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Northeastern University

Lecture 2: Intro to Networks

CS 7295, Fall 2021

Course Homepage on Canvas

https://c.dunne.dev/cs7295f21/

(project details + assignments to be added)

Feel free to interrupt with questions!

Plan for Today

Discuss:

- Network definitions!
- The readings
- Node-link visualizations
- Force-directed general layouts
- Layered layouts

For next time:

- Reading — How to Read Papers

In 1 week:

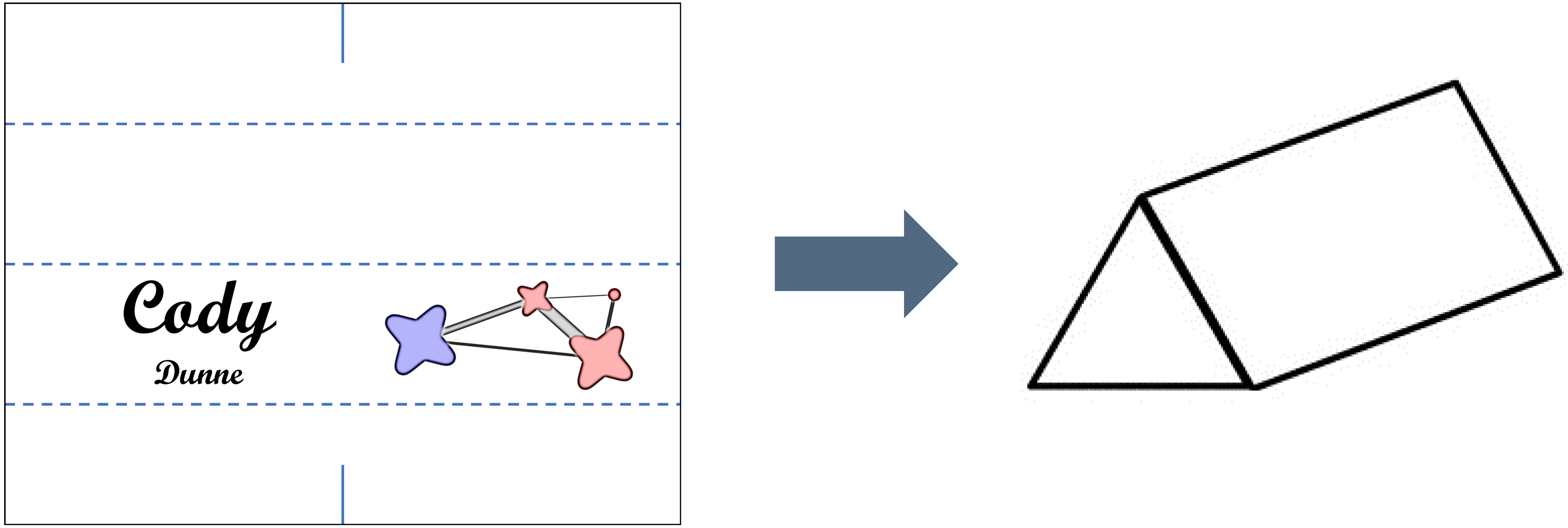
- Assignment 1 — Read the Syllabus

Previously, on CS 7295…

In-Class Sketching — Table Tents

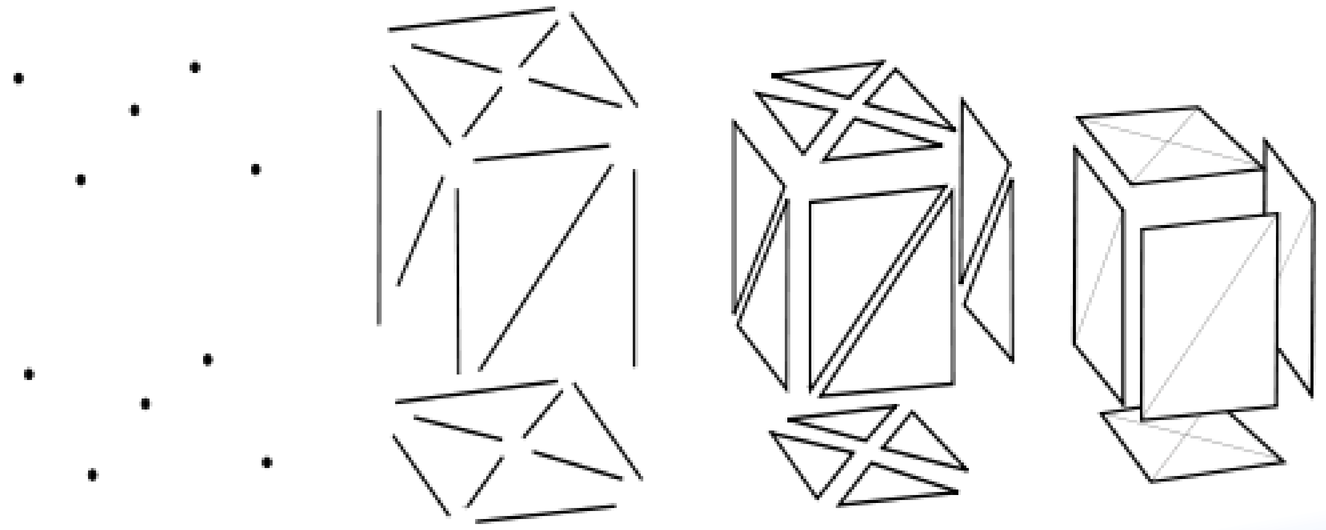
~~*15 min*~~

1. Take a pre-made tent card and remove the strips along the long edge by folding one way then the other along the provided crease.
2. Then fold it in half along the center crease.
3. Once you're sure the table tent works, unfold the paper.
4. On one side of one of the two main faces, and with the proper orientation (see image above): Write your first name in large, legible text. Write your last name in smaller text.
5. Then, beside your name draw a simple visualization that holds some meaning for you.

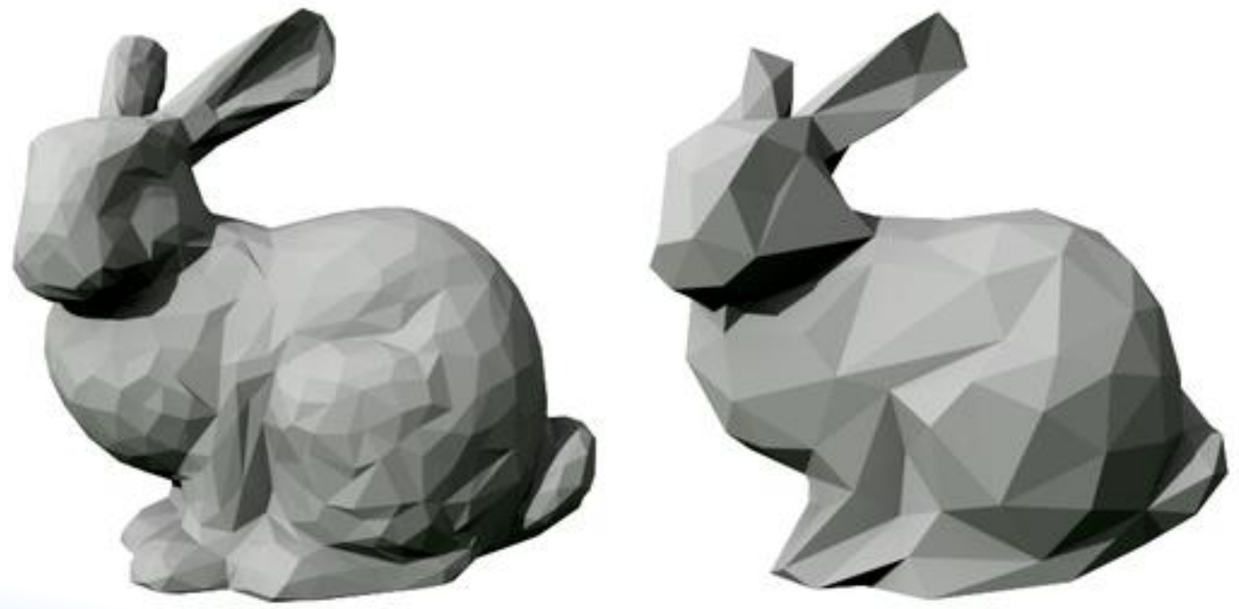


(static or interactive) (abstract or spatial)

