EEE 321 ecological networks

coordinators: Jordi Bascompte and Fernando Pedraza

co-teachers: Eva Knop, Leandro Cosmo, Subhendu Bhandary, Fernando Çonçalves, and Miguel Román

Introduction to course

outline of course

			Thursday March 13	Friday March 14	Tuesday March 18	Wednesday March 19	Thursday March 20	Friday March 21	Tuesday March 25	Wednesday March 26	Thursday March 27	Friday March 28	Tuesday April 1	Wednesday April 2	Thursday April 3
From	To														
10:15	12:00	LECTURE	Outline and Intro	Food webs		Mutualistic networks	Null models	Spatial networks		Network robustness	Genetic networks	Ecological dynamics in networks		Evolutionary dynamics in networks	Exam
	Speaker	LECTURE	Bascompte	Bascompte		Bascompte	Bascompte	Román		Gonçalves	Román	Bhandary		Cosmo	Pedraza
12:00	13:00		Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch		Lunch	Lunch
	Lead	EXERCISE	Pedraza	Pedraza	Knop	Cosmo	Pedraza	Bhandary		Gonçalves	Román	Bhandary		Cosmo	
13:00	17:00	EXERCISE	Toolkit for network analysis	Measuring modularity	Sampling an ecological network	Measuring nestedness	Null models	Spatial networks	Open time	Measuring network robustness	Analyzing genetic networks	Models of ecological dynamics in networks	Open time	Models of evolutionary dynamics in networks	

- Slides on lectures available at OLAT (Download/Slides), as well as 2-3 specific readings for that lecture (Download/Readings).

general readings

- Barabási, A.-L. (2002). Linked: The New Science of Networks. Perseus Books Group (or Barabási, A.-L. (2016). Network Science. Cambridge University Press)
- Bascompte, J. and Jordano, P. (2013). Mutualistic Networks. Princeton University Press
- Pascual, M. and Dunne, J.A. (2006). Ecological Networks: Linking Structure to Dynamics in Food Webs. Oxford University Press
- Pimm, S.L. (1982). Food Webs. Chicago University Press
- Several authors (2009). Complex Systems and Networks. (Special Section). *Science* 325: 405-432.

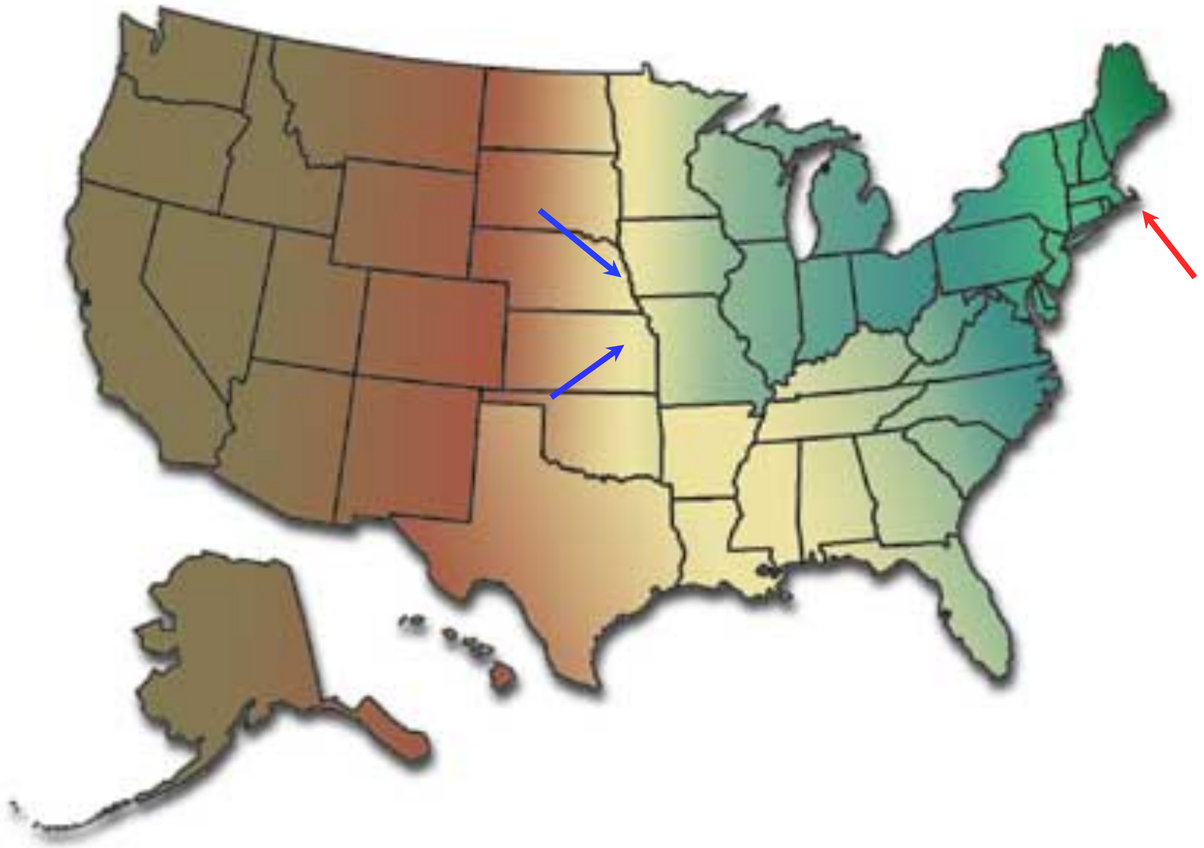
course grading

- Practicals with RStudio: up to 3 points
- Multiple-choice test: up to 2 points

Introduction to network theory

social networks

160 letters from Wichita (Kansas) and Omaha (Nebraska) to Sharon (Mass)



Milgram (1967)

social networks

In the Nebraska study, the chains varied between 2 and 10 intermediate acquaintances, with the median at 5

What a small world!

El mundo es un pañuelo!

C’est petit le monde!

Die Welt ist klein!

Milgram (1967)

