Small Worlds and World Wide Web

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Rational Choice Sociology: Theory and Empirical Applications
Venice International University, November 29 till December 3, 2010

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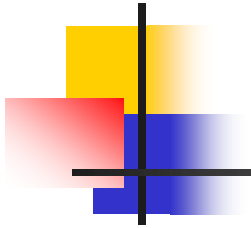

- The Small World Experiment
- The ‚New' Science of Networks
- Between Order and Randomness
- Small World Phenomena in the World Wide Web
- Properties of the Largest Communication Network
- Robustness of Large Networks

The Small World Experiment

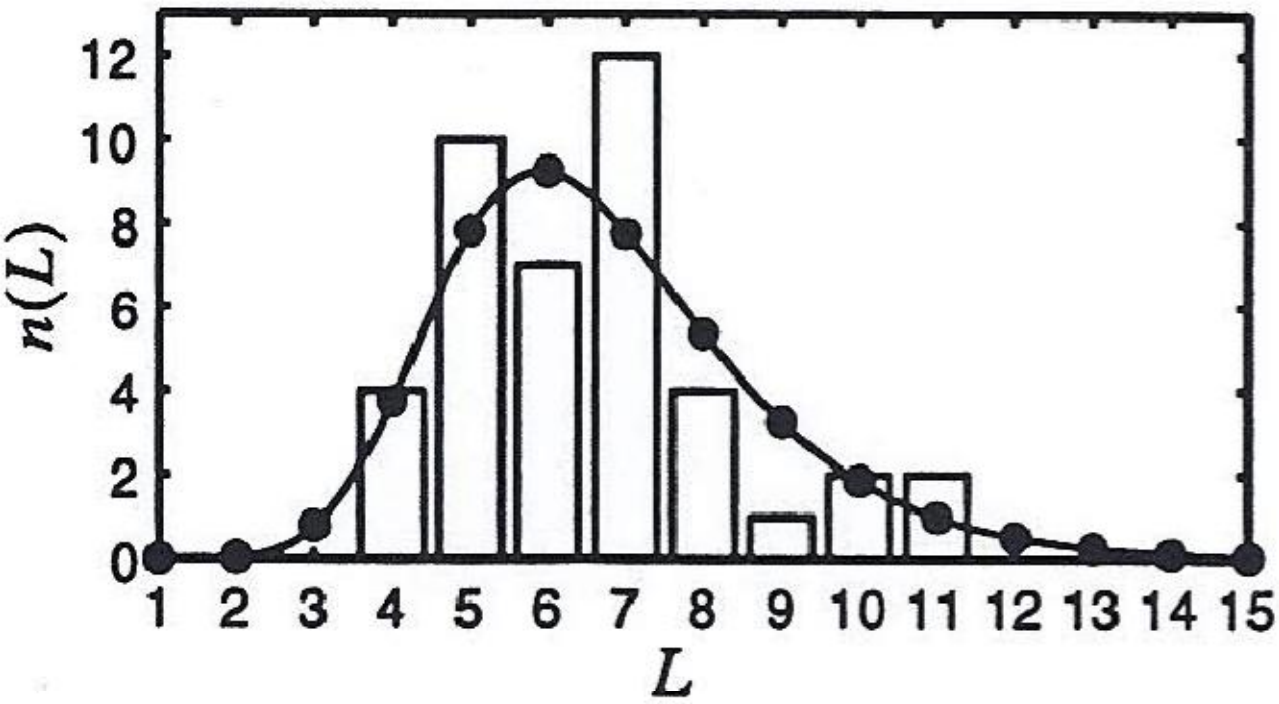

Figure 1: Comparison between *n*(*L*), the number of completed chains of length *L*, taken from the original small-world experiment (bar graph) and from an example of the Watts et al. model with $N = 10^8$ individuals