visualization: the visual representation of data to reinforce human cognition



computer graphics



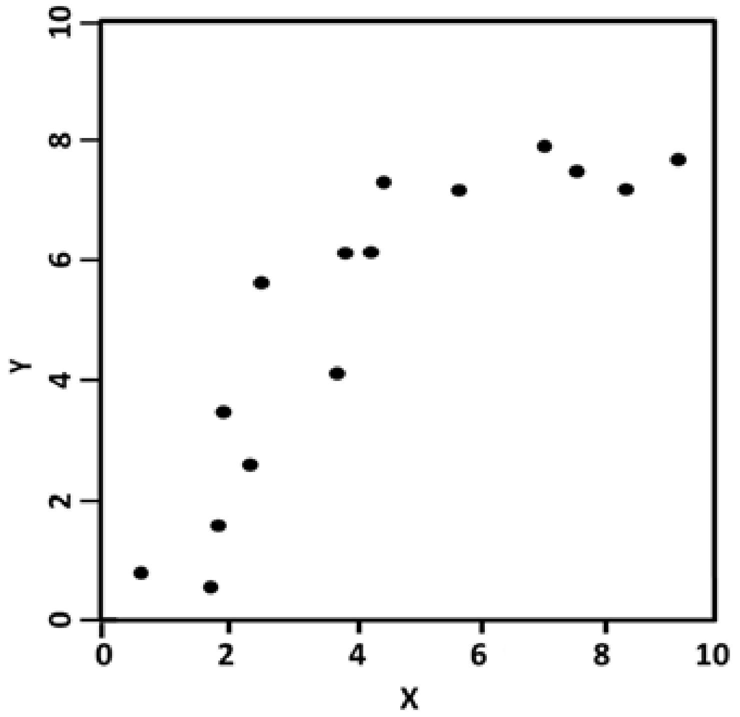
HCI

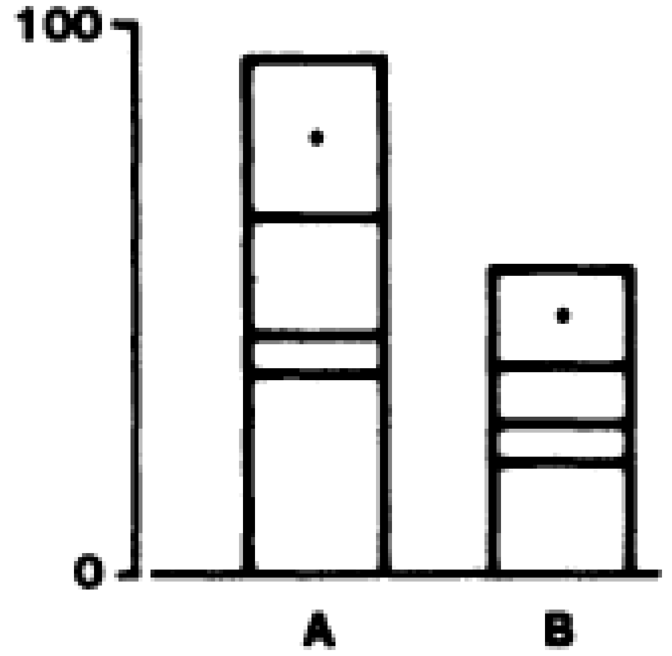
design

visualization

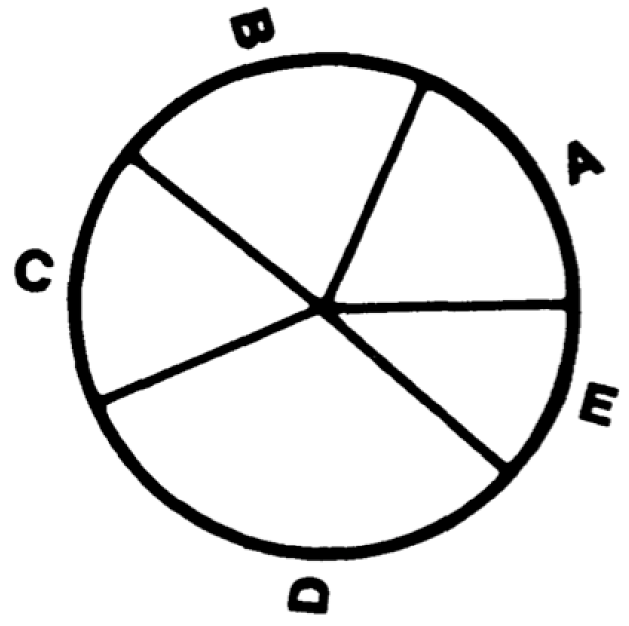
psychology

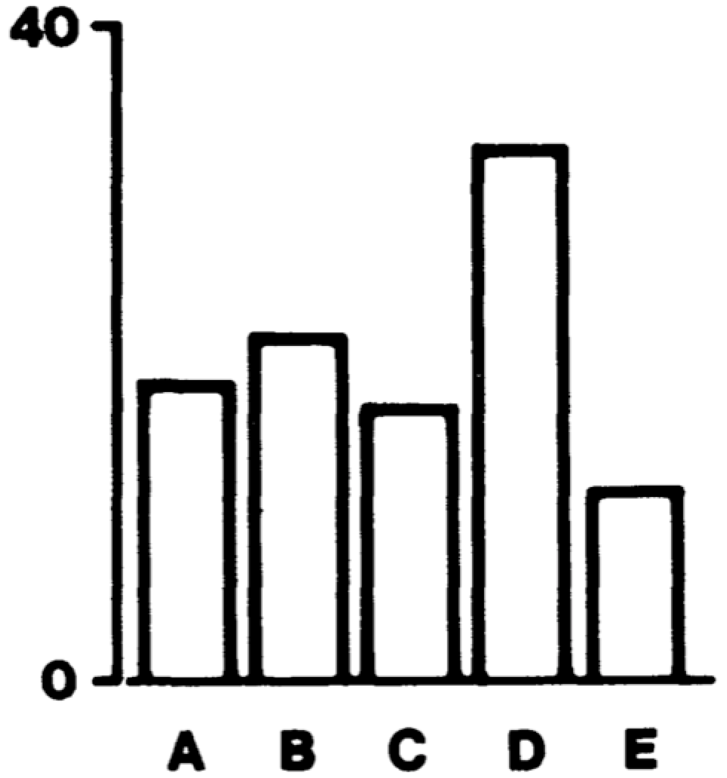
art





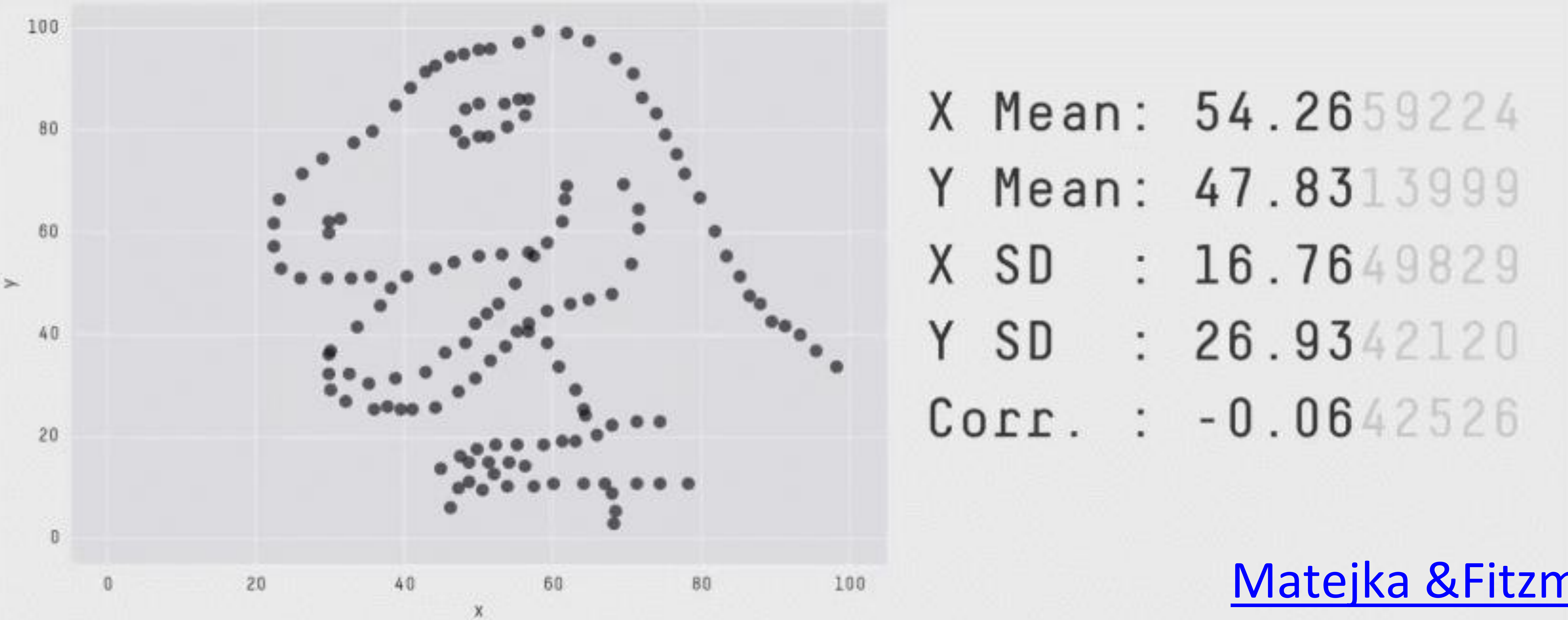
statistics





No catalogue of techniques can convey a willingness to look for what can be seen, whether or not anticipated. Yet this is at the heart of exploratory data analysis. ... the picture-examining eye is the best finder we have of the wholly unanticipated.

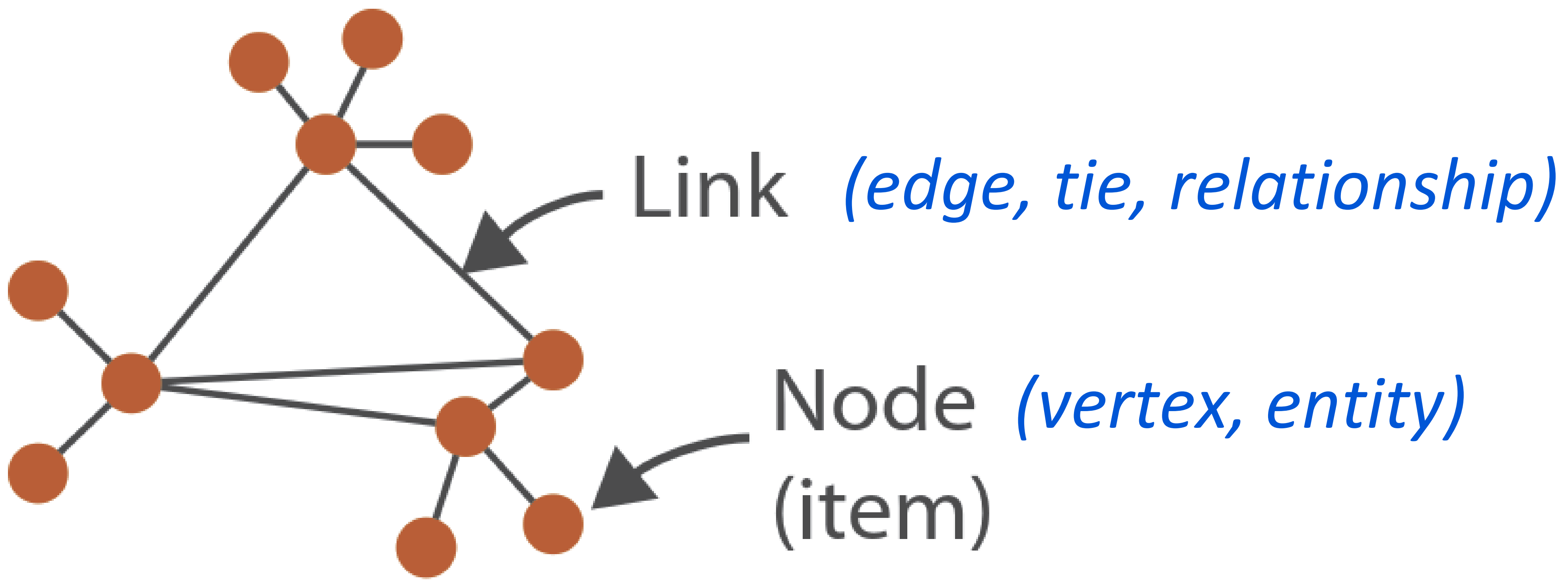
– Tukey, 1980



[Matejka &Fitzmaurice, 2017]

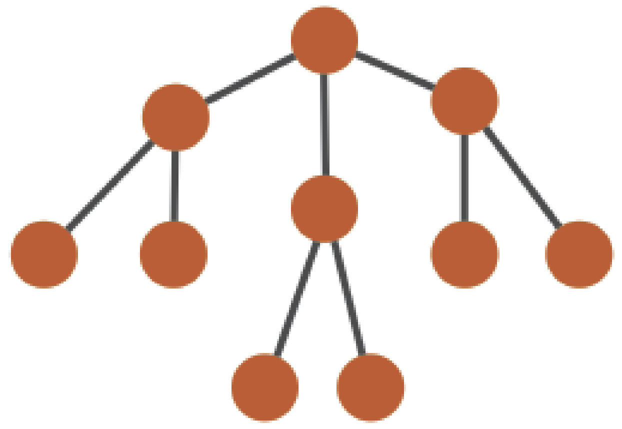
Networks

➔ Networks *(graphs)*



Network = entities and relationships between them

➔ *Trees*



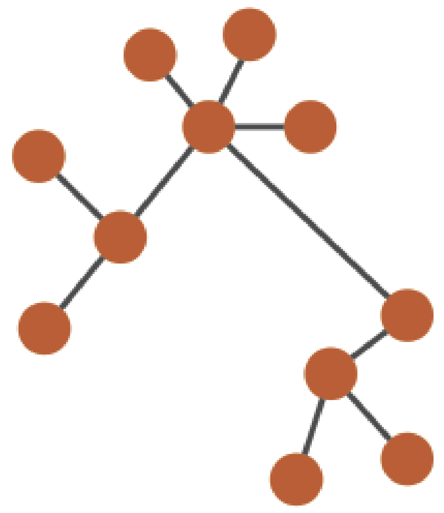
Tree = *undirected*, *connected*, *acyclic* network