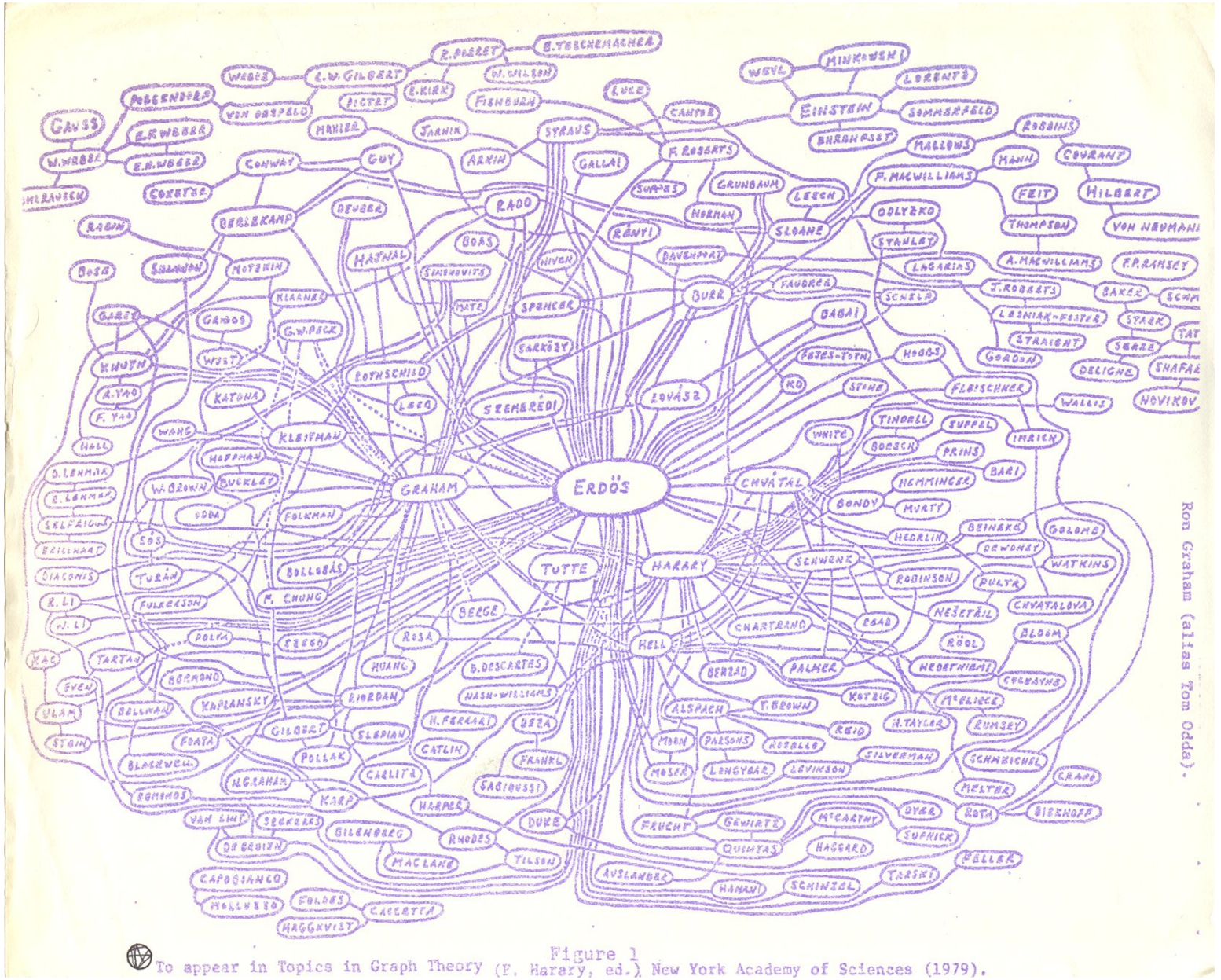
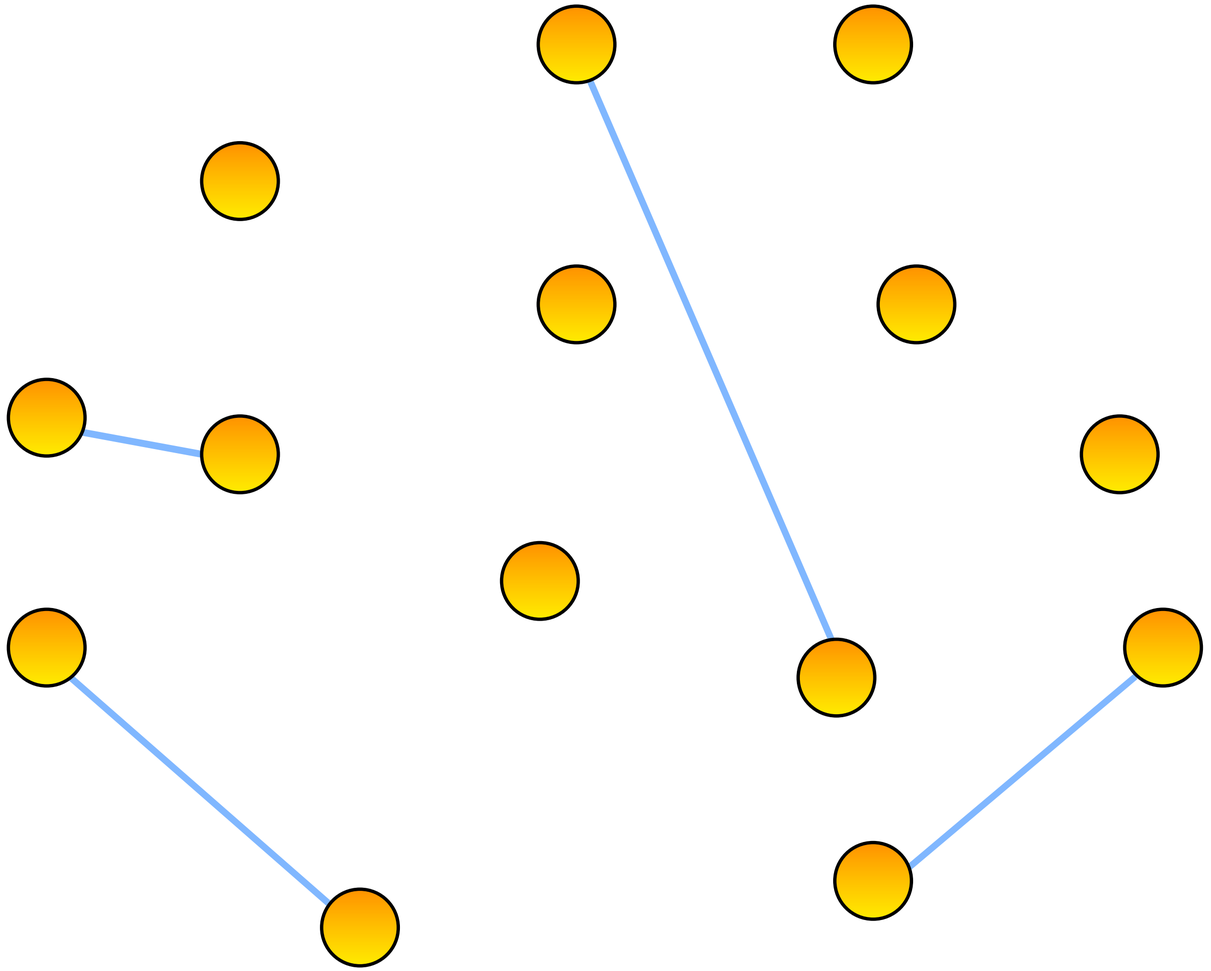


