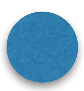
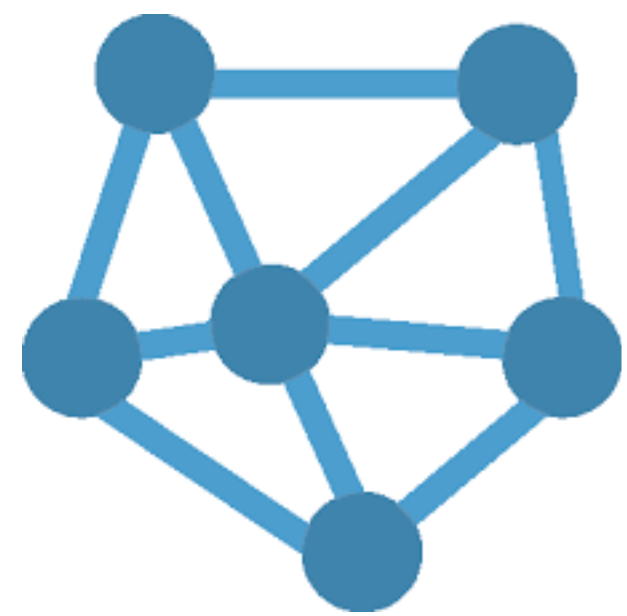
Redes Complejas

Redes - Grafos



Vértices *(Nodes)*

Aristas *(Edges)*

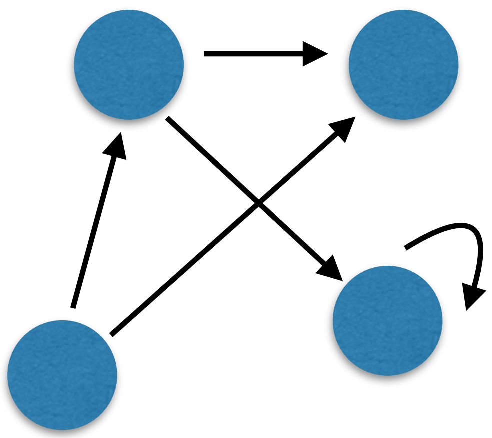


Red

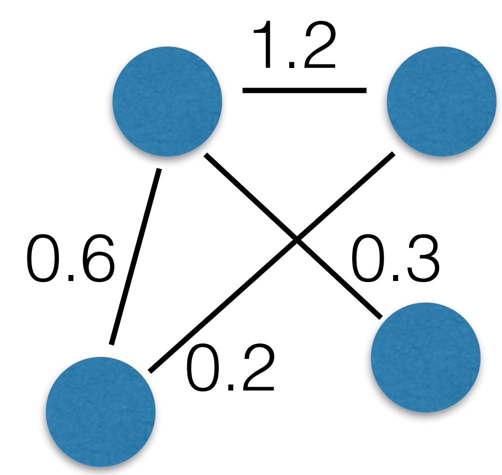
Traveling salesman, Erdös, Dijkstra, …

Tipos de grafos

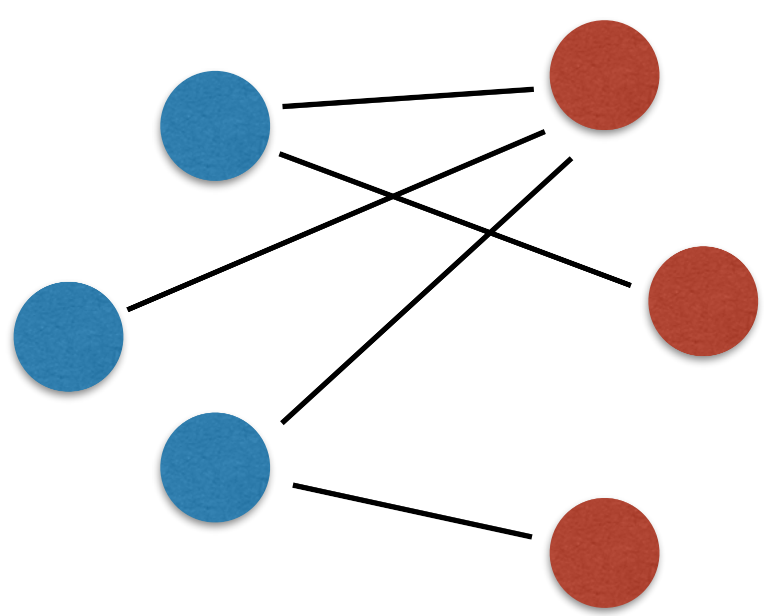
Dirigidos



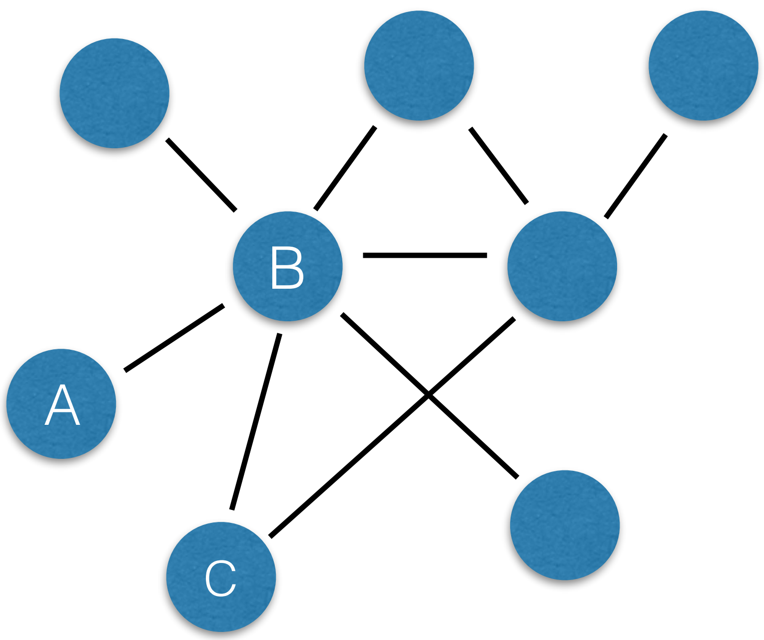
Pesados



Bipartitos



Representando Grafos



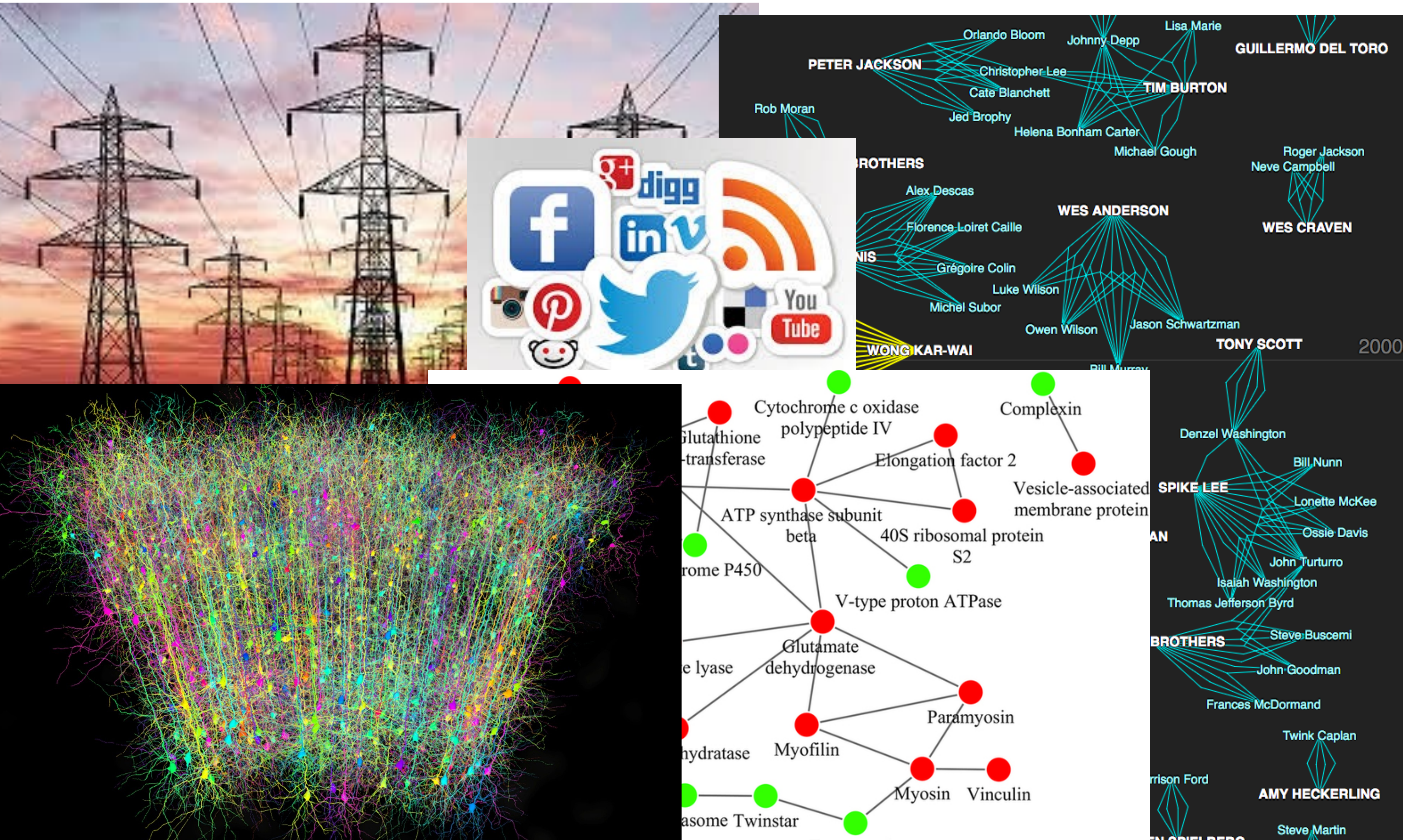
Lista de aristas

(A,B), (B,C), ...