The ‚New' Science of Networks

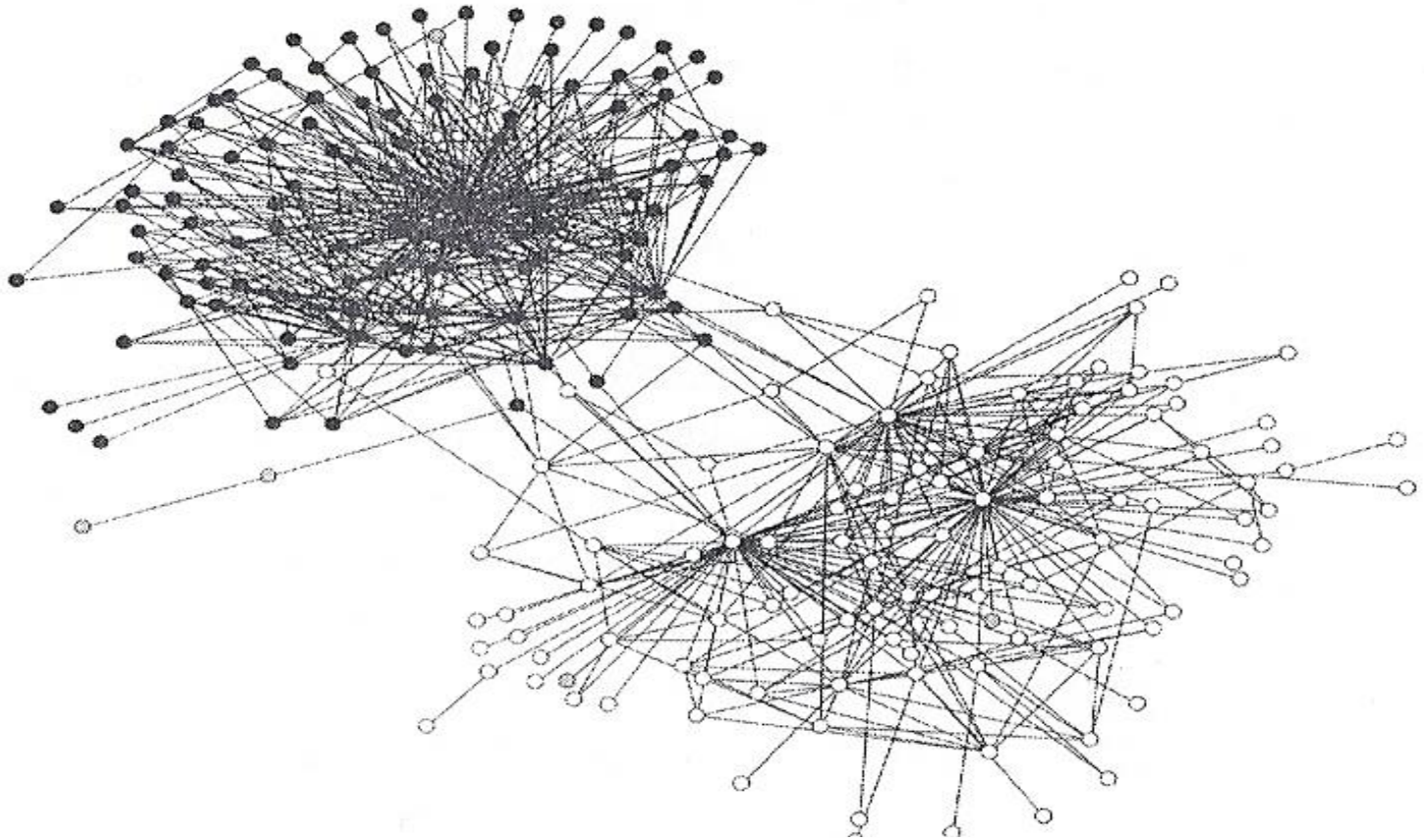

Figure 2: Citation patterns in the Small World literature (Freeman 2004, p. 166)
(white points: social networkers; black points: physicists; grey points: economists, biologists etc.)

