




# Graph Visualization

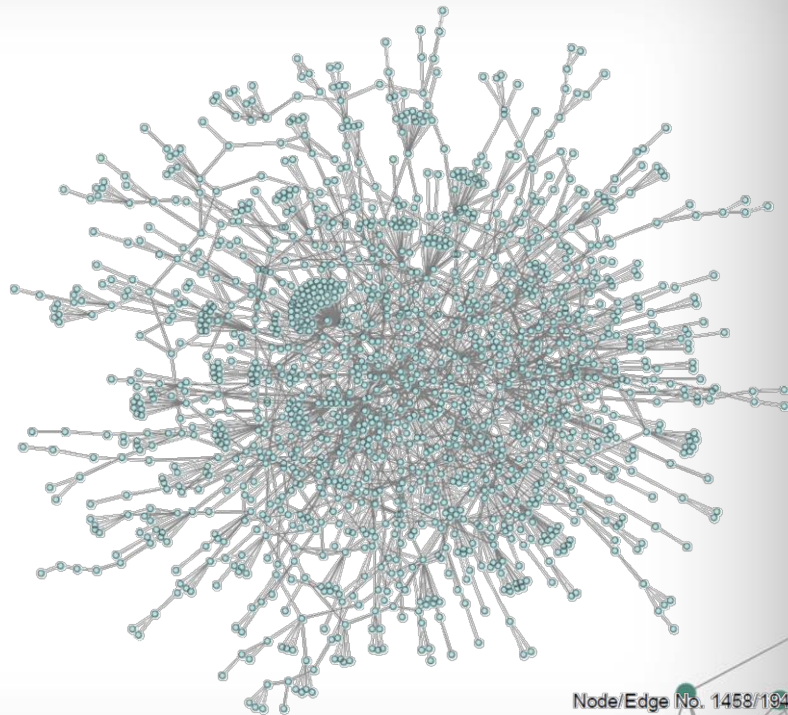
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# GEM Force Directed Layout

- Edges exert **spring force** on their nodes
  - preset globally uniform desired edge length
  - spring force diminished by node degree, making higher degree nodes “heavier”
- Nodes mutually repel each other
  - strength  $\approx 1/\text{distance}$
- All nodes experience global forces
  - gravitational force toward center
  - small random perturbation force



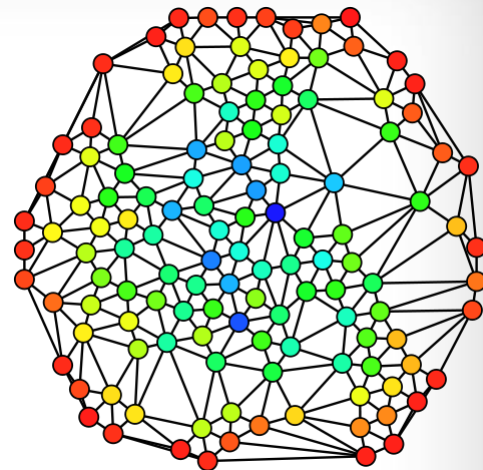
Node/Edge No. 1458/1948

yeast protein interactions

Frick, Ludwig & Mehldau. A Fast Adaptive Layout Algorithm for Undirected Graphs. Proc. Graph Drawing, 1994.

# Centralities

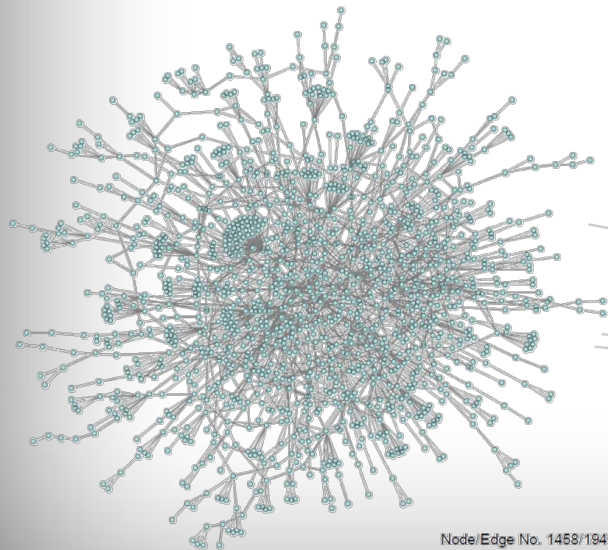
- Node degree is a simple centrality measure
  - high degree nodes better connected than low degree nodes
  - PageRank: sum of PageRanks of incoming links
- Isolation metric is total distance to all other nodes
  - Closeness centrality =  $1/\text{isolation metric}$
  - Graph centrality =  $1/\text{distance to the farthest node}$
- Betweenness centrality of a node
  - portion of all shortest paths between any two nodes that pass through the given node
  - Can also compute for an edge



