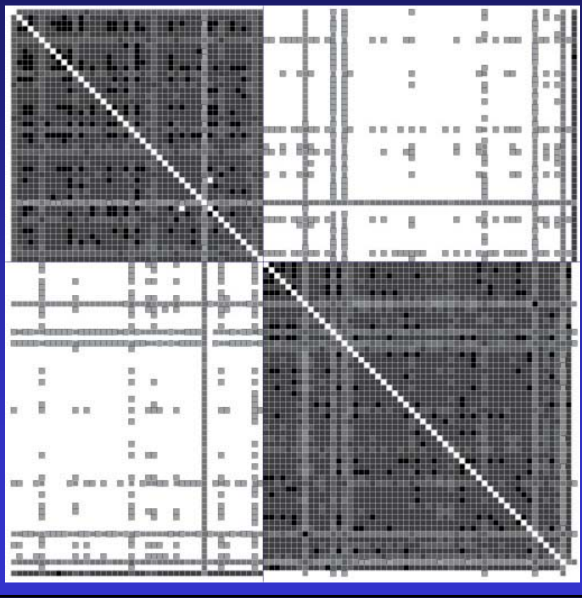
Co-voting similarity, 109th senate



Building theory into the visualization

Abstraction helps – consider dense networks –

Co-voting similarity, 109th senate



Simplify the problem: Identify strategies appropriate for problems

1. What are the best ways to visualize network diffusion?

1) Find the problem: network diffusion covers at least 4 key events:
   - *Global: Spread* over the population
   - *Local:* Distinguishing who passes among those who could pass.
   - Dynamics 1: Population saturation – time to spread
   - Dynamics 2: Dynamic network substrate – changing networks

2) Seek Clarity
   - the more text needed to explain a figure, the less useful they are.
   - For diffusion, this often means privileging the display of transmission over non-transmission.

Simplify the problem: Identify strategies appropriate for specific problems

1. What are the best ways to visualize network diffusion?

3) Layer *relevant* information

- Use color, size, arrangement, to build data-rich images. They should communicate a key point immediately, but reward repeated study.

- For diffusion studies, this means finding ways to embed the theory-relevant information into the image.

4a) Balance replication…

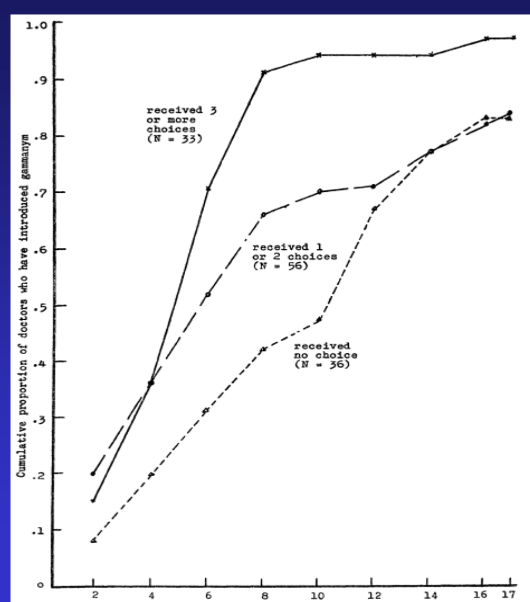
- Two users with the same data should get the same result, as it is, using the same program twice can give you different results…

4b) …against unthinking adherence to the heuristic solution.

- The algorithm rarely gets it right the first time

Diffusion Problems: Global/Local traces

The traditional network diffusion image is the logistic curve. Consider Coleman, Katz and Menzel (1957):

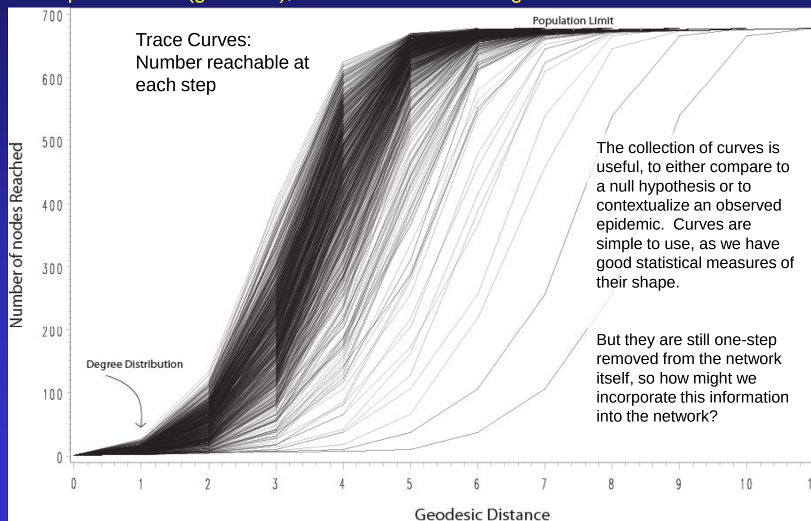


These curves count the cumulative number of "adopters" by time, but don't express much about network structure, because they aggregate across all transmissions.

That is, they show an aggregate outcome without really identifying a social process.