Arrange Networks and Trees

Node–Link Diagrams

Connection Marks

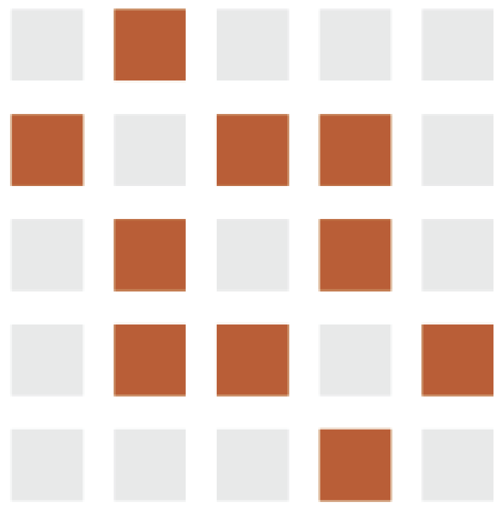
✔ NETWORKS ✔ TREES



Adjacency Matrix

Derived Table

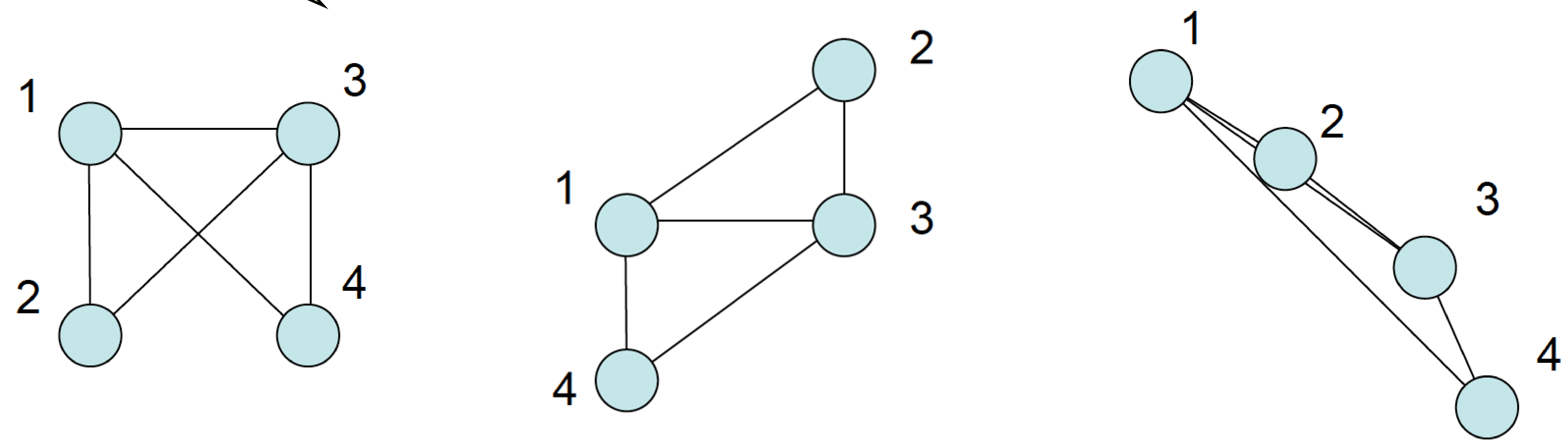
✔ NETWORKS ✔ TREES



Networks

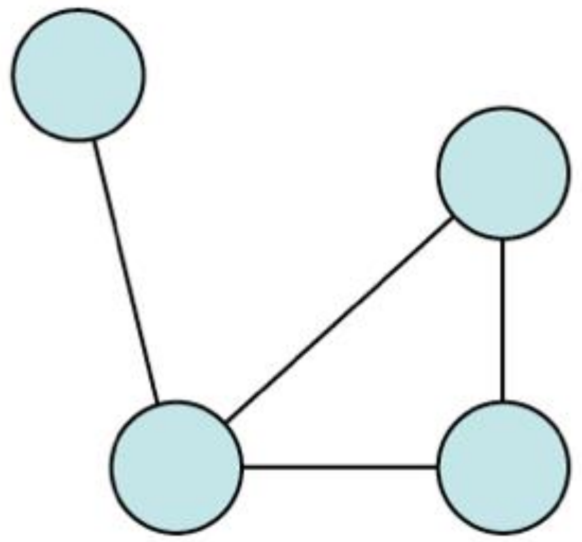
- A network *G* consists of a set of nodes *N* and a set of edges *E*
- An edge $e_{n1,n2} \in E$ connects two nodes $n1, n2 \in N$
- E.g., $G = \{1,2,3,4\}$, $E = \{(1,2),(1,3), (2,3),(3,4),(4,1)\}$

Note all the same network,
just different layouts!

