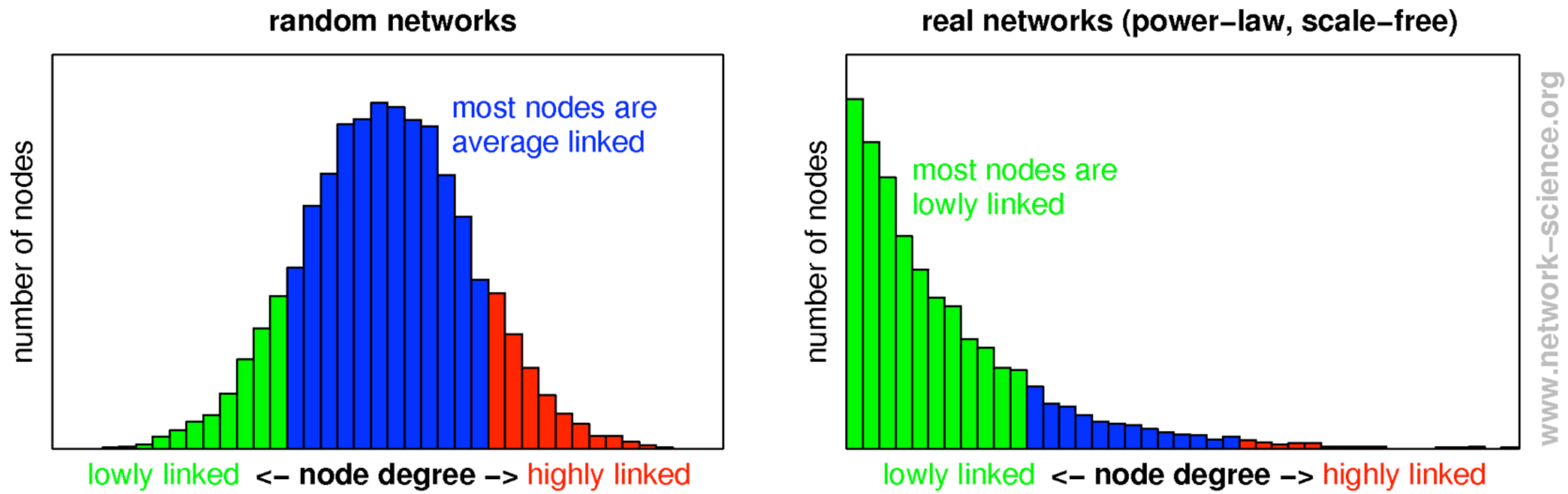
Lecture 5

Review

- Common properties of real networks
- Capture principal features of network structure
- Alternatives to measure them

