Exploring Game-Theoretic Formation of Realistic Networks

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Properties of Real-world Networks:

small-world property:

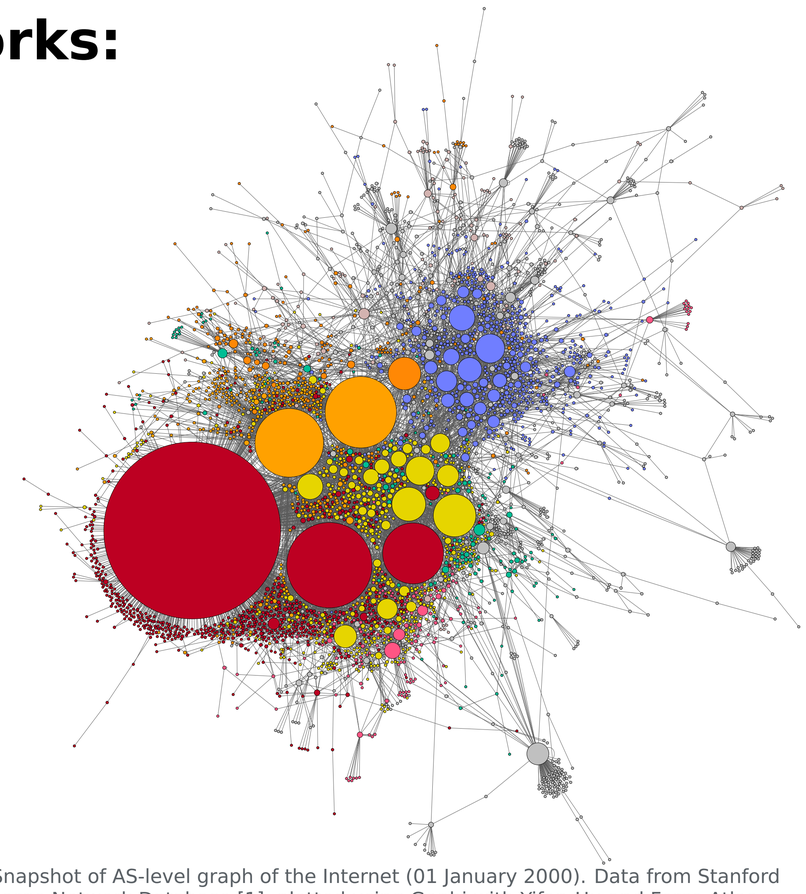
diameter in $O(\log n)$,
small average path length

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 $2 \leq \beta \leq 5$

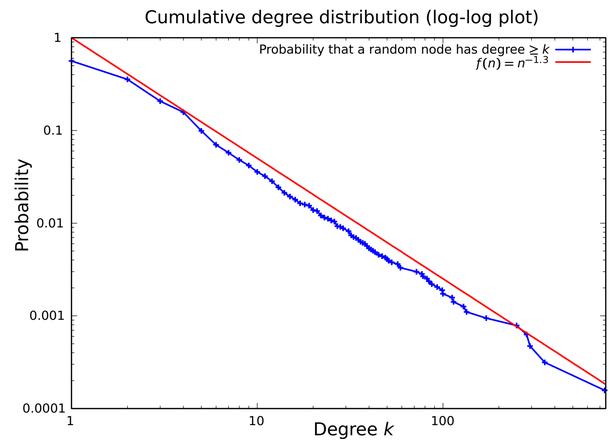


Snapshot of AS-level graph of the Internet (01 January 2000). Data from Stanford Large Network Database [1], plotted using Gephi with Yifan-Hu and Force Atlas layout. The graph has 3570 nodes colored by their modularity class and 7750 edges. Node sizes are proportional to their degree.