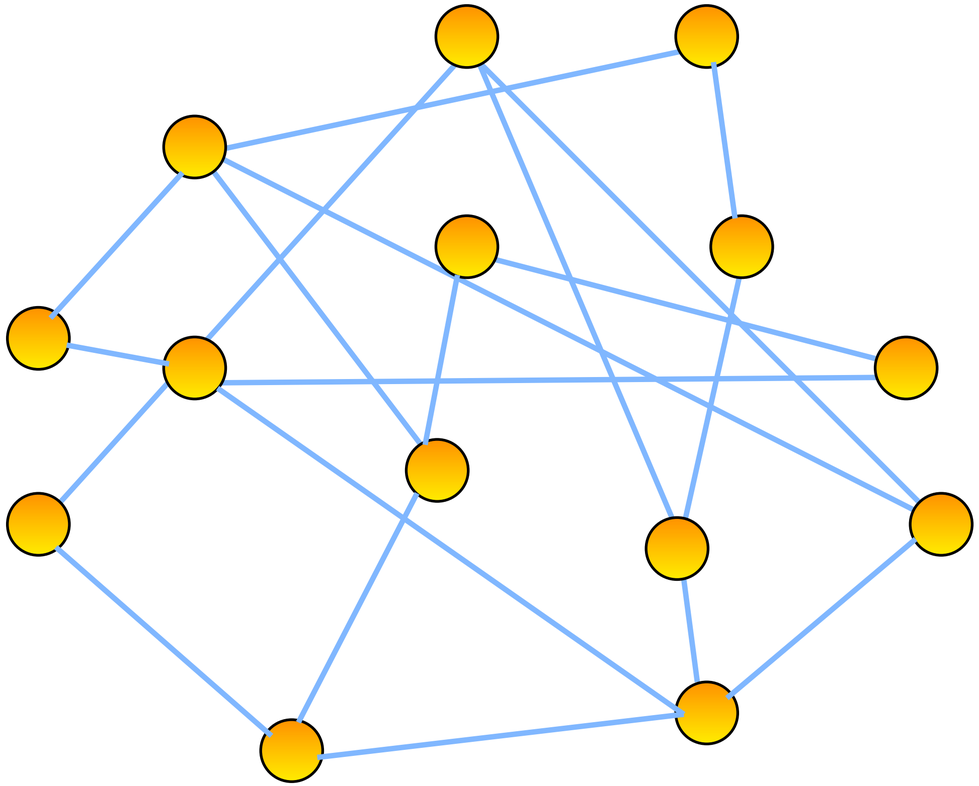
Figure 1

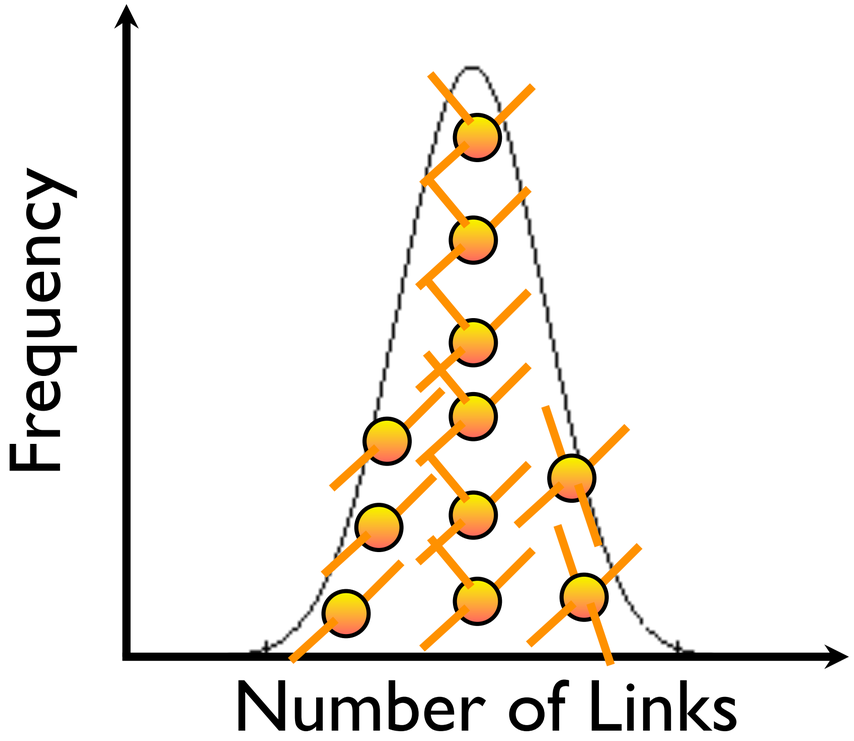
To appear in Topics in Graph Theory (F. Harary, ed.) New York Academy of Sciences (1979).