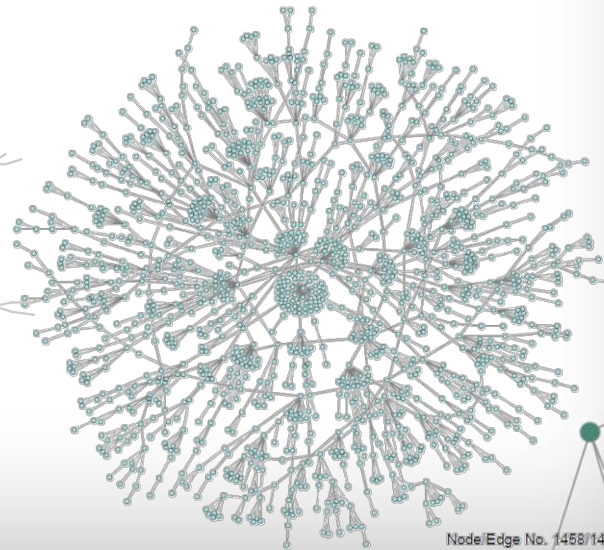
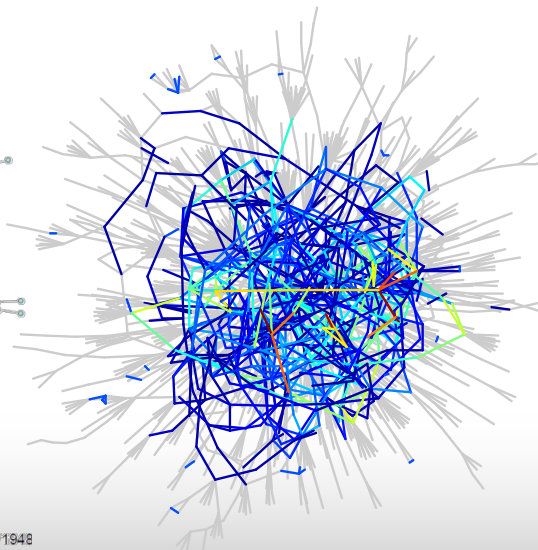
red = low BC, blue = high BC  
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# Simplification

- Removing lowest BC edges that don't disconnect graph results in a tree shaped “backbone”
- Simplifies force-directed layout, then can later add less significant edges back in



Node/Edge No. 1458/1948



Node/Edge No. 1458/1458

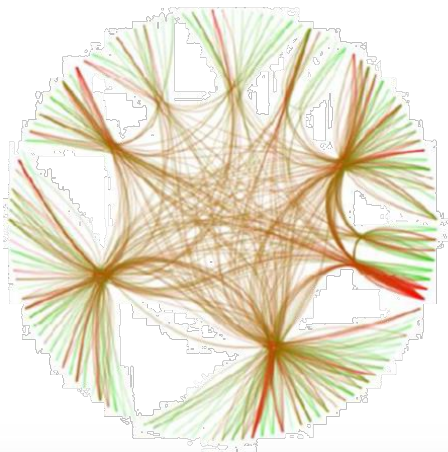


# Edge Bundles

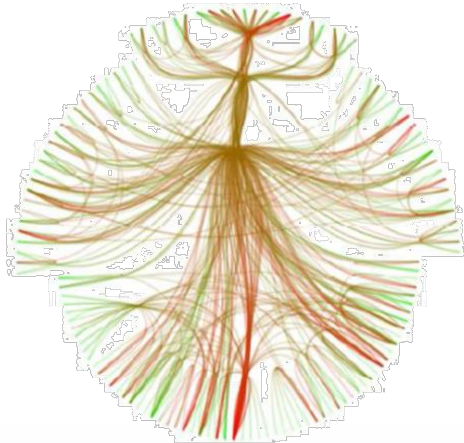
Holten. Hierarchical edge bundles:  
Visualization of adjacency relations  
in hierarchical data. IEEE TVCG  
12(5), 2006, pp. 741–748

- Aggregate “similar” edges into “wire bundles” to simplify presentation
- Will need measure of edge similarity