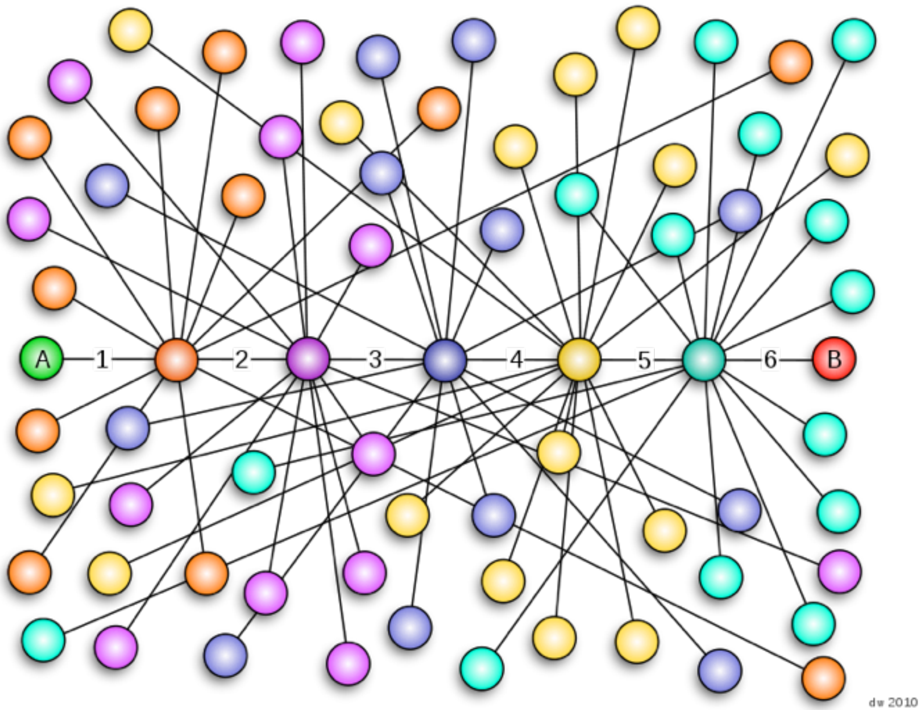
Degree distribution

captures the distribution of the degree over the whole network



Small-world

captures the mean distance between vertex pairs

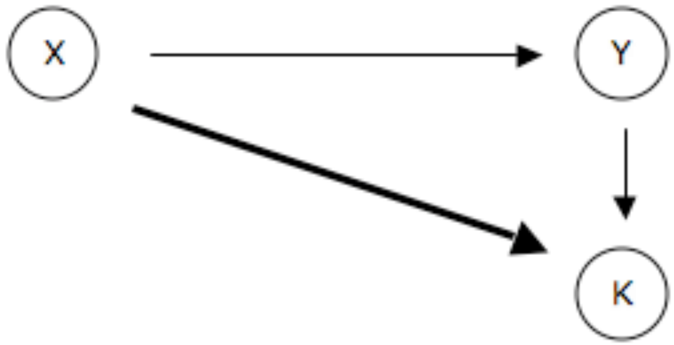


$$\ell = \frac{1}{\frac{1}{2}n(n+1)} \sum_{i \geq j} d_{ij}$$

If the mean distance scales logarithmically (or slower) with network size for a fixed mean degree