Between Order and Randomness

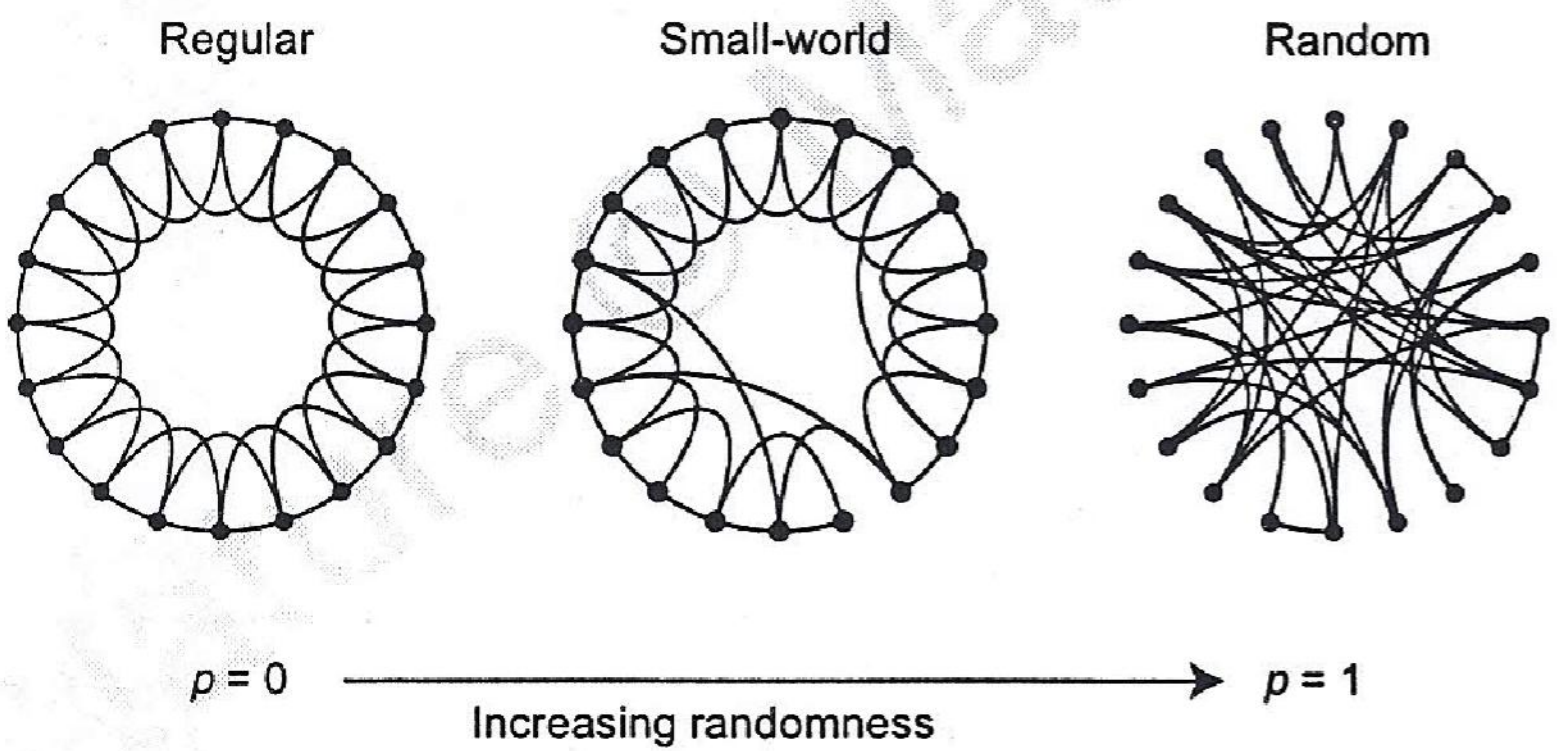

Figure 3: Random Rewiring of a Regular Graph (*n* = 20 und *k* = 4)

