Exploring Game-Theoretic Formation of Realistic Networks

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Properties of Real-world Networks:

small-world property:

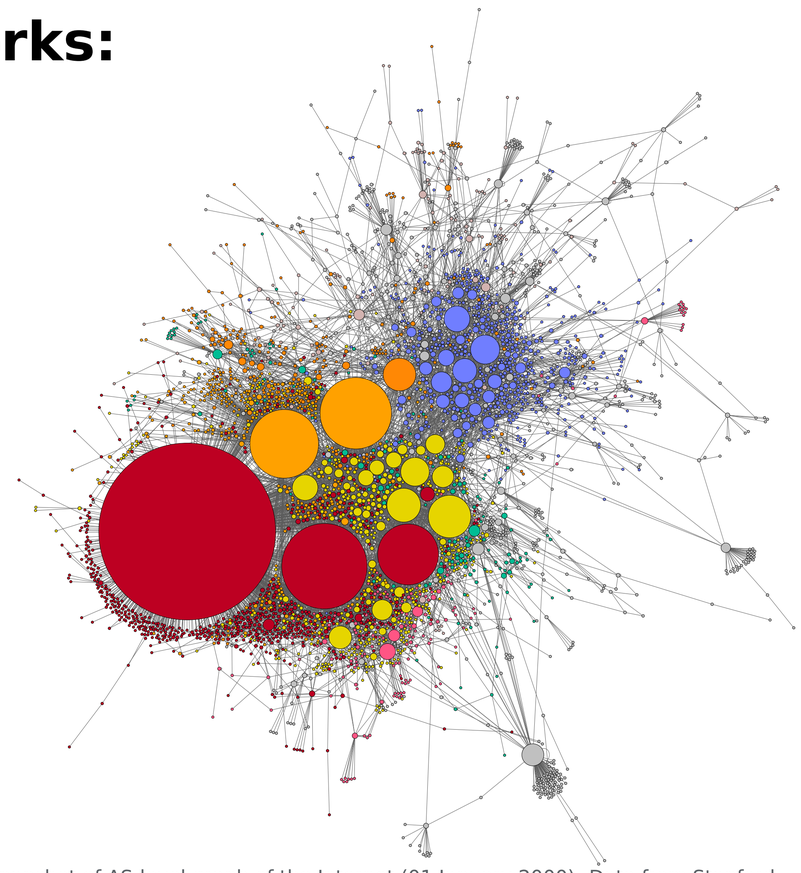
diameter in $O(\log n)$,
small average path length

high clustering:

many triangles and small cliques, average clustering coefficient in [0.2, 0.8]

power-law degree distribution:

probability that a node has degree k is proportional to $k^{-\beta}$, for some constant $2 \leq \beta \leq 5$

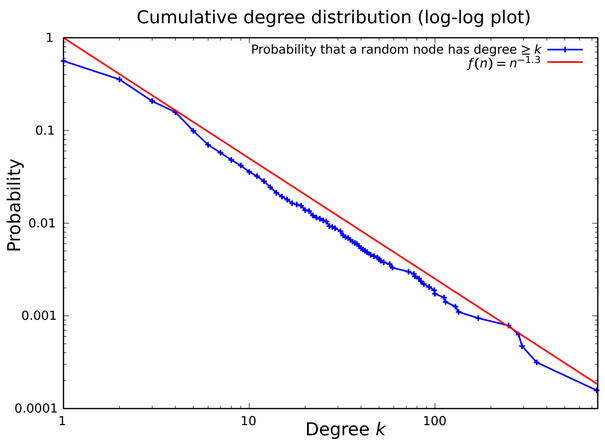


Snapshot of AS-level graph of the Internet (01 January 2000). Data from Stanford Large Network Database [1], plotted using Gephi with Yifan-Hu and Force Atlas layout. The graph has 3570 nodes colored by their modularity class and 7750 edges. Node sizes are proportional to their degree.

diameter: 9
avg path length: 3.801

average clustering coefficient: 0.351

fitted power-law exponent: 2.3



[1] http://snap.stanford.edu/data/as.html

Networks via Game-Theory

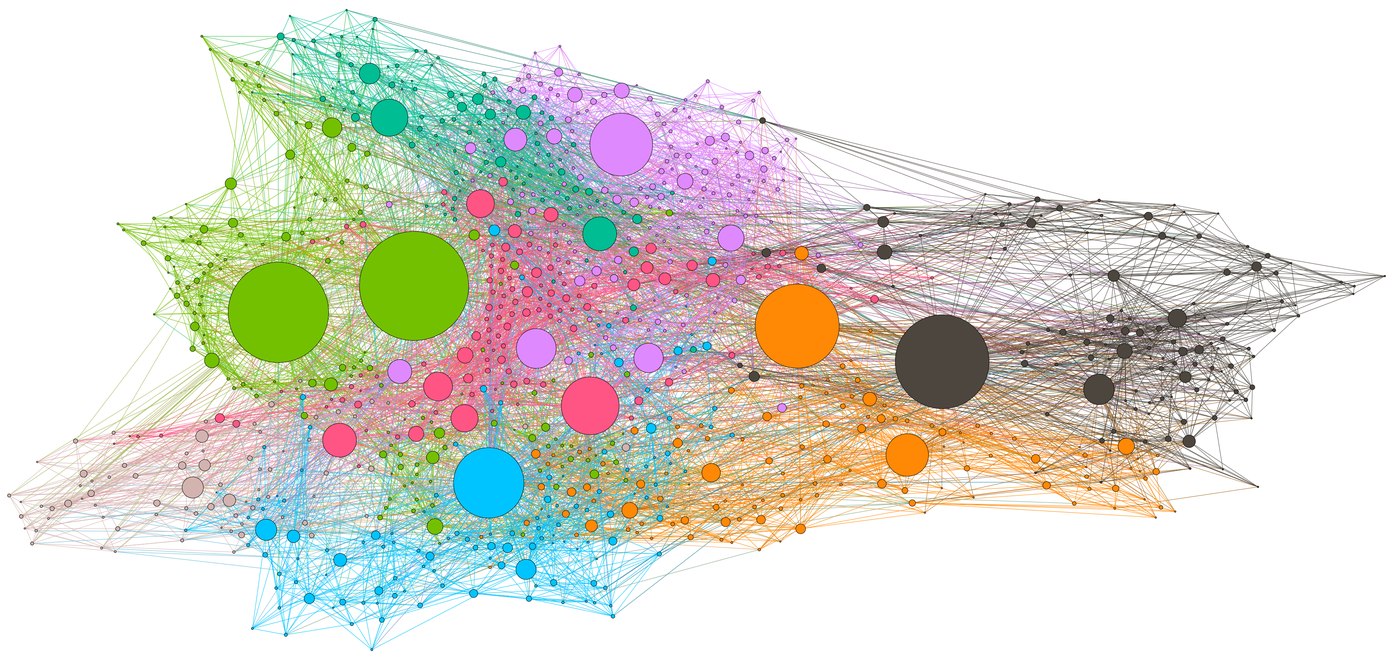
- nodes are selfish and rational agents
- agents strive for good position in the network
- each agent tries to minimize some cost function
- strategy of an agent = subset of other agents
- costly links are formed according to strategies
- strategies of all agents determines the edge-set
- consider pure Nash equilibrium of the game