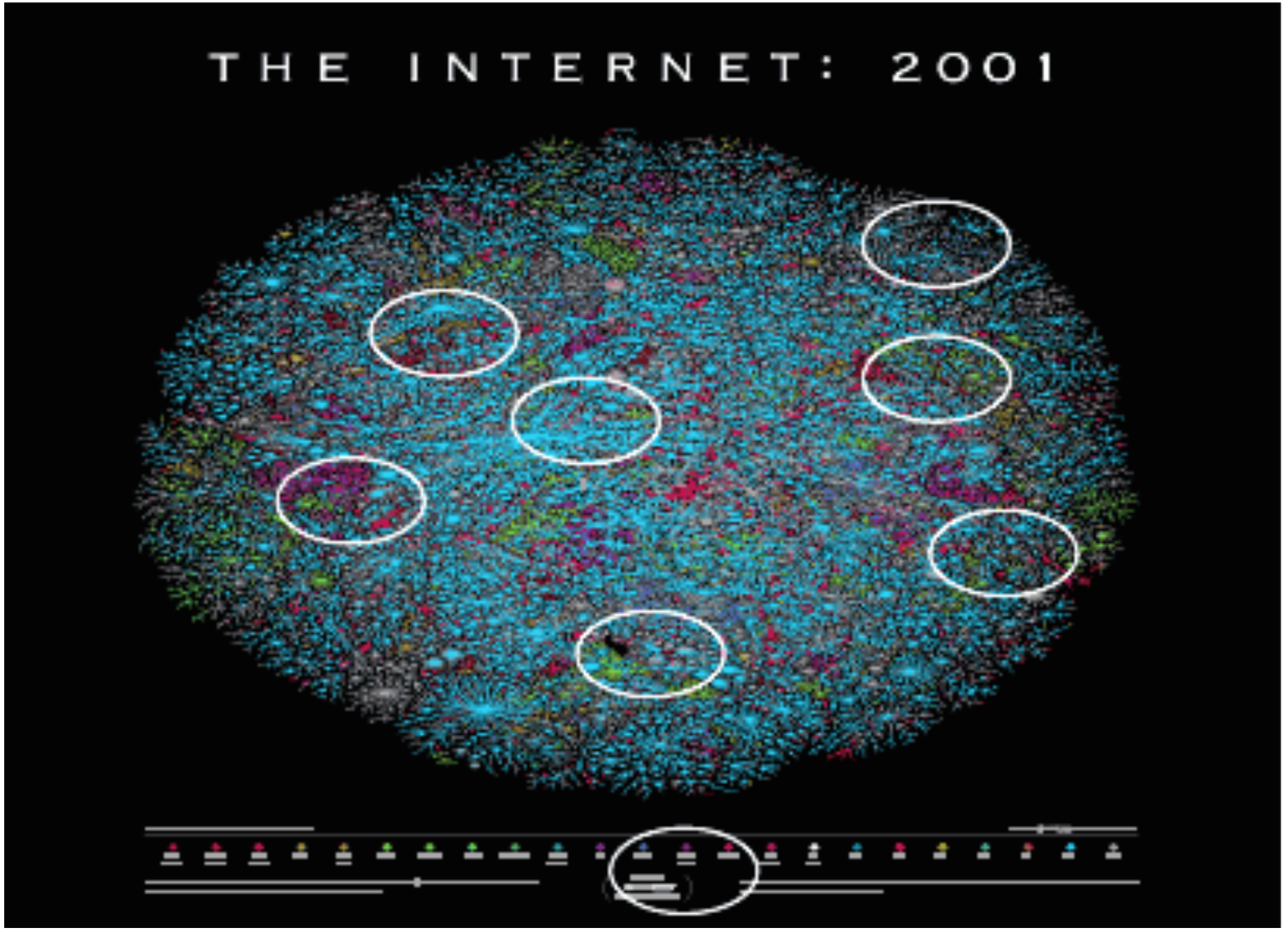
Erdös-Rényi model

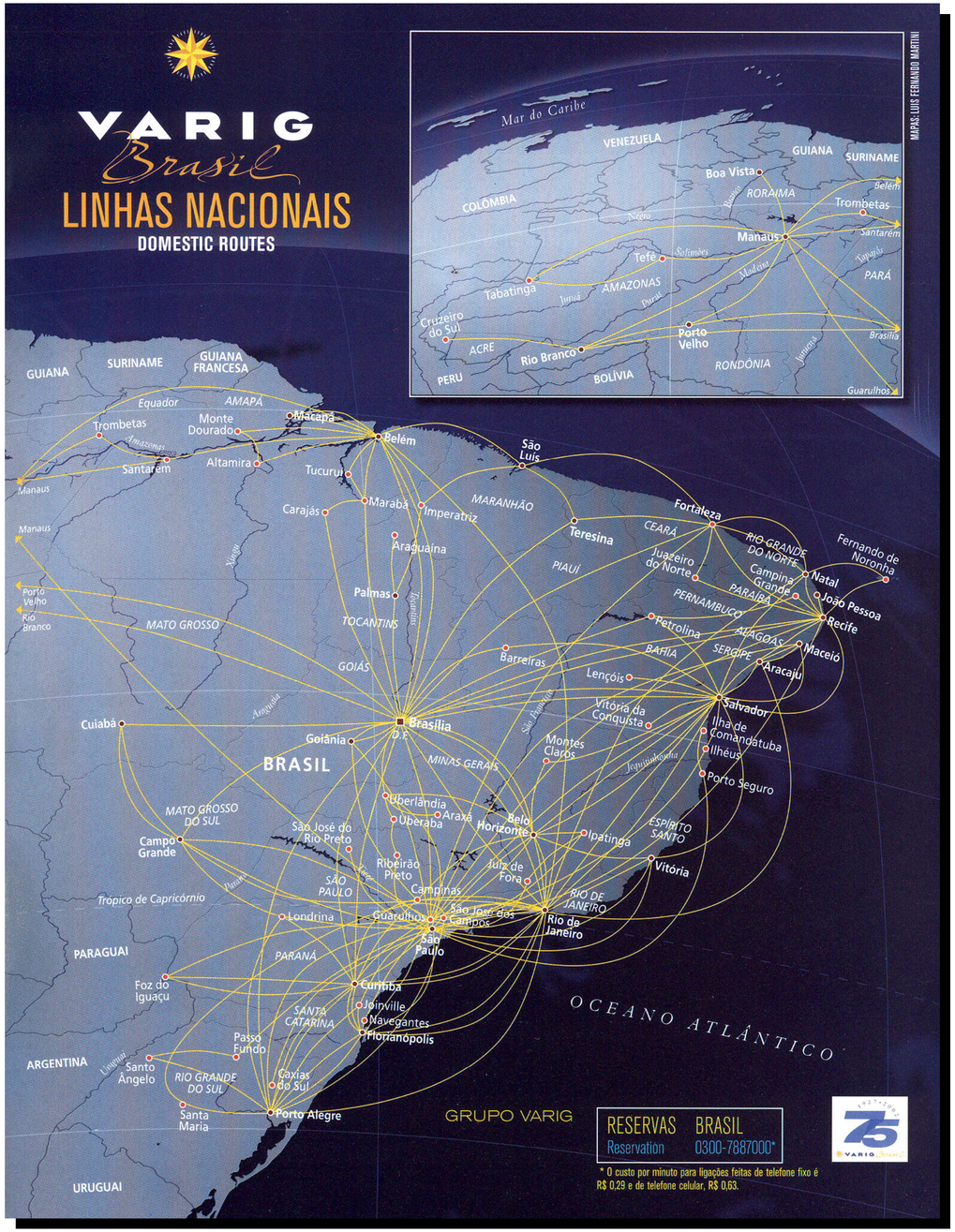


Erdös-Rényi model






THE INTERNET: 2001


VARIG
Brasil
LINHAS NACIONAIS
DOMESTIC ROUTES
MAPAS: LUIS FERNANDO MARTINI
Mar do Caribe
VENEZUELA
GUIANA
SURINAME
COLÔMBIA
Boa Vista
RORAIMA
Belém
Trombetas
Manaus
Santarém
PARÁ
Tefé
Tabatinga
AMAZONAS
Cruzeiro do Sul
ACRE
Rio Branco
Porto Velho
RONDÔNIA
PERU
BOLÍVIA
Brasília
Guarulhos
GUIANA
SURINAME
GUIANA FRANCESA
Equador
AMAPÁ
Macapá
Monte Dourado
Altamira
Tucuruí
São Luís
Carajás
Marabá
Imperatriz
MARANHÃO
Fortaleza
CEARÁ
Teresina
PIAUÍ
Juazeiro do Norte
RIO GRANDE DO NORTE
Fernando de Noronha
Natal
Campina Grande
PARAÍBA
João Pessoa
PERNAMBUCO
Recife