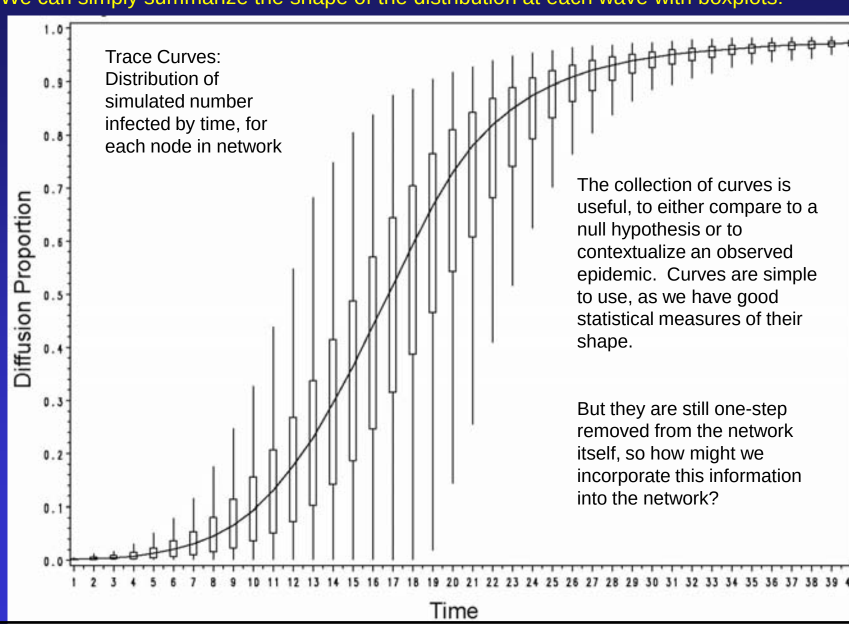
Diffusion Problems: Global/Local traces

An alternative is to think of a network trace as the likely number reached from any given node, where "likely" is determined either by an edge transmission p(transfer|dist) or simple distance (geodesic), and follow each starting node.



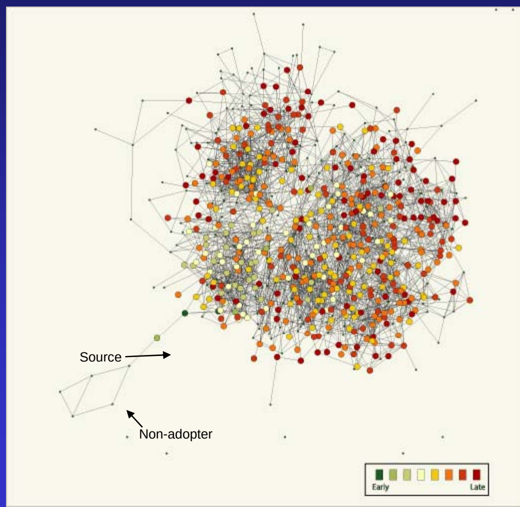
Diffusion Problems: Global/Local traces

We can simply summarize the shape of the distribution at each wave with boxplots:



Diffusion Problems: Global/Local traces

If your goal is to map an observed transmission process across a fixed network, node coloring can be effective.

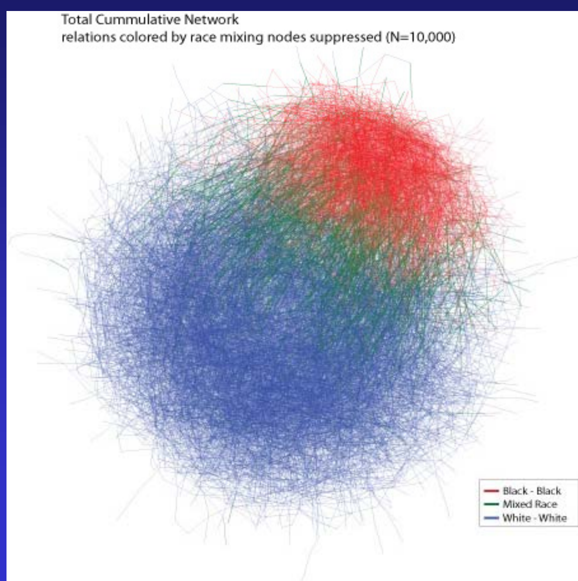


But is hard when the graph is not simple.

How might we capture the relevant aspects of diffusion in a network of >10,000 nodes?

Diffusion Problems: Putting transmission in context (social space)

Start with Context: First the network space, the field for potential diffusion



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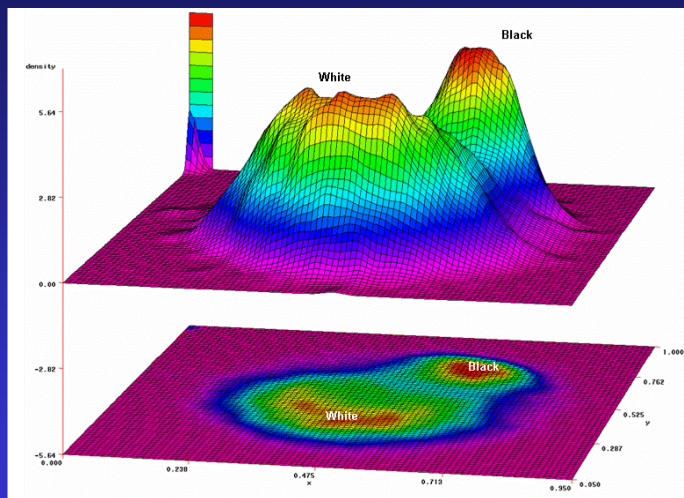
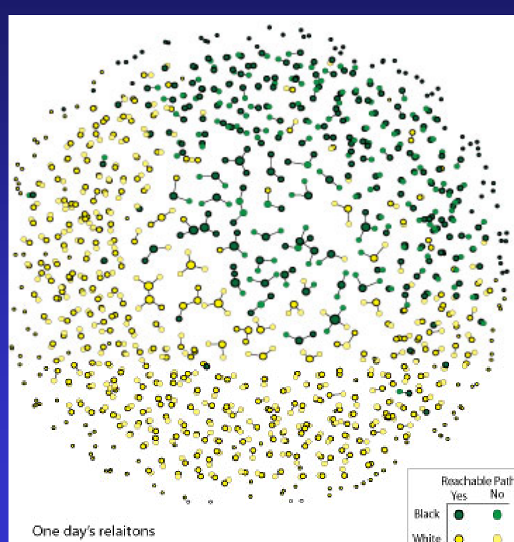


(alternative "contour sociogram" view)

