Universität Zürich[UZH]

Blockchain & Distributed Ledger Technologies

UZH Blockchain Center

A05: Scale-Free Networks

Network Science '21: Assignment 5

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Objectives

1. Explore the scale-free property of real networks and the difference with random networks
2. Get familiar with the `powerlaw` package

A05.1 Scale-Free Networks

A05.1 Everyday networks are not Poisson: parameter estimation and model selection

Task: *For all given networks compute the degree distribution $P(k)$ and the average degree $\langle k \rangle$ and use the* `powerlaw` *package to fit $P(k)$.*

1. Compute the power-law exponent γ of the degree distribution $P(k) \sim k^{-\gamma}$ and the corresponding error
2. Superimpose in the same plot of the power-law fit (a) the Poisson and (b) the exponential distribution with mean value equal to $\langle k \rangle$. Which distribution is more likely to describe the data?
3. What does it mean in practice for the Internet?

A05.1 Hints

- The Poisson distribution with mean value $\langle k \rangle = \lambda$ can be computed as:

$$P(k,\lambda) = \frac{\lambda^k}{k!} \exp(-\lambda)$$

- The exponential distribution with mean value $\langle k \rangle = \lambda$ can be computed as:

$$P(k,\lambda) = \lambda^{-1} \exp(-k/\lambda)$$

- For the factorial $k!$ you can use the `factorial` function that can be imported from the module `scipy.special`

A06.1 Datasets provided

Datasets provided:

- Sex Escorts: Nodes represent female (sex-sellers) and male (sex-buyers) and Edges represent a sexual encounter between a male and a female **[1]**
- Internet: Nodes represent autonomous systems (AS) , i.e. collections of connected IP routing prefixes controlled by independent network operators, and Edges represent physical connections between them **[2]**
- Amazon: Nodes represent Amazon products and Edges represent frequently co-purchased products **[3]**
- Actor-actor collaborations: Nodes represent actors and Edges represent appearances in the same movie **[4]**

A06.1 Datasets provided

[1] L E C Rocha, F Liljeros, and P Holme, Information dynamics shape the sexual networks of Internet-mediated prostitution, Proceedings of the National Academy of Sciences of the USA 107 (13), 5706-5711 (2010)
[2] B. Zhang, R. Liu, D. Massey, and L. Zhang, Collecting the Internet AS-level topology, SIGCOMM Computer Communication Review, 35 (2005), pp. 53–61.
[3] J. Yang and J. Leskovec. Defining and Evaluating Network Communities based on Ground-truth. ICDM, 2012.
[4] A-L. Barabasi and R. Albert , Emergence of Scaling in Random Networks, Science (286), 509–512 (1999)

A05.2 Preferential Attachment model

A05.2 Barabási-Albert model

Task: *Build networks with the Barabási-Albert model. Connect* $m = 3$ *for each new node and grow until* $N = 50, 100, 500, 1000, 5000$*, then compute some network properties. Compare them with randomised versions of the networks.*

1. Compute the average clustering coefficient, assortativity, average shortest path length and diameter
2. Compare them by scatterplots with the same measures on randomised versions of the networks (use log x axis)
3. Which of these measures is relatively unchanged by randomisation? Why?

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