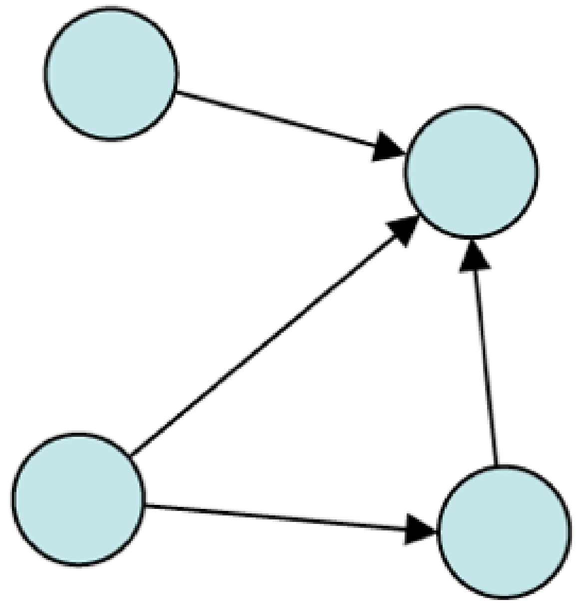


Modified from slide by Frank van Ham

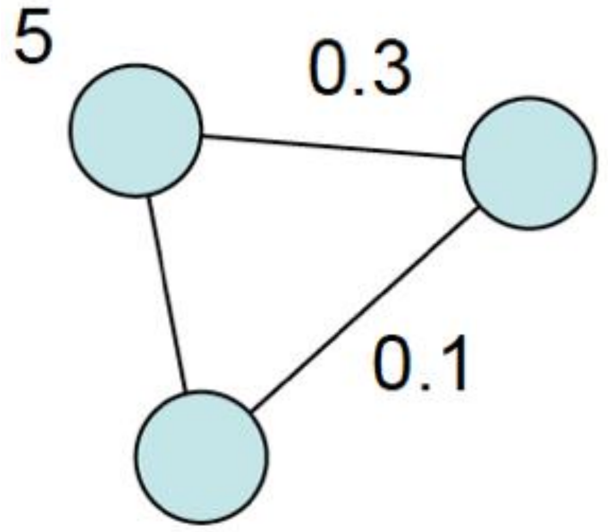
A bunch of definitions



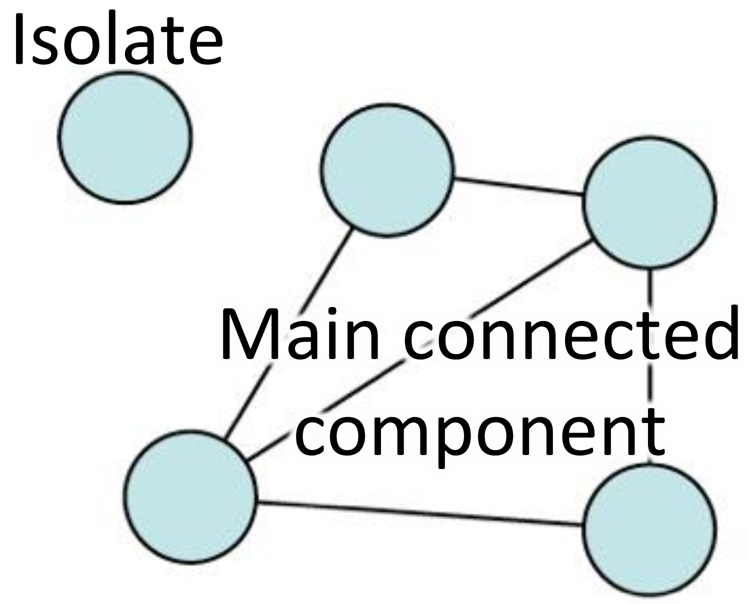
An undirected graph



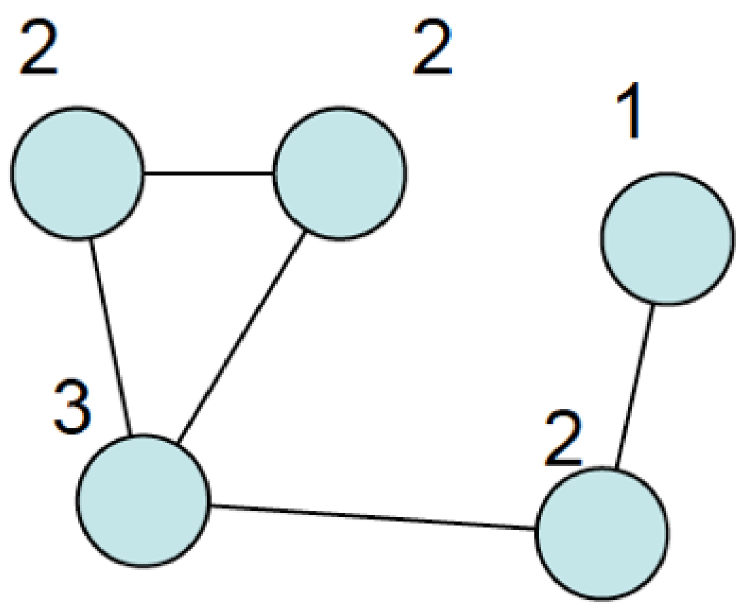
A directed graph



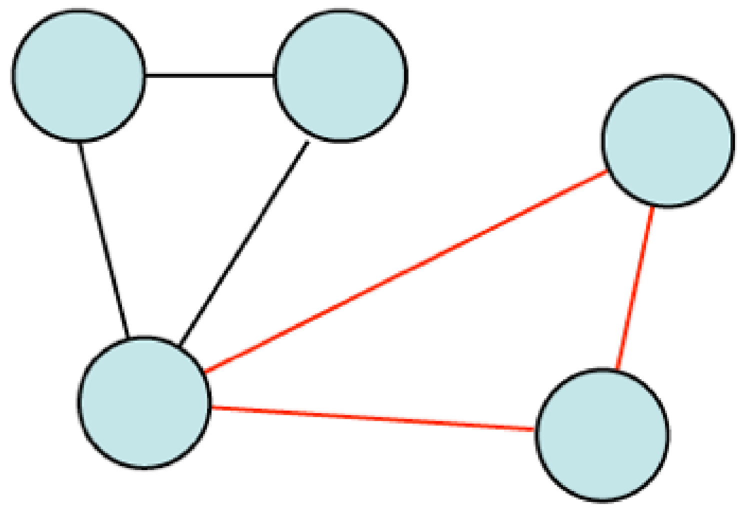
Weighted



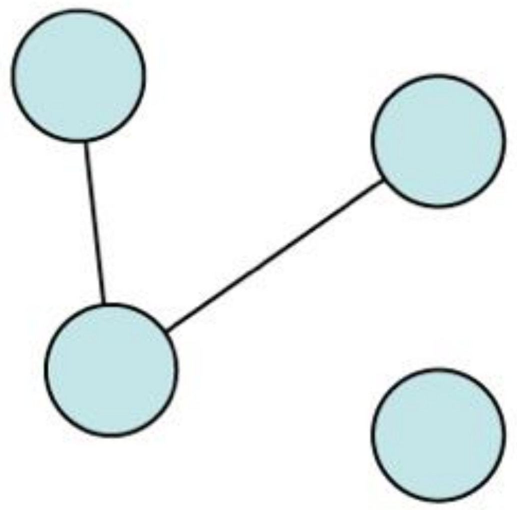
Unconnected



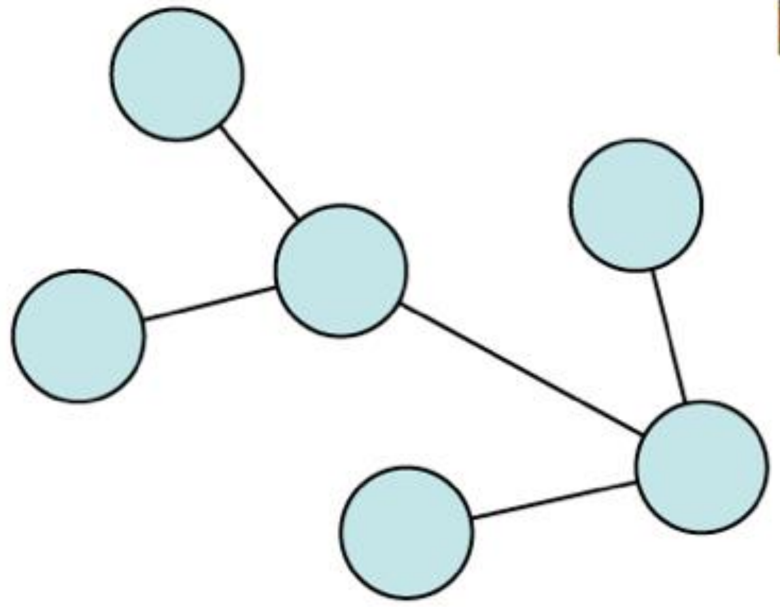
Node degrees



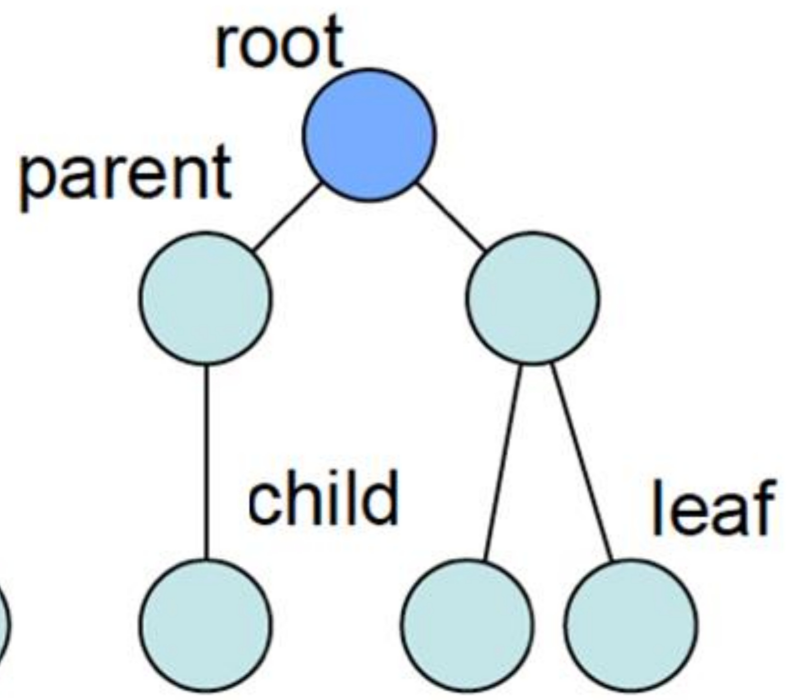
A cycle



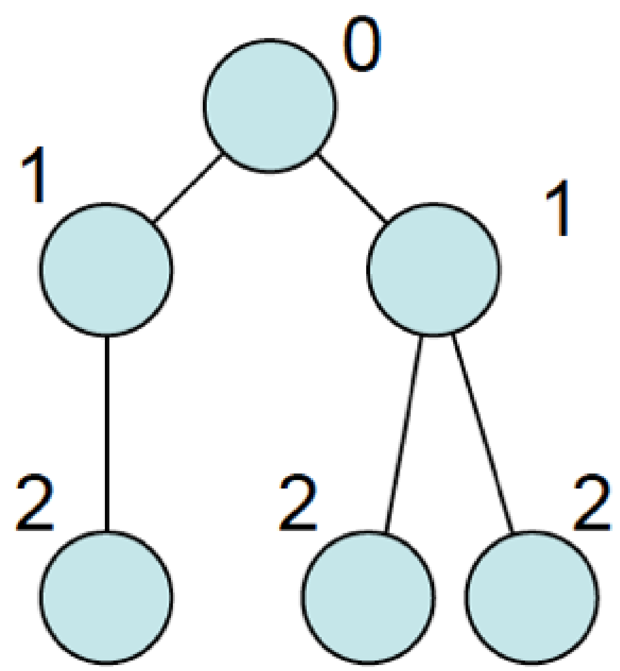
An acyclic graph



A connected acyclic graph, a.k.a. a **tree**



A rooted tree or hierarchy



Node depths

Questions Re: Readings?

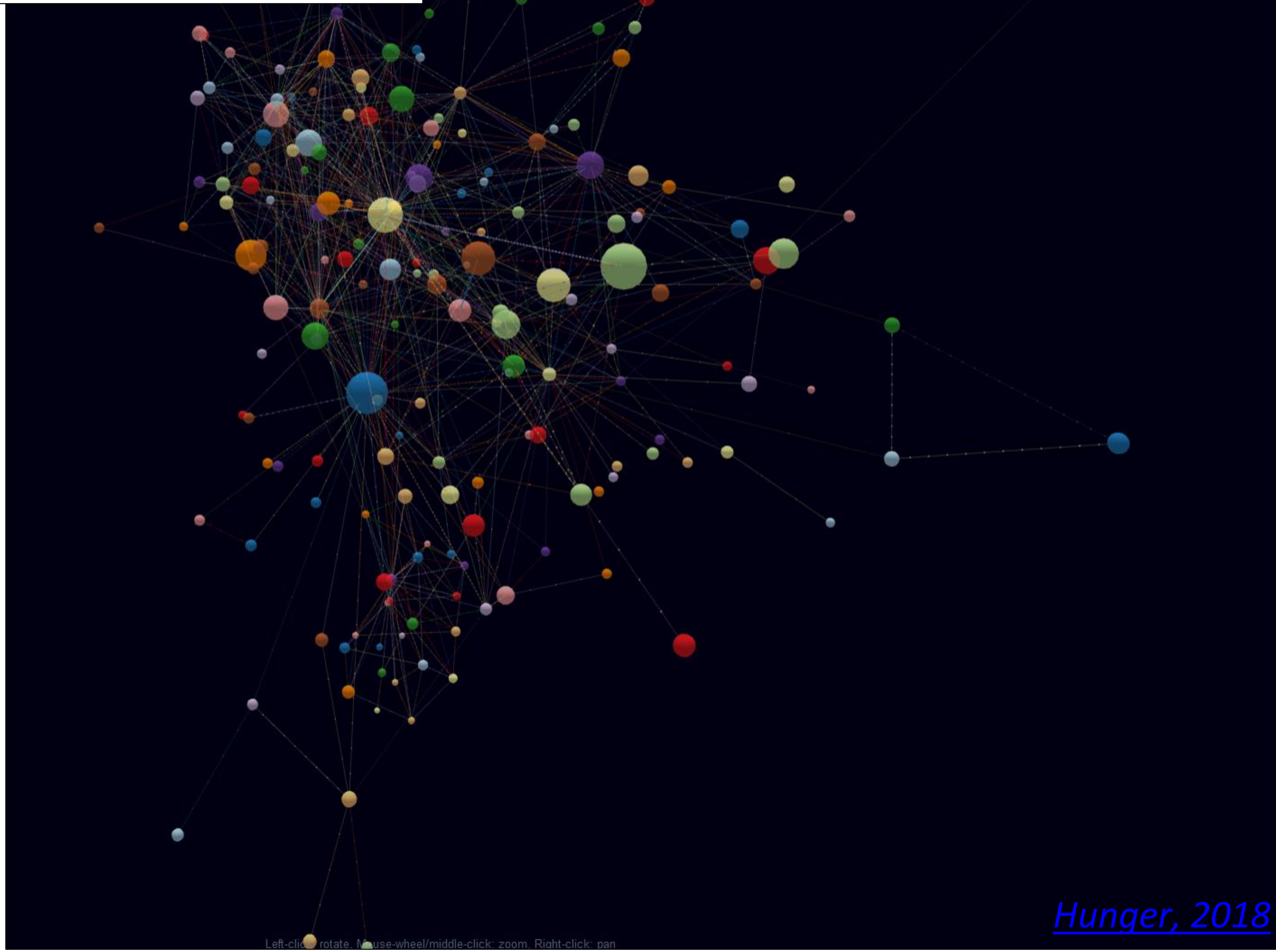
- Fleischer & Hirsch C. (2001) Graph drawing and its applications. Chapter 1 In: *Drawing graphs: methods and models*. doi: 10.1007/3-540-44969-8_1 (EZproxy metadata, PDF)

- Bastert & Matuszewski (2001) Layered drawings of digraphs. Chapter 5 In: *Drawing graphs: methods and models*. doi: 10.1007/3-540-44969-8_5 (EZproxy metadata, PDF)

