Netzwerkmodelle

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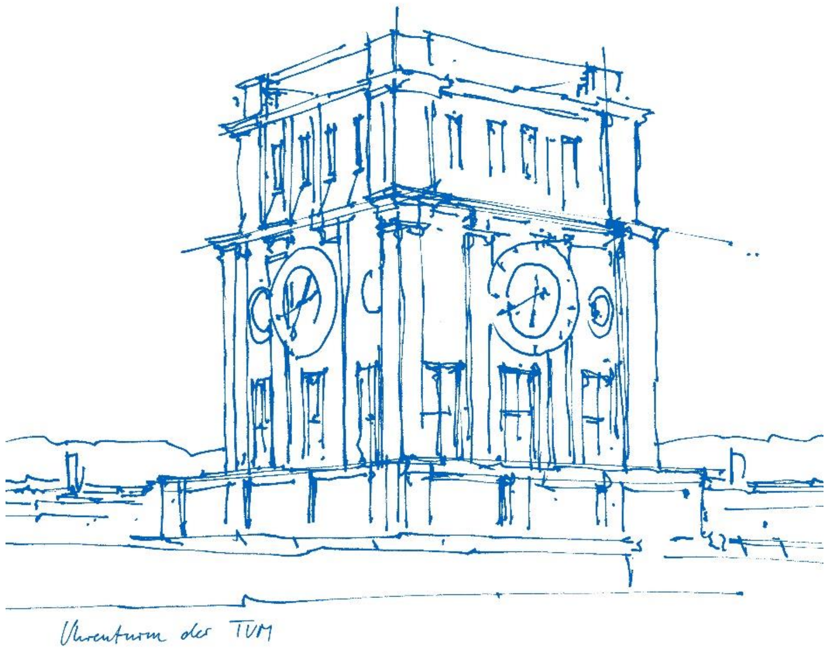
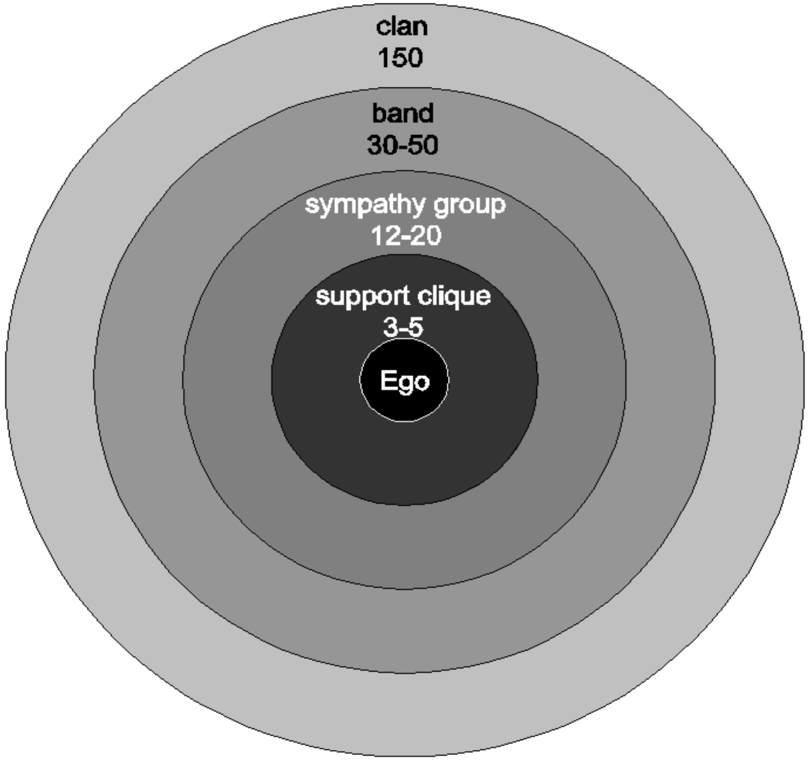


Hierarchical Organization

W. X. Zhou, D. Sornette, R. A. Hill, R. I. M. Dunbar, Discrete hierarchical organization of social group sizes, Proc. Biol. Sci. 272 (1561), pp. 439–444, 2005.