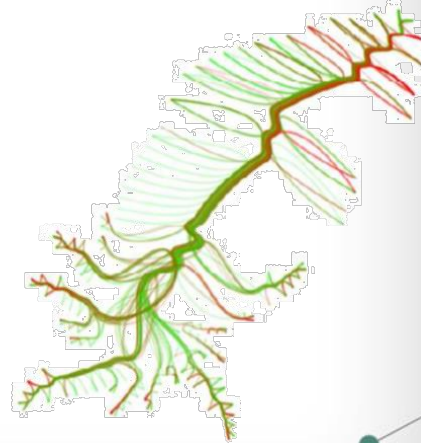
389 Enron  
emails  
between 132  
employees  
on 8/2001



radial layout



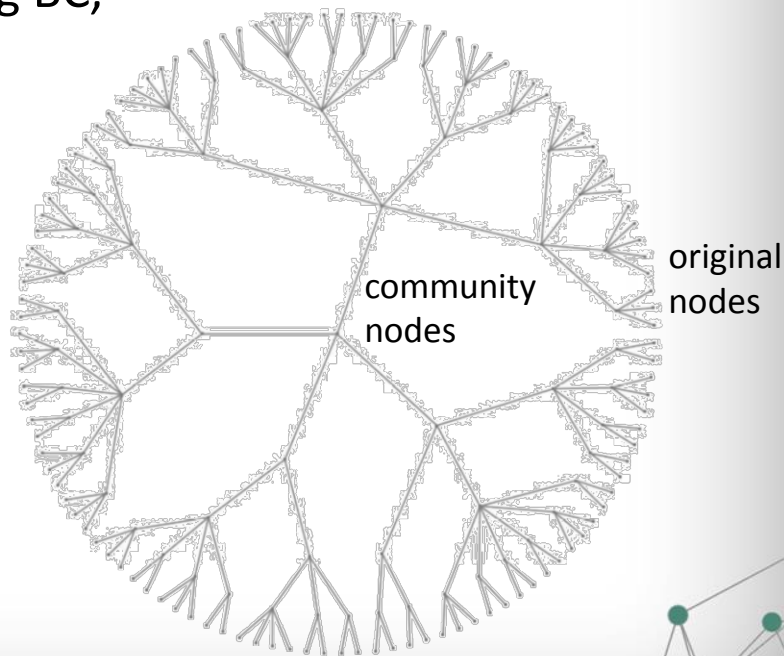
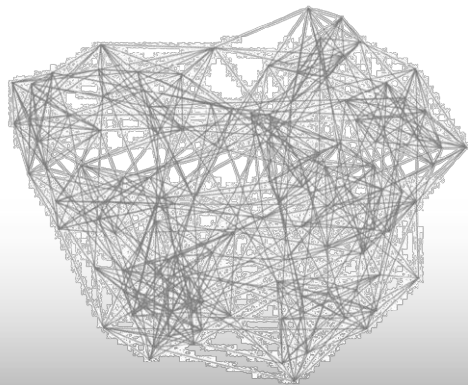
“small worlds” layout



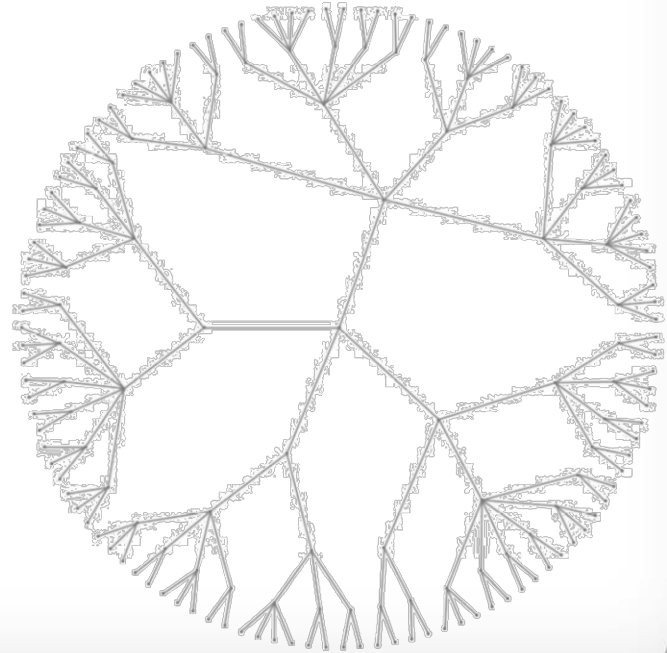
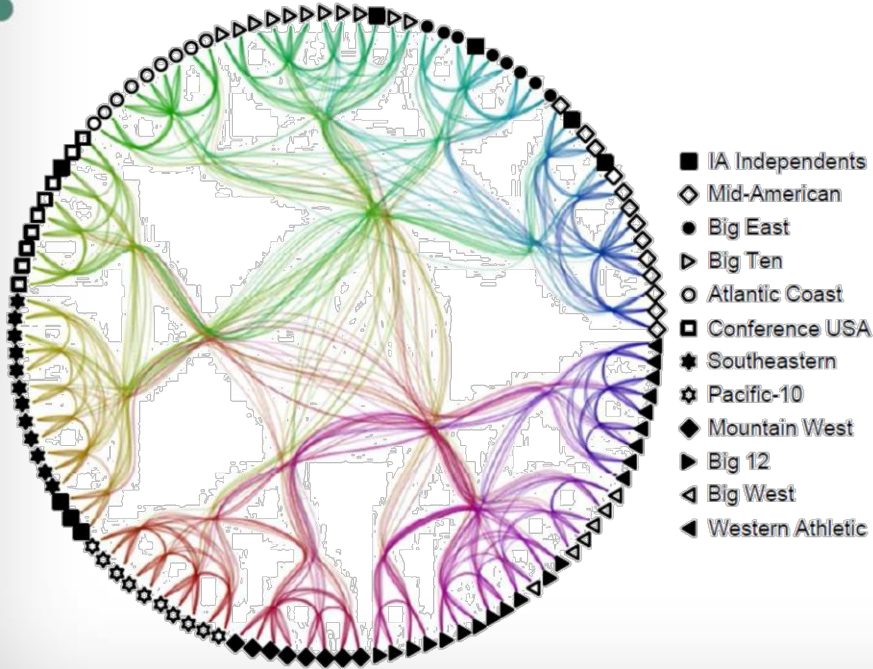
force-directed layout

