E5 - Mathematische Physik

Professor Blanchard

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Physik komplexer Systeme

- … i.w.S. Statistische Mechanik
- Selbstorganisierte Kritikalität
- Perkolation
- Epidemiologie
- Nicht-Linearität, Chaos
- Universalität
- Komplexe Netzwerke:
  - EU-Projekte
  - Korruption
  - Vorurteile
  - …

Komplexe Netzwerke

- Seit 1998 neuer „Hype“ in der Physik
- „Skalenfreie Netze“, „Small Worlds“
- Graphentheorie, Perkolation, Eigenwertspektren
- Modell-Entwicklung, -Analyse, Mechanismen verstehen
- Netzwerk-Entstehung, -Wachstum, -Struktur
- Zugänge:
  – Analytische Abschätzungen
  – Computersimulationen

NEMO (EU-Projekt)

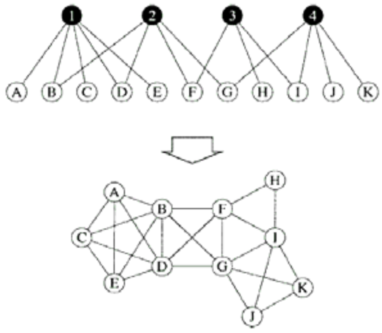
Network Models, Governance and R&D collaboration networks

- 9 europäische Forschungsinstitute (Wien, Madeira, Hamburg, Bielefeld, …), 1.4M€
- 2006-2009 EU-Projektförderung
  wir suchen also bis mindestens ~2008
- Diplomarbeiten
  – Analysis, Graphentheorie, Modell-Entwicklung
  – Computersimulationen, -modelle

NEMO -> ForschungsKollaborationen

- 5 Rahmenprogramme der EU zur Forschungsförderung, 20 Jahre Datensatz
- Modellannahme:
  Kollaboration in Projekt = Link im Netzwerk

•Gesamtnetzwerk ist skalenfrei, small world
•Thematische Netzwerke
•Kollaborations-Modelle „cameo“ = Seltenheit
•Wissensausbreitung in diesen Netzwerken



Clustering von Netzwerken

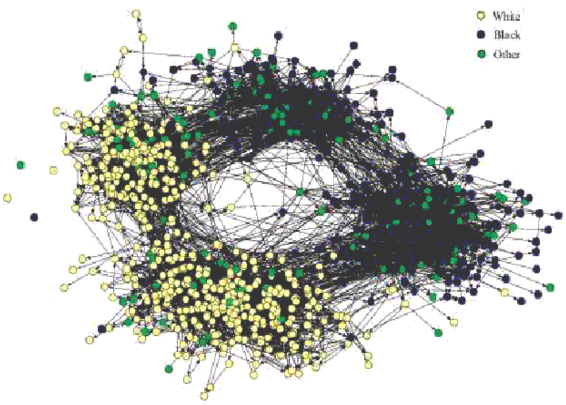
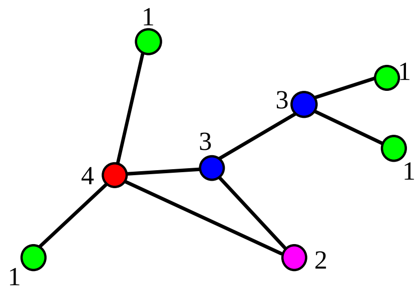


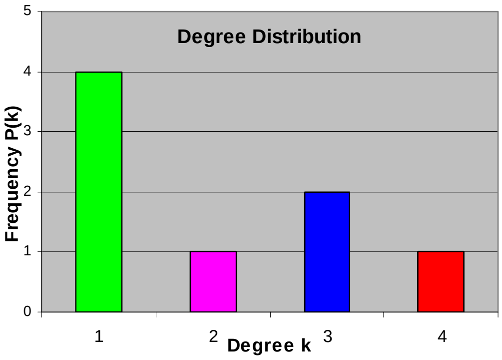
FIG. 8 Friendship network of children in a US school. Friendships are determined by asking the participants, and hence are directed, since A may say that B is their friend but not *vice versa*. Vertices are color coded according to race, as marked, and the split from left to right in the figure is clearly primarily along lines of race. The split from top to bottom is between middle school and high school, i.e., between younger and older children. Picture courtesy of James Moody.

degree of a node

k_x = deg(x) = $|N_1(x)|$
= number of N_1-Neighbours of node x

P(k) = *Degree-Distribution (frequency)*
= **number of nodes** with deg=k





Degree Distribution with ER G(N,p) is ~ Poisson

The average is good estimator
for the whole distribution (bellshaped)

$$\langle k \rangle = (N-1)p$$
$$= (N-1)\frac{M}{N(N-1)/2} = \frac{2M}{N}$$
$$= \mu$$

The degree has a binomial distribution. For N>>1 it becomes Poissonian:

$$P(k) = e^{-\mu}\frac{\mu^k}{k!}$$

with an exponential tail for large k

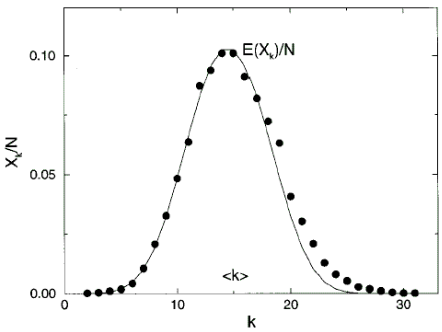


FIG. 7. The degree distribution that results from the numerical simulation of a random graph. We generated a single random graph with $N=10\,000$ nodes and connection probability $p=0.0015$, and calculated the number of nodes with degree k, X_k. The plot compares X_k/N with the expectation value of the Poisson distribution (13), $E(X_k)/N = P(k_i = k)$, and we can see that the deviation is small.

scale free degree distribution

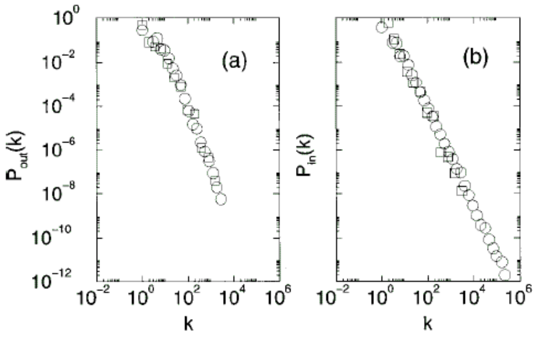


FIG. 2. Degree distribution of the World Wide Web from two different measurements: □, the 325 729-node sample of Albert *et al.* (1999); ○, the measurements of over 200 million pages by Broder *et al.* (2000); (a) degree distribution of the outgoing edges; (b) degree distribution of the incoming edges. The data have been binned logarithmically to reduce noise. Courtesy of Altavista and Andrew Tomkins. The authors wish to thank Luis Amaral for correcting a mistake in a previous version of this figure (see Mossa *et al.*, 2001).

In MEASURED networks, the degree distribution is **not** Poissonian (with exponential tail) for large k

but "fat tail"
→ falling **power-law**

$$P(k) = \frac{1}{k^{\gamma}}$$

$$\gamma \sim 2.5$$

An average <k> doesn‘t really make sense here
= no *built-in scale*

→ „scale-free“

? Interesse an ?

Interdisziplinarität	„Computerphysik“
Methodenvielfalt	Physik komplexer Systeme
Abstraktion	„Sozio-Physik“

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