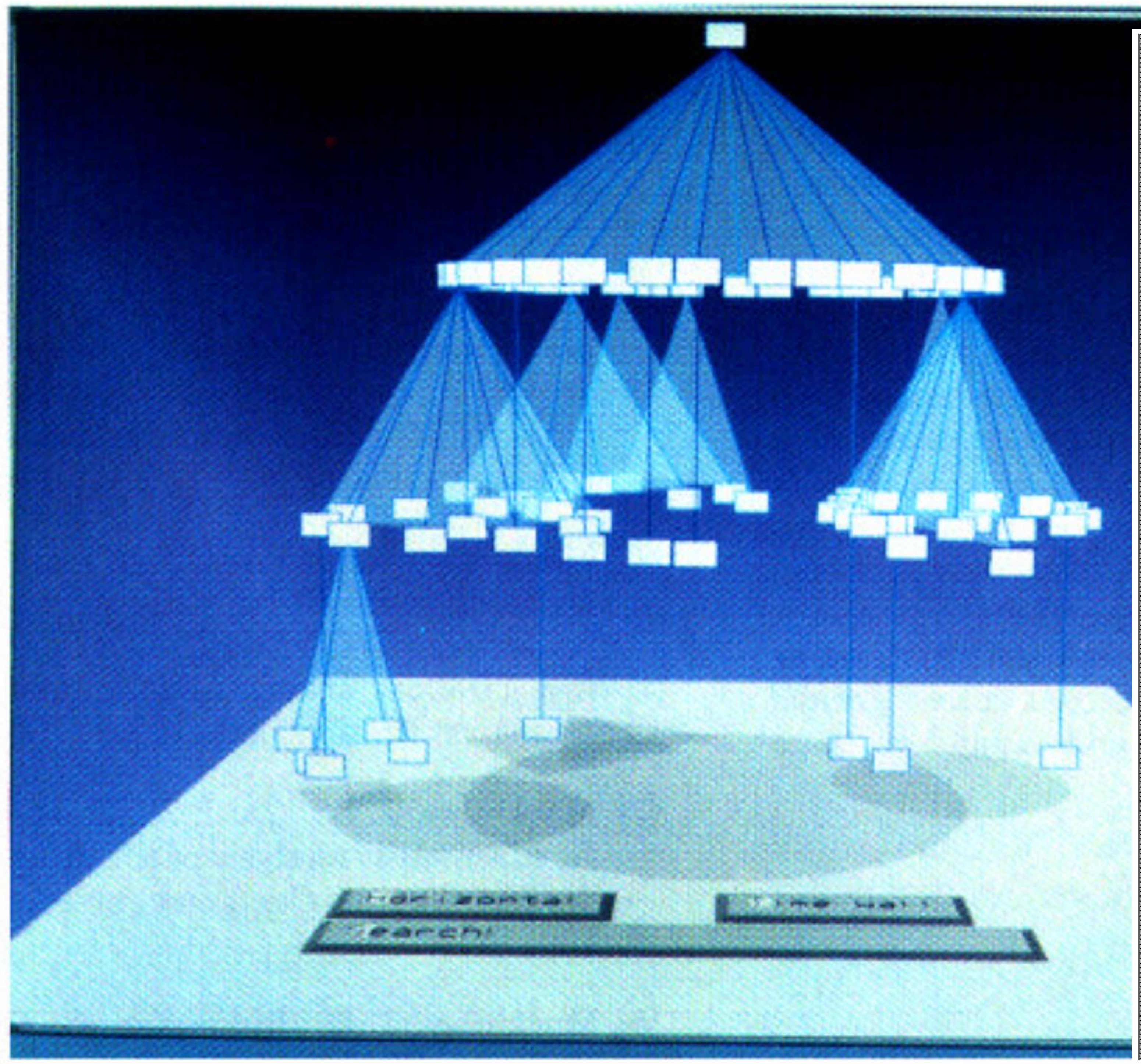
Reading Disgreement—3D

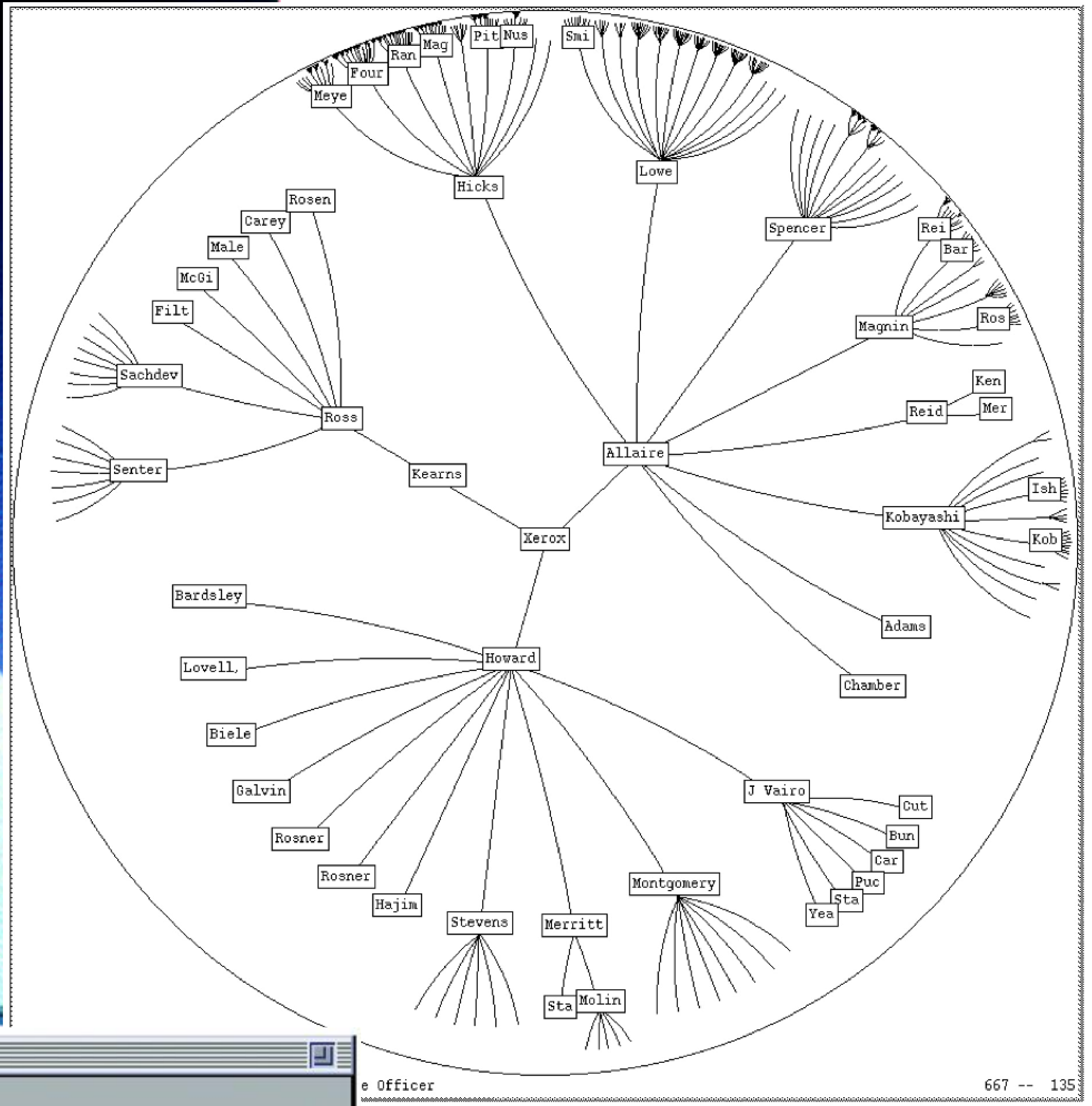
Three-dimensional drawings are suitable to display large and dense graphs such as file system graphs or WWW structure graphs. They are also used in algorithm animation, business graphics, database design, visualization of multimedia documents, software engineering tools, and VLSI schematics. Chapter 7 describes techniques for three-dimensional drawings.

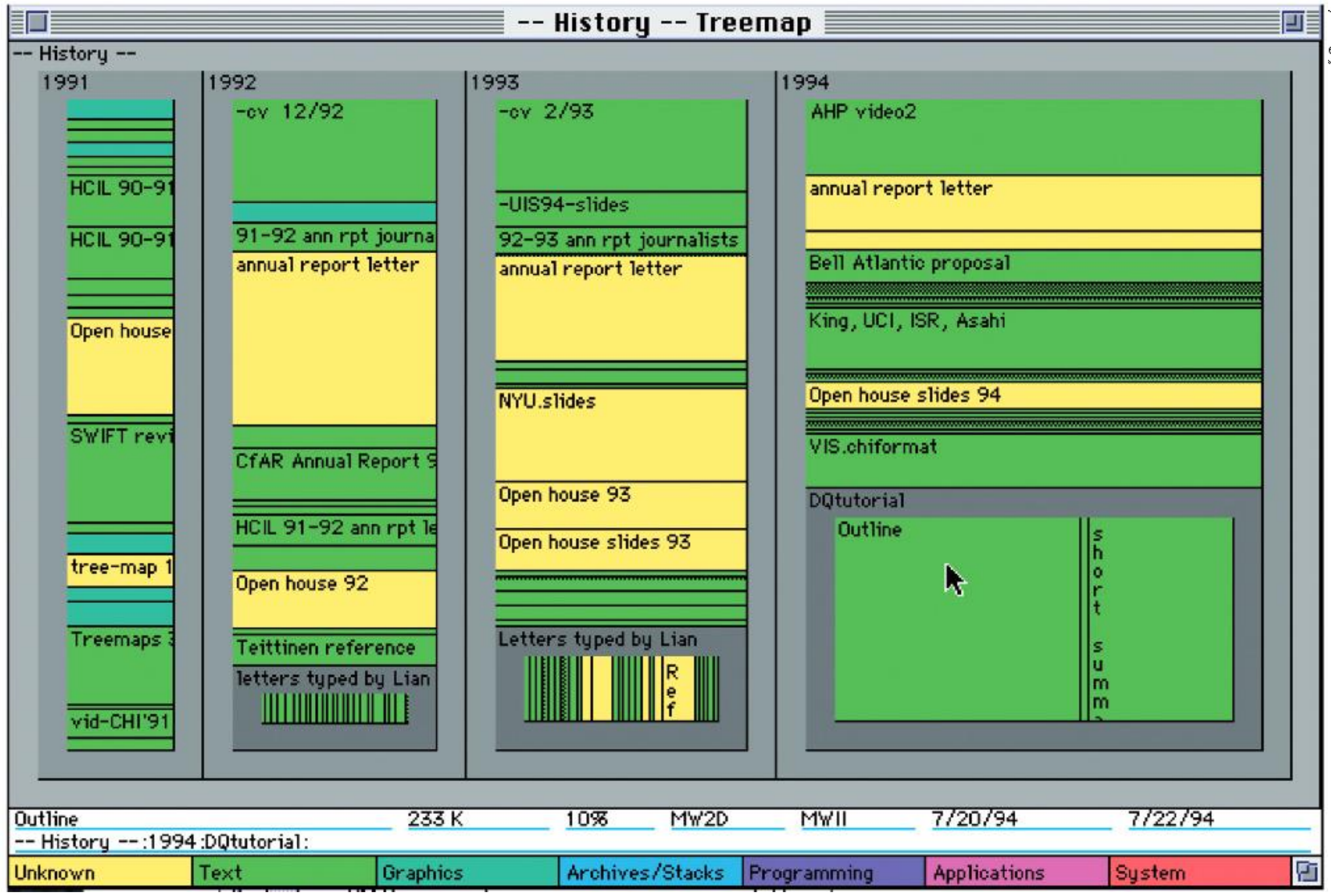
[Hemsley, 2018]

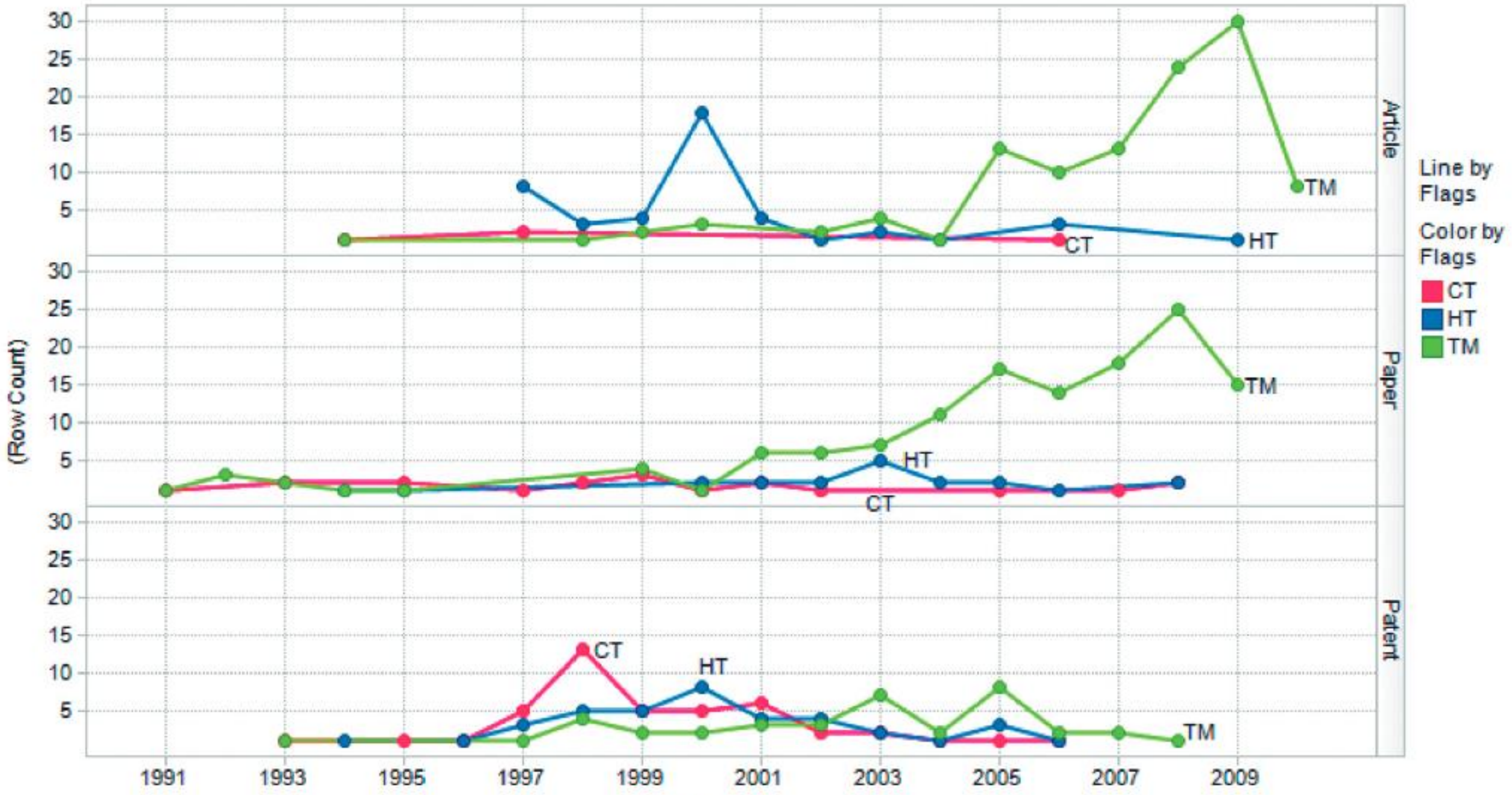


[Hunger, 2018]