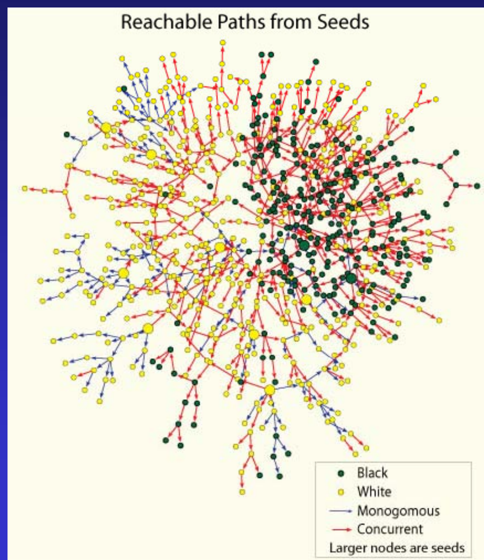
Diffusion Problems: Putting transmission in context (social space)

Start with Context: Next a snapshot of a single day (limited to time-relevant)



Diffusion Problems: Transmission sequence

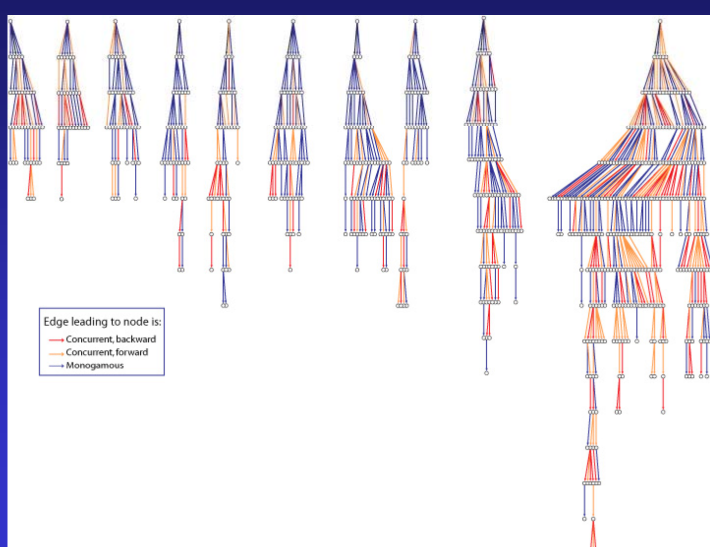
Start with Context: Now follow only the diffusion paths



Space-Based layout of the transmission flow; shows diffusion penetrates the full space, but little else…

Diffusion Problems: Transmission sequence

Start with Context: Now follow only the diffusion paths

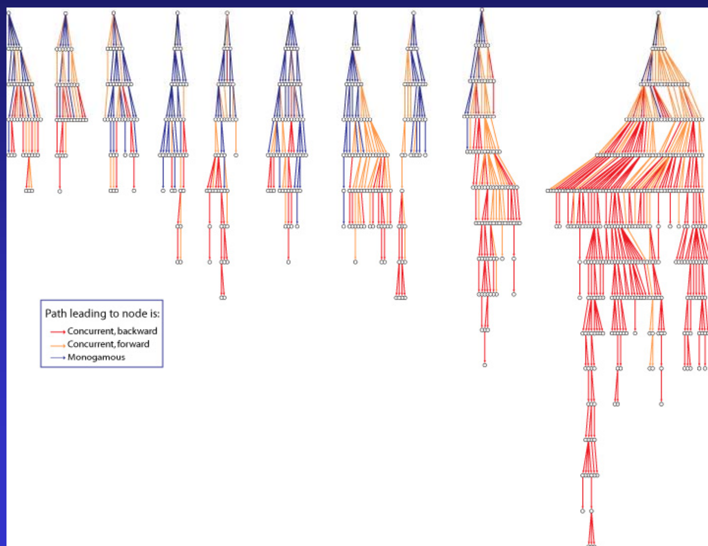


Tree Based Layout.

Since concurrency is an edge property, we color the edges by the concurrency status of the tie…

Diffusion Problems: Transmission sequence

Start with Context: Now follow only the diffusion paths



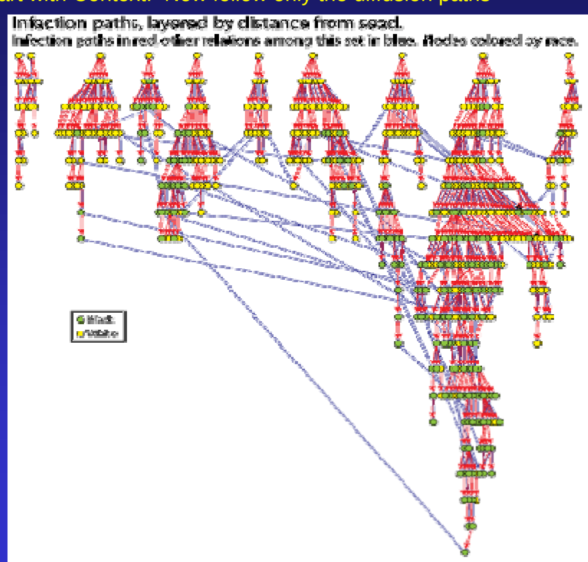
Tree Based Layout.

..but since the path carries the infection, we highlight the cumulative effect of concurrency by noting any place where a transmission would have been impossible were it not for an earlier concurrent edge.

This is one way to deal with the importance of network dynamics.

Diffusion Problems: Transmission sequence

Start with Context: Now follow only the diffusion paths

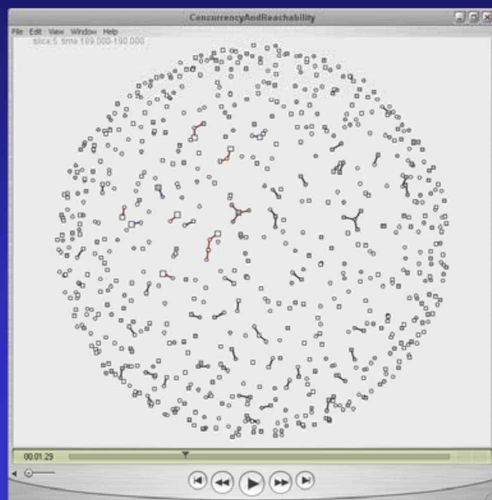


An alternative version, here including non-transmission edges amongst the transmission set.