Nodos	A	B	C
A	0	1	0
B	1	0	1
C	0	1	0

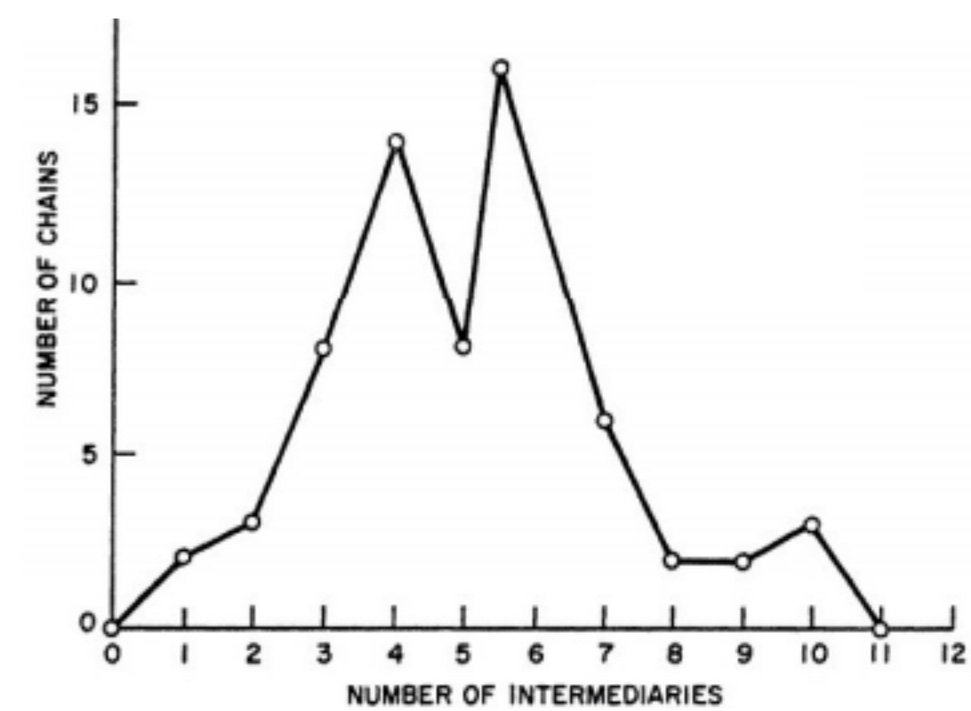
Matriz de adyacencia

Redes en el mundo



Seis grados de separación:
El experimento de Milgram (1967)

- 300 personas al azar en ciertas ciudades de EE.UU.
- Se les pedía que le hagan llegar una carta a un agente de bolsa en Boston, pero sólo mandándola a amigos/concidos
- Se midió cuántos pasos eran necesarios para llegar

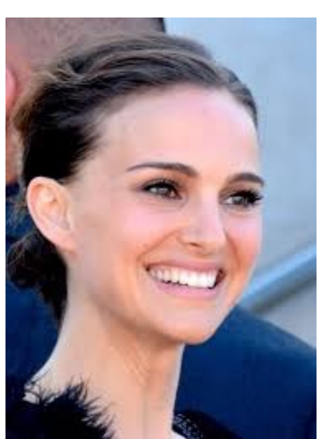


Seis grados de separación

Número de Erdös (1969): número de pasos hasta llegar Erdös via coautoría de artículos

Número de Bacon: número de pasos hasta llegar Kevin Bacon via coparticipación en películas

Número de Erdös-Bacon: suma de ambos



7

Erdös-Bacon-Sabbath… 11

Mundos Pequeños

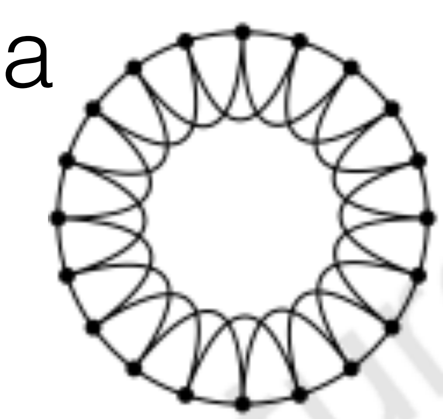
- Cada persona conectada con 100 amigos
- A dos pasos, llegamos a 100*100=10000 personas
- A 5 pasos, 10^10 personas.. ¡todo el mundo!

…pero qué está mal?

¡Los amigos de mis amigos son amigos entre sí!