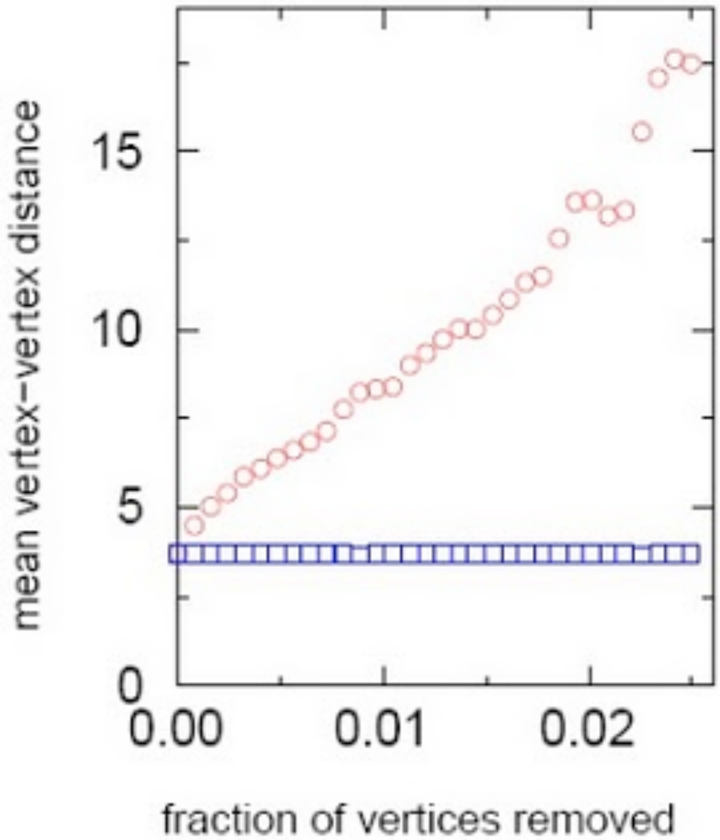
Transitivity

captures the heightened number of triangles in the network



Resilience

captures the ability to recover from removal of vertices



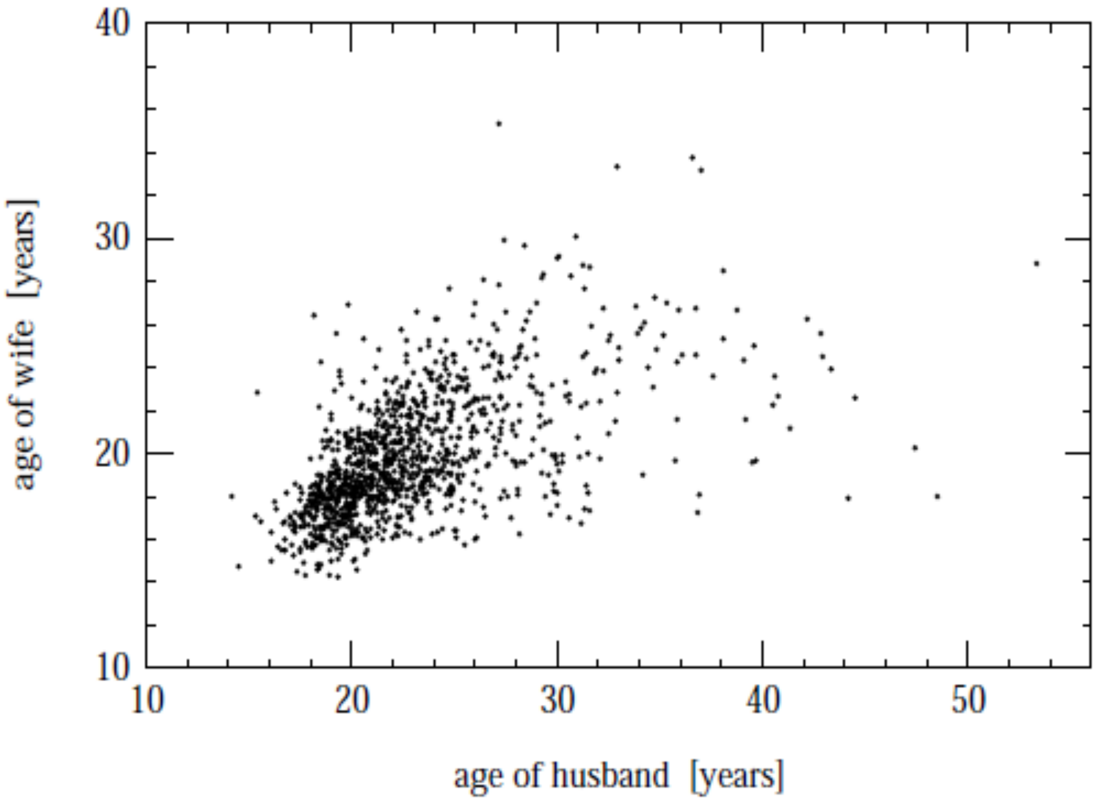
Mixing patterns

captures whether the probability of connection between depends on types

		woman			
		black	hispanic	white	other
men	black	0.258	0.016	0.035	0.013
	hispanic	0.012	0.157	0.058	0.019
	white	0.013	0.023	0.306	0.035
	other	0.005	0.007	0.024	0.016

Degree correlation

captures whether high degree vertices associate preferentially to other high degree vertices

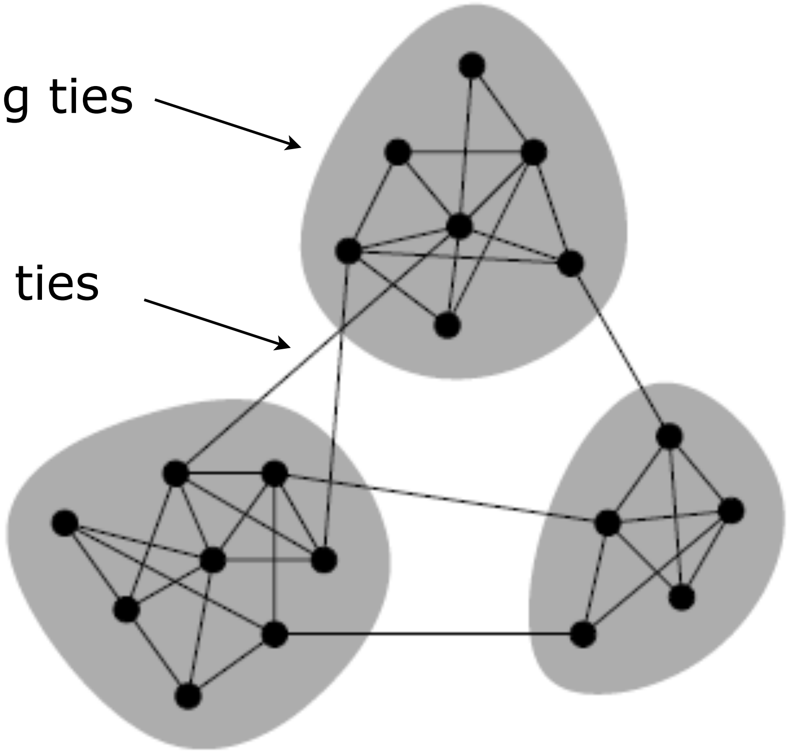


Community structure

captures whether there are groups of vertices that have a high density of edges between them, with a owe density of edges between groups