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

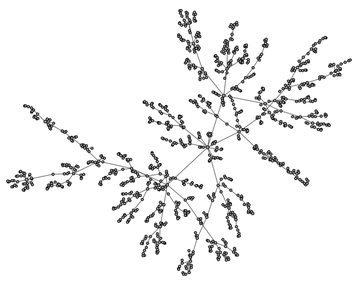
Networks via Game-Theory

- 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

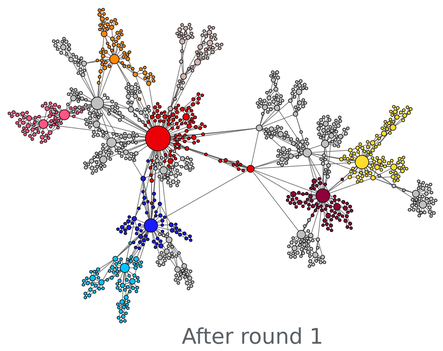
Our Model:

Strategic Network Augmentation

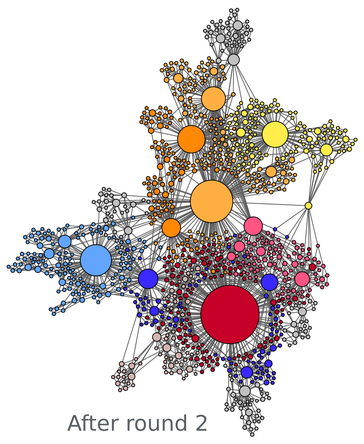
1. start with sparse connected initial network
2. activate agents in round-robin/random fashion
3. active agent buys local edge to improve centrality
4. edge-cost is proportional to node degree
5. iterate until all agents are happy