An attempt to get both hierarchy and space click here:

Dynamic Display Problems: How do we capture network dynamics?

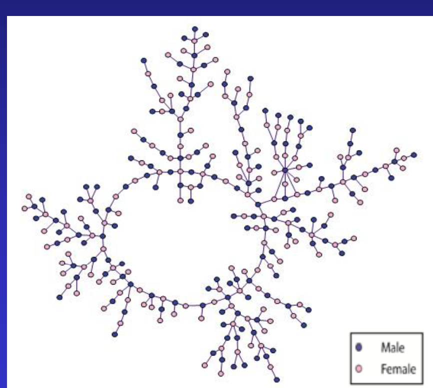
Network Movies: In the diffusion context, nicely shows the daily dynamics

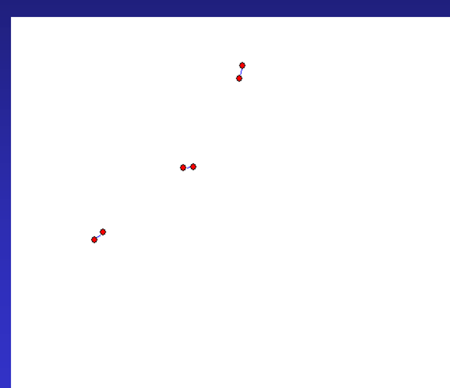


http://csde.washington.edu/statnet/movies/ConcurrencyAndReachability.mov

Dynamic Display Problems: How do we capture network dynamics?

Dynamics complicate the standard point-and-line representation, since you cannot really follow all “possible” paths:





Dynamic Display Problems:

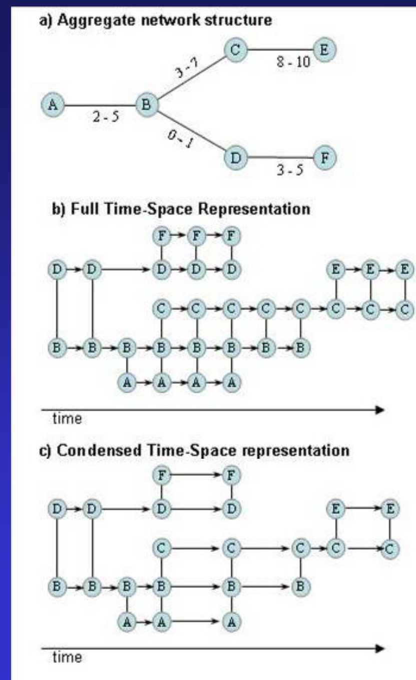
Temporal projections of “net-time”

Time-Space graph representations
“Stack” a dynamic network in time, compiling all “node-time” and “edge-time” events (similar to an event-history compilation of individual level data).

Consider an example:

a) Repeat contemporary ties at each time observation, linked by relational edges as they happen.

b) Between time slices, link nodes to later selves “*identity*” edges



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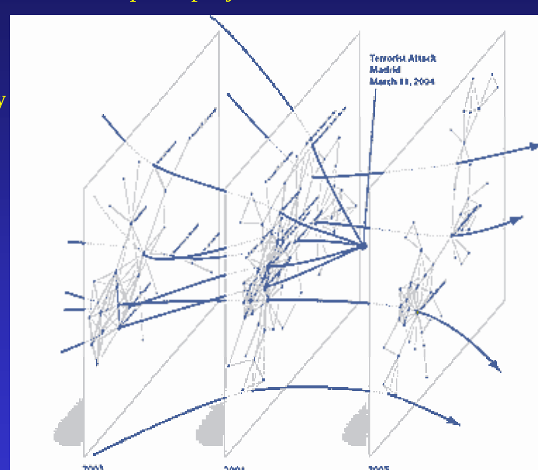

Example from Skye Bender-deMoll

Dynamic Display Problems:

Temporal projections of "net-time"

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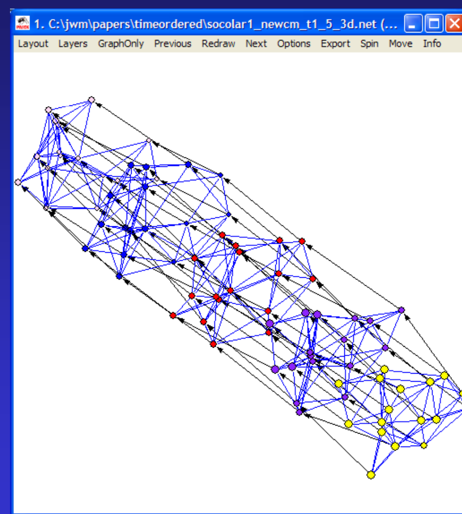
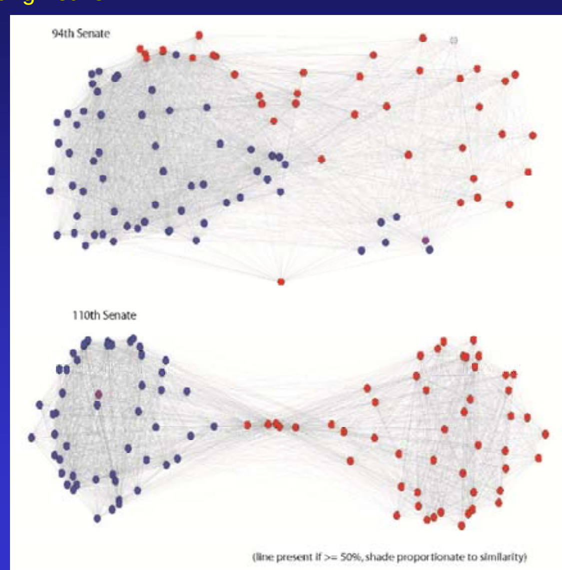


Problem II: Political Polarization

Consider again our senate voting network:

Network is simultaneously dense, (since every pair has some score) and dynamic, as the network evolves over time.