Petrolina
ALAGOAS
Maceió
BAHIA
SERGIPE
Aracaju
Barreiras
Lençóis
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Palmas
TOCANTINS
MATO GROSSO
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Vitória
MATO GROSSO DO SUL
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Foz do Iguaçu
Curitiba
Joinville
SANTA CATARINA
Navegantes
Florianópolis
Passo Fundo
ARGENTINA
Santo Ângelo
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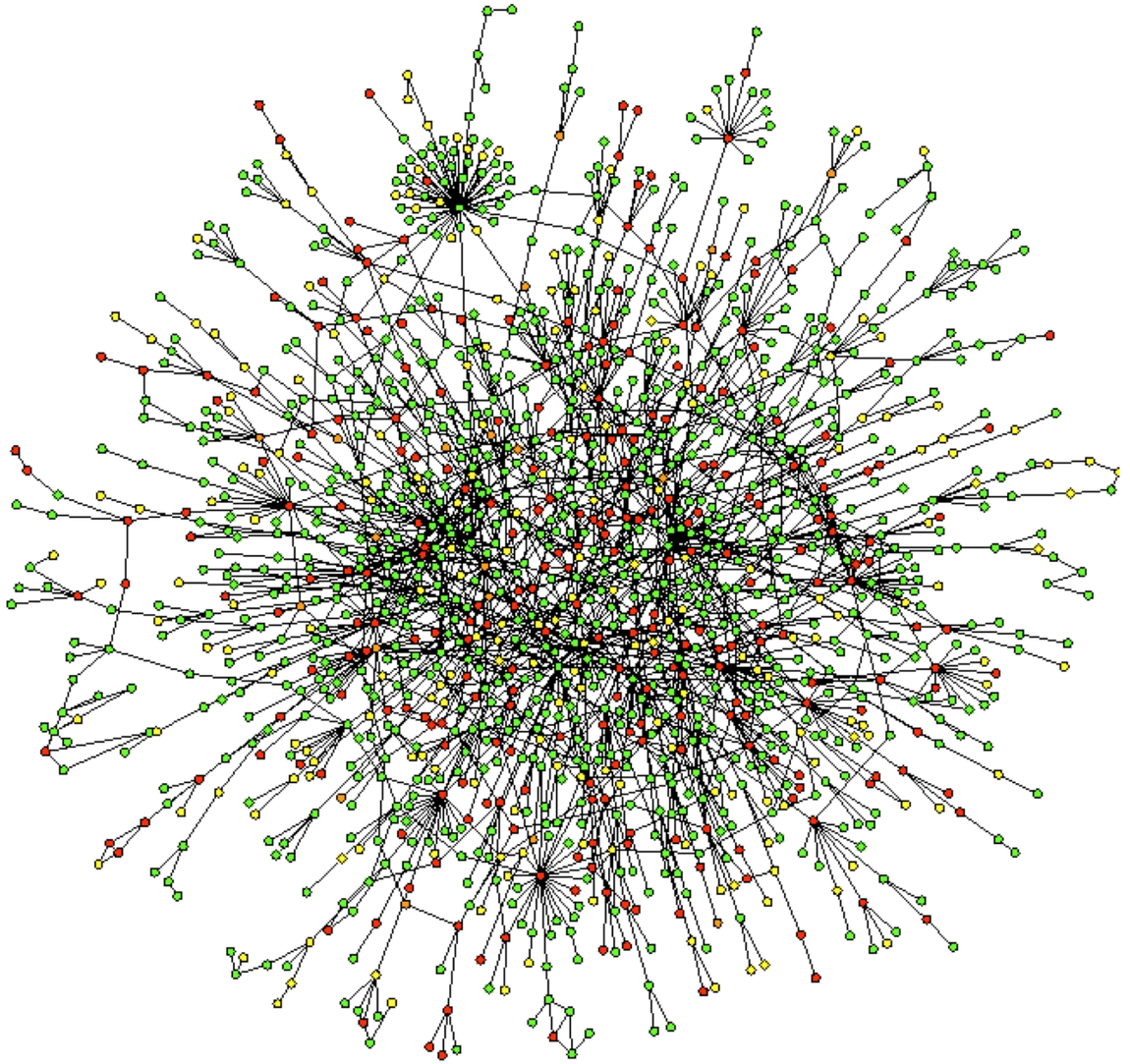
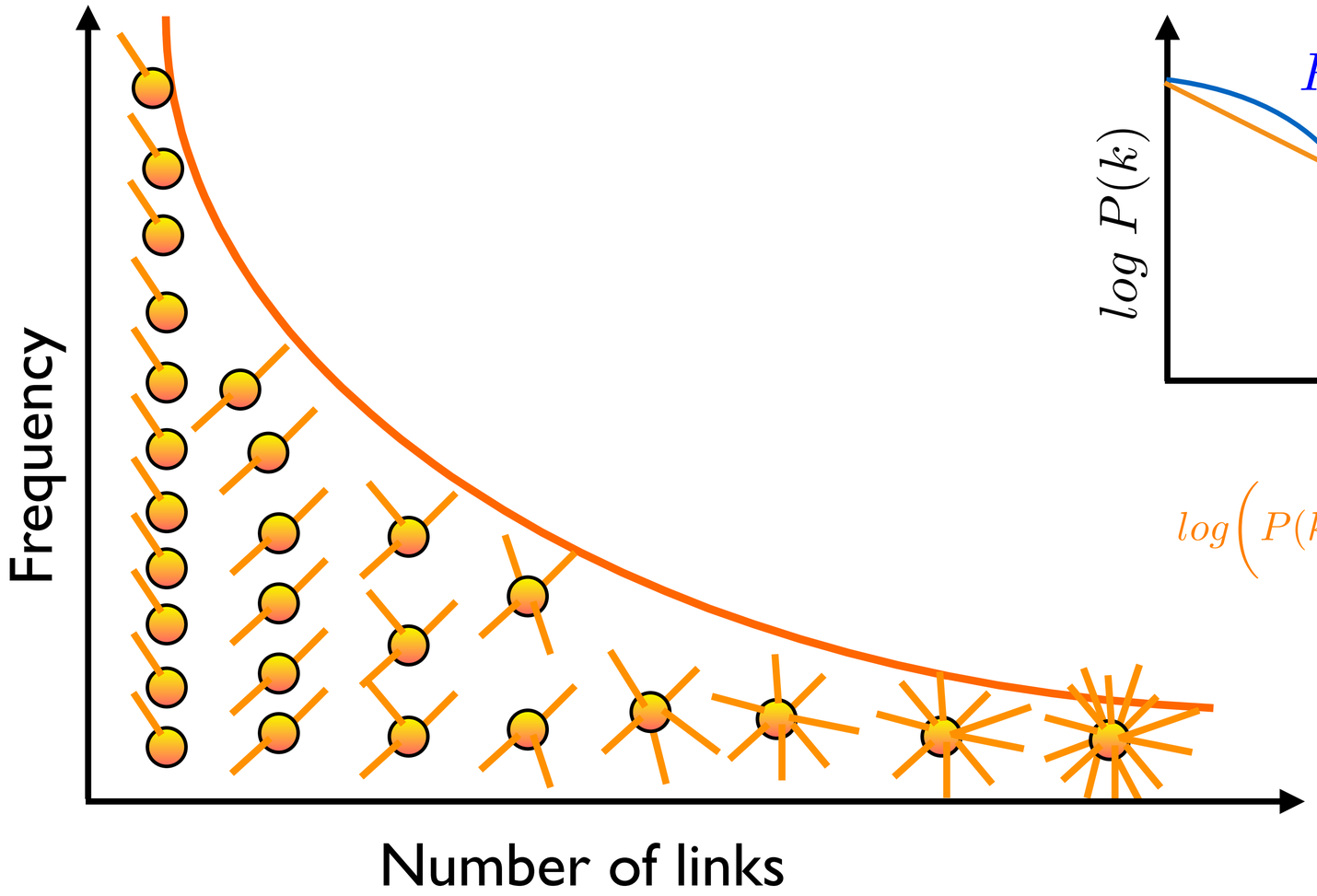
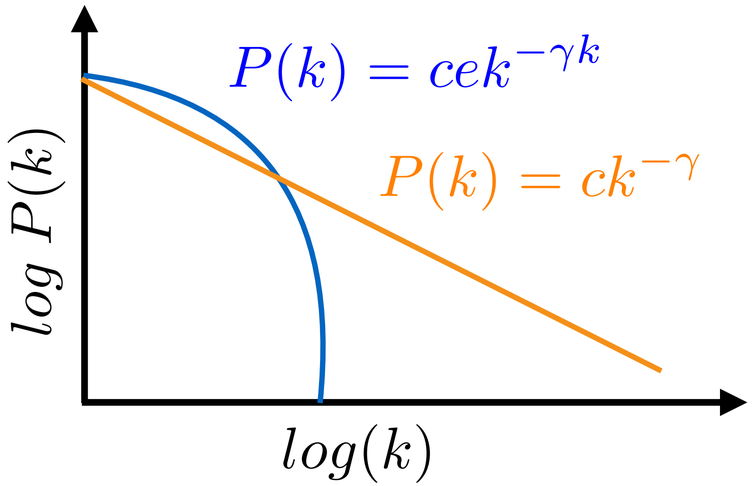
75

protein networks



complex networks are heterogeneous





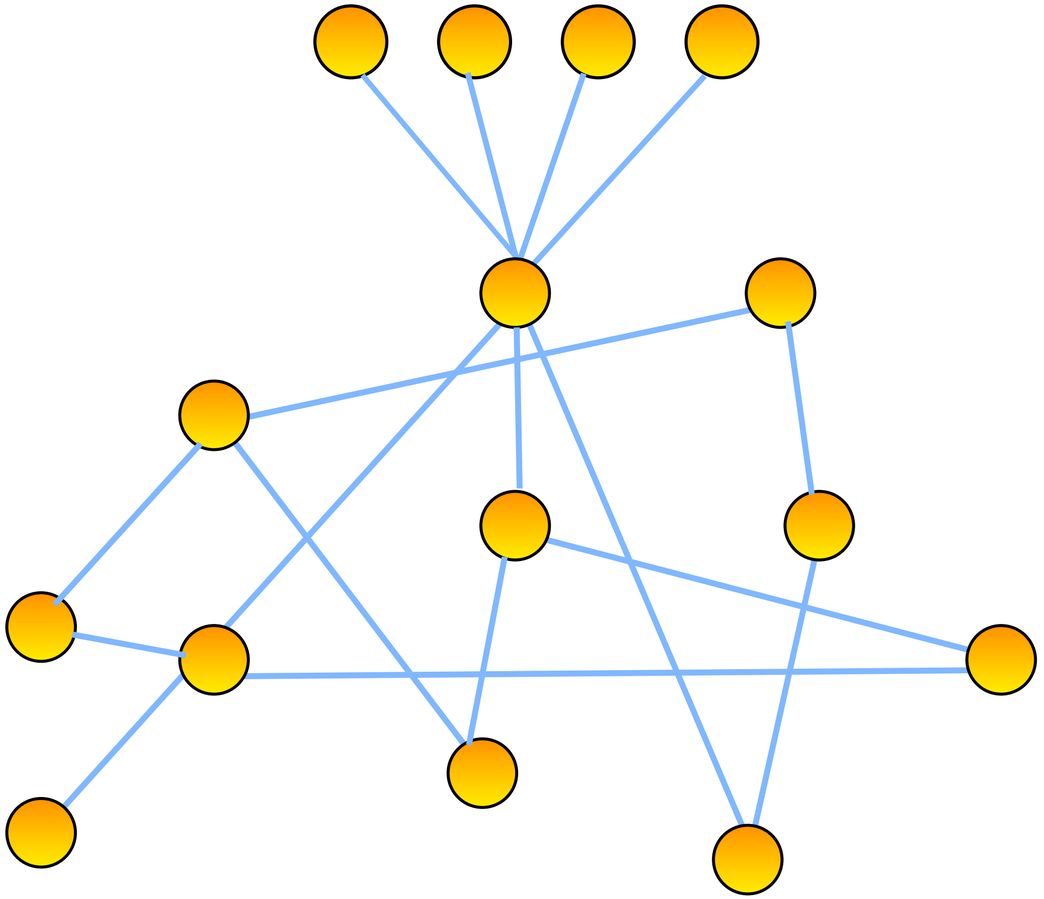
$$log\Big(P(k)\Big) = log(c) - \gamma\ log(k)$$