[Shneiderman et al., 2011]

Rainbow:

3D: 39%

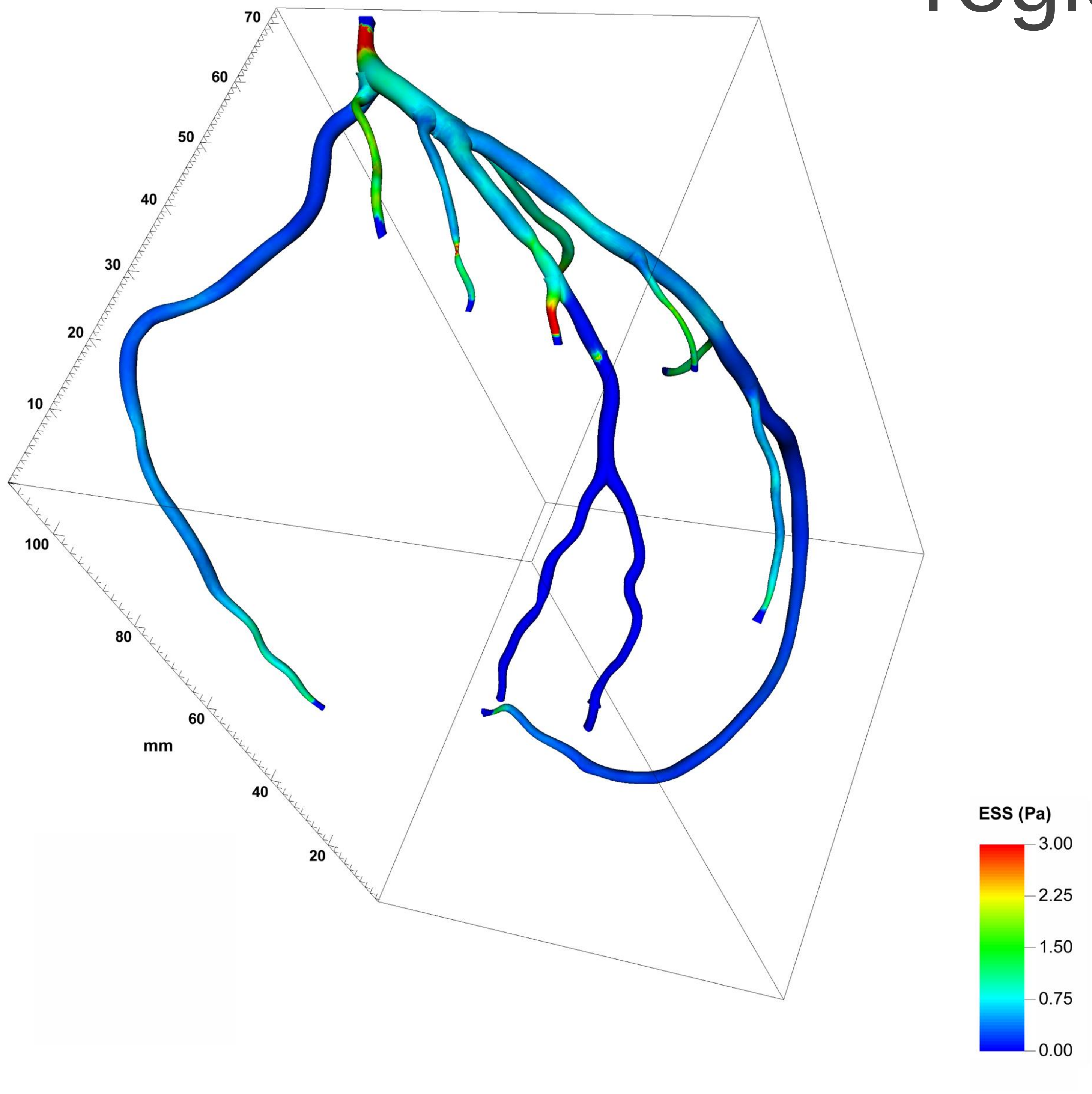
2D: 62%

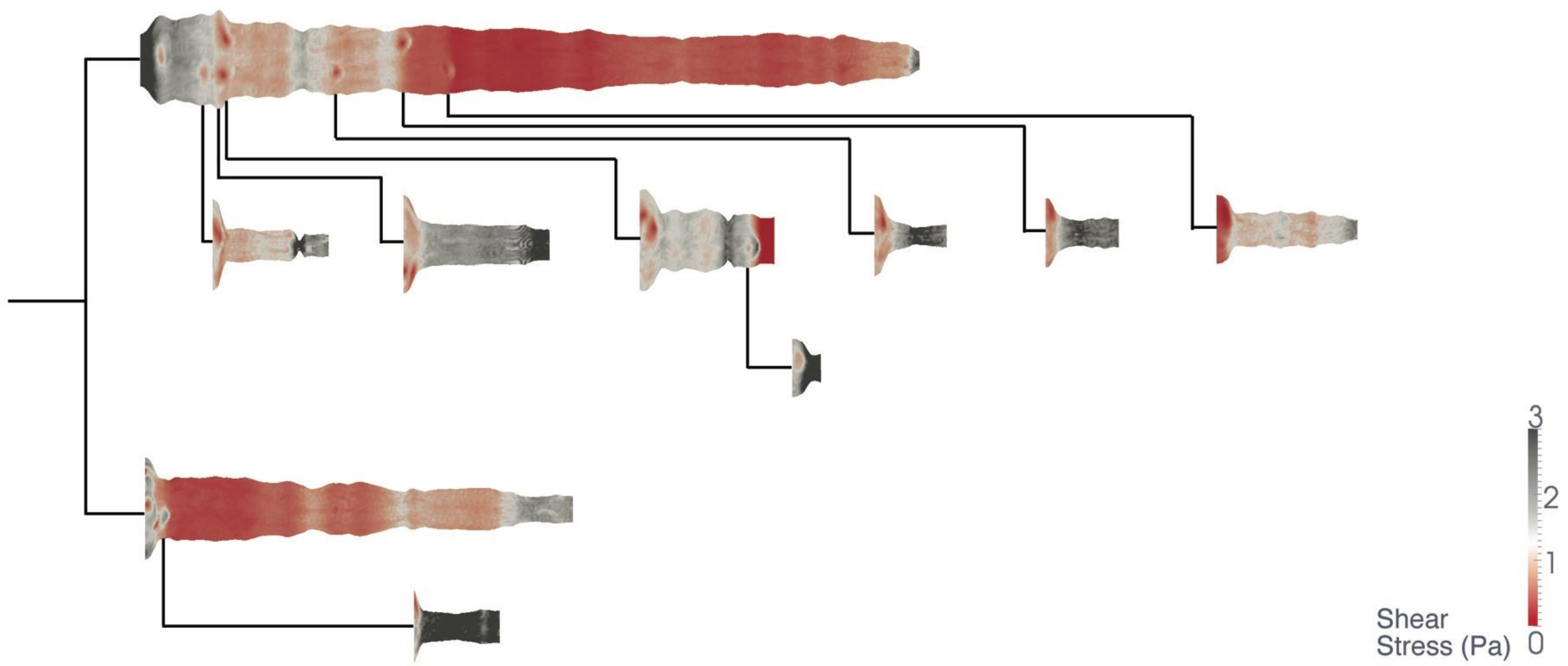
How many diseased regions found?

Diverging:

3D: 71% (*Δ +31%*)

2D: 91% (*Δ +29%*)

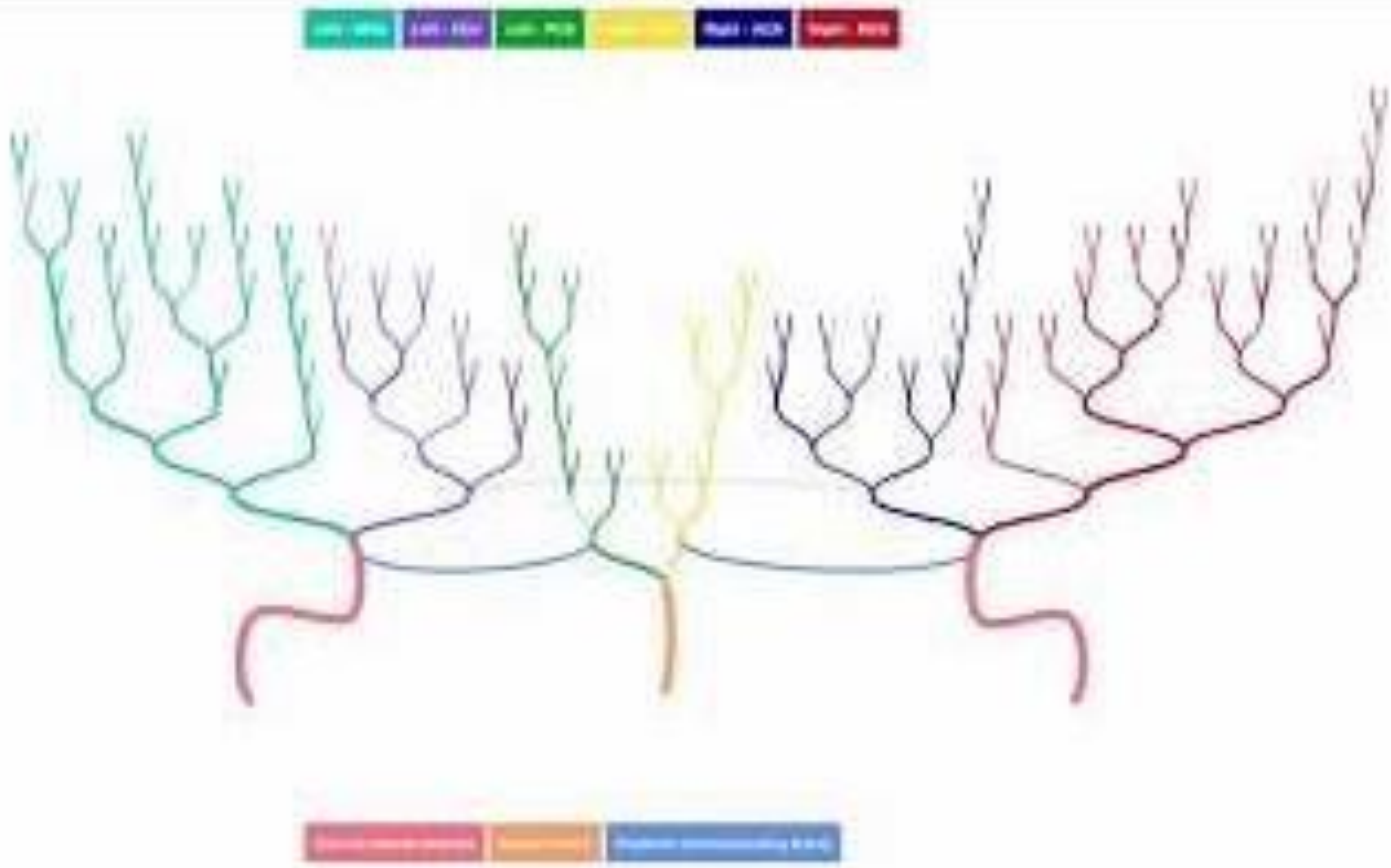




[Borkin et al., 2011]

Isosurface Projection

CerebroVis



Pandey et al. VIS 2019

Reading Disgreement—Orth.