strong ties

weak ties



Dunbar's number is a theoretical cognitive limit to the number of people with whom one can maintain stable social relationships. No precise value has been proposed for Dunbar's number, but a commonly cited is 150.

Examples of large networks

- connections among people (friendship)
- relation among political parties
- trade among organizations, countries
- citation networks
- computer networks (internet)
- transportation networks (airlines, streets, electric networks)
- connections among words in text
- flow charts
- Petri nets, hybrid systems

Visualize networks?
gain insight into principal features

Today

- Network visualization (Pajek)
- Mathematics of model networks
- Poisson Random graphs

Next class...

- Generalized random graphs

Later...

- Markov + exponential graphs
- Small-world graphs

Pajek + R + igraph

Basics

- Enables analyses of large networks
- First look at networks
- Data must be prepared in an input (ASCII) file
- http://vlado.fmf.uni-lj.si/pub/networks/pajek/
- http://vlado.fmf.uni-lj.si/pub/networks/pajek/doc/pajekman.pdf

Basics

- number of vertices
- number of arcs
- number of directed loops
- number of edges
- number of undirected loops
- properties: densities, clusters, components, etc

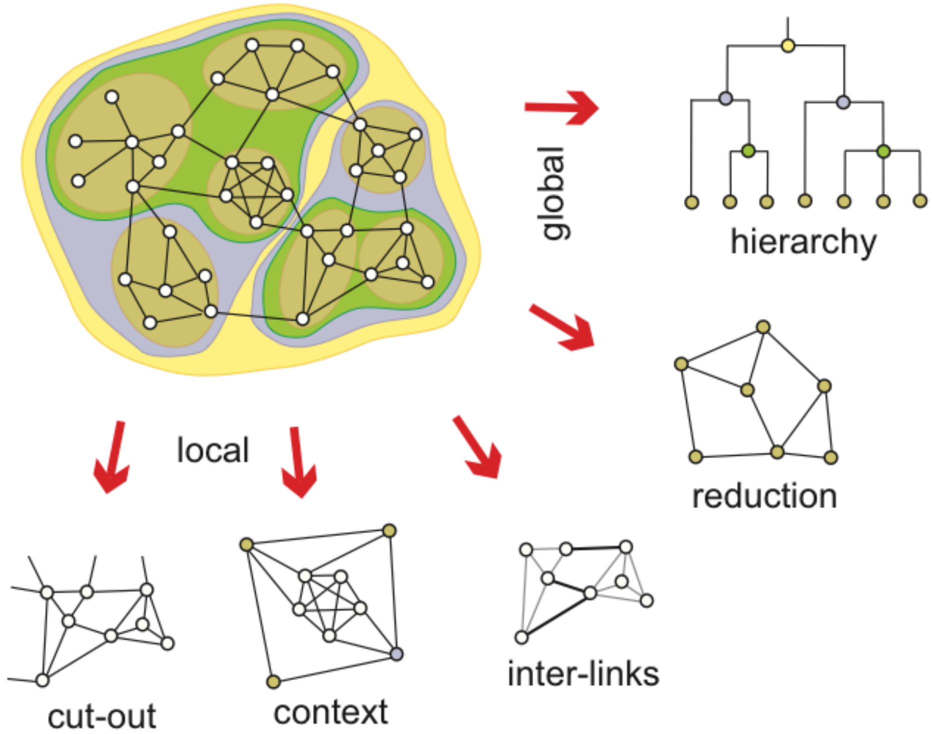
powerful visualization tools $\longrightarrow$ decomposition of a large network into several smaller networks that can be treated further using more rigorous tools