No tan aleatoria…

sino más ordenada



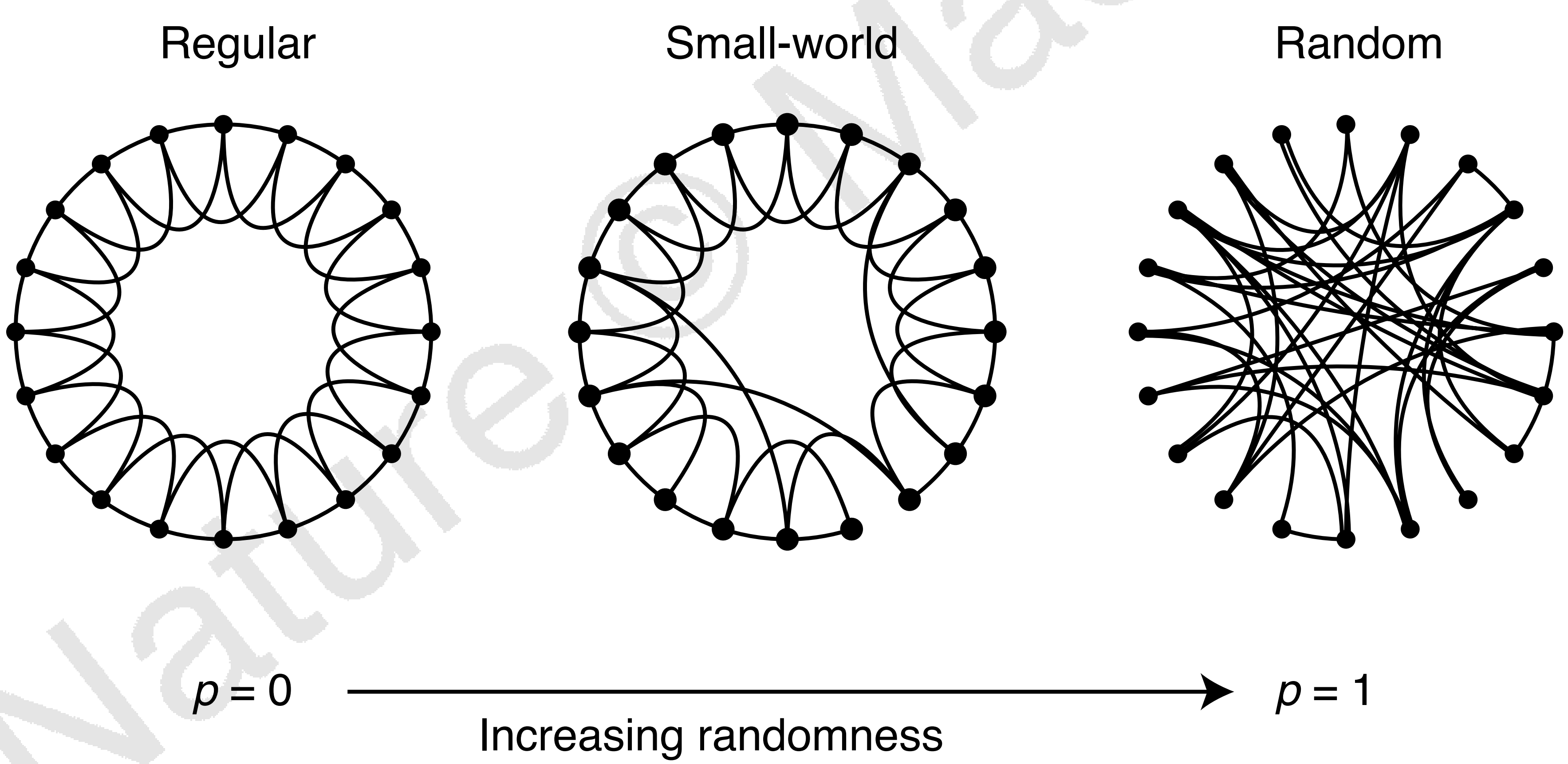
Mundos Pequeños

1998

Collective dynamics of 'small-world' networks

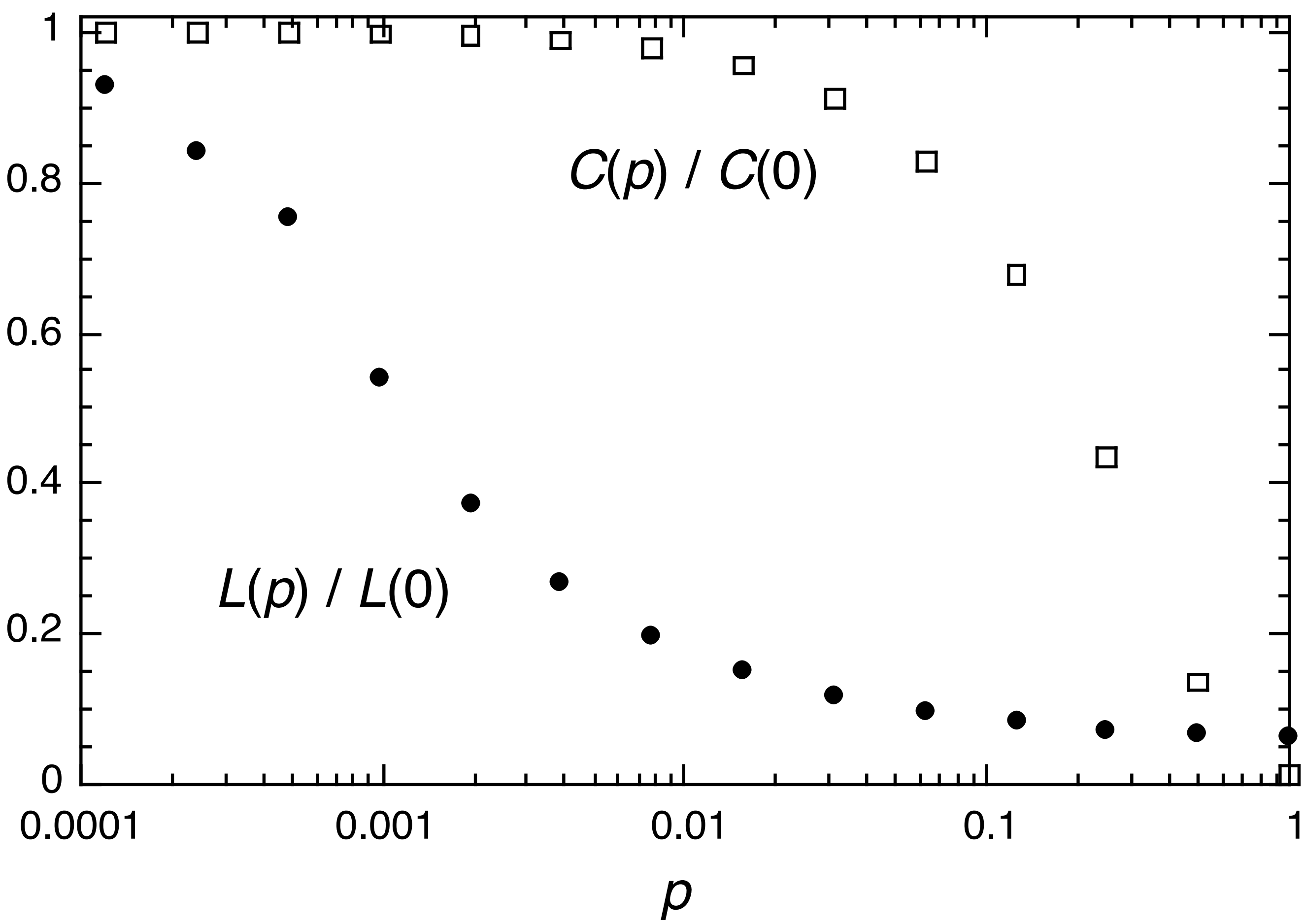
Duncan J. Watts* & Steven H. Strogatz

Department of Theoretical and Applied Mechanics, Kimball Hall, Cornell University, Ithaca, New York 14853, USA



Mundos Pequeños

Clustering y Longitud de camino medio



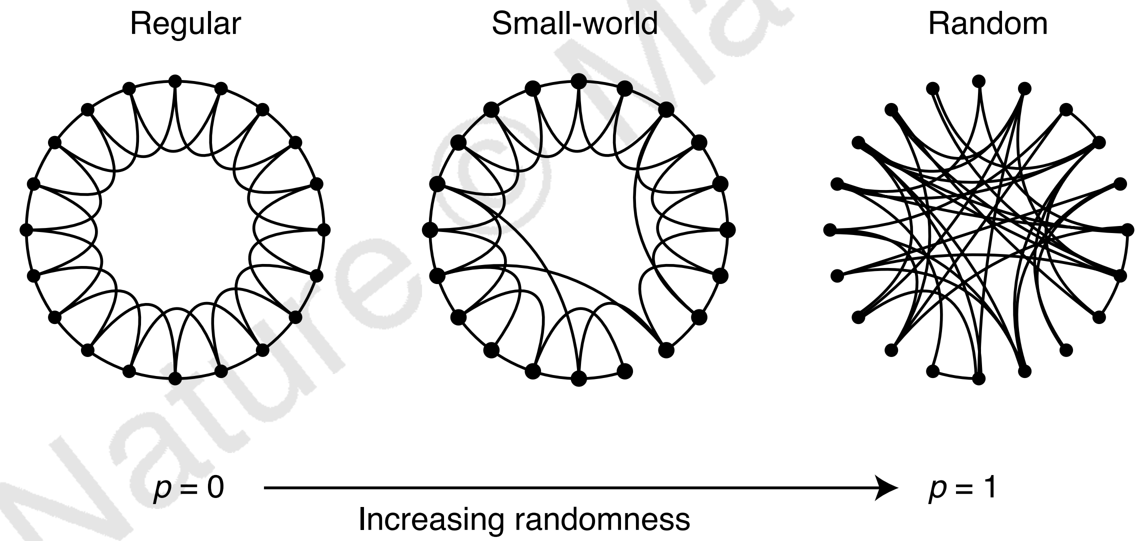
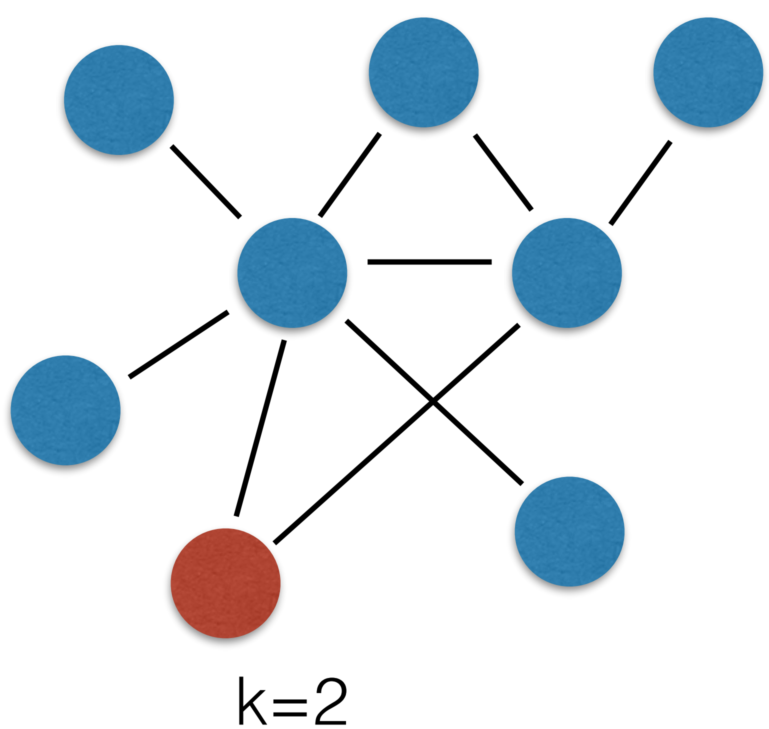
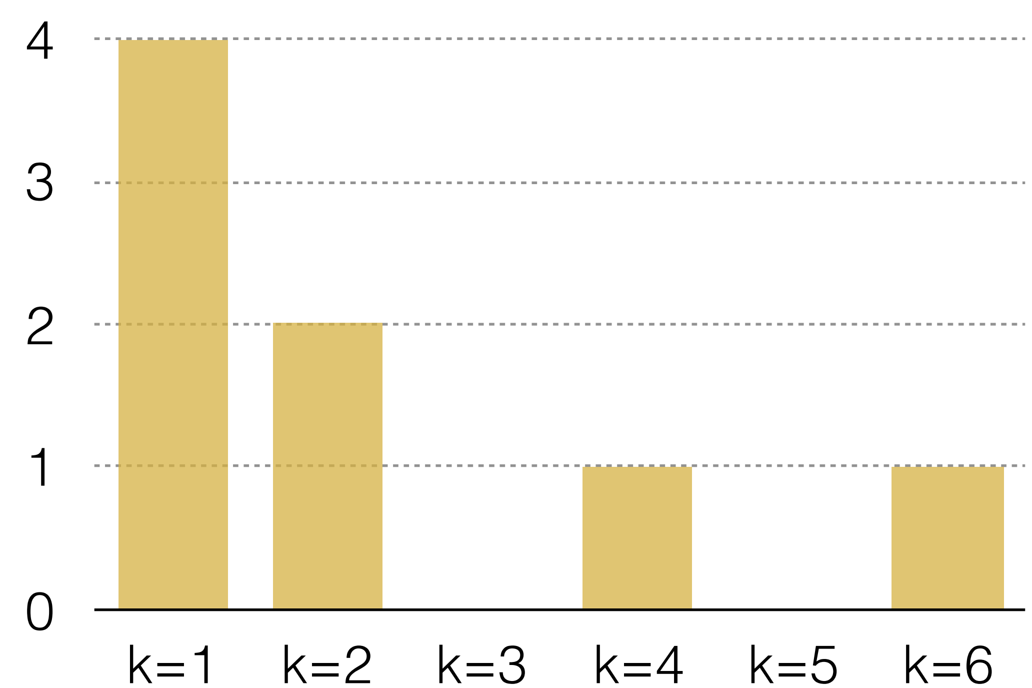