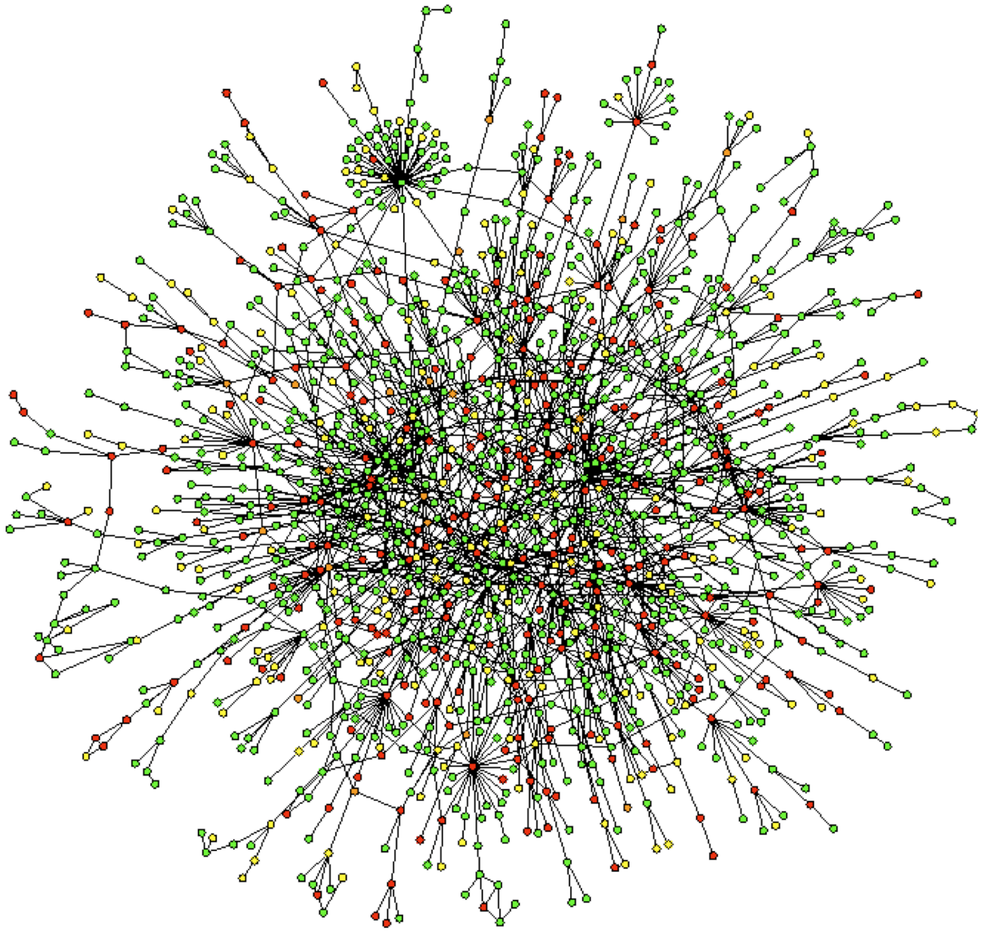
Most real networks have the same internal structure

Why?

What are the implications?

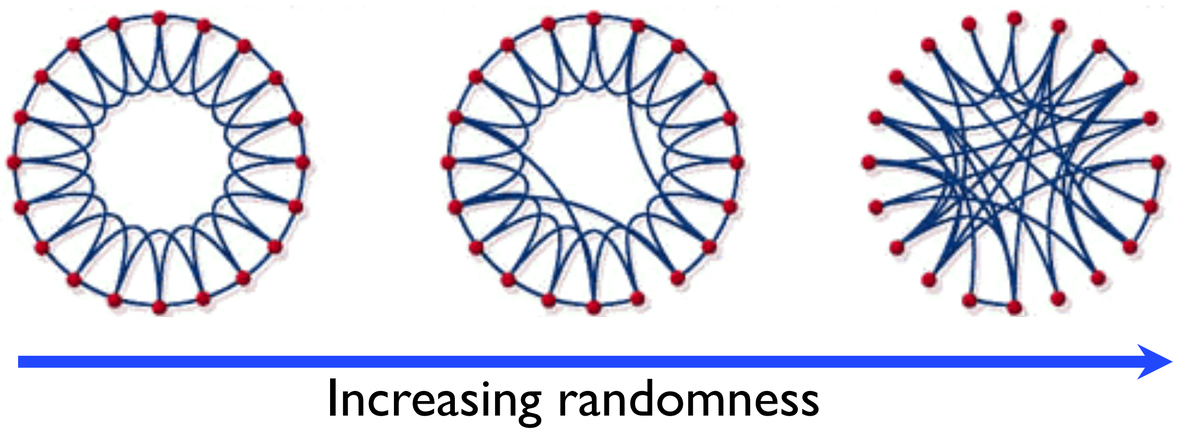
preferential attachment

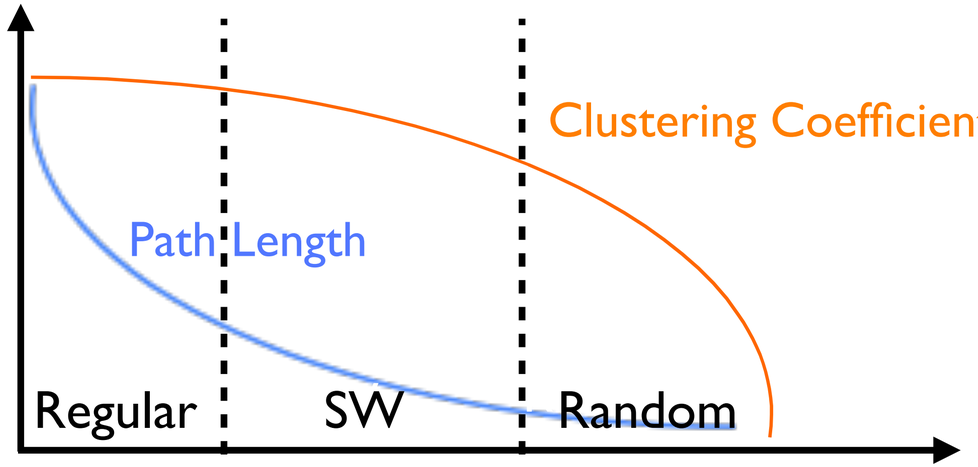




Rich get richer!