Weak/Strong Ties

Mark Granovetter, PhD thesis

Survey: Blue-collar worker in a suburb of Boston

How do they use their networks to find a job

Result: Not friends and family, but acquaintance and loose connections

Weak ties have different

- Networks
- Knowledge
- Resources

M. S. Granovetter, Getting a Job: A Study of Contacts and Careers, Harvard University Press, Chicago, 1974.

Differences in Network Size

- Network characteristics differ with ego characteristics
  - Single, childless egos have larger networks than egos who are married or have dependents
  - Networks exhibit homophily by gender
  - Female networks have more kin in their networks than males
  - Socio-economic status is positively correlated with network size and diversity
  - Married and cohabited people have smaller core networks
- Large networks contain a larger proportion of weak ties than small networks

Global Connections

Everybody on earth is somehow connected to everyone else in short distances

F. Karinthy, Chains, In: Everything is Different, Budapest, 1929.

S. Milgram, An Experimental Study of the Small World Problem, Sociometry 32 (4): 425-443, 1969.

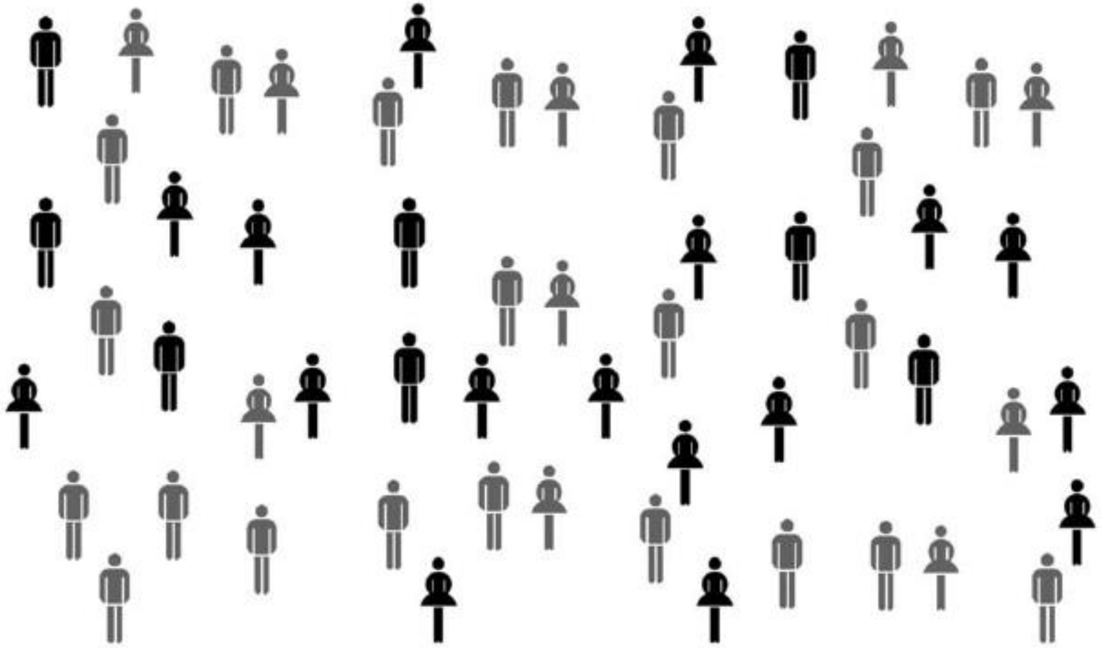
Six Degrees of Kevin Bacon (The Oracle of Bacon)

Summary: How do Networks look like?

Birds of a feather flock together

Those close by, form a tie

Friends of friends become friends



After all, what is Facebook?

Facebook?

“Indeed, no matter what Facebook allows us to do, I have found that most of us can maintain only around 150 meaningful relationships, online and off — what has become known as Dunbar’s number. Yes, you can ‘friend’ 500, 1,000, even 5,000 people with your Facebook page, but all save the core 150 are mere voyeurs looking into your daily life.”

