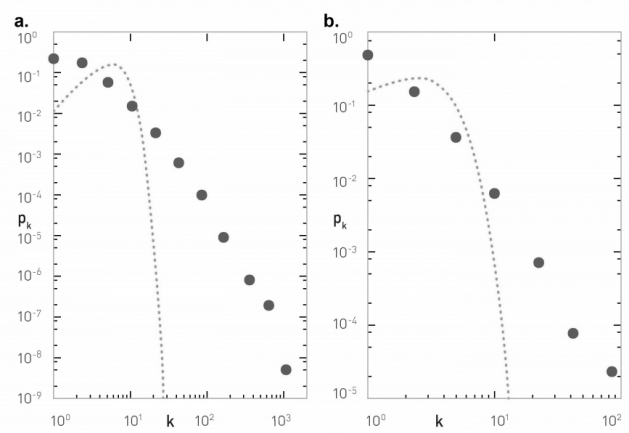


# 7. Übung zu Complex Networks

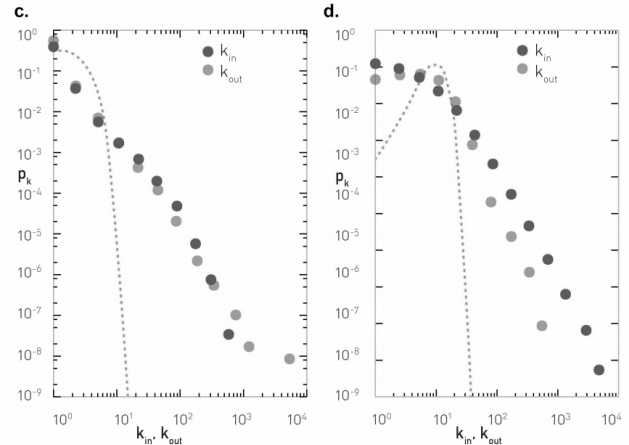
Soziale Netzwerke → häufig, Grad ungleich = Potenzgesetz

Internet  
(Router-Level)



Protein-Protein-Interaktionen

E-Mail



Zitate

Gradverteilung:  $p(k) \sim k^{-\gamma}$ ,  $p(k) = \underbrace{(\gamma-1)}_{\text{mit}} k^{\gamma-1} k^{-\gamma}$

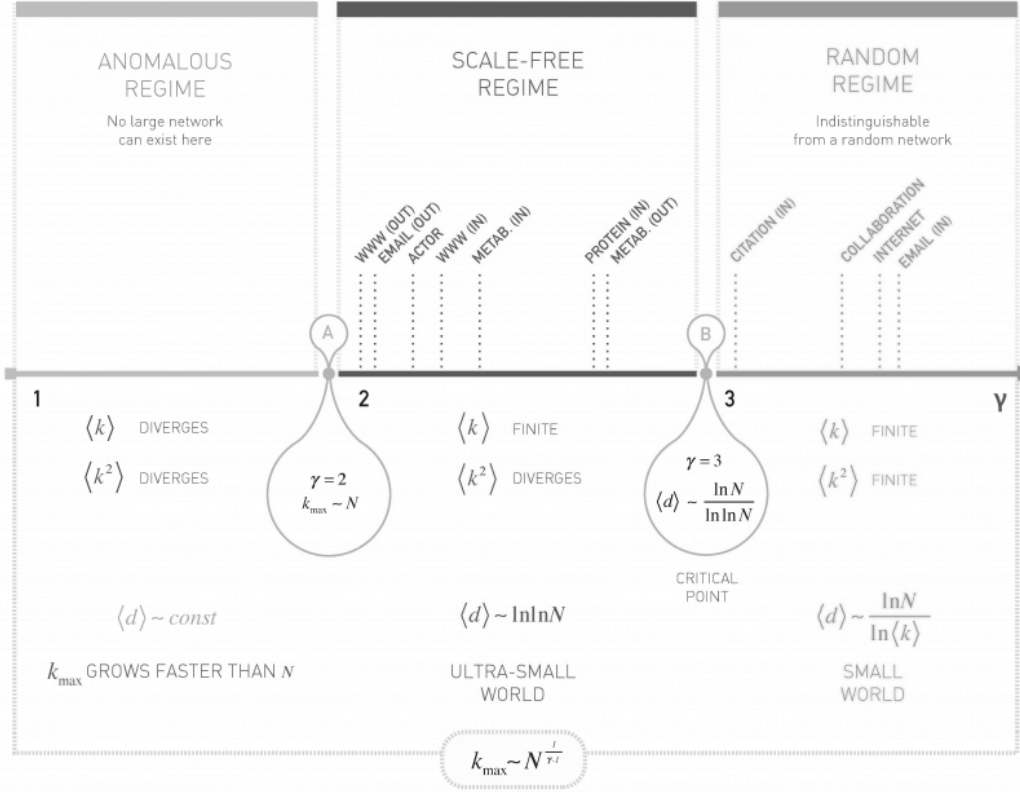
Proportionalitätsfaktor aus der Normierung

TABLE II. The scaling exponents characterizing the degree distribution of several scale-free networks, for which  $P(k)$  follows a power law (2). We indicate the size of the network, its average degree  $\langle k \rangle$ , and the cutoff  $\kappa$  for the power-law scaling. For directed networks we list separately the indegree ( $\gamma_{in}$ ) and outdegree ( $\gamma_{out}$ ) exponents, while for the undirected networks, marked with an asterisk (\*), these values are identical. The columns  $l_{real}$ ,  $l_{rand}$ , and  $l_{pow}$  compare the average path lengths of real networks with power-law degree distribution and the predictions of random-graph theory (17) and of Newman, Strogatz, and Watts (2001) [also see Eq. (63) above], as discussed in Sec. V. The numbers in the last column are keyed to the symbols in Figs. 8 and 9.