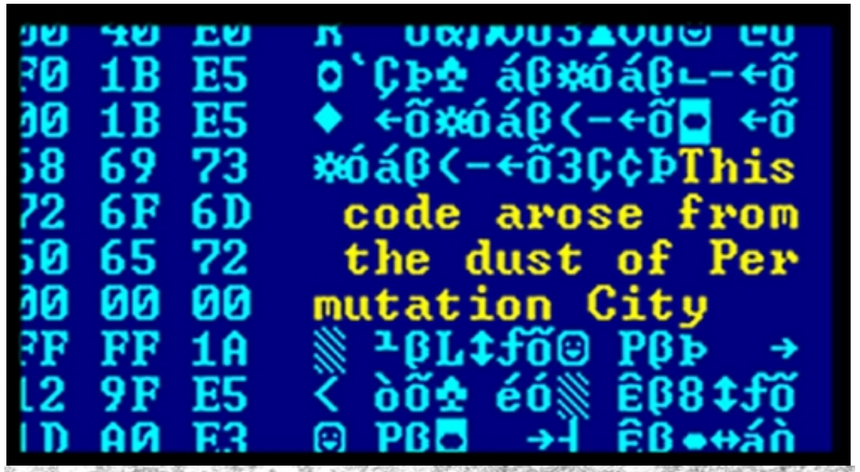
back to the small world

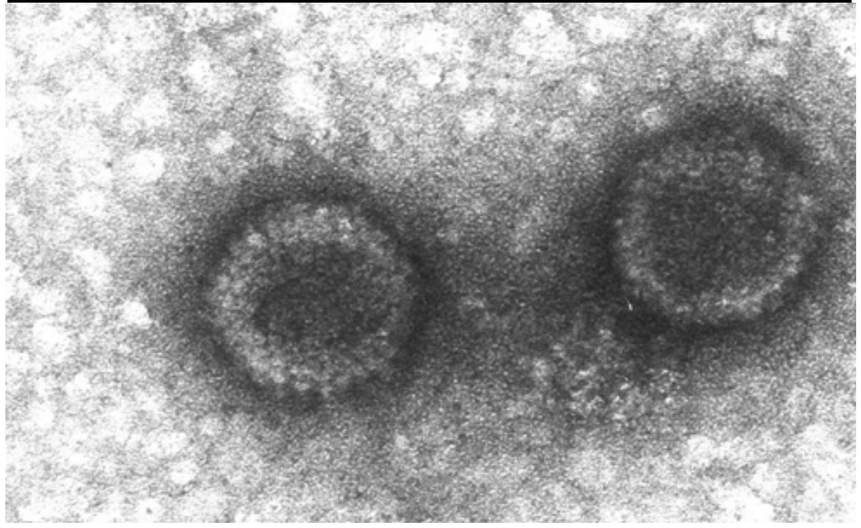




Watts and Strogatz (1998)