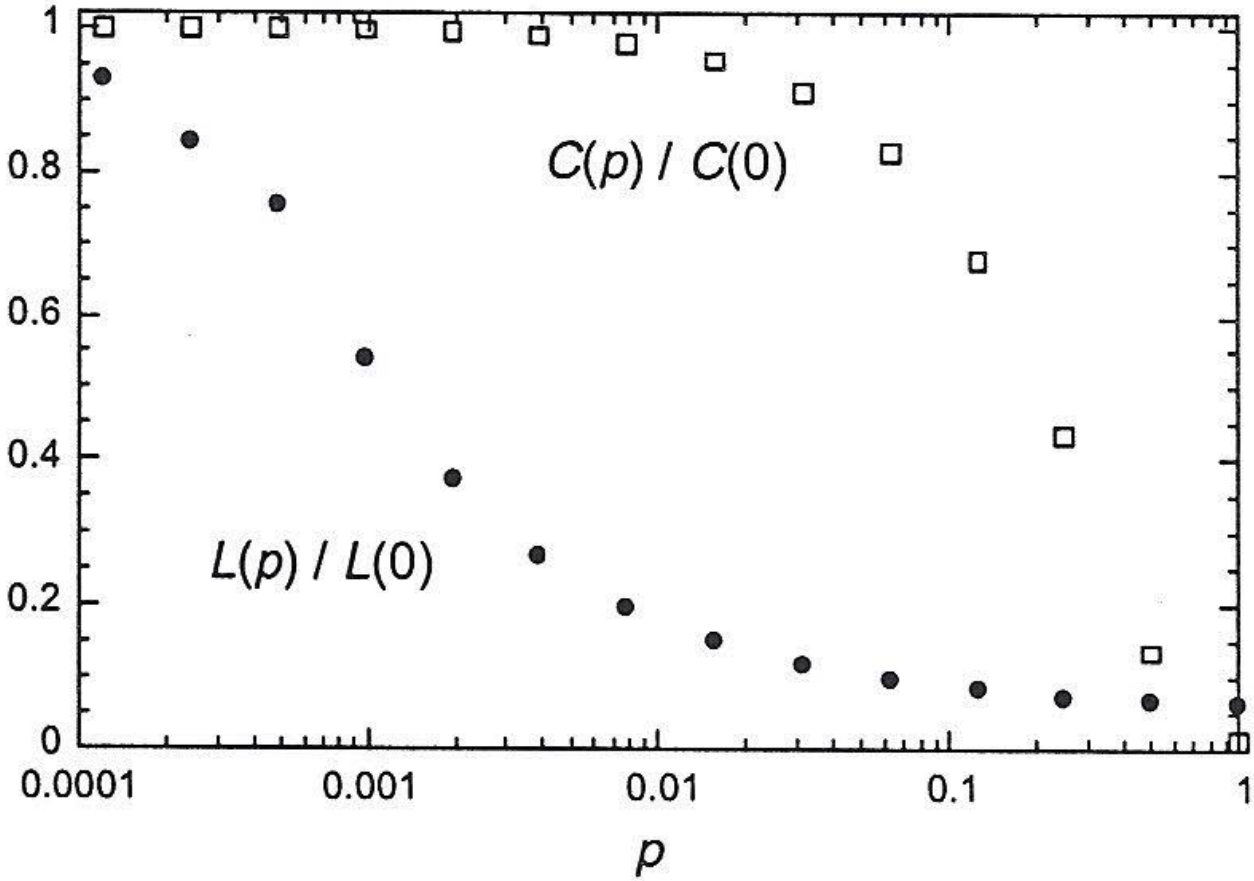

Figure 4: The data shown in the figure are averages over 20 random realizations of the rewiring process and have been normalized by the values *L*(0), *C*(0) for a regular lattice.

(All the graphs have n = 1.000 vertices and an average degree of k = 10 edges per vertex.)

Small World Phenomena in the World Wide Web

Network	Number of nodes	Average degree	distance		clustering		degree correlation
			$L_{observed}$	L_{random}	$C_{observed}$	C_{random}	
Film actors	449 913	113.4	3.48	2.75	0.78	0.00025	0.208
company directors	7 673	14.4	4.60	3.35	0.88	0.00188	0.276
math coauthorship	253 339	3.9	7.57	9.11	0.34	0.00002	0.120
physics coauthorship	52 909	9.3	6.19	4.88	0.56	0.00018	0.363

Table 1: Average distance, clustering and degree correlation of some observed and random networks

