

Lecture 5: Degree distributions and power laws

Matthew J. Salganik

Sociology 204: Social Networks, Spring 2021
Princeton University

2/2: Scale-free networks: implications, empirical work, and additional modeling



Follow up work:

- ▶ Implications
- ▶ Empirical
- ▶ Modeling

Epidemic Spreading in Scale-Free Networks

Romualdo Pastor-Satorras¹ and Alessandro Vespignani²

¹*Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Campus Nord, Mòdul B4,
08034 Barcelona, Spain*

²*The Abdus Salam International Centre for Theoretical Physics (ICTP), P.O. Box 586, 34100 Trieste, Italy*
(Received 20 October 2000)

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- Diseases are harder to stop when spreading in scale-free networks

<http://dx.doi.org/10.1103/PhysRevLett.86.3200>

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Error and attack tolerance of complex networks

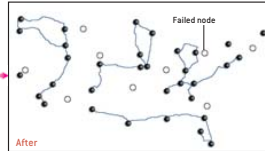
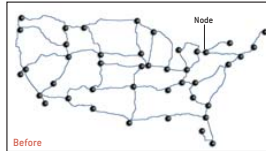
Réka Albert, Hawoong Jeong & Albert-László Barabási

*Department of Physics, 225 Nieuwland Science Hall, University of Notre Dame,
Notre Dame, Indiana 46556, USA*

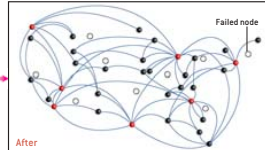
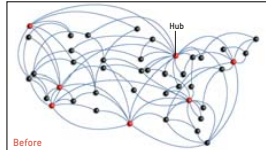
<http://dx.doi.org/10.1038/35019019>

Implication

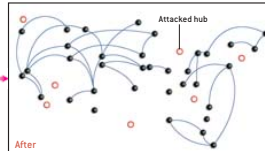
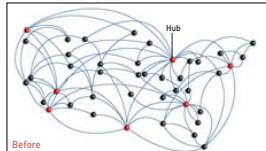
Random Network, Accidental Node Failure



Scale-Free Network, Accidental Node Failure



Scale-Free Network, Attack on Hubs

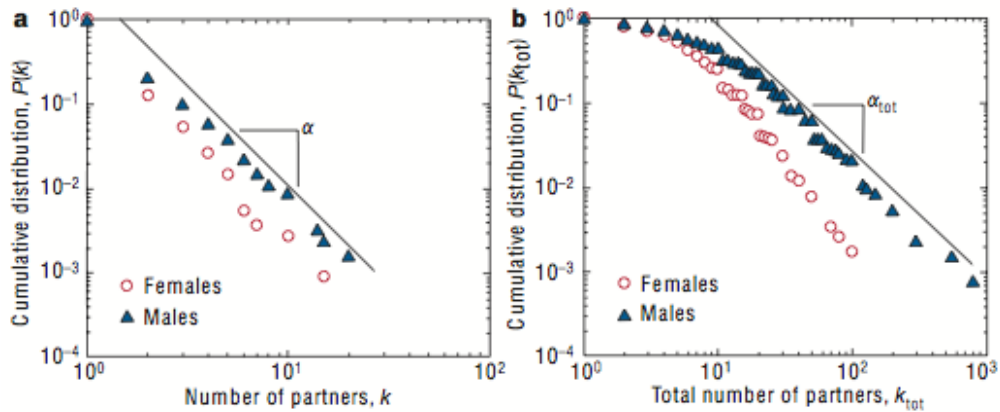


The web of human sexual contacts

Promiscuous individuals are the vulnerable nodes to target in safe-sex campaigns.

<https://doi.org/10.1038/35082140>

Empirical



ARTICLE

<https://doi.org/10.1038/s41467-019-08746-5>

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Scale-free networks are rare

Anna D. Broido¹ & Aaron Clauset^{2,3,4} 

- Formal definitions of scale-free networks: Super-weak, weakest, weak, strong, strongest

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COMMENT

<https://doi.org/10.1038/s41467-019-09038-8>

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Rare and everywhere: Perspectives on scale-free networks

Petter Holme  ¹

<https://doi.org/10.1038/s41467-019-09038-8>

Organization of growing random networks

P. L. Krapivsky and S. Redner

Center for BioDynamics, Center for Polymer Studies, and Department of Physics, Boston University, Boston, Massachusetts 02215

(Received 7 November 2000; published 24 May 2001)

- Generalizes growth process

<https://doi.org/10.1103/PhysRevE.63.066123>

Scale-Free Networks from Varying Vertex Intrinsic Fitness

G. Caldarelli,¹ A. Capocci,² P. De Los Rios,^{3,4} and M. A. Muñoz⁵

¹*INFN UdR ROMA1 Dipartimento Fisica, Università di Roma “La Sapienza,” Piazzale Aldo Moro 2 00185, Roma, Italy*

²*Département de Physique, Université de Fribourg-Pérolles, CH-1700 Fribourg, Switzerland*

³*Institut de Physique Théorique, Université de Lausanne, CH-1004 Lausanne, Switzerland*

⁴*INFN UdR Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy*

⁵*Instituto de Física Teórica y Computacional Carlos I, Universidad de Granada, Facultad de Ciencias, 18071-Granada, Spain*

(Received 15 July 2002; published 3 December 2002)

- power laws can from from “good-get-richer” in addition to “rich-get-richer”

<https://doi.org/10.1103/PhysRevLett.89.258702>

Question from previous year:

“Is it possible for hubs to exist even where a network doesn't follow a power law distribution? Meaning, the fact that some nodes will be more connected than other nodes, but without the entire network being scale-free?”

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A note on terminology:

- ▶ power law
- ▶ scale-free
- ▶ hubs

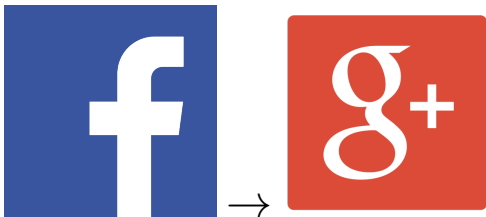
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- ▶ many (but not all) real networks have a power law degree distribution
- ▶ diseases spread more easily on networks with power law degree distribution than on other types of networks
- ▶ networks with power law degree distribution are robust to random failure but fragile to targeted attack

- ▶ Gladwell, M. (1999). Six degrees of Lois Weisberg. *The New Yorker*.
- ▶ Watts, Chapter 4, 114-129.
- ▶ Feld, S.L. (1981) The focused organization of social ties. *American Journal of Sociology*.



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