–Dunbar, *NY Times* op-ed, 2010

Density

Network level metric

Density of the network matrix

Number of edges / number of possible edges

$$d(G) = \frac{E}{(N \cdot (N - 1))\ /\ 2}$$

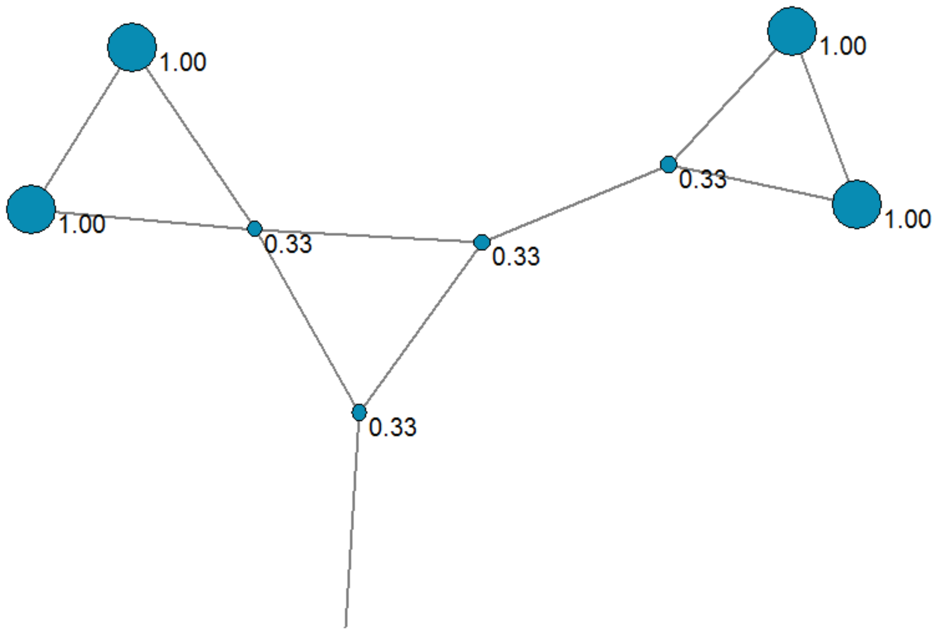
Problem: Density is a function of network size -> larger networks, lower density.

Clustering Coefficient

Measure for transitivity

Links between neighbors / possible links

Network level: Average of nodes



Why Random Networks

A lot of research questions are discussed by using algorithmic generated networks rather than observed real networks.

Why:

- Easy to obtain
- Experiments: change parameters
- Real world networks are not available (e.g. privacy)
- Not enough real world networks are available

To describe and analyze diffusion processes:

- e.g. diffusion of innovation, opinions, rumors, and computer viruses

Assessing Random Networks

Degree distribution

Centralization

Clustering coefficient

Average path distance

Random Networks

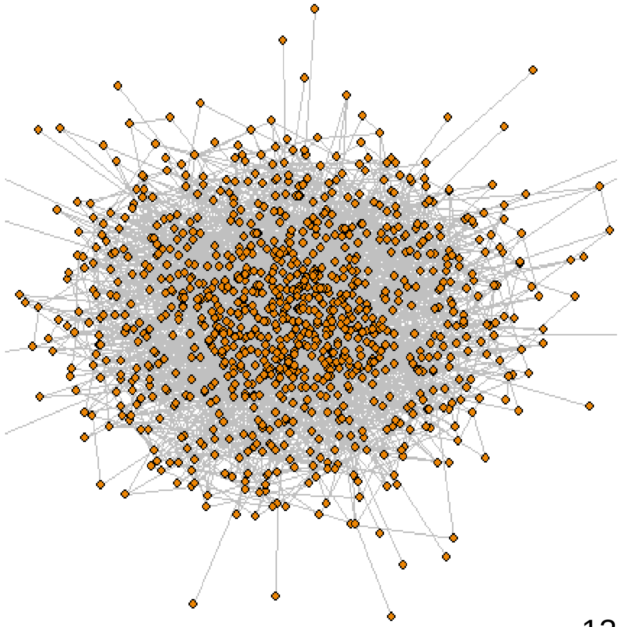
Erdos/Renyi (1959):

Classical random network algorithm

Create *N* nodes

Add an edge for every pair of nodes with probability *p*

Parameter: N, p



Algorithm

Create N nodes

a)