Basics

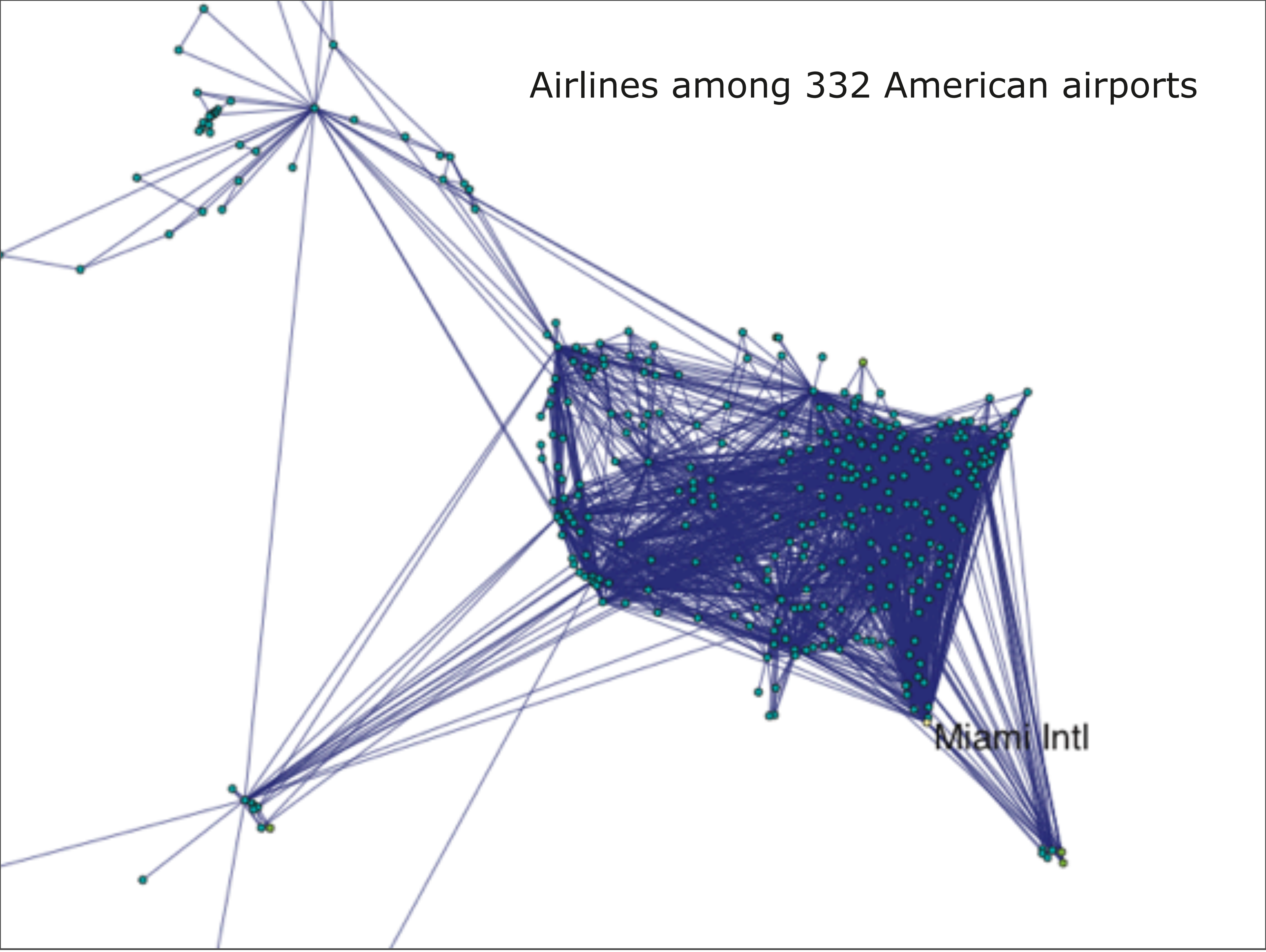
- Find clusters (components, neighborhoods of vertices, cores, etc.)