Our Model:

Strategic Network Augmentation

1. start with sparse connected initial network
2. activate agents in round-robin/random fashion
3. active agent buys local edge to improve centrality
4. edge-cost is proportional to node degree
5. iterate until all agents are happy

Final equilibrium graph generated via global strategic network augmentation, plotted using Gephi with Force Atlas layout. The graph has 1000 nodes colored by their modularity class. Node sizes are proportional to their degree.



diameter: 4
avg path length: 2.71

average clustering coefficient: 0.321

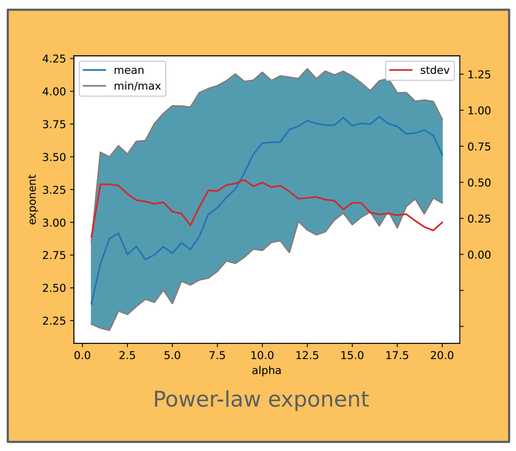
fitted power-law exponent: 3.2

nodes: 1000
edges: 7423

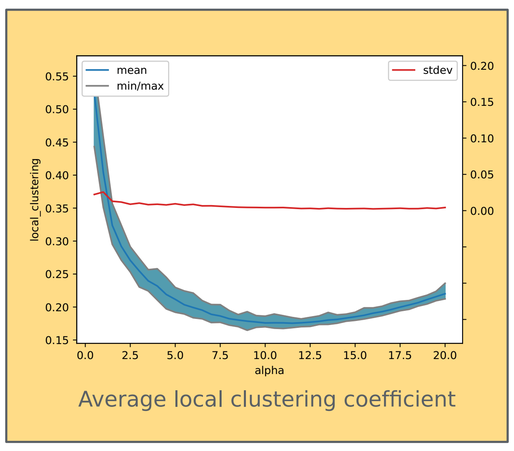
maximum degree: 205
minimum degree: 7

average degree: 14.84

Results for the global model ($n = 10000$)

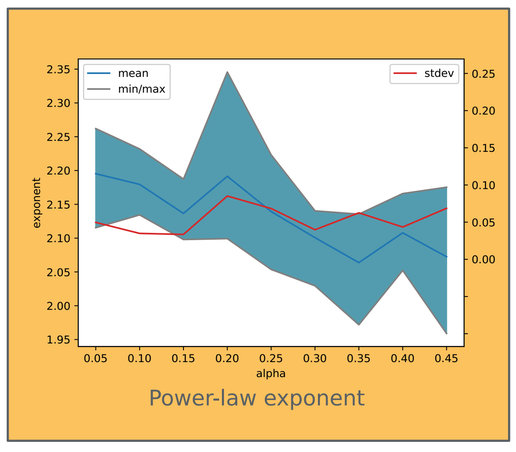


Power-law exponent

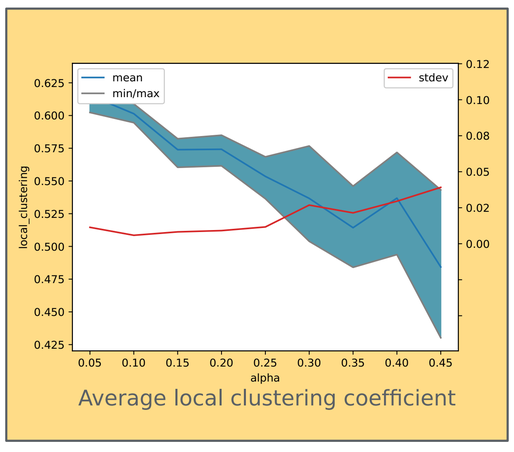


Average local clustering coefficient

Results for the local model ($n = 20000$)



Power-law exponent



Average local clustering coefficient

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