Network	Size	$\langle k \rangle$	$\kappa$	$\gamma_{out}$	$\gamma_{in}$	$l_{real}$	$l_{rand}$	$l_{pow}$	Reference	Nr.
WWW	325 729	4.51	900	2.45	2.1	11.2	8.32	4.77	Albert, Jeong, and Barabási 1999	1
WWW	$4 \times 10^7$	7		2.38	2.1				Kumar <i>et al.</i> , 1999	2
WWW	$2 \times 10^8$	7.5	4000	2.72	2.1	16	8.85	7.61	Broder <i>et al.</i> , 2000	3
WWW, site	260 000				1.94				Huberman and Adamic, 2000	4
Internet, domain*	3015–4389	3.42–3.76	30–40	2.1–2.2	2.1–2.2	4	6.3	5.2	Faloutsos, 1999	5
Internet, router*	3888	2.57	30	2.48	2.48	12.15	8.75	7.67	Faloutsos, 1999	6
Internet, router*	150 000	2.66	60	2.4	2.4	11	12.8	7.47	Govindan, 2000	7
Movie actors*	212 250	28.78	900	2.3	2.3	4.54	3.65	4.01	Barabási and Albert, 1999	8
Co-authors, SPIRES*	56 627	173	1100	1.2	1.2	4	2.12	1.95	Newman, 2001b	9
Co-authors, neuro.*	209 293	11.54	400	2.1	2.1	6	5.01	3.86	Barabási <i>et al.</i> , 2001	10
Co-authors, math.*	70 975	3.9	120	2.5	2.5	9.5	8.2	6.53	Barabási <i>et al.</i> , 2001	11
Sexual contacts*	2810			3.4	3.4				Liljeros <i>et al.</i> , 2001	12
Metabolic, <i>E. coli</i>	778	7.4	110	2.2	2.2	3.2	3.32	2.89	Jeong <i>et al.</i> , 2000	13
Protein, <i>S. cerev.</i> *	1870	2.39		2.4	2.4				Jeong, Mason, <i>et al.</i> , 2001	14
Ythan estuary*	134	8.7	35	1.05	1.05	2.43	2.26	1.71	Montoya and Solé, 2000	14
Silwood Park*	154	4.75	27	1.13	1.13	3.4	3.23	2	Montoya and Solé, 2000	16
Citation	783 339	8.57			3				Redner, 1998	17
Phone call	$53 \times 10^6$	3.16		2.1	2.1				Aiello <i>et al.</i> , 2000	18
Words, co-occurrence*	460 902	70.13		2.7	2.7				Ferrer i Cancho and Solé, 2001	19
Words, synonyms*	22 311	13.48		2.8	2.8				Yook <i>et al.</i> , 2001b	20

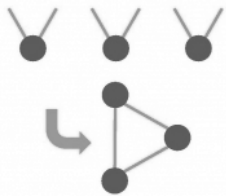
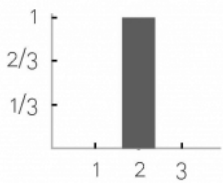
$\gamma$ -Bereiche,  
häufig  $2 < \gamma < 3$   
Variation:  
 $\langle k^2 \rangle \sim \int_0^{\infty} k^{-2} k^{-\gamma} dk$   
divergiert für  $\gamma > 2$   
⇒ Skalensfrei  
typischer Grad:  
 $\langle k \rangle \sim \sqrt{k}$   
für  $\gamma > 2$

Wann gibt es  
keine Skalentransitivität  
Netzwerke mit  
 $\gamma < 2$ ?

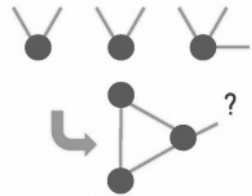
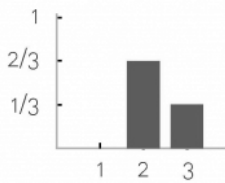


Beobachtung: i) 1. Moment des Gradverteilung konvergiert  
ii) Grad des hubs wächst sehr stark (für Erwartung:  $\langle k \rangle$  groß)  
↳ Punkt  $k_{\text{max}} > N$   
ohne Vielfachbindungen unmöglich

a. Graphical



b. Not Graphical



Es bleiben offene Enden / stubs übrig.

Projekte: Übersetzung des Buches "Network Science"

→ Material in der tubcloud

→ 1. Entwurf bis 27.6

→ Korrekturlesen bis 11.7.

→ Jährliche Festsung SoS 18.7.

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6. <sup>te</sup> Lebensblatt: Abgabe in der Pause der Begegnung des SFB 910 (ca. 12:00)

10:00 - 12:00 Vorträge (Gesamtkonzert, ausgewählte Teilprojekte)  
EW201

ausschließend: Mittagspause / Postpräsentation der zukünftigen  
Teilprojekte  
Galerie (1. Etage EW-Gebäude)

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Soziale Netzwerke → Stichwort: Big Data

siehe Folien des Habilitationsvortrags  
vom August 2017