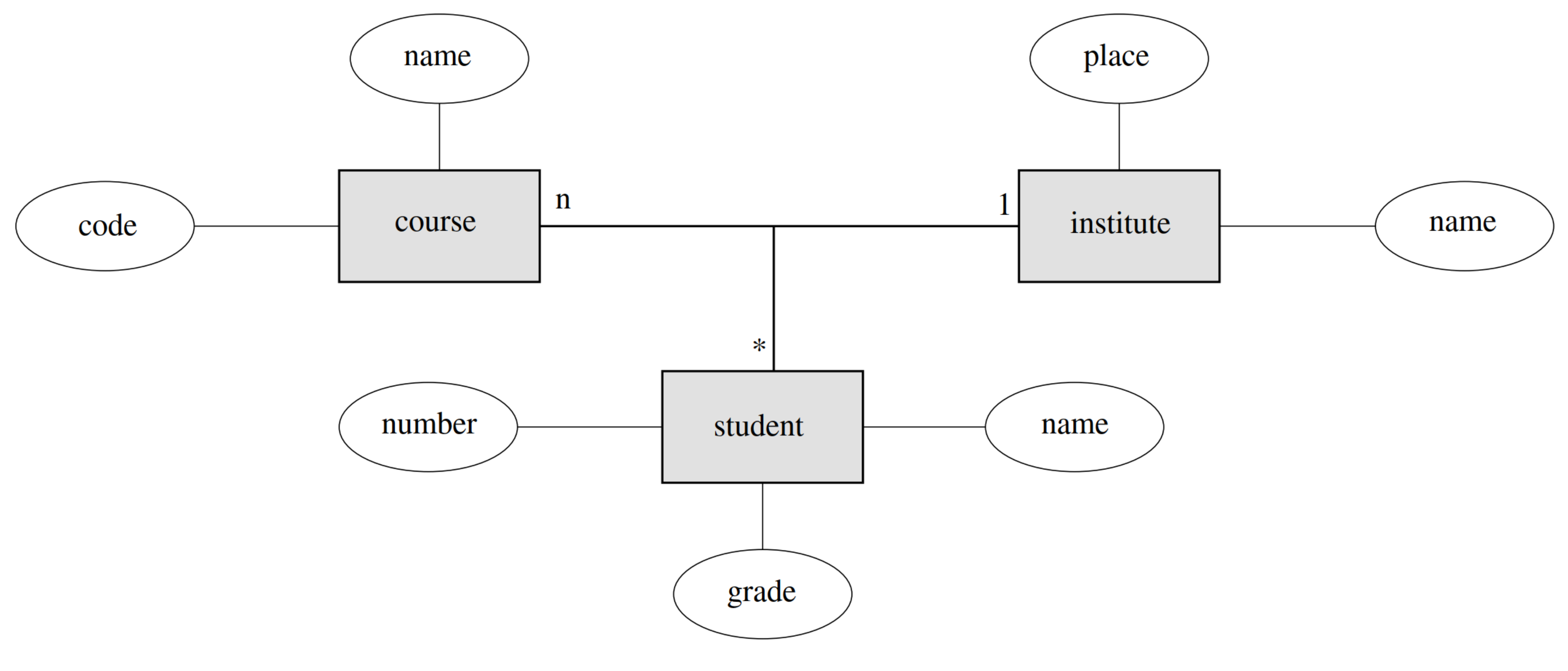


Fig. 1.8. Entity-relationship diagram.

A subclass of planar graphs are trees (see Figures 1.8 and 1.12, for example). They can be found in algorithm animation, circuit design, visualization of class hierarchies, flowcharts, project management diagrams, and syntax trees. We deal with trees in Chapter 3.

Planar graphs are often drawn orthogonally as in Figure 1.8 because orthogonal drawings usually look much tidier than drawings with arbitrarily curved edges (note that the near-orthogonal drawings in Figures 1.3, 1.4, 1.5 and 1.9 are not bad either). Other applications for orthogonal drawings include architectural floorplan design, network visualization, data base schemas, flow diagrams, entity relationship diagrams, molecular structure diagrams, project management charts, software engineering diagrams, VLSI schematics, and workflow visualization. Algorithms for orthogonal drawings can be found in Chapter 6.

Hall of Fame?

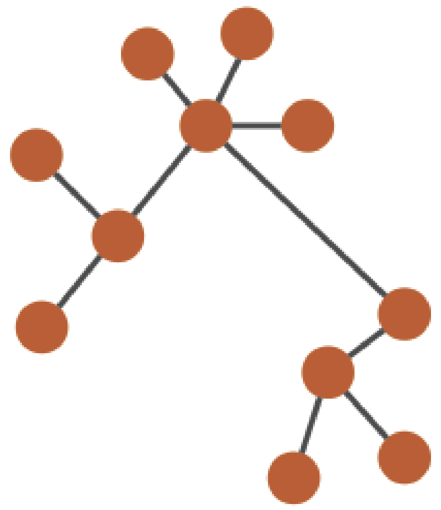
or

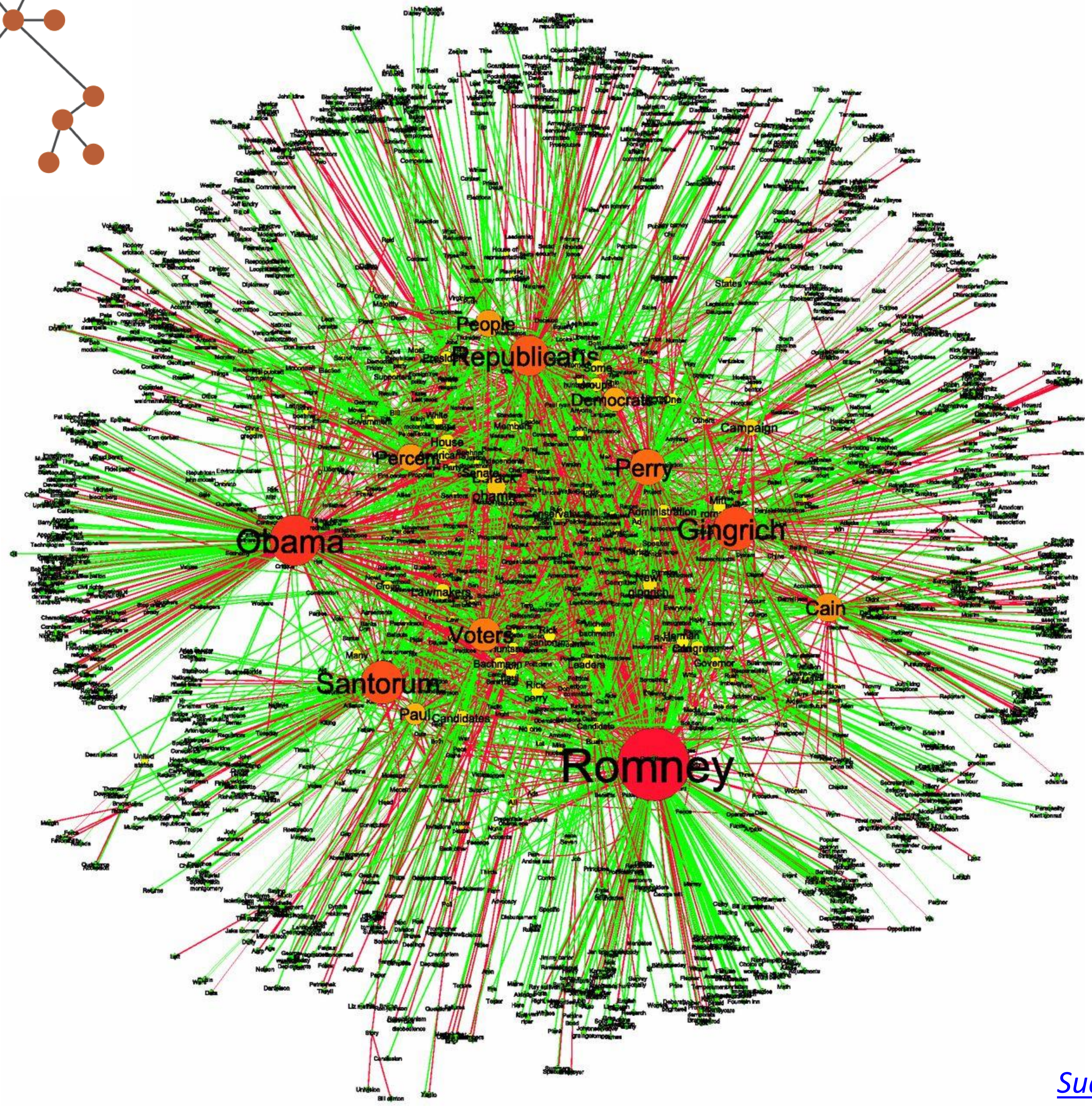
Hall of Shame?

Node–Link Diagrams

Connection Marks

✔ NETWORKS ✔ TREES





US presidential election network for 2012 primaries.

- Nodes: key entities from noun phrases. Sized by degree.

- Edges: relationships from verbs. Colored by positive (green) and negative (red) weights.

[Sudhahar et al., 2015]