Properties of the Largest Communication Network

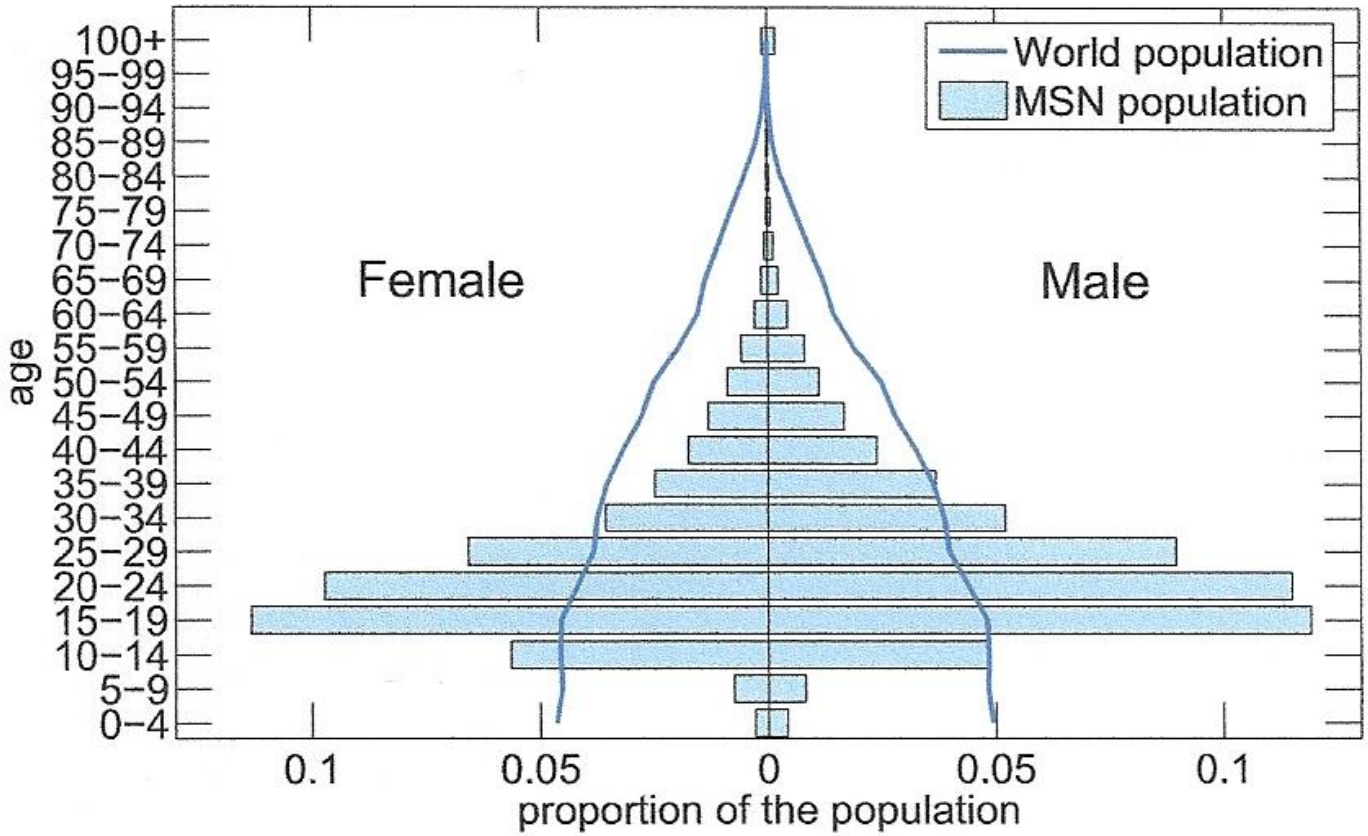

Figure 5: World and Messenger user population age pyramid. Ages 15–30 are overrepresented in the Messenger population.

