

Network Science: Understanding the Internal Organization of Complex Systems (Invited Talk)

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Abstract

Systems as diverse as the World Wide Web, Internet or the cell are described by highly interconnected networks with amazingly complex topology. Recent studies indicate that these networks are the result of self-organizing processes governed by simple but generic laws, resulting in architectural features that makes them much more similar to each other than one would have expected by chance. I will discuss the order characterizing our interconnected world and its implications to network robustness. I will also discuss a recently developed analytical framework to study the controllability of an arbitrary complex network, identifying the set of driver nodes whose time-dependent control can guide the system's dynamics.

Introduction

The following material was collected from the Center for Complex Network Research (www.barabasilab.com). Web addresses are noted where possible.

People

Albert-László Barabási is a Distinguished University Professor at Northeastern University, where he directs the Center for Complex Network Research, and holds appointments in the Departments of Physics, Computer Science and Biology, as well as in the Department of Medicine, Harvard Medical School and Brigham and Women Hospital, and is a member of the Center for Cancer Systems Biology at Dana Farber Cancer Institute. A Hungarian born native of Transylvania, Romania, he received his Masters in Theoretical Physics at the Eötvös University in Budapest, Hungary and was awarded a Ph.D. three years later at Boston University. After a year at the IBM T.J.

Watson Research Center, he joined Notre Dame as an Assistant Professor, and in 2001 was promoted to the Professor and the Emil T. Hofman Chair. Barabási recently released on April 29th his newest book "Bursts: The Hidden Pattern Behind Everything We Do" (Dutton, 2010) available in five languages. He has also authored "Linked: The New Science of Networks" (Perseus, 2002), currently available in eleven languages, is co-author of "Fractal Concepts in Surface Growth" (Cambridge, 1995), and the co-editor of "The Structure and Dynamics of Networks" (Princeton, 2005). His work led to the discovery of scale-free networks in 1999, and proposed the Barabasi-Albert model to explain their widespread emergence in natural, technological and social systems, from the cellular telephone to the WWW or online communities. His work on complex networks have been widely featured in the media, including the cover of Nature, Science News and many other journals, and written about in Science, Science News, New York Times, USA Today, Washington Post, American Scientist, Discover, Business Week, Die Zeit, El Pais, Le Monde, London's Daily Telegraph, National Geographic, The Chronicle of Higher Education, New Scientist, and La Republica, among others. He has been interviewed by BBC Radio, National Public Radio, CBS and ABC News, CNN, NBC, and many other media outlets. (barabasilab.com/personnel/who.php?who=Barabasi)

Awards

Barabási is a Fellow of the American Physical Society. In 2005 he was awarded the FEBS Anniversary Prize for Systems Biology and in 2006 the John von Neumann Medal by the John von Neumann Computer Society from Hungary, for outstanding achievements in computer-related science and technology. In 2004 he was elected into the Hungarian Academy of Sciences and in 2007 into the Academia Europaea. He received the C&C Prize from the NEC

C&C Foundation in 2008. In 2009 APS chose him Outstanding Referee and the US National Academies of Sciences awarded him the 2009 Cozzarelli Prize. In 2011 Barabási was awarded the Lagrange Prize-CRT Foundation for his contributions to complex systems and was awarded Doctor Honoris Causa from Universidad Politécnica de Madrid. (<http://barabasilab.com/personnel/who.php?who=Barabasi>)

Selected Projects

Mobile Phone Viruses

2009-02-04: Mobile viruses are little more than a nuisance today, but given our increased reliance on wireless communication, in the near future they could pose more risk than their PC based counterparts. Despite of the more than three hundred mobile viruses known so far, little is known about their spreading pattern, partly due to a lack of data on the communication and travel patterns of mobile phone users. Starting from the traffic and the communication pattern of six million mobile phone users, we model the vulnerability of mobile communications against potential virus outbreaks... (<http://www.barabasilab.com/labprojectpage01.php?id=4>)

HuDiNe

2008-08-08: HuDiNe - the human disease network. Data available for download or online exploration. (<http://www.barabasilab.com/labprojectpage01.php?id=2>)

Individual Mobility Patterns

2008-06-05: The mapping of large-scale human movements is important for urban planning, traffic forecasting and epidemic prevention. Work in animals suggested that their movements might be explained in terms of a random walk, a mathematical rendition of a series of random steps, or a Lévy flight, a random walk punctuated by an occasional larger step. The role of Lévy statistics in animal behaviour is controversial, but the idea of extending it to human behaviour was boosted in 2006 by a report of Lévy flight-like patterns in human movement tracked via dollar bills. Our study, based on tracking the trajectory of 100,000 cell-phone users for six months, reveals behaviour close to a Lévy pattern, but deviating from it as individual trajectories show a high degree of temporal and spatial regularity: work and other commitments mean we are not as free to roam as a foraging animal. But by correcting the data to accommodate individual variation, simple and predictable patterns in human travel begin to emerge. (<http://www.barabasilab.com/labprojectpage01.php?id=1>)

Courses

Welcome to the Network Science course website. Please tune in for updates, messages, homework assignments and useful links. At the Center for Complex Network Research, Northeastern University Physics Department, 110 Forsyt Street, Boston, MA 02115 (on the 5th Floor of Charles A. Dana building)

The course will be presented by Prof. Albert-László Barabási, assisted by Dr. Baruch Barzel, and with visualizations by Prof. Mauro Martino. (<http://barabasilab.neu.edu/courses/phys5116/>):

Selected Publications

A.-L. Barabási and H. E. Stanley, *Fractal Concepts in Surface Growth* (Cambridge University Press, Cambridge, 1995).

A.-L. Barabási, M. Krishnamurthy, F. Liu, and T. Pearsall (eds.), *Epitaxial Growth – Principles and Applications* (Materials Research Society, Vol. 570, Warrendale, PA, 1999).

J. Mirecki Millunchick, A.-L. Barabási, N. A. Modine, and E. D. Jones (eds.), *Morphological and Com-positional Evolution of Heteroepitaxial Semiconductor Thin Films* (Materials Research Society, Vol. 618, Warrendale, PA, 2000).

A.-L. Barabási, *Linked: The New Science of Networks* (Perseus, Cambridge, MA, 2002) [available in Check, Croatian, Chinese, Finnish, Hebrew, Hungarian, Italian, Japanese, Korean, Turkish].

M. Newman, D. Watts and A.-L. Barabási, *The Structure and Dynamics of Networks* (Princeton University Press, 2006).

(<http://barabasilab.com/personnel/who.php?who=Barabasi>).