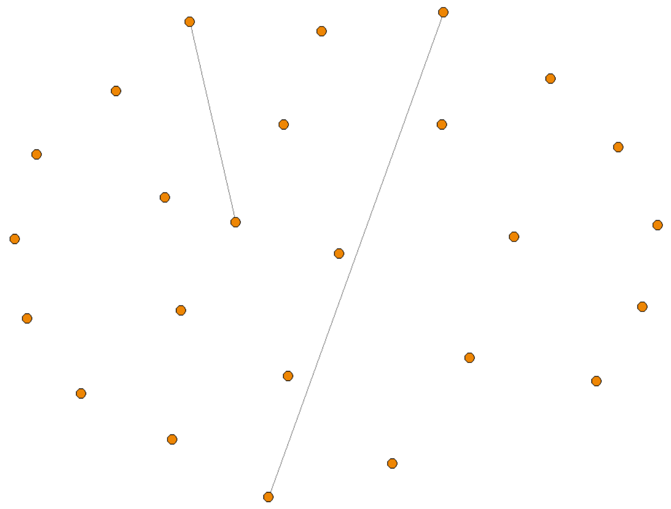
Add an edge for every pair of nodes with probability *p*

- Put 1 in matrix with probability *p*, 0 otherwise

b)

Randomly pick 2 nodes and connect them

Repeat till E = N^2 * p



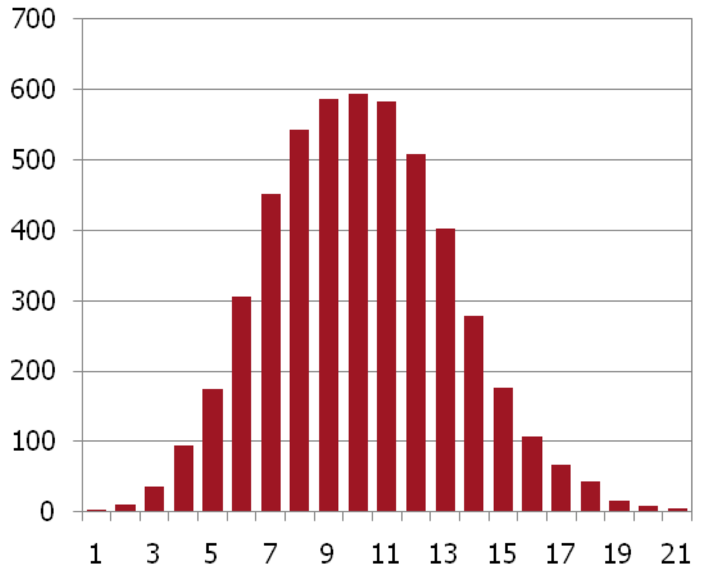
Properties of Random Graphs

Short path distances

(Almost) no local clustering

Poisson-distribution of degree

Many known properties (largest component, largest cliques, etc.)



Problems?

Erdos/Renyi networks:

- Edges are independent
- Each has same probability for existence

What are real world network properties?

Those Who Have …

Scientific citations (Merton, 1968)

- The probability of being cited, is proportional to the citations received in the past.
- Very unequal distribution.

Moreno 1934: Friendship choices in school classes followed a very unequal distribution

- Some get named a lot and others only very selectively

Many names: Zipf law, power law, Pareto, 80-20, etc.

Barabási and Albert (1999) create random networks with power-law degree distributions: “preferential attachment.”

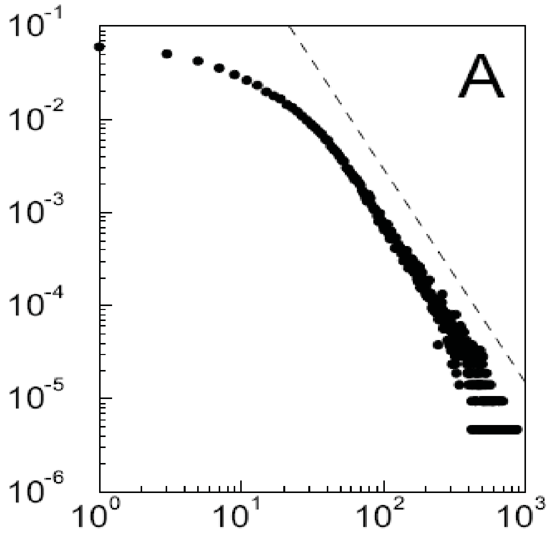
Stylized Networks - Algorithms

<u>Barabási/Albert (1999):</u>

- Two characteristics:
  - networks evolve
  - new nodes connect more likely with already well connected nodes

Algorithm

- Starting with a small number m_0 of nodes
- Add nodes using *preferential attachment*



Power-law degree distribution

$P(k) \sim k^{-\gamma}$

Scale-free

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Plus: Local Clustering?