Table 1 Empirical examples of small-world networks

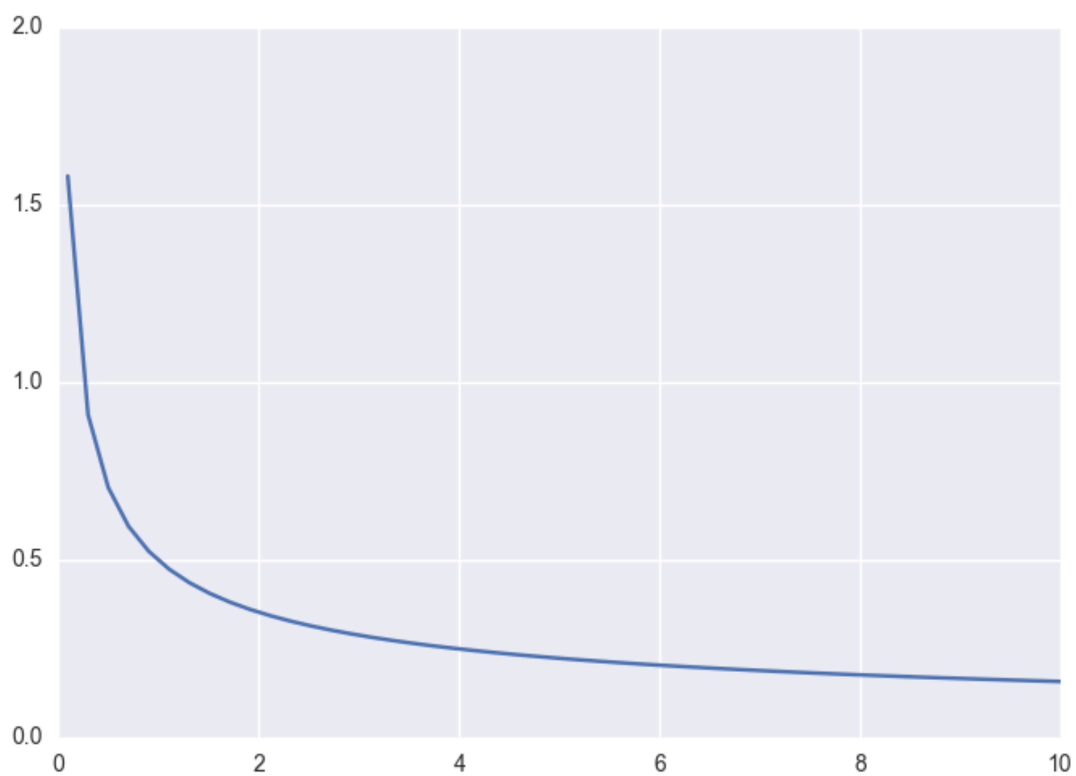
	L_{actual}	L_{random}	C_{actual}	C_{random}
Film actors	3.65	2.99	0.79	0.00027
Power grid	18.7	12.4	0.080	0.005
C. elegans	2.65	2.25	0.28	0.05

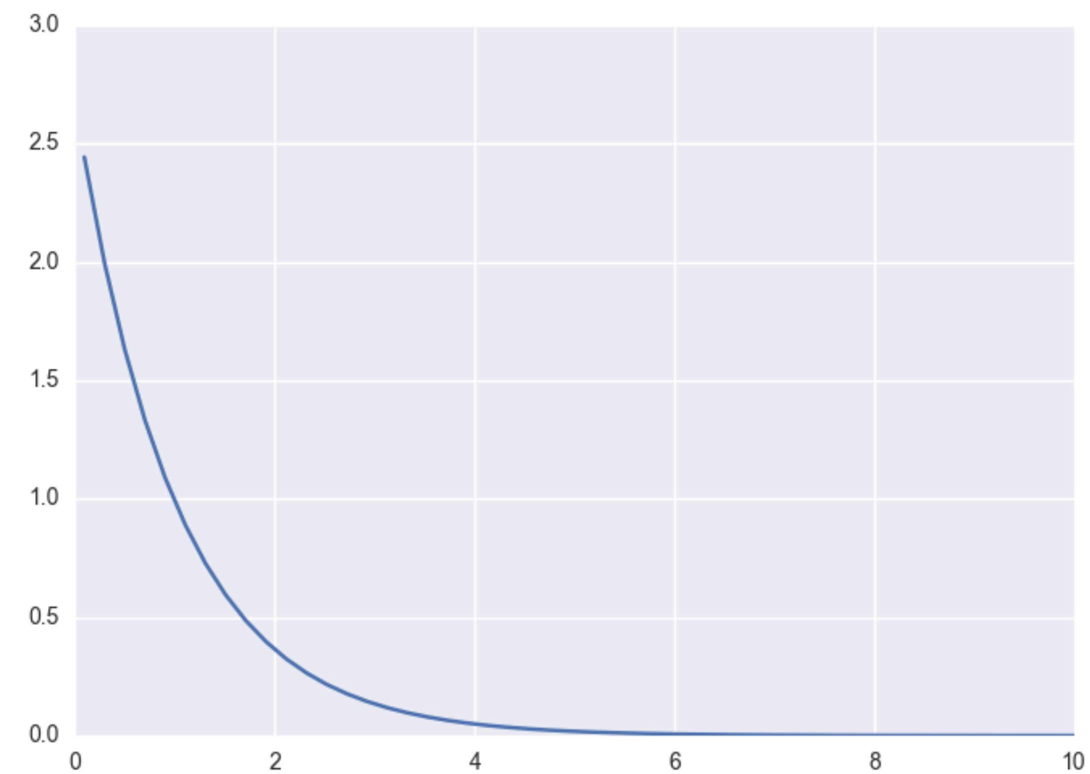
Distribución de grado
“Número de vecinos”