# Community Discovery

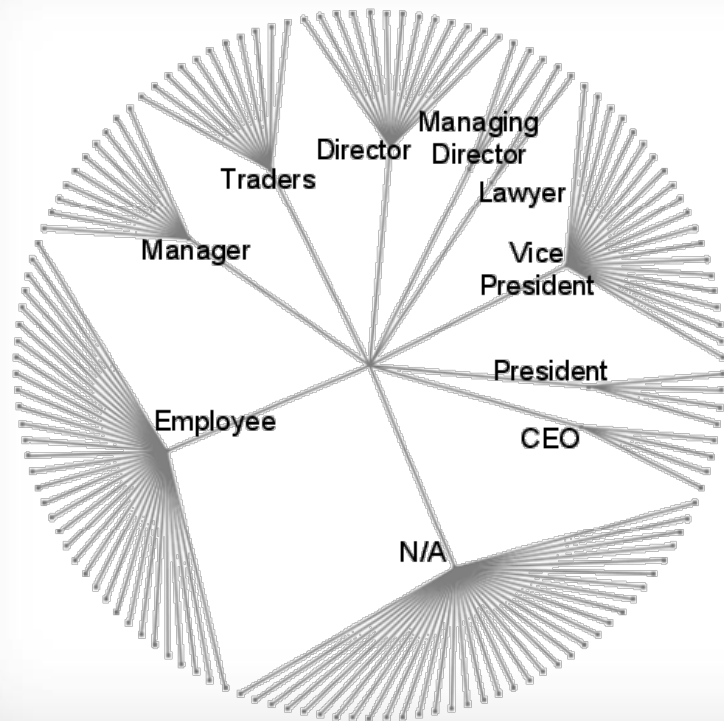
- Remove edges in order of decreasing BC, from highest to lowest
- At lowest level reveals communities
- Creates community hierarchies as higher BC edges merge lower-level communities



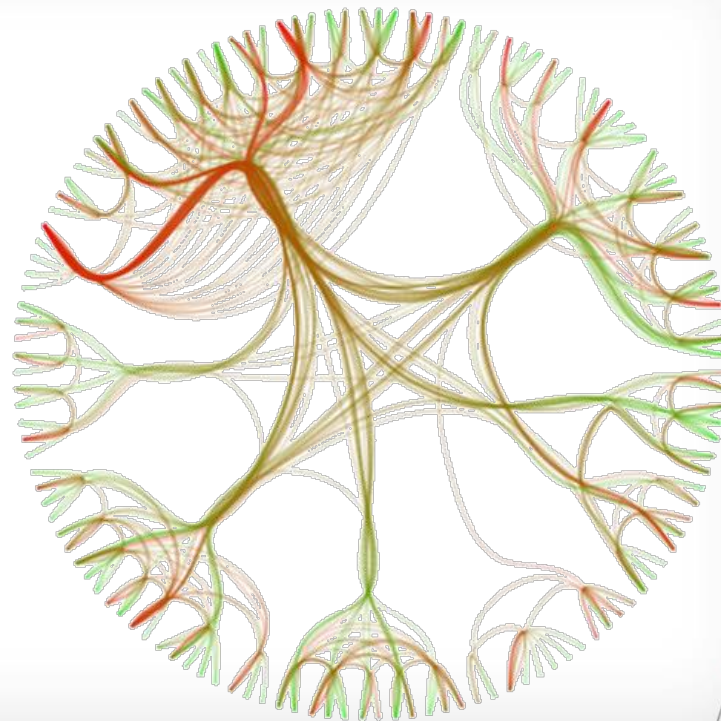
# Edge Bundle Communities



# Enron



actual communities



discovered communities



# Filtering & Details