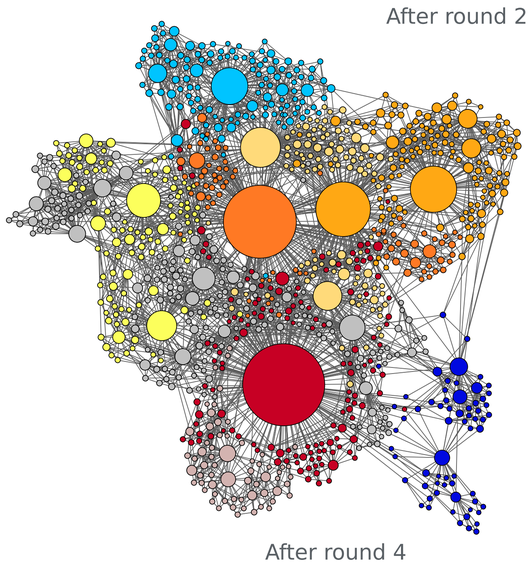
Initial random spanning tree



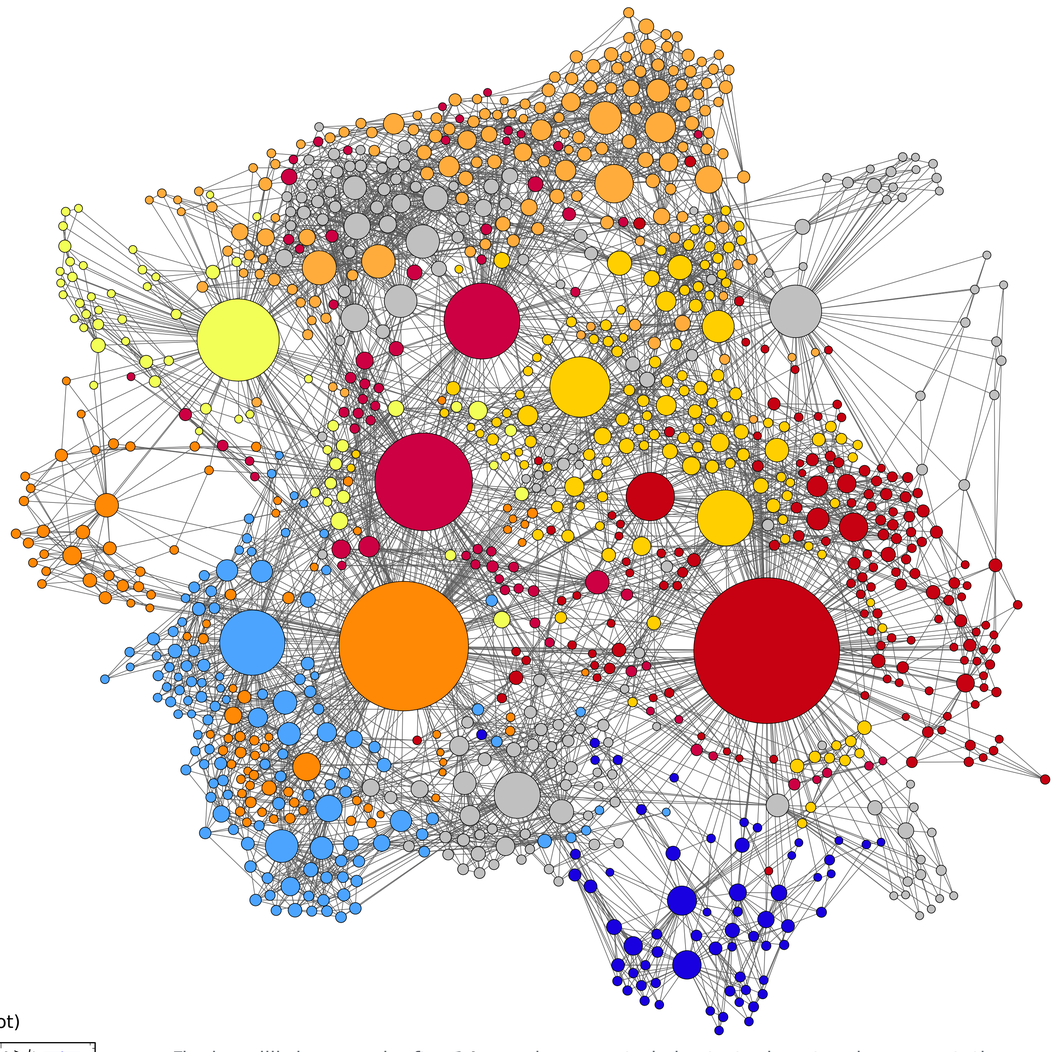
After round 1



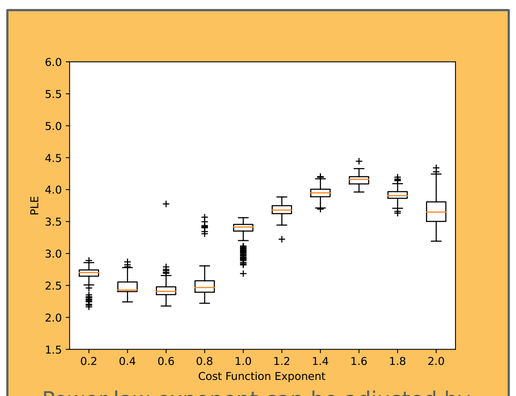
After round 2



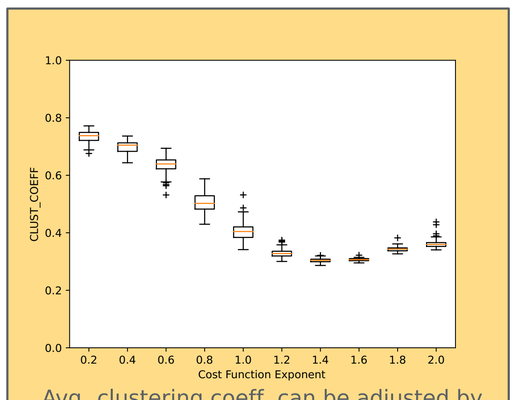
After round 4



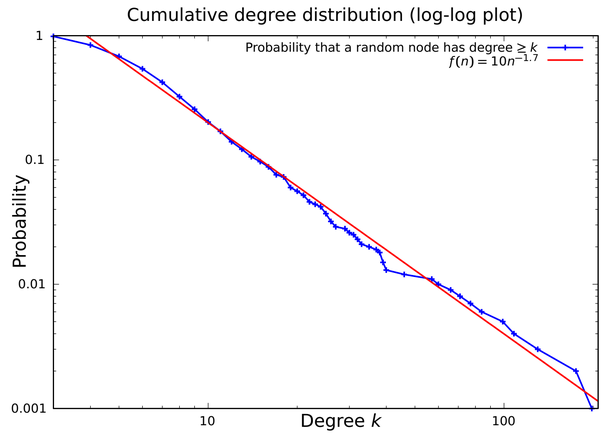
Final equilibrium graph after 14 rounds generated via strategic network augmentation, plotted using Gephi with Yifan-Hu and Force Atlas layout. The graph has 1000 nodes colored by their modularity class and 4244 edges. Node sizes are proportional to their degree.



Power-law exponent can be adjusted by fine-tuning the parameters of our model.



Avg. clustering coeff. can be adjusted by fine-tuning the parameters of our model.



diameter: 5
avg path length: 2.984

average clustering coefficient: 0.551

fitted power-law exponent: 2.7

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