Distribuciones frecuentes





Ley de potencias

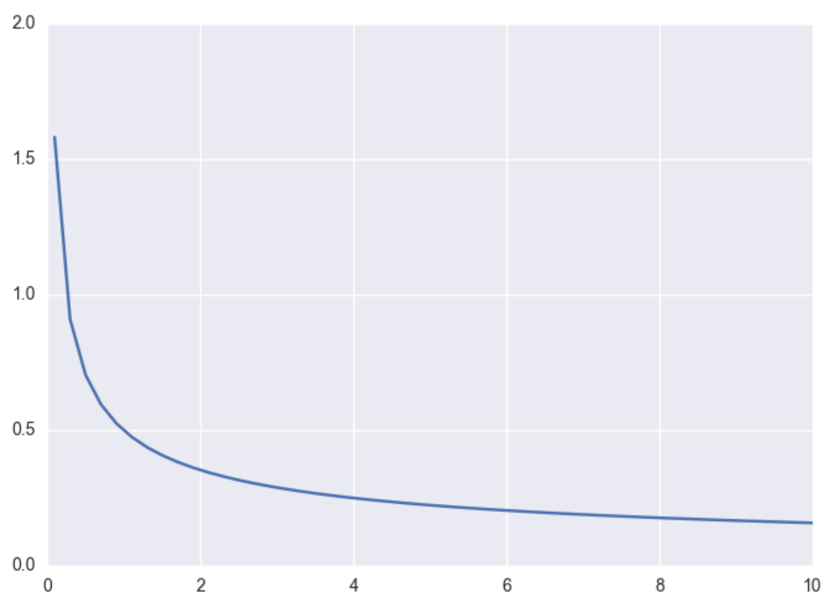
$$f(x) = Ax^{-b}$$

Exponencial

$$f(x) = Ae^{-bx}$$

Gráficos Log-Log y Semilog

Ley de potencias

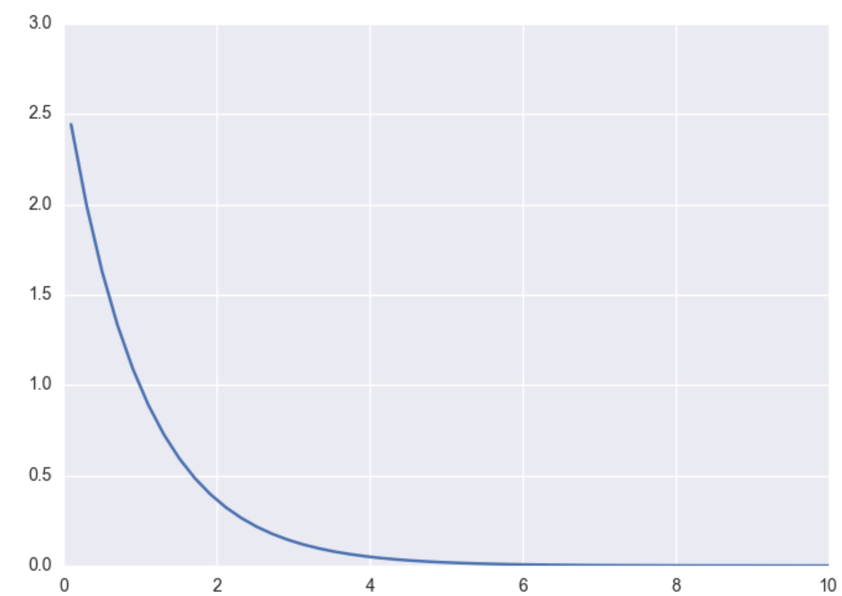


`plt.loglog()` ↓

Log

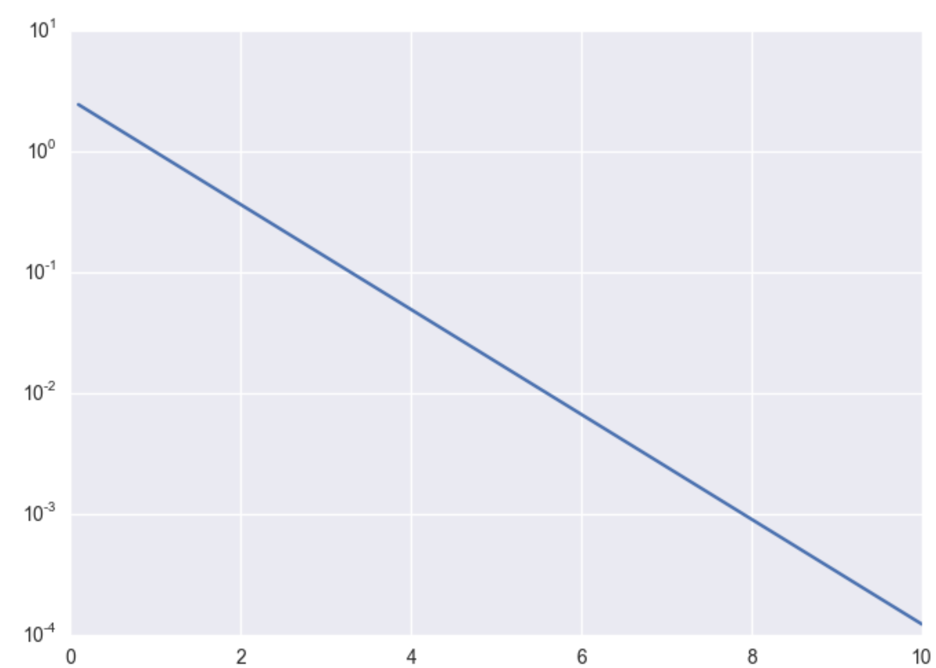
Log

Exponencial



`plt.semilogy()` ↓

Log



Lin

Redes Libres de Escala

1999

Emergence of Scaling in Random Networks

Albert-László Barabási* and Réka Albert

Systems as diverse as genetic networks or the World Wide Web are best described as networks with complex topology. A common property of many large networks is that the vertex connectivities follow a scale-free power-law distribution. This feature was found to be a consequence of two generic mechanisms: (i) networks expand continuously by the addition of new vertices, and (ii) new vertices attach preferentially to sites that are already well connected. A model based on these two ingredients reproduces the observed stationary scale-free distributions, which indicates that the development of large networks is governed by robust self-organizing phenomena that go beyond the particulars of the individual systems.

- Las redes se expanden a través de la adición de nuevos vértices
- Los nuevos vértices se ligan preferentemente a sitios bien conectados (*preferential attachment)*

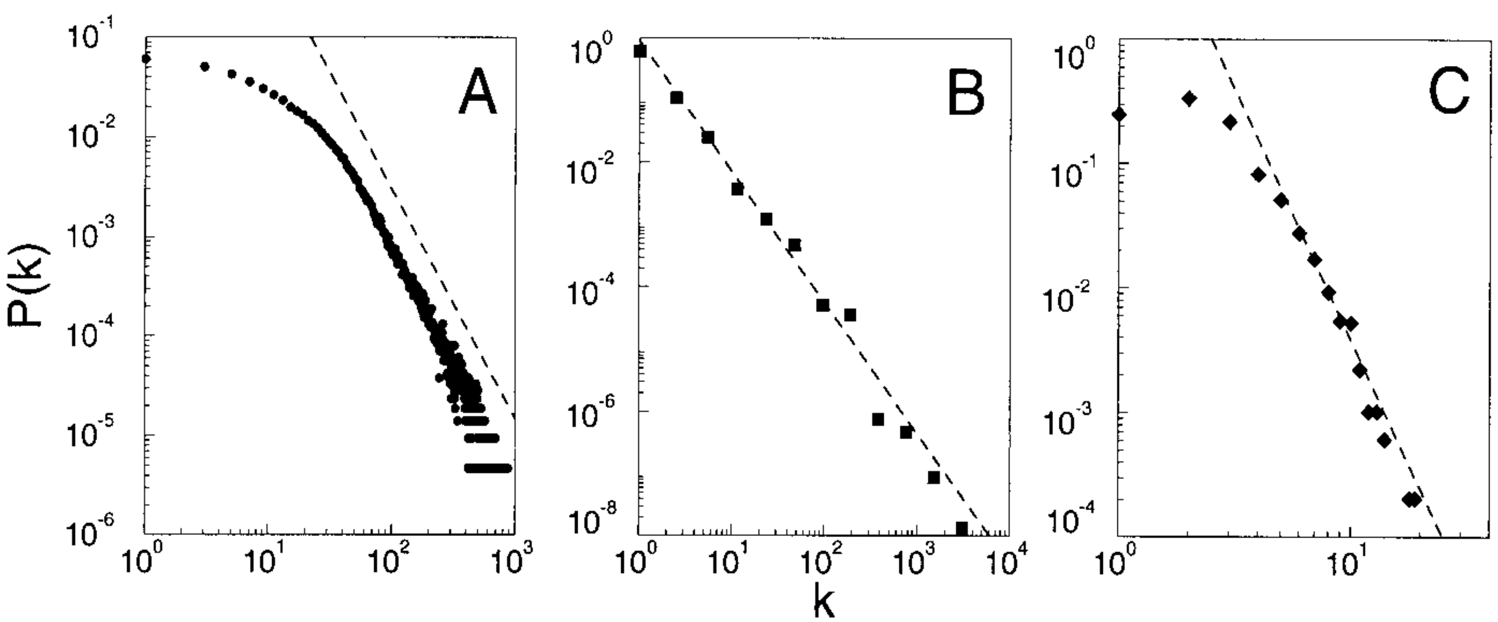
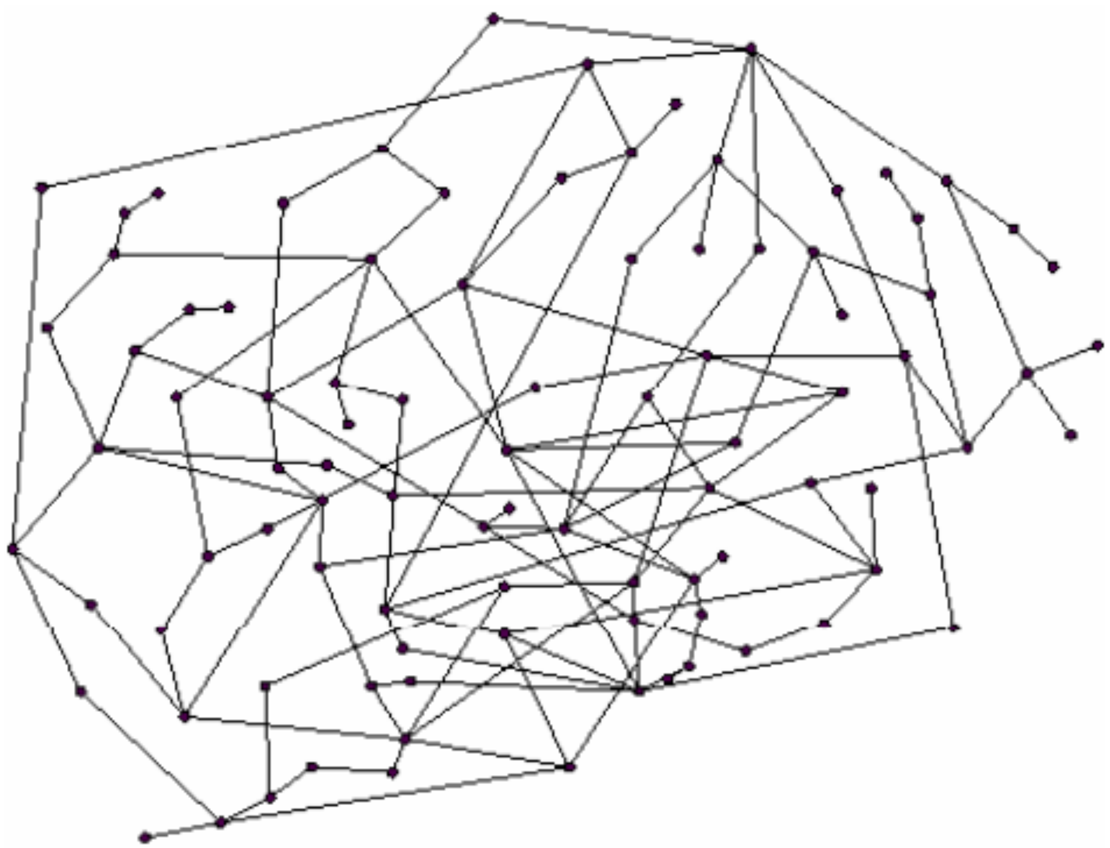