Problem II: Political Polarization

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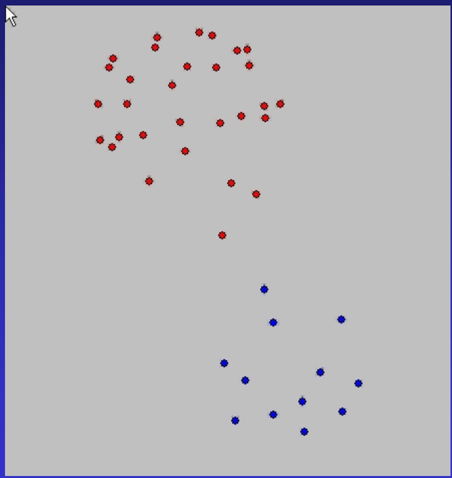
Network is <u>dense</u>, since every cell has some score and dynamic the pattern changes over time.



Problem II: Political Polarization

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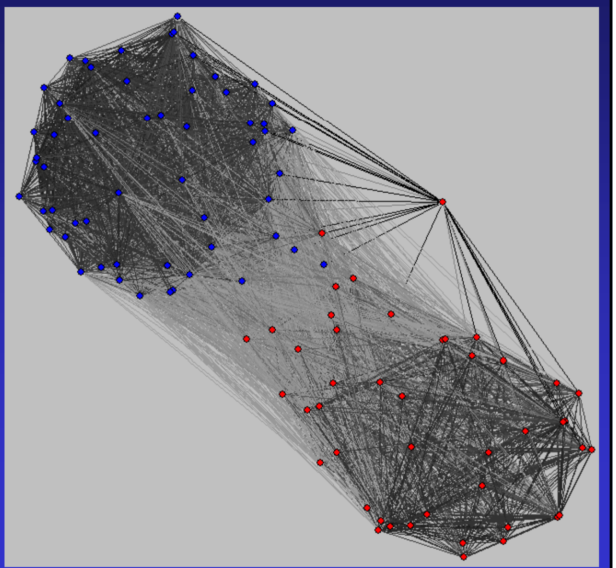
Network is <u>dense</u>, since every cell has some score and dynamic the pattern changes over time.

One problem is that many nodes are structurally equivalent, generating "duplicate" information.

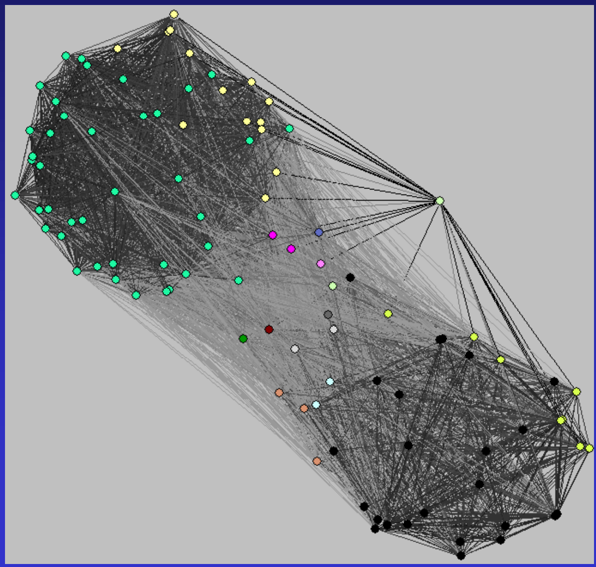


Problem II: Political Polarization

Consider again our senate voting network:

Network is dense, since every cell has some score and dynamic the pattern changes over time.

Color by structural equivalence…

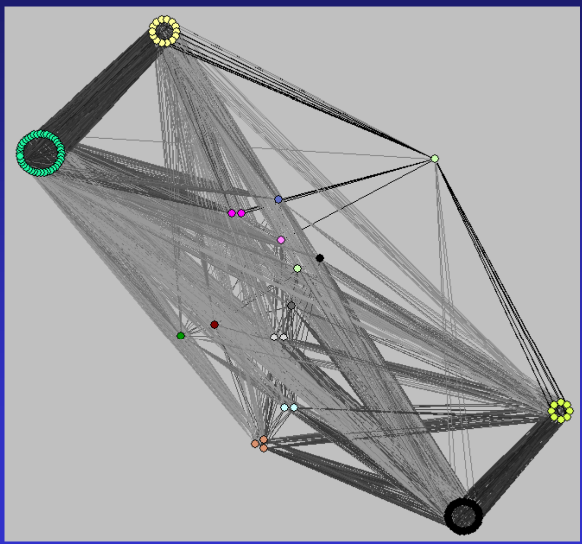


Problem II: Political Polarization

Consider again our senate voting network:

Network is dense, since every cell has some score and dynamic the pattern changes over time.

Adjust position to collapse SE positions.



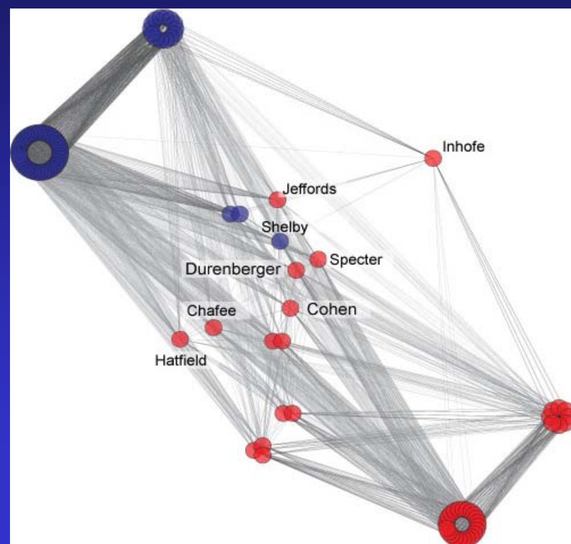
Problem II: Political Polarization

Consider again our senate voting network:

Network is dense, since every cell has some score and dynamic the pattern changes over time.