Stylized Networks

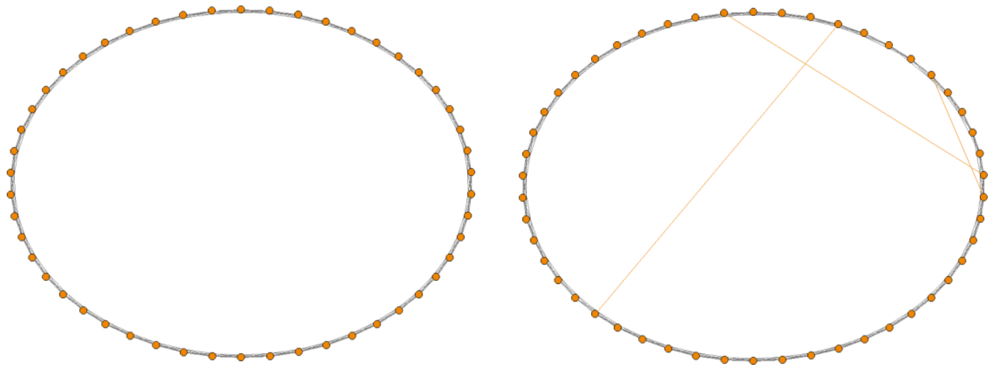
Watts/Strogatz (1998):

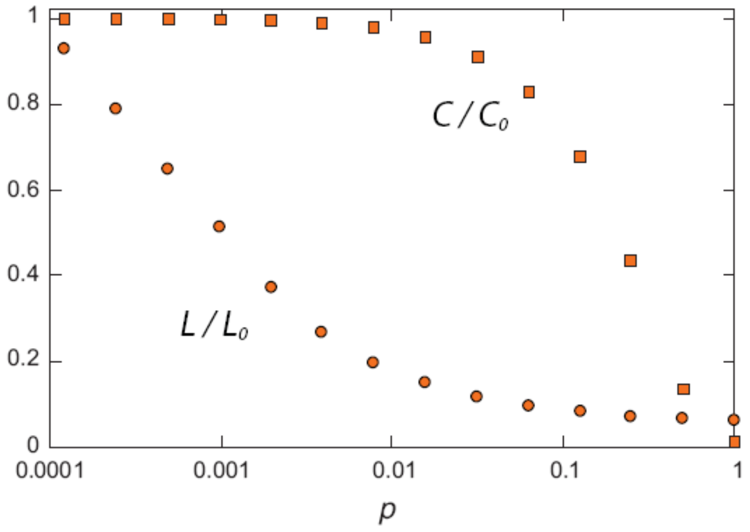
Regular lattice

Reconnect edges with probability *p* to a random target node

Small-world networks:

- locally clustered
- short path distances





Stylized Networks

Hamill & Gilbert (2009):

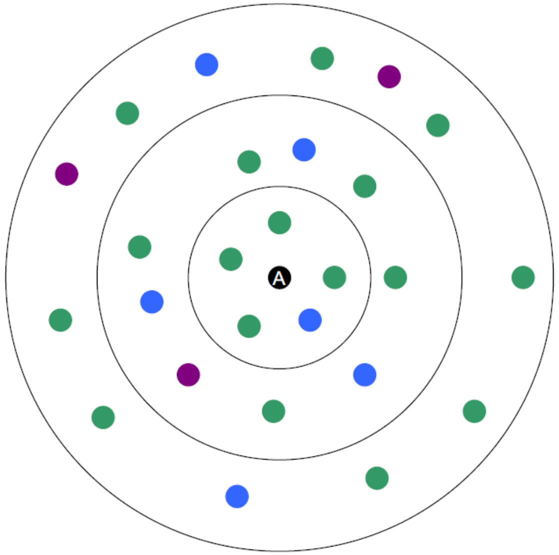
Random arrangement of actors in a
two-dimensional space

Actors have different social reach (radius, social circles)