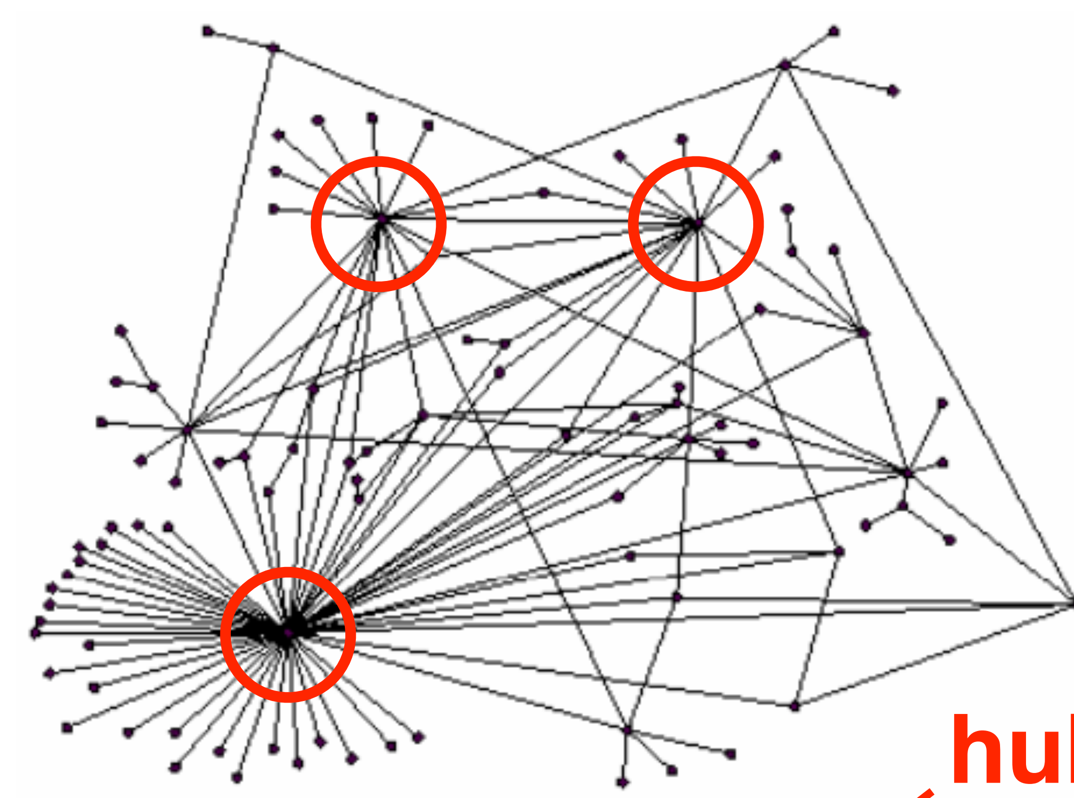
Fig. 1. The distribution function of connectivities for various large networks. (**A**) Actor collaboration graph with $N = 212{,}250$ vertices and average connectivity $\langle k \rangle = 28.78$. (**B**) WWW, $N = 325{,}729$, $\langle k \rangle = 5.46$ (*6*). (**C**) Power grid data, $N = 4941$, $\langle k \rangle = 2.67$. The dashed lines have slopes (A) $\gamma_{actor} = 2.3$, (B) $\gamma_{www} = 2.1$ and (C) $\gamma_{power} = 4$.

Redes Libres de Escala

Red aleatoria (Erdös)