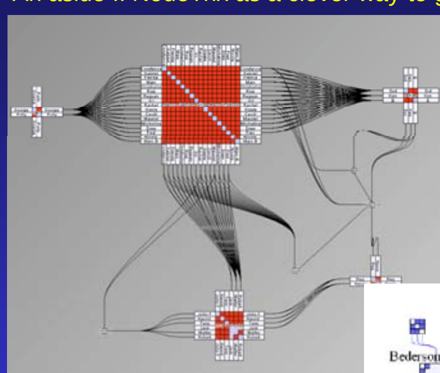
And then adjust color, line width, etc. for clarity.

While we've gone some distance with identifying relevant information from the mass, how do we account for time?



Problem II: Political Polarization

An aside I: NodeTrix as a clever way to get at position within nets:



By treating sub bits of the matrix as a graph, you retain more information.

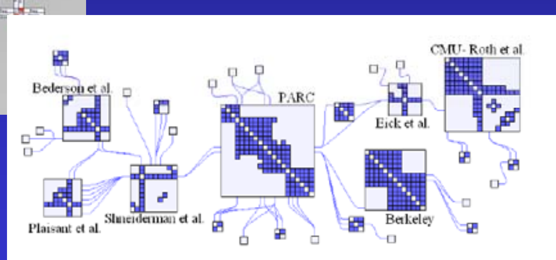
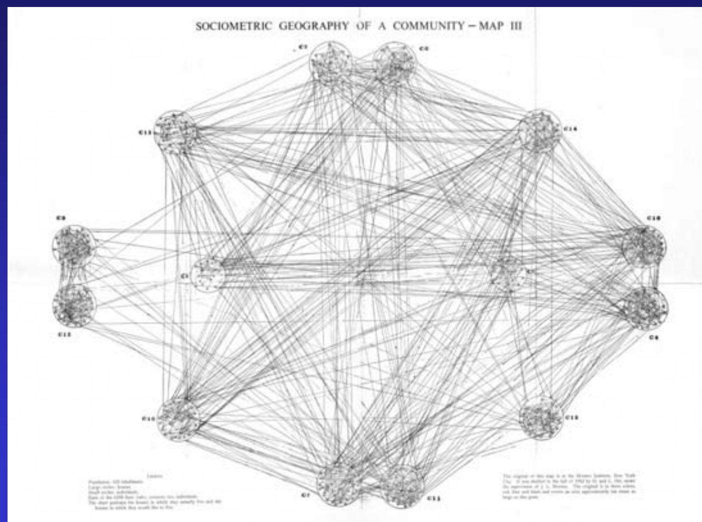


Fig. 1: NodeTrix Representation of the largest component of the Info-Vis Co-authorship Network

NodeTrix: a Hybrid Visualization [pdf]
Henry N., Fekete J-D. and McGuffin M.
@ IEEE Transactions on Computer Graphics and Visualization (Proceedings Visualization/Information Visualization 2007)

Problem II: Political Polarization

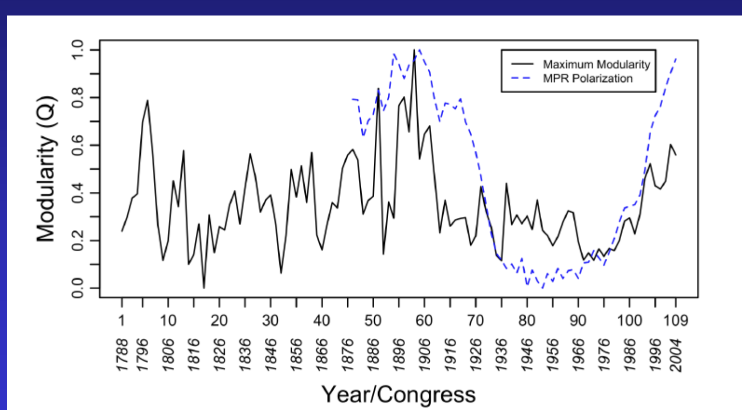
An aside II: This was also Moreno's idea in 1934…



Problem II: Political Polarization

Consider again our senate voting network:

The extent of political polarization has been increasing recently:

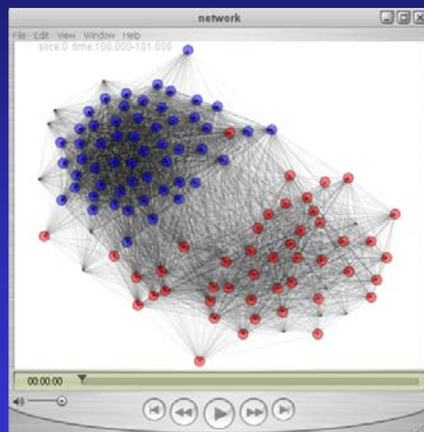


Party polarization in Congress: a social networks approach,
A. Waugh, L. Pei, J. H. Fowler, P. J. Mucha and M. A. Porter,

Problem II: Political Polarization

Consider again our senate voting network:

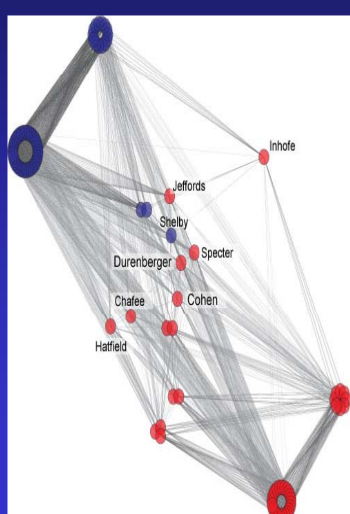
How to visualize this dynamically? Try a movie:

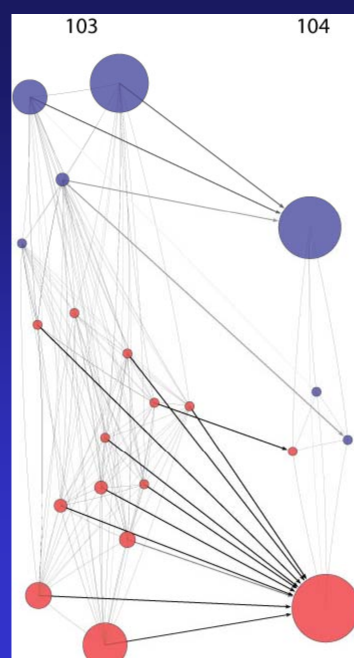


Party polarization in Congress: a social networks approach,
A. Waugh, L. Pei, J. H. Fowler, P. J. Mucha and M. A. Porter,

Problem II: Political Polarization

Movie is swamped by global density. So let's combine a time-space projection with the block model.