eradication in viruses





infection rate

spreading rate

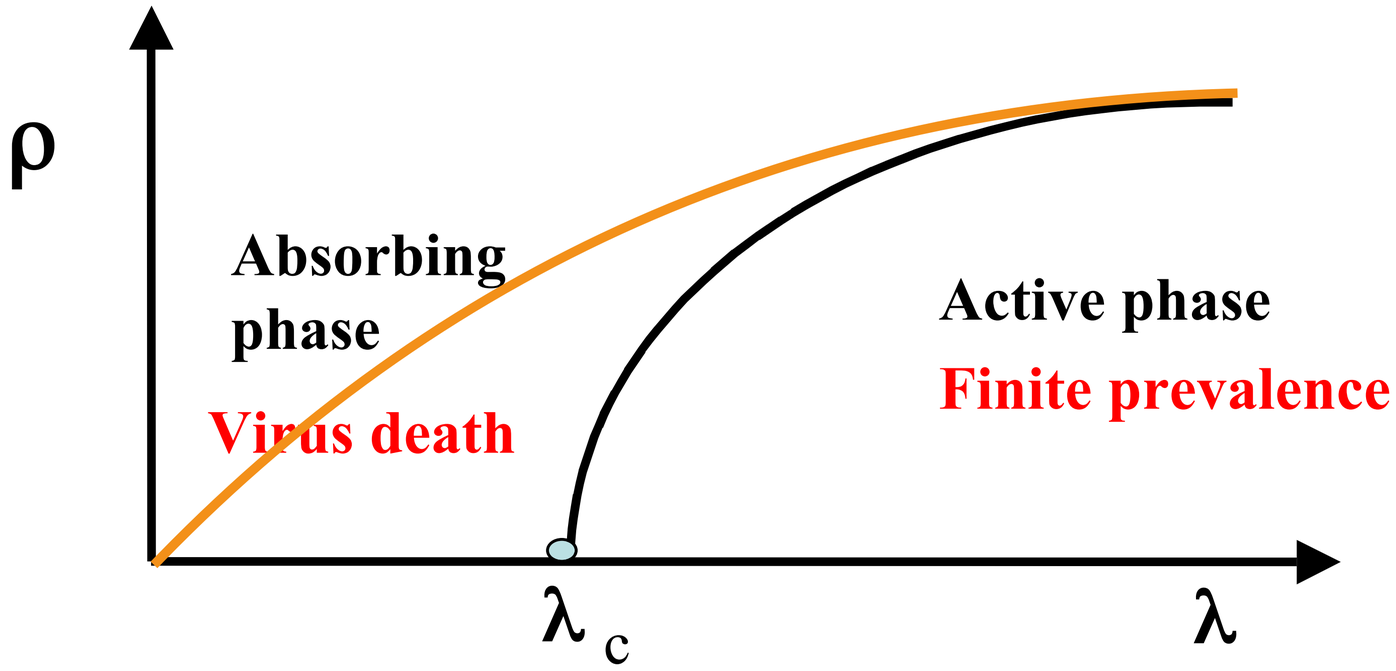
$$\lambda = \frac{\mu}{\delta}$$

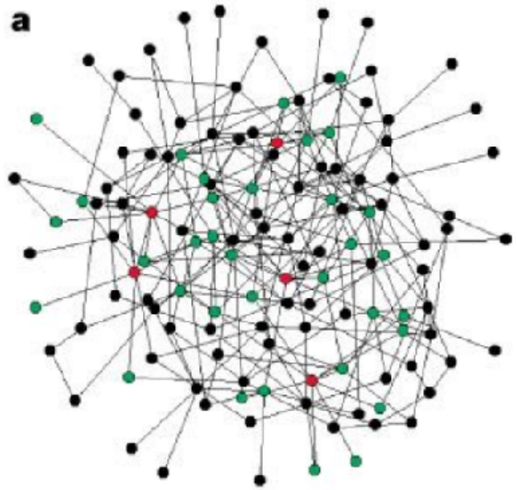
recovery rate

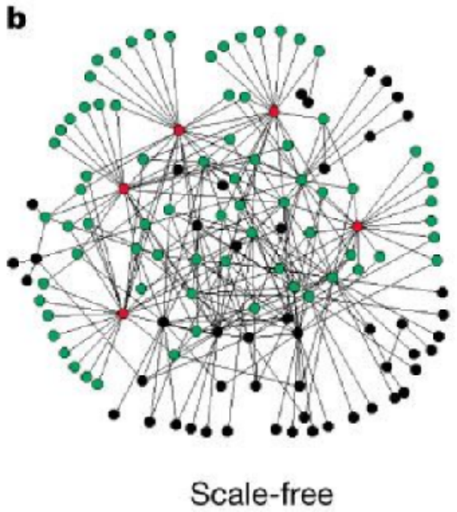
prevalence

$$\rho = 1 - \frac{\delta}{\mu}$$

eradication in viruses

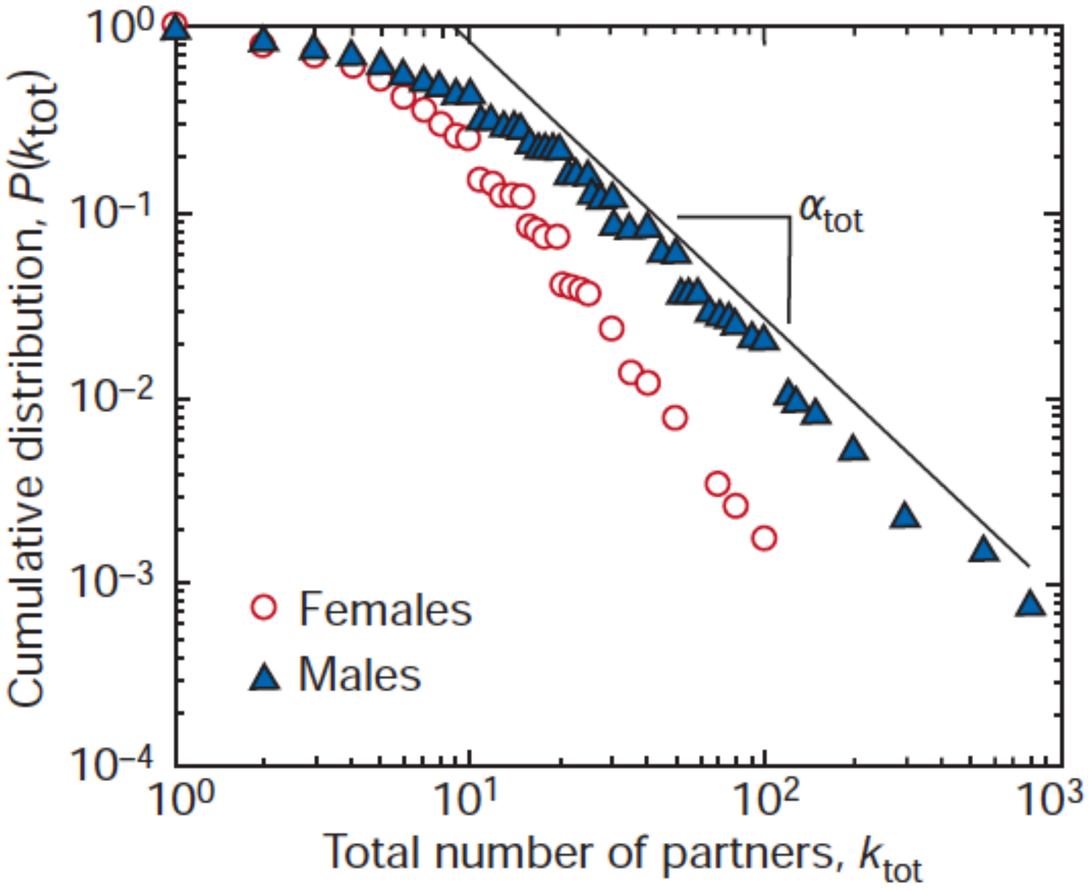


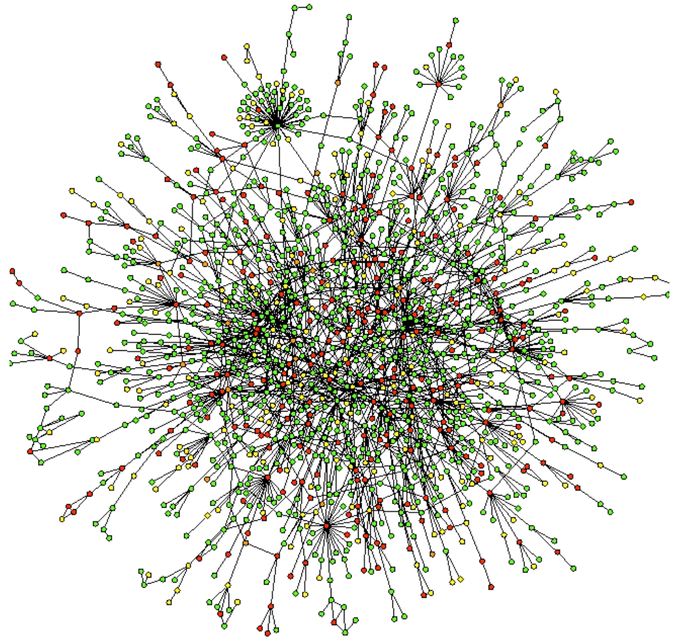




Pastor Satorras and Vespignani (2001)

sexually transmitted diseases

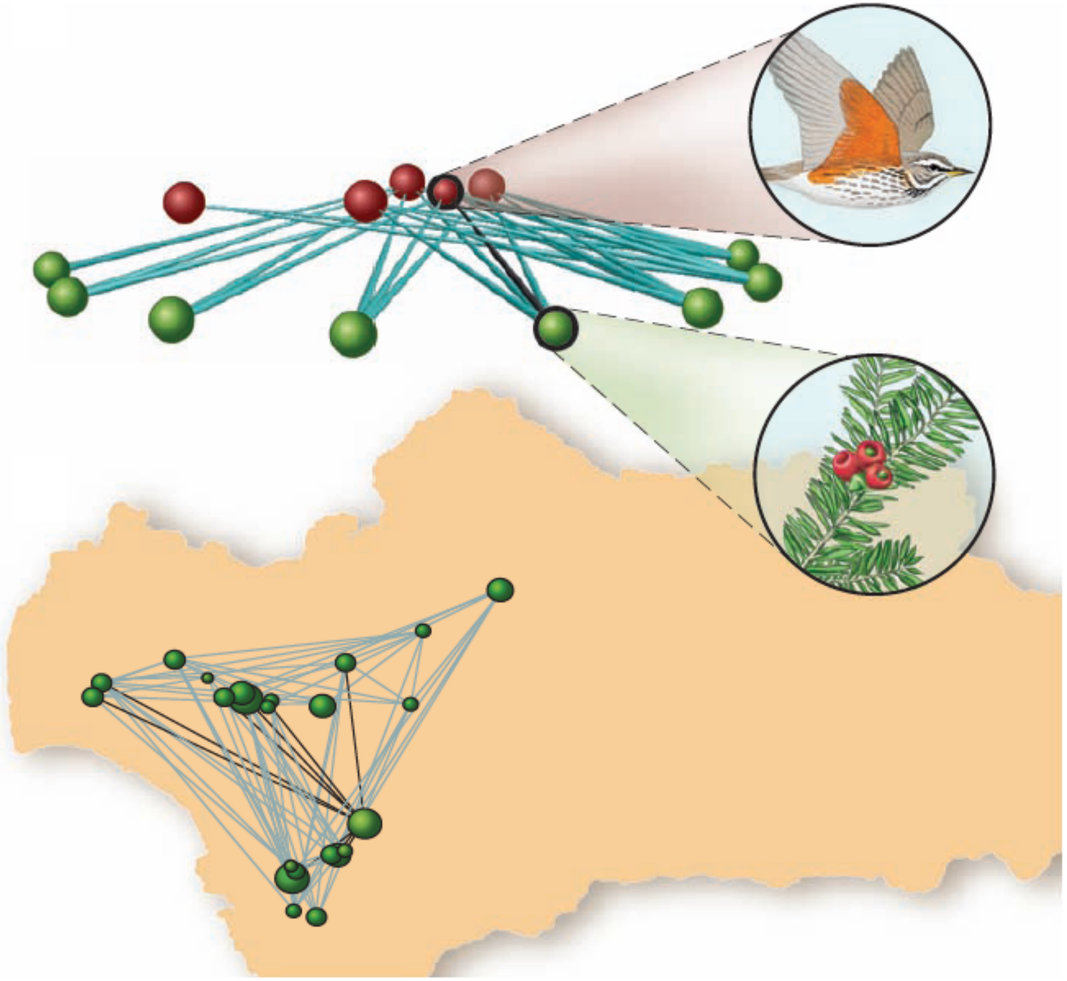




Absence of eradication thresholds in scale-free networks

Lijeros *et al.* (2001)

wrapping up: why networks?



- networks allow introducing heterogeneity into our previous homogeneous theories.
- networks put the focus on the patterns of interactions among elements.
- networks allow searching for commonalities among disparate systems.