Node–Link Diagrams

Connection Marks

✔ NETWORKS ✔ TREES

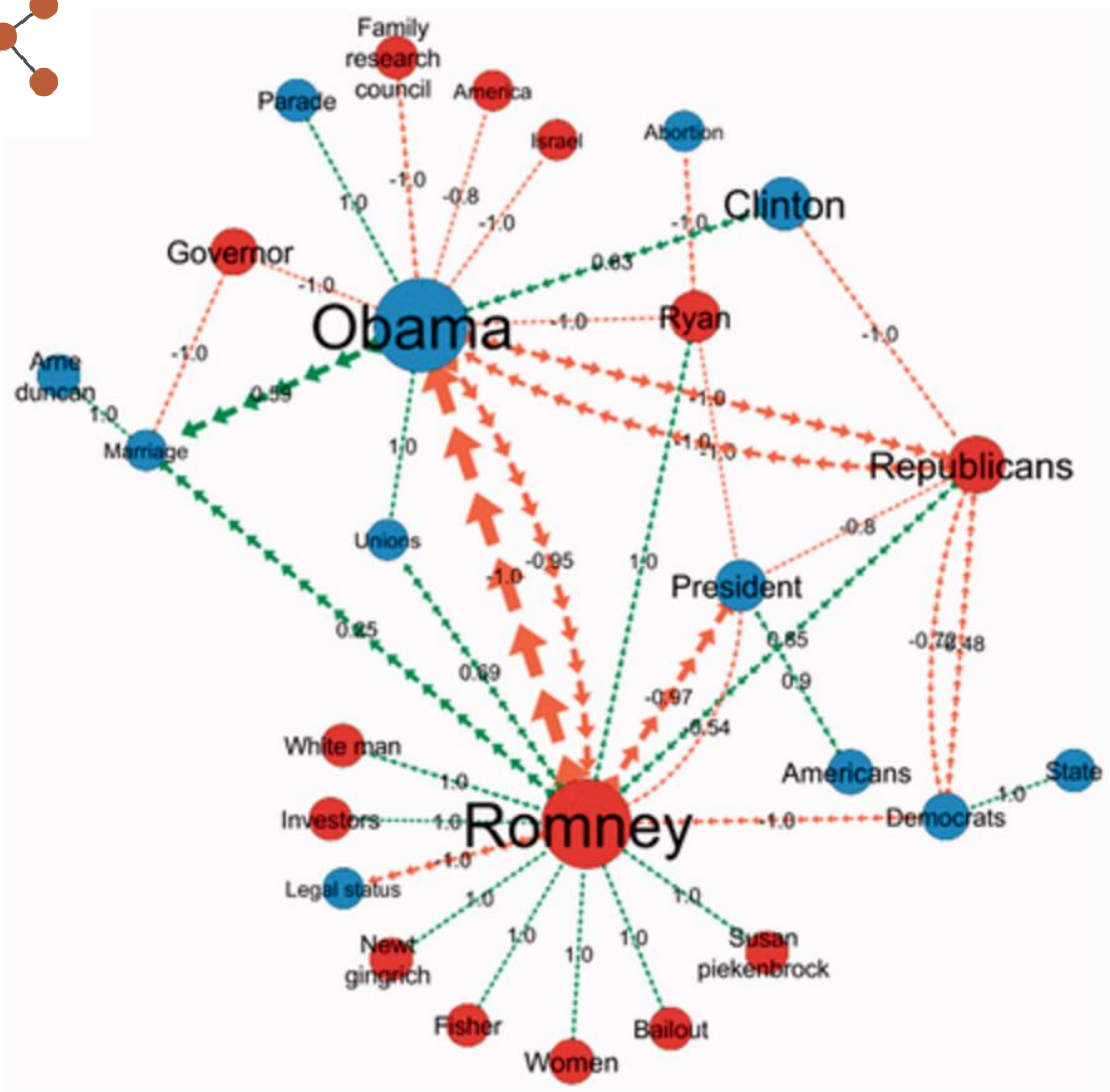


Figure 4.

Download figure | Open in new tab | Download powerpoint

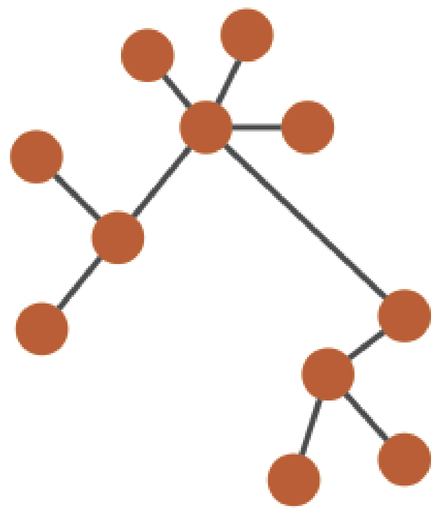
A subset of the election network, coloured by partitioning it via the first eigenvalue of the symmetrised adjacency matrix (see Appendix A8). Note that the split captures well the expected distinction between the Republican (red) and Democratic (blue) camps. The orange and green links show negative and positive relations between entities.

[Sudhahar et al., 2015](#)

Node–Link Diagrams

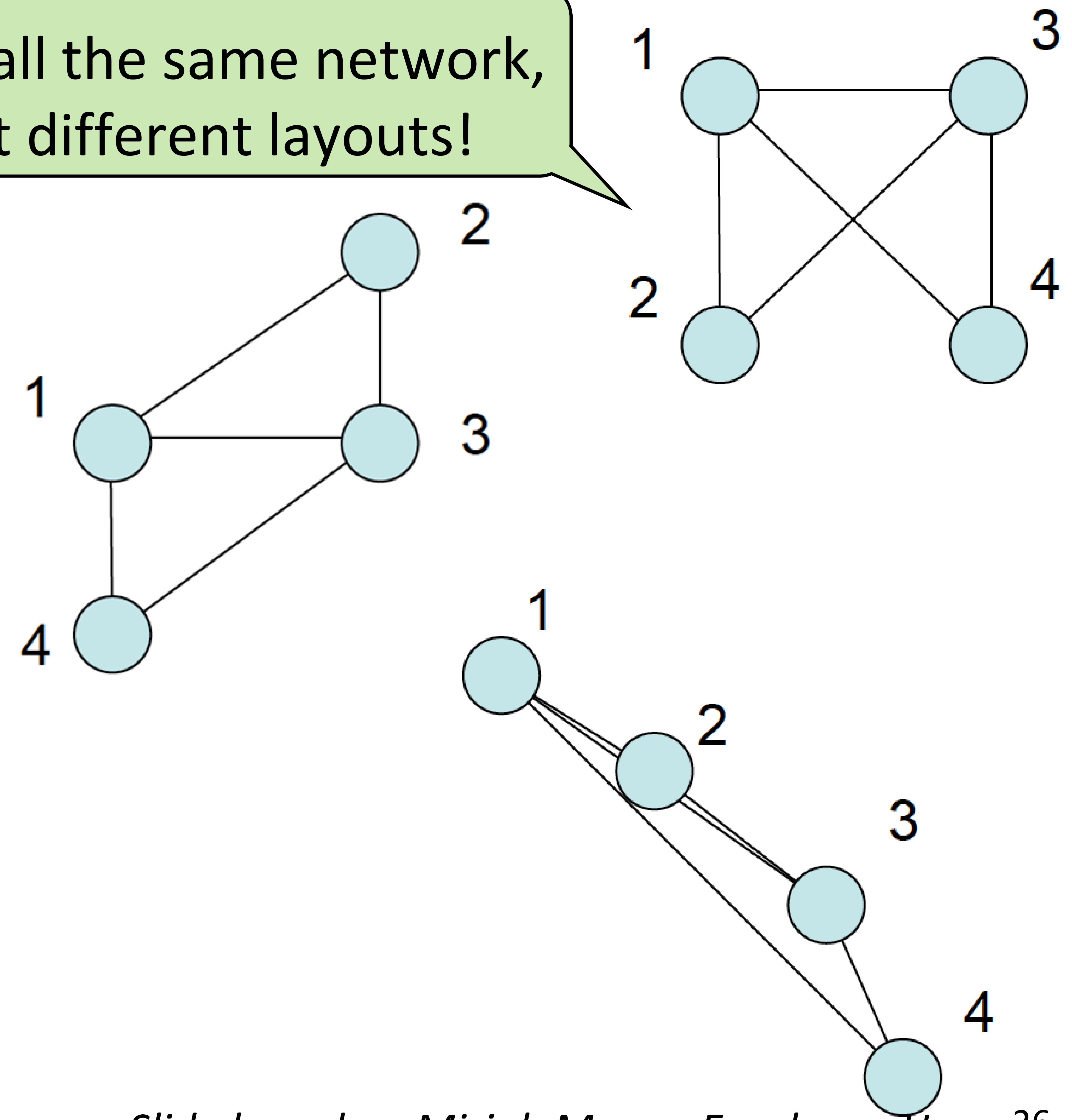
Connection Marks

✔ NETWORKS ✔ TREES

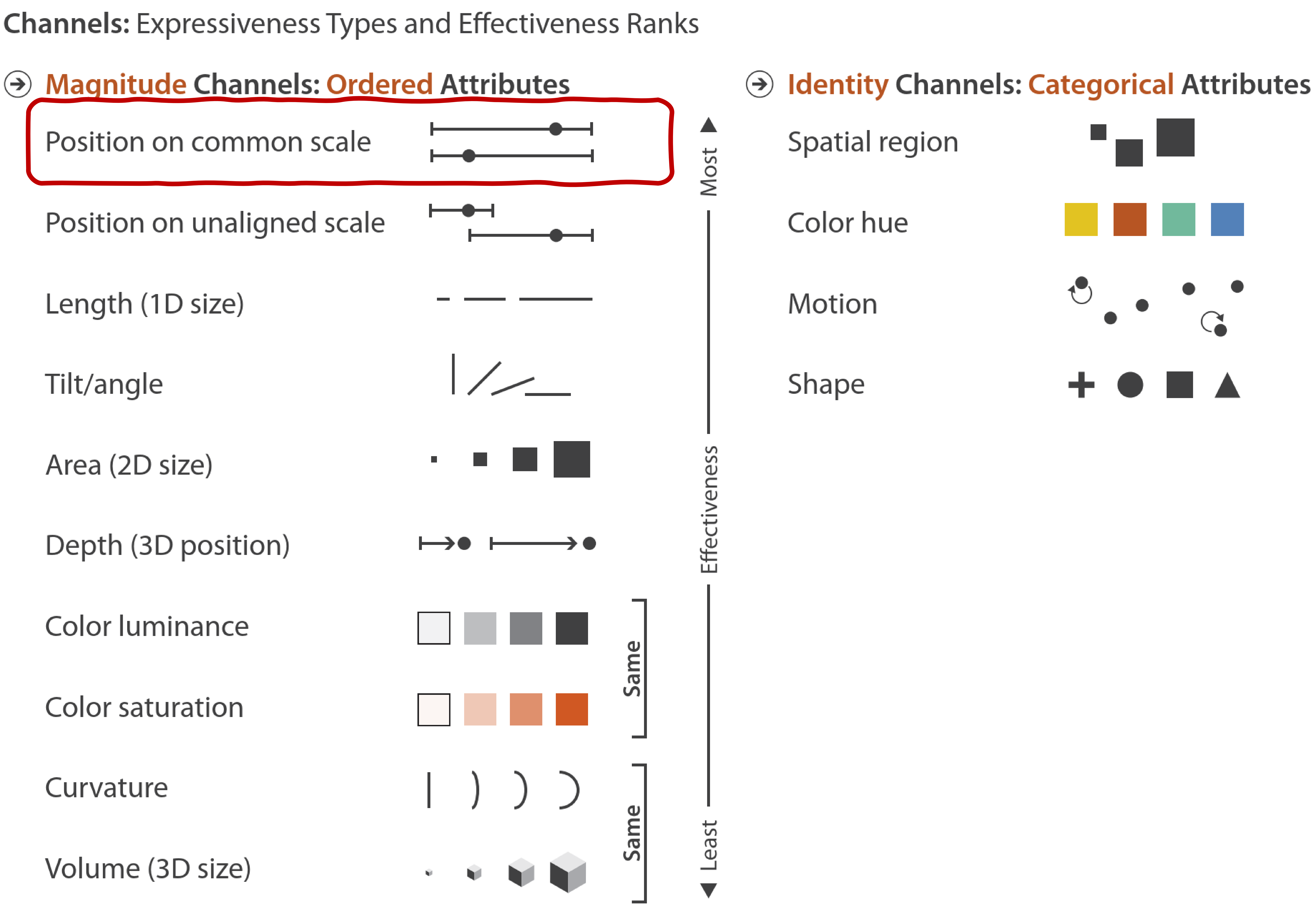


- Primary concern is the *spatial layout* of nodes and edges, a.k.a. *graph drawing*
- The goal is often to effectively depict the graph structure for *topology-based tasks*:
  - connectivity, path-following
  - network distance
  - clustering
  - ordering (e.g., hierarchy level)
- But not always topology-based tasks. E.g., understanding attributes, statistics, metrics

Note all the same network, just different layouts!



Spatial Layout



[Munzer, 2014](). See also:
[Cleveland & McGill, 1984]()
[Heer & Bostock, 2010]()
[Mackinlay, 1986]()

For Next Time & Communication

Homepage: https://c.dunne.dev/cs7295f21/
(project details + assignments to be added)

For next time:
- Reading — How to Read Papers

In 1 week:
- Assignment 1 — Read the Syllabus

Everyday Required Supplies:
- 5+ colors of pen/pencil
- White paper
- Laptop and charger

Use Canvas Discussions for general questions, email the instructor for questions specific to you.