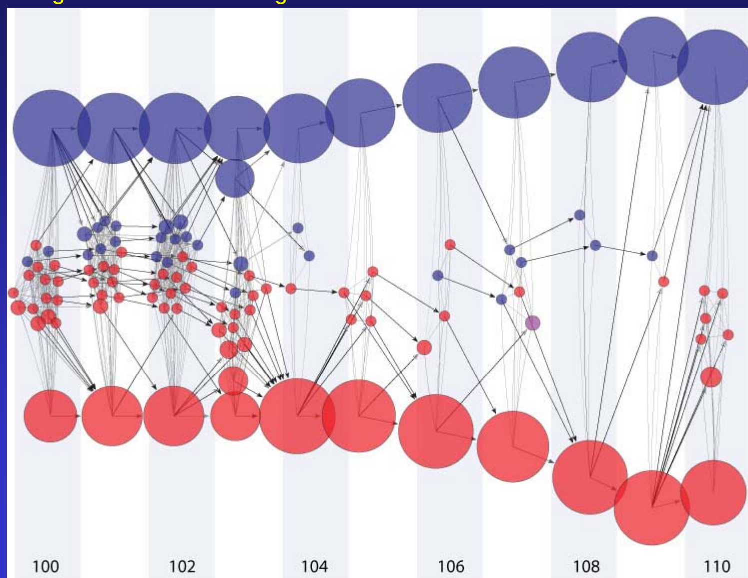




Problem II: Political Polarization

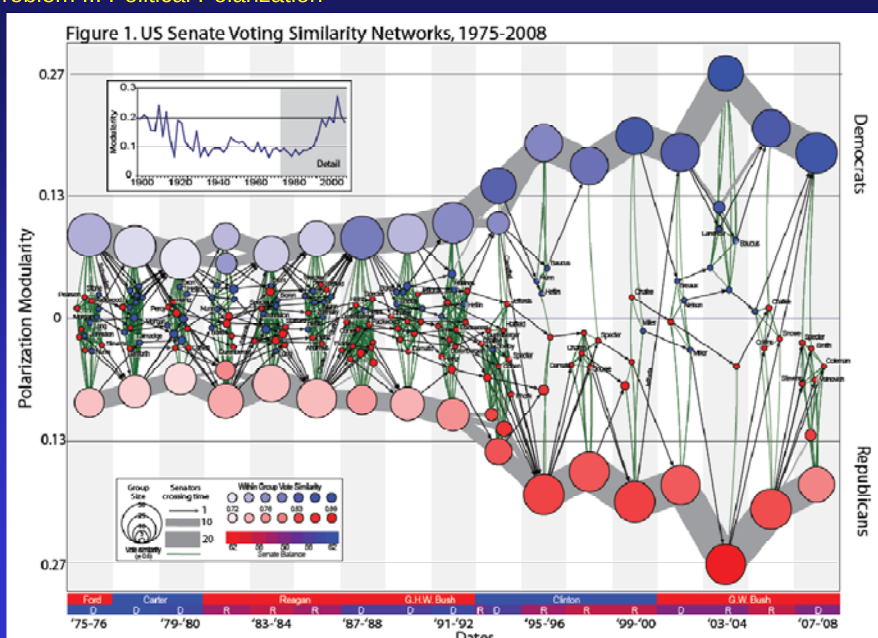
Consider again our senate voting network:

← Polarization →



← Time →

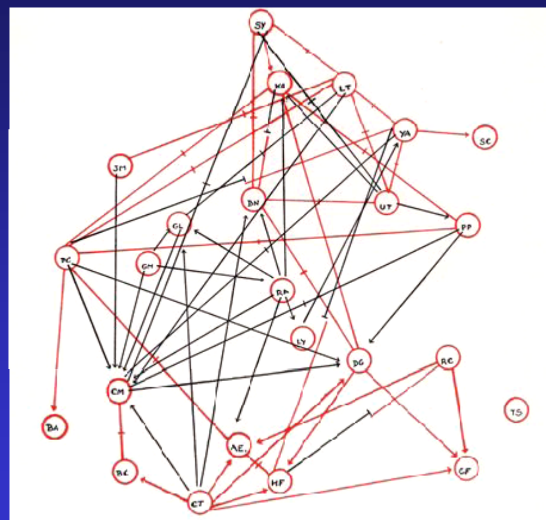
Problem II: Political Polarization



Conclusions: Developing a visual language of networks

The simplicity of Moreno's sociograms was balanced against a determined consistency in presentation style that allowed one to compare across settings.

The aim of solid scientific visualization should be to (re-) develop such conventions.

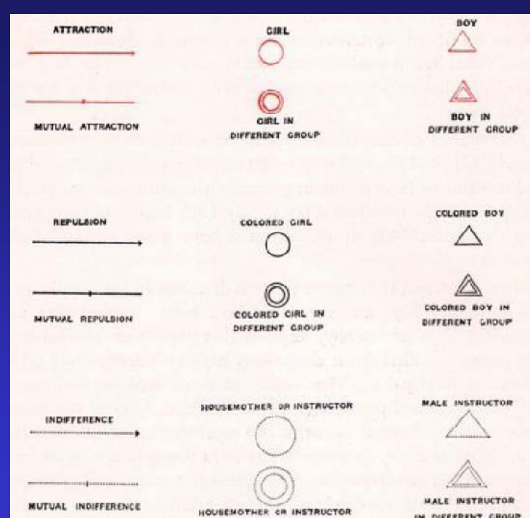


Conclusions: Developing a visual language of networks

"Nouns" are the easy -- identifying symbols to represent known node/edge types should be easy to do.