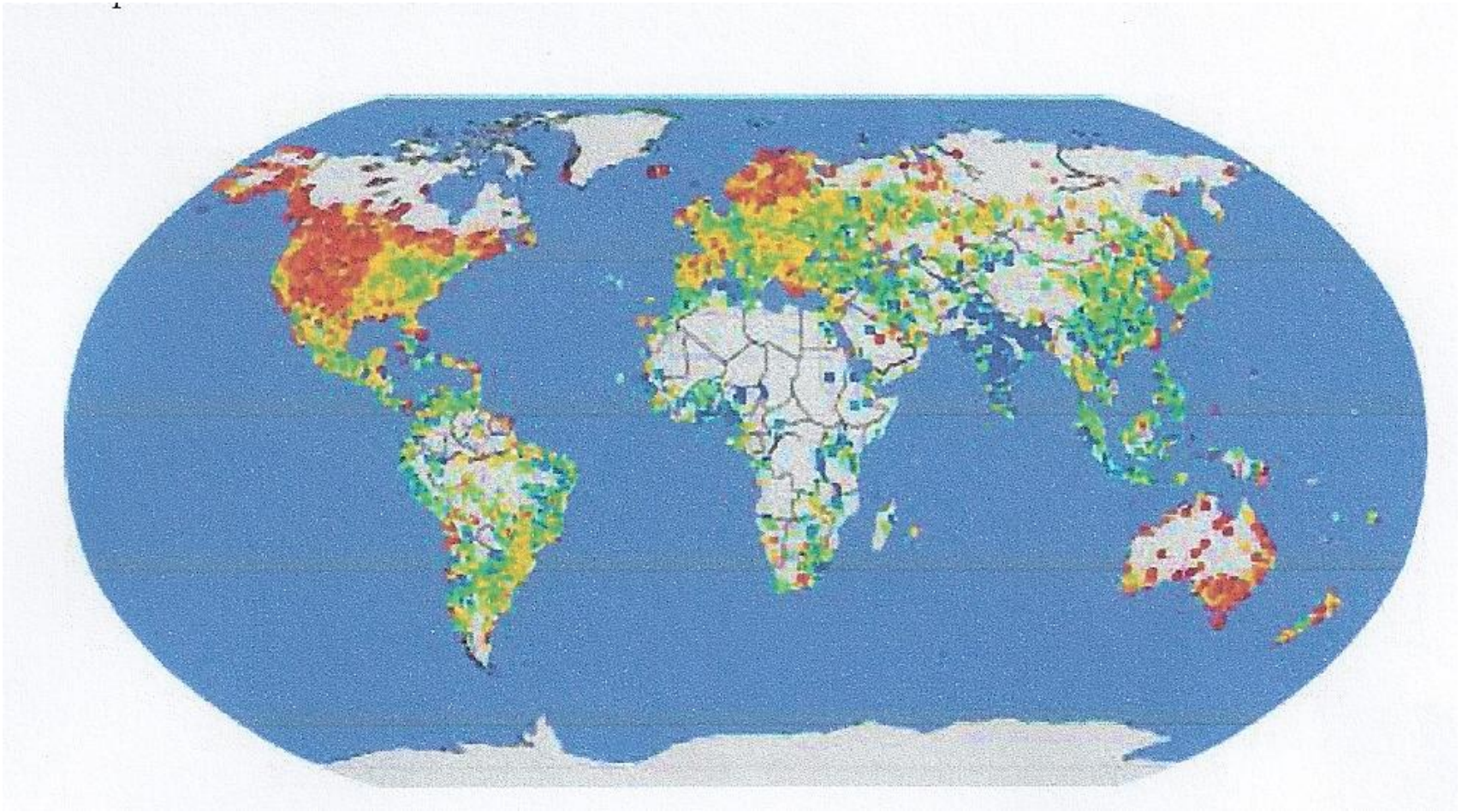

Figure 6: Number of Messenger users per capita
(Color intensity corresponds to the number of users per capita in the cell of the grid.)

	Random	Communication
Age	0.030	0.162
Gender	0.434	0.426
Location (ZIP)	0.001	0.230
Country	0.046	0.734
Language	0.030	0.798

Table 2: Probability of users sharing an attribute for random pairs of people versus for pairs of people who communicate.