- Extract vertices that belong to the same clusters and show them separately (detailed local view)

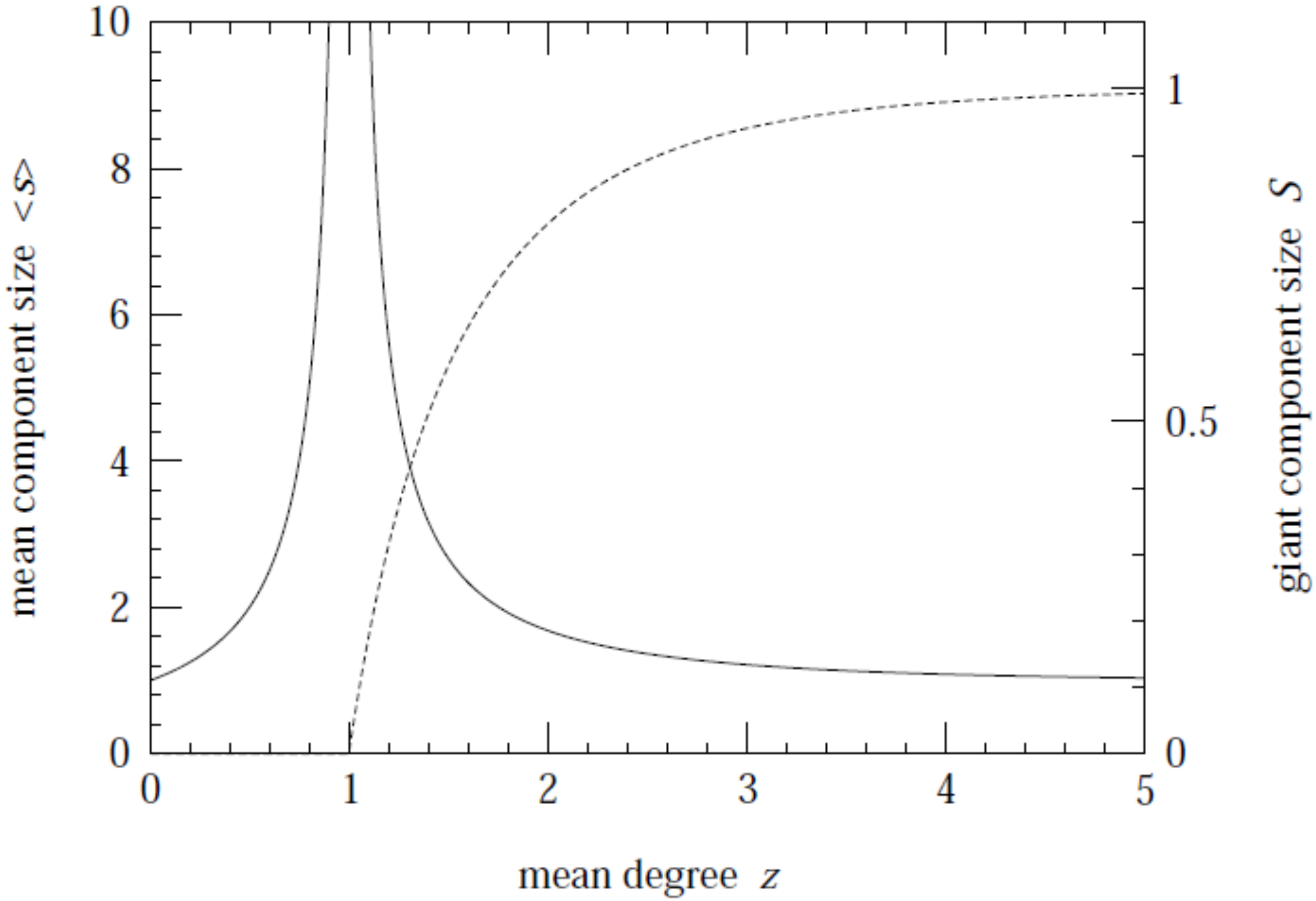
- Shrink vertices in clusters and show relations among clusters (global view).



Airlines among 332 American airports



Mathematics of model networks



mean component size <s>
giant component size S
mean degree z
0
2
4
6
8
10
0
1
2
3
4
5
0
0.5
1

- caveat -
In almost all other respects, the properties of random networks do not match those of real world networks

Other properties...

- Low transitivity, C=p
- Poisson distribution (unlikely)
- Random mixing pattern
- No correlation degree between degrees of adjacent nodes
- No community structure

A good straw man but rarely taken seriously in modeling of real systems!

Look at generalized models...