Connect two nodes if they are both within the radius of the other node

Local clusters

Nodes with larger reach connect clusters



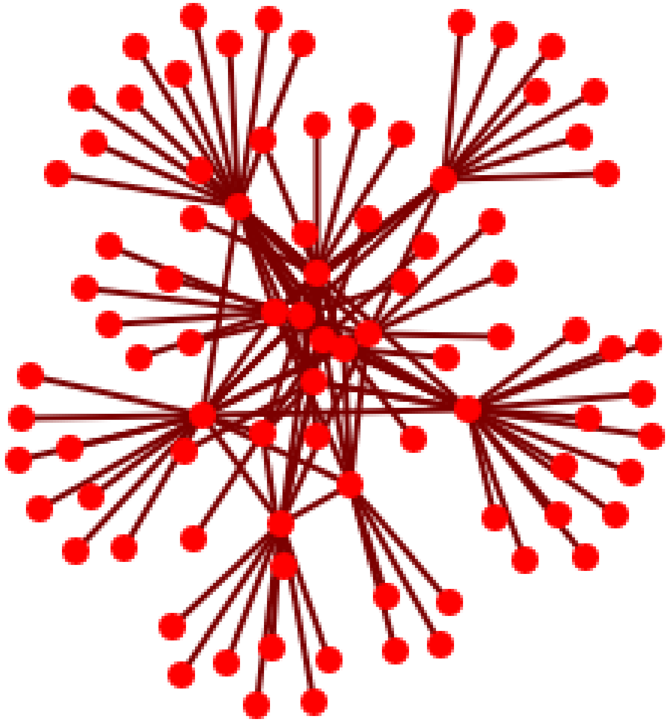
Core Periphery Structure

Two kinds of nodes

- Core of interconnected nodes
- Periphery of pendants with

Properties

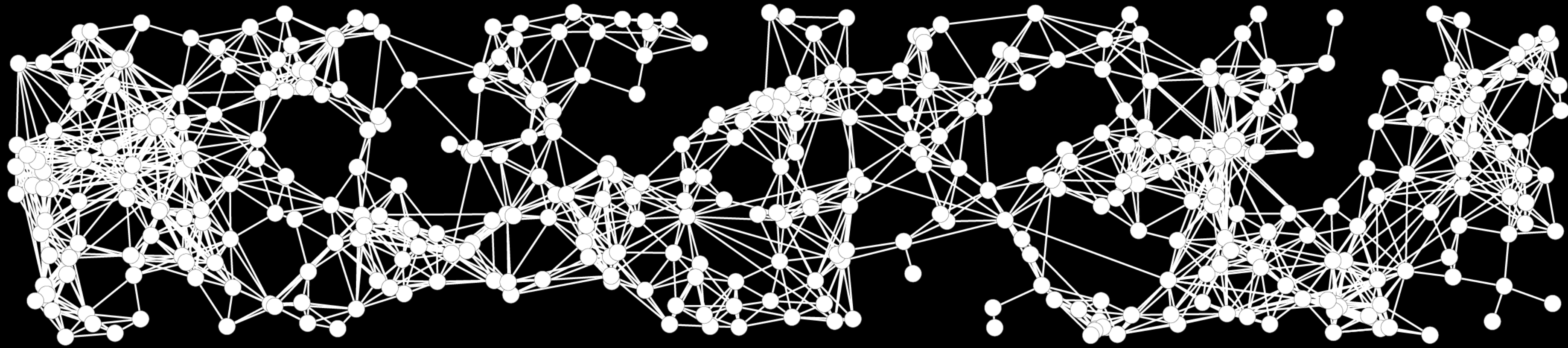
- Short distances
- Some local structure (core vs non-core)



Networks Attributes by Algorithm

Attributes	Erdos Renyi	Regular Lattice	Small World	Barabasi Albert	Hamill Gilbert
1. Maximum degree	14,60	6,00	8,90	89,70	19,10
2. Density	0,01	0,01	0,01	0,01	0,01
3. Degree variance	6,06	0,00	0,54	47,62	9,53
4. Skewness	0,38	0,00	0,20	6,25	0,86
5. Degree correlation	0,05	-	-0,03	-0,14	0,68
6. Clustering coefficient	0,01	0,60	0,45	0,03	0,56
7. Local edges	0,03	1,00	0,89	0,16	0,95
8. Average path distance	3,64	83,83	6,21	3,50	10,78

“Our mission is to go forward, and it has only just begun.
There's still much to do, still so much to learn. Engage!”
Jean-Luc Picard, Star Trek TNG, Season 1 Episode 26



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