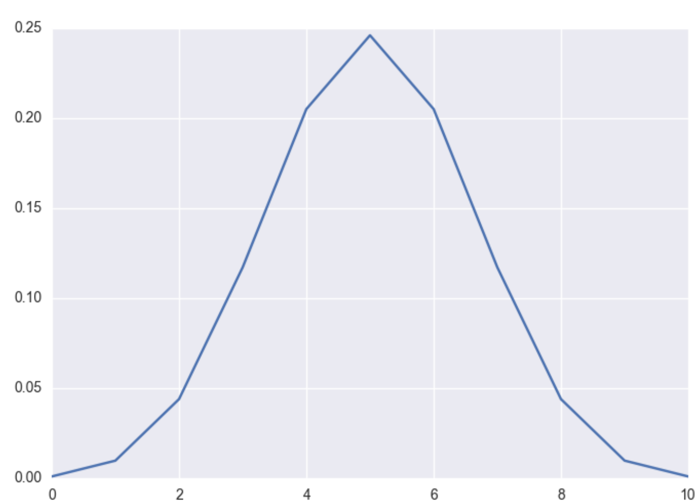


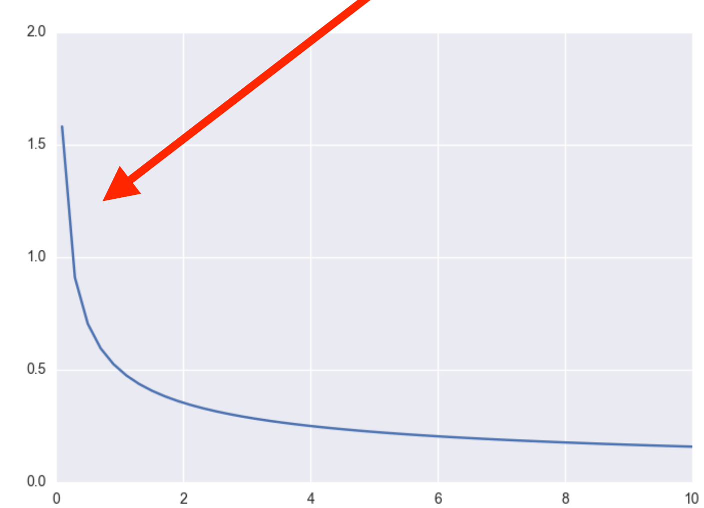
Red *scale-free*



hubs

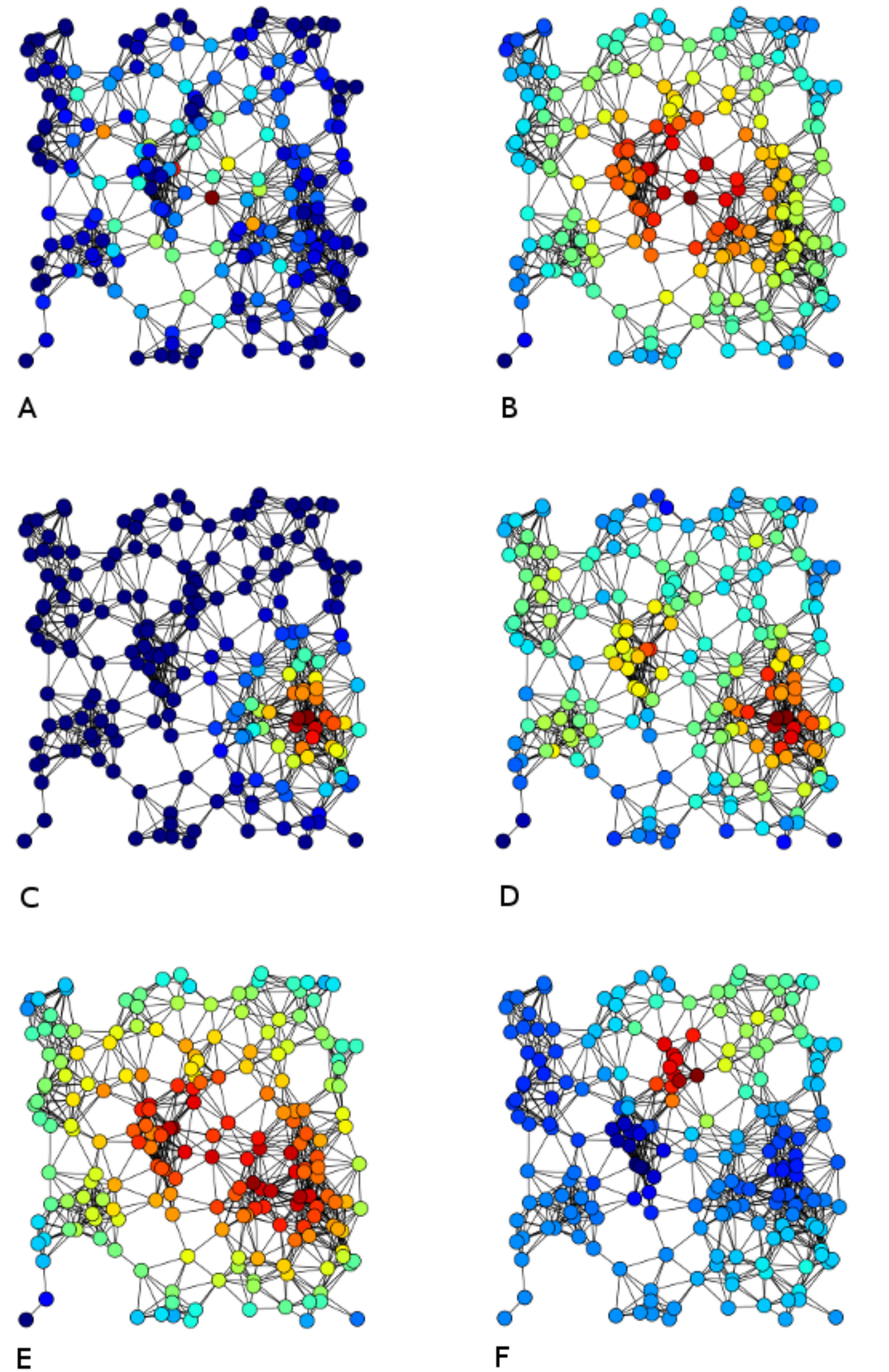
Distribución de grado:



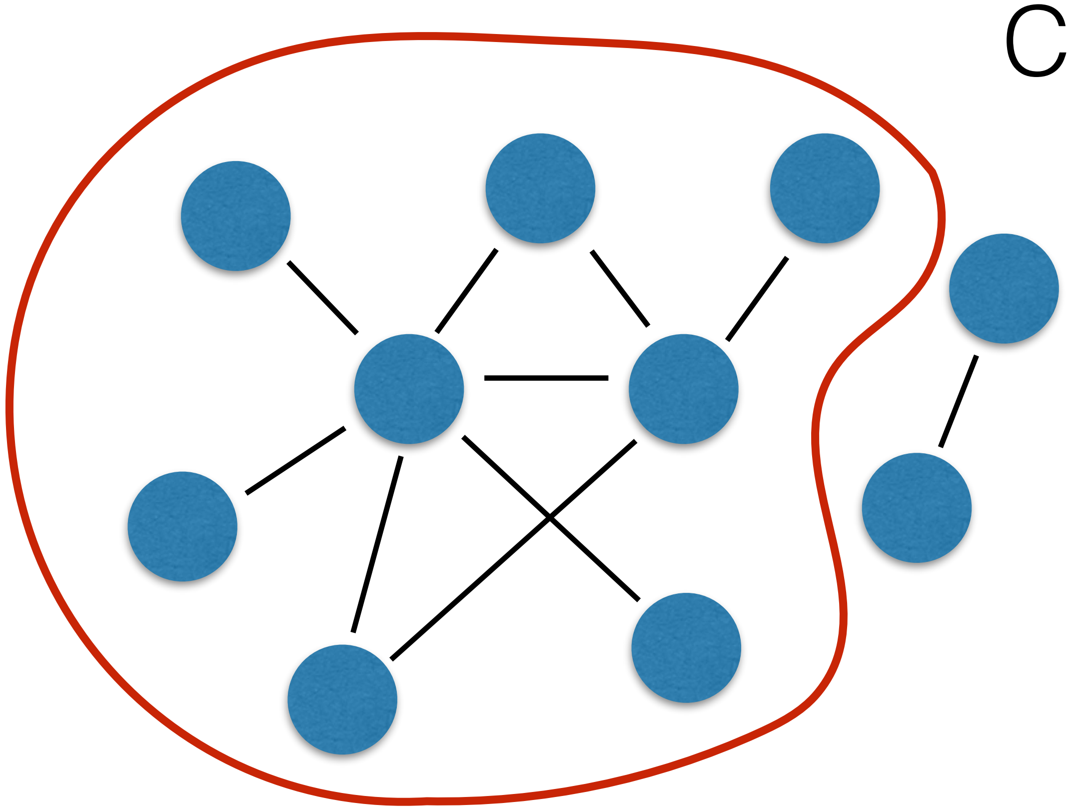


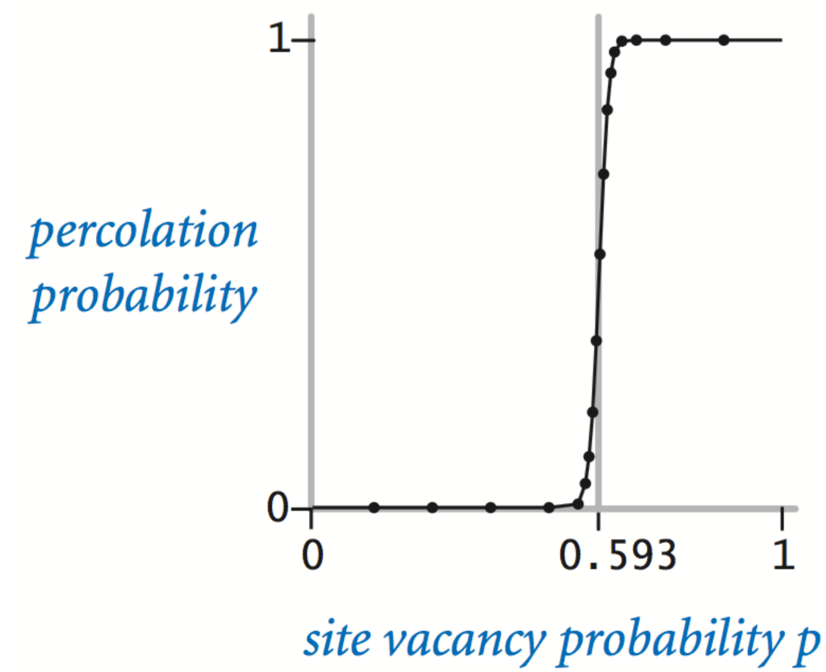
Centrality

A. Betweenness
B. Closeness
C. Eigenvector
D. Degree
E. Harmonic
F. Katz

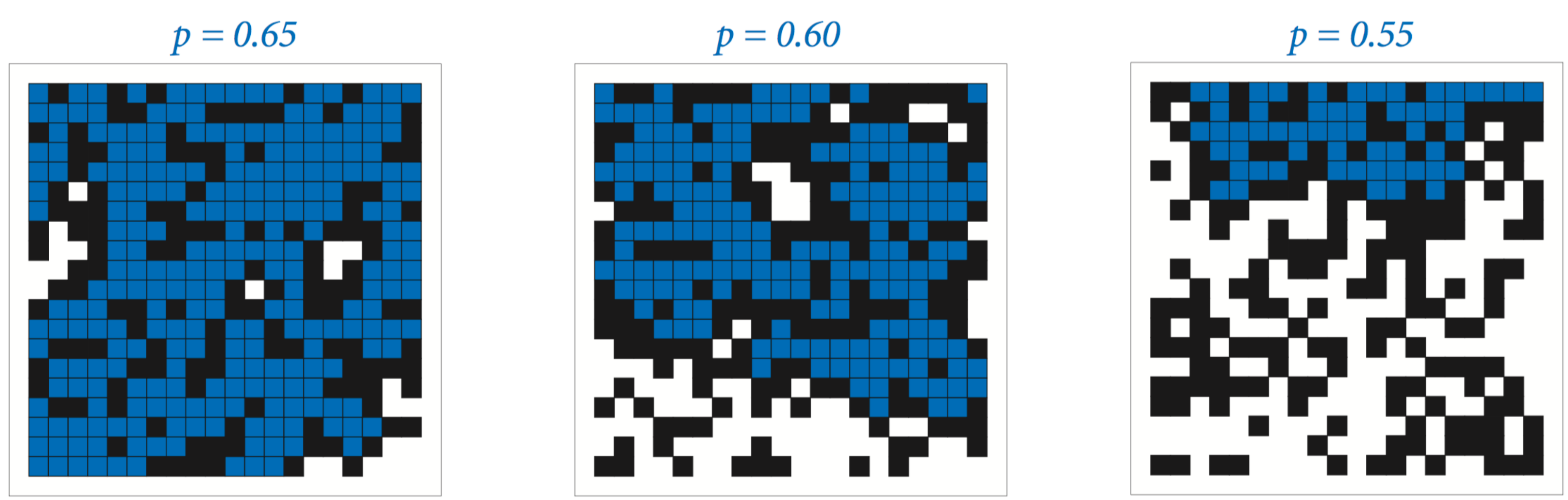


Componentes Conexas





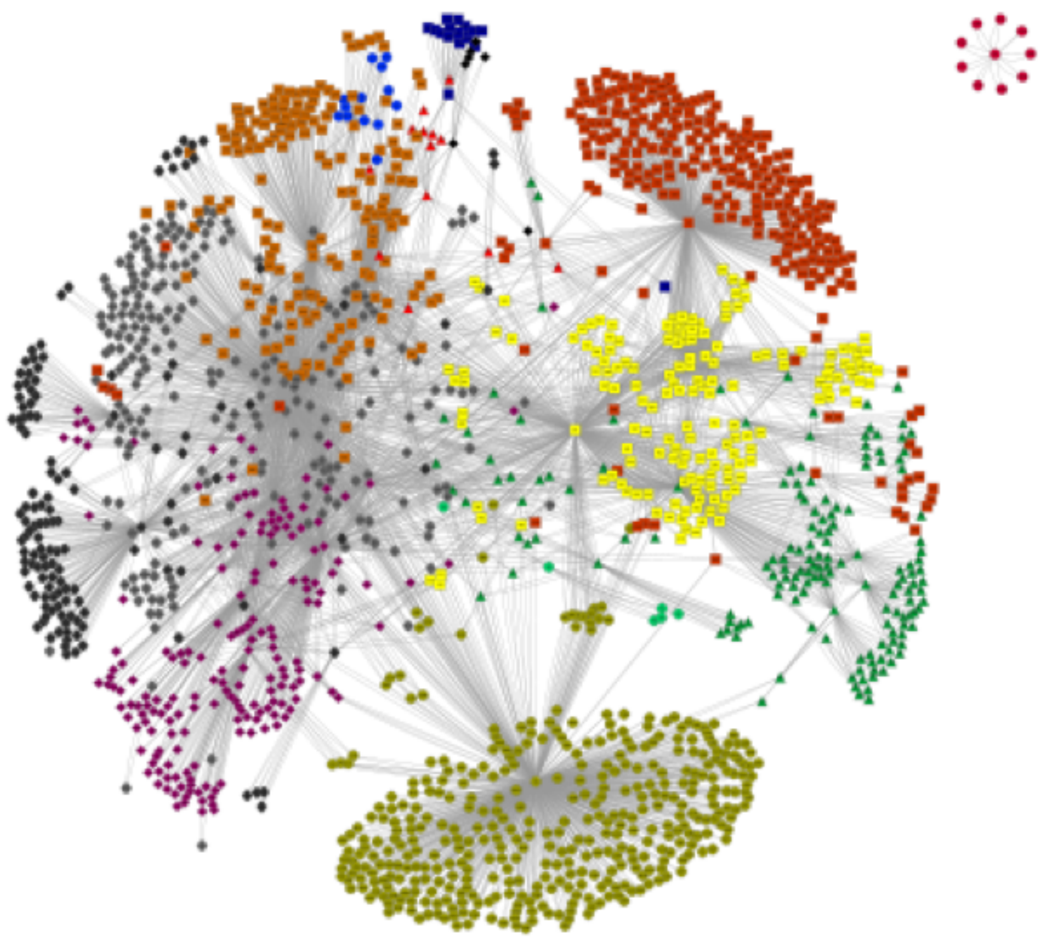
Percolación



Comunidades

Algoritmo de Girvan-Newman

1. Calcular betweenness de todas las **aristas**
2. Eliminar la arista con mayor betweenness
3. Recalcular betweenness de aristas afectadas
4. Iterar hasta que no haya aristas

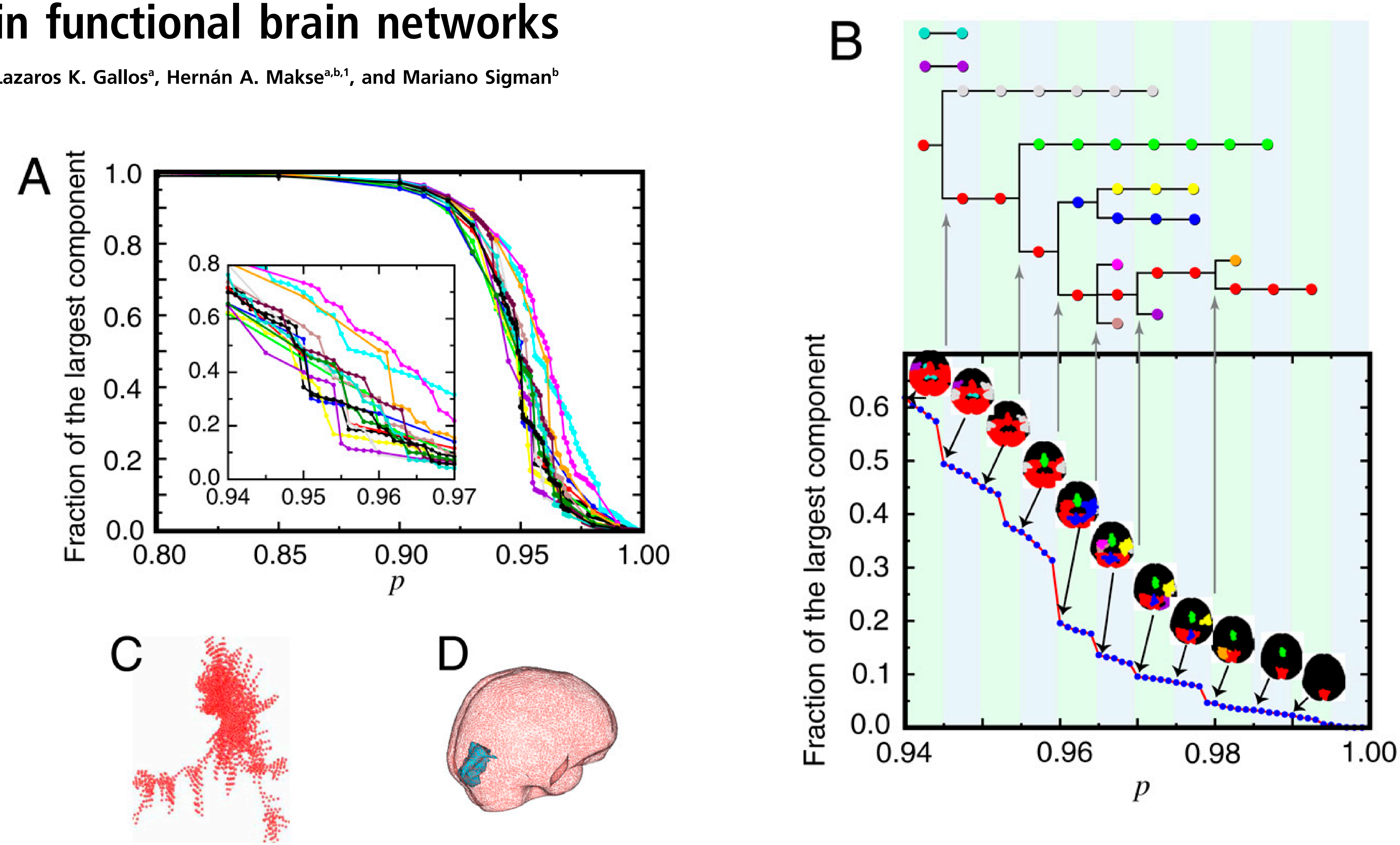


Salida: *Dendrograma*

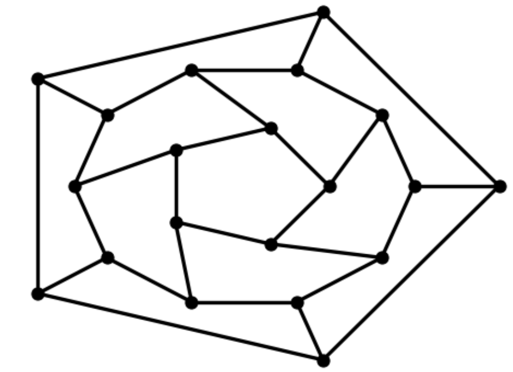
Redes del Cerebro: Modularidad

A small world of weak ties provides optimal global integration of self-similar modules in functional brain networks

Lazaros K. Gallos[a], Hernán A. Makse[a,b,1], and Mariano Sigman[b]



networkx



- https://networkx.github.io/
- Grafos dirigidos, pesados, multigrafos, …
- ```
  import networkx as nx
  G = nx.Graph()
  G.add_edges_from([(1, 2), (1, 3)])
  ```
- pero también:
  ```
  ws = nx.watts_strogatz_graph(30, 3, 0.1)
  nx.algorithms.centrality.betweenness_centrality()
  ```
  ```