Shape, color, size-for-magnitude and usually be made pretty intuitive.

The tradeoff is clutter; use shapes, in particularly, very sparingly.



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5.2 The Generalized Blockmodeling Approach

Table 5.2.4. *Block Types*

null	nul	all 0*
complete	com	all 1*
regular	reg	1-covered rows and columns
row-regular	rre	each row is 1-covered
column-regular	cre	each column is 1-covered
row-dominant	rdo	∃ all 1 row*
column-dominant	cdo	∃ all 1 column*
row-functional	rfn	∃! one 1 in each row
column-functional	cfn	∃! one 1 in each column
non-null	one	∃ at least one 1

* Except for diagonal blocks, which may differ slightly.

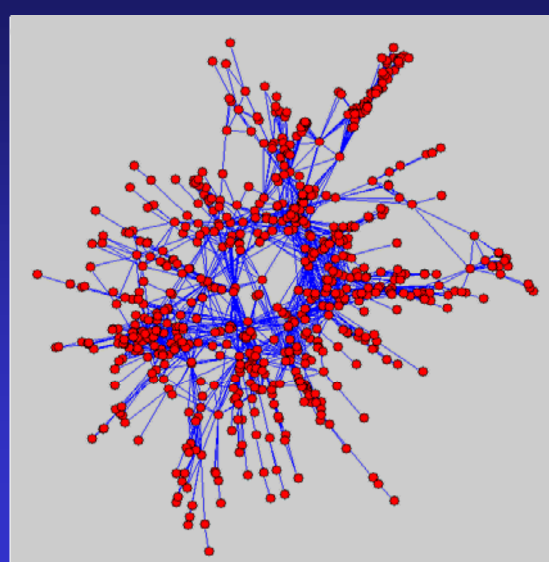
Conclusions: Developing a visual language of networks

"Style" is always evident; we can (almost) as easily recognize the signature of a particular approach as one can the voice of an author.

This is both a characteristic of authors and the programs the use; but is typically done without reflection.

A review of elements suggests some simple features to examine for style.

For my eye, for example, most graphs use lines that are too thick and colors that are too harsh.

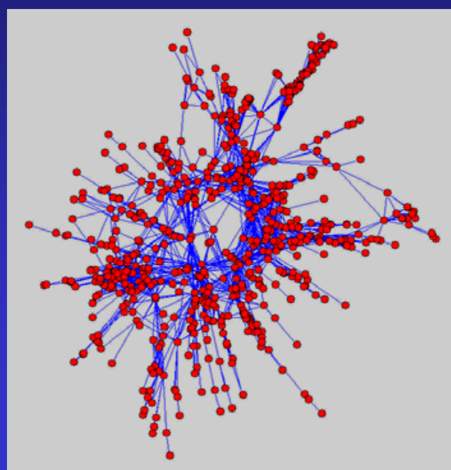


Communication Challenges in Network Visualization

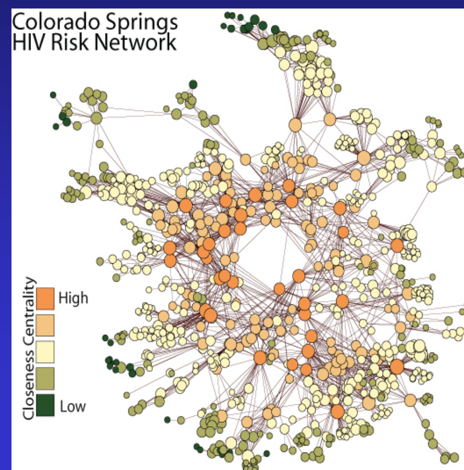
Types of problems

So what distinguishes a scientifically *effective* visualization?

•*Basic quantitative visualization craft:* ("style" or "rhetoric")



Before



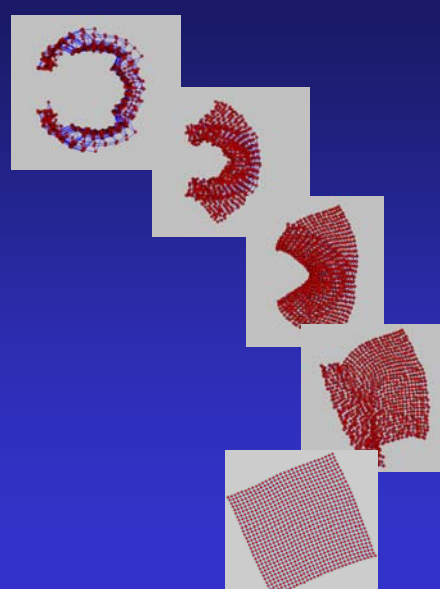
After

Conclusions: Developing a visual language of networks

The real challenge is to identify the *active grammar* underlying a language of networks. We're looking for implied rules that link visual representations to social characteristics. For example: proximity-as-social-distance.

The key value of a grammar, is that dictionaries (or "pattern books") collapse under the weight of observed diversity, while grammars admit many new utterances.

The current body of graph-heuristics are a place to start for this grammar -- they provide aesthetic "parts of speech" – but not style.



Conclusions

We are not there yet, nor are we usually “at our best” – thoughtless application of canned package visualizations often create goopy messes that convey little substantive information.

The solution is thoughtful application of a well-honed graphical style – the classic elements laid out by Tufte over 20 years ago for statistical visualization –tailored to the theoretical challenges of networks.

Conclusions

Our approach has been to develop visualization methods that:

- focus on particular network process – the “same” layout is not appropriate for all network process
- clearly contextualize – remove information that is not needed to tell the story, but place the key point within the social process
- Layer multiple information elements – node, edge, spatial arrangement and movement are all opportunities for conveying information.