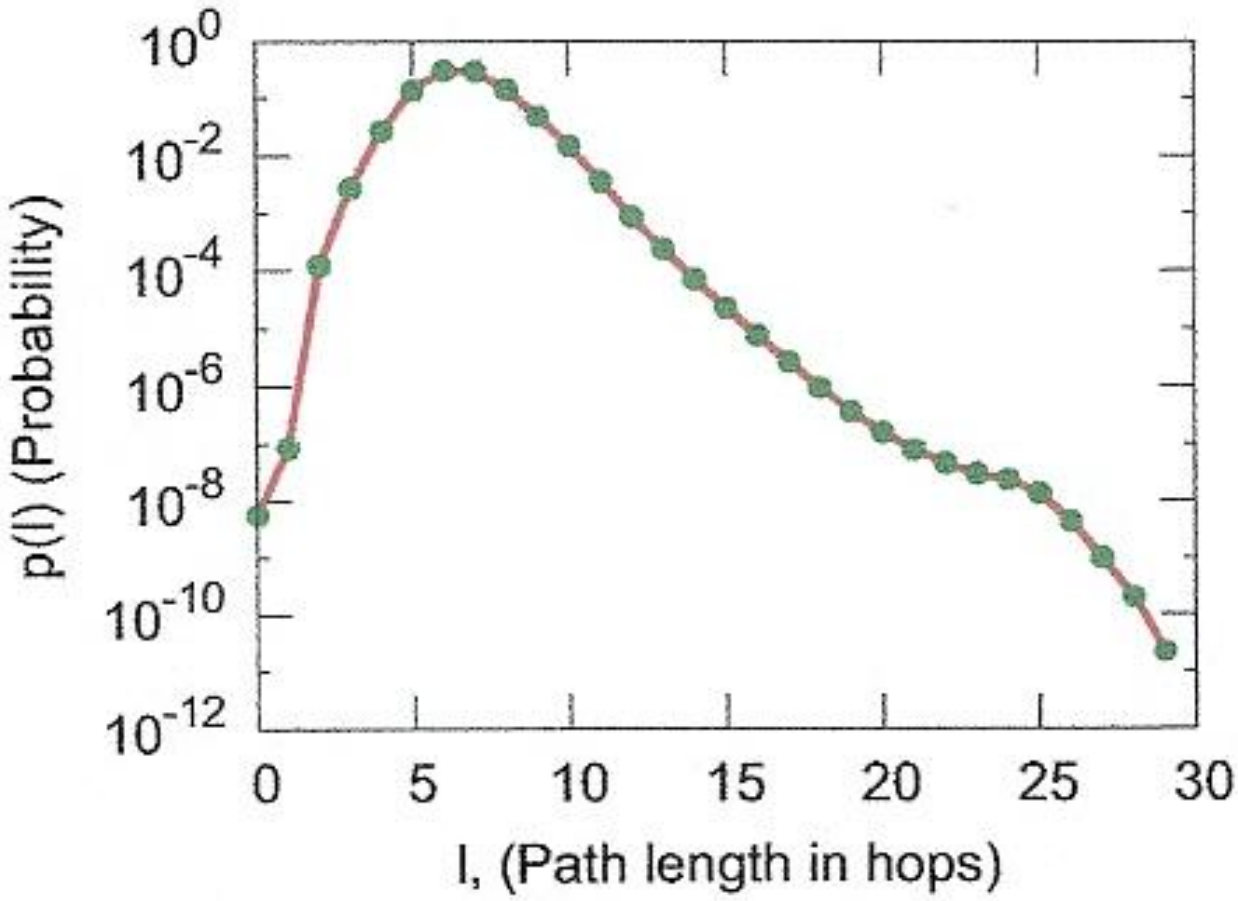

Figure 7: Distribution over the shortest path lengths

(Average shortest path has length 6.6,
the distribution reaches the mode at 6 hops)

Robustness of Large Networks

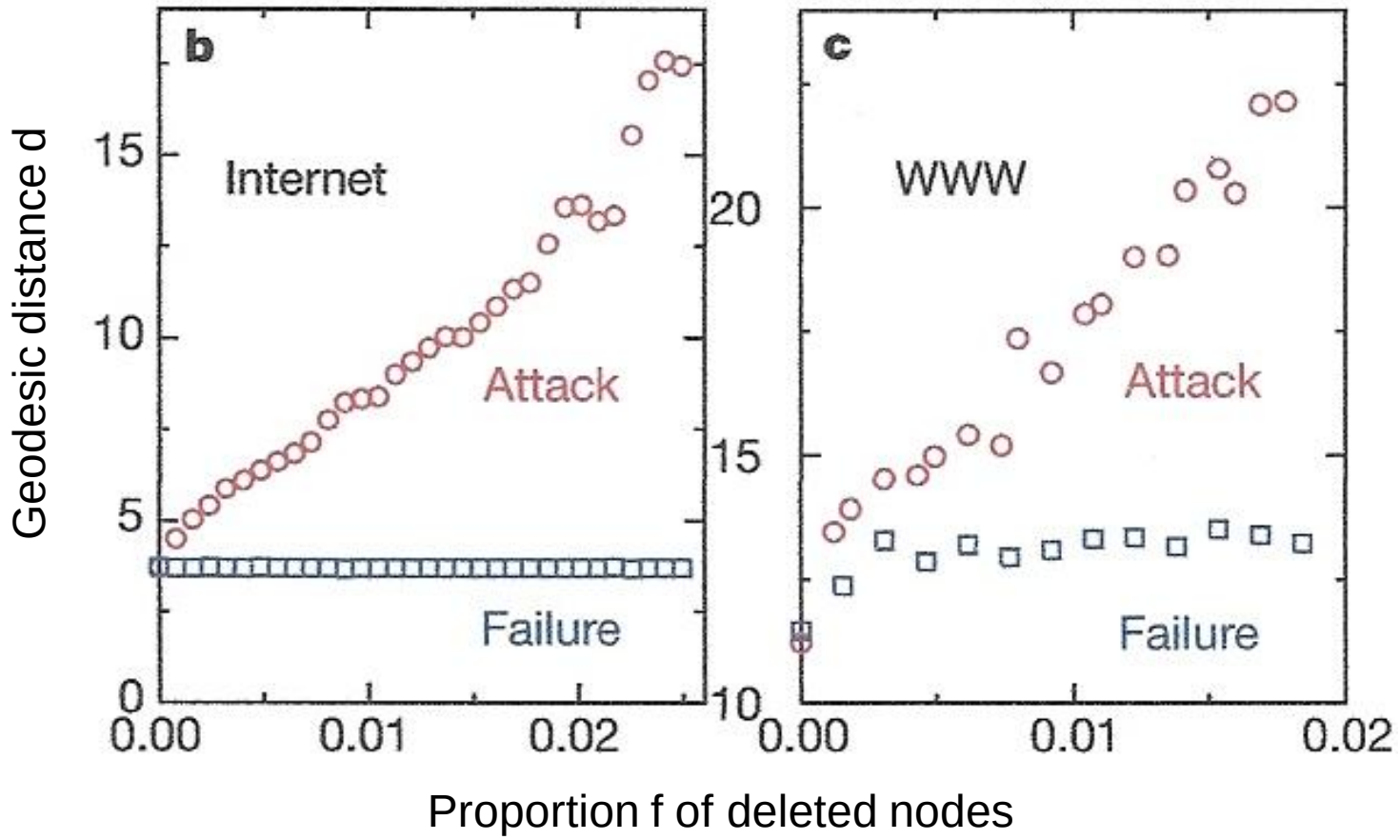

Figure 8: Change of geodesic distance after random removal or attack

Internet 6,209 nodes and 12,200 edges; WWW 325,729 nodes and 1,498,353 edges

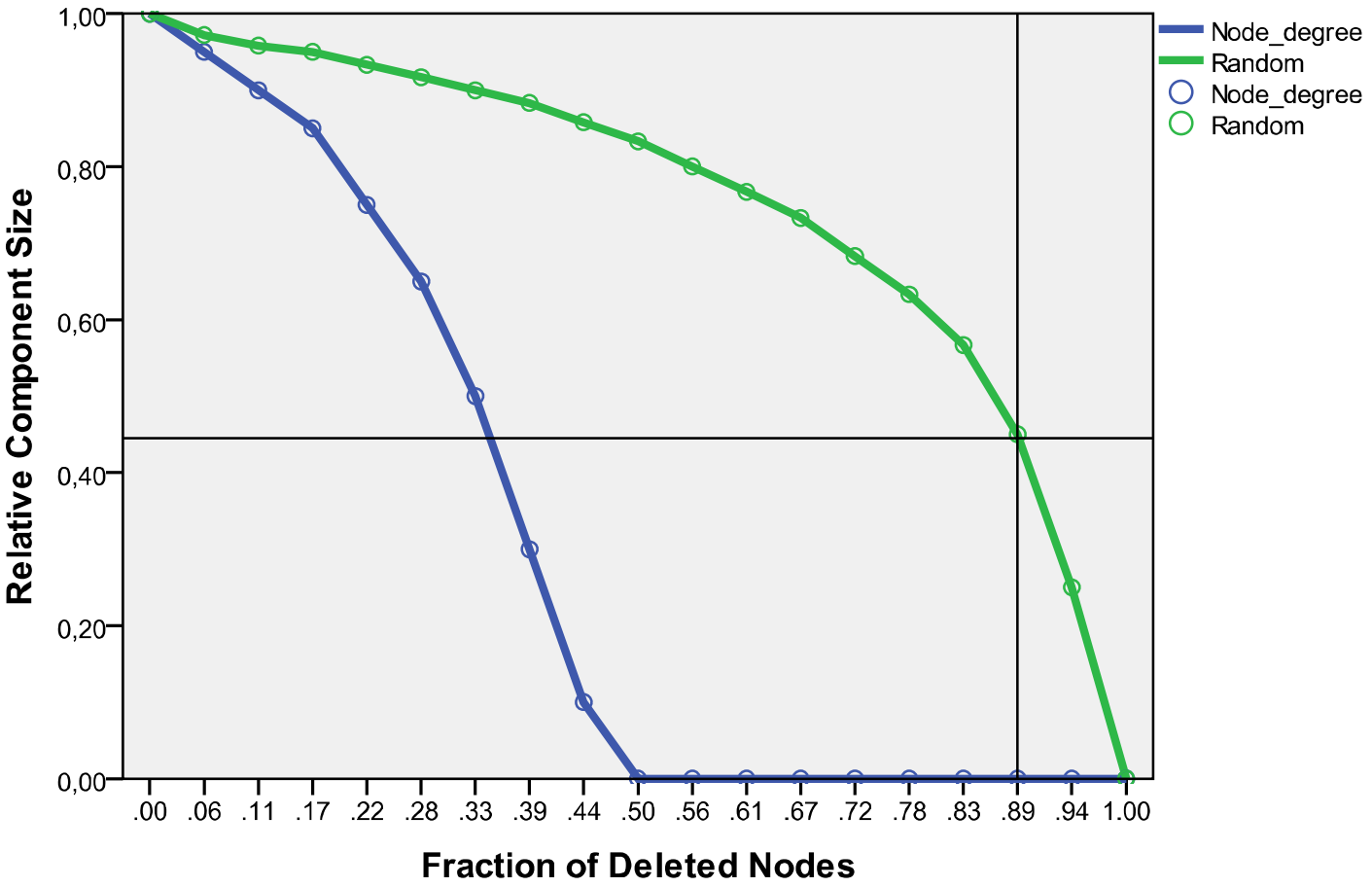

Figure 9: Relative size of the largest connected component in the Messenger communication network as a function of number of nodes removed

(green: random removal; blue: removal in order of node degree)

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- Which properties of networks are the important ones to focus on?
- Developing more sophisticated models of networks, both to help us understand network topology and to study the processes taking place on networks
- To understand the behavior and function of the networked systems


Thank you for your attention

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