Monday, May 19: Connecting the Nets: Network Evolution

Dynamics and Robustness in Complex Ecological Networks: How Does Nature Keep it Together and How Does it Fall Apart?

Integrative research on the structure and function of complex ecological networks is advancing with breakneck speed. As the structure of these networks become clearer, so do the implications of this structure for robustness of ecosystems to species loss and invasion. At the same time, the dynamics of these networks are also becoming increasingly well understood. This allows new analyses and visualizations of the effects of species loss and other perturbations on the dynamics of ecosystems. My presentation will describe many of these advances and their empirical support including spatial and temporal aspects of network structure as well as the network dynamics of species invasions and loss. It will conclude with a discussion of future research on these networks involving evolution, economics, structured populations, non-trophic interactions and spatially explicit network dynamics.

Neo Martinez *explores interdependence in complex systems, most specifically that of feeding relationships within ecosystems. His work on the network architecture and dynamics of these relationships has helped move ecology from a focus on species and their pair-wise interactions to a focus on large systems of species comprising complex ecological networks. This work also addresses network science in general and has developed new technologies for informatics and computational biology including widely used network visualization software. Major findings of his research include discoveries of a very simple and highly general "niche model" of the network structure of ecosystems and constraints on the nonlinear dynamics of these networks needed to enable the great biodiversity of ecosystems to persist. Current research includes studying evolution of species within networks, the structure of ancient food webs in paleoecosystems, and the ecology and economy of human-natural networks. Neo holds a B.S. in Biology from Cornell University, an M.S. in Limnology and Oceanography from the University of Wisconsin, and an interdisciplinary M.S. and Ph.D. in Energy and Resources from the University of California at Berkeley where he co-founded and currently directs the Pacific Ecoinformatics and Computational Ecology Lab.*

Complex Laws for Next-Generation Wars: From Iraq and Global Terrorism, to Street Gangs and Online Guilds*

We show that common dynamical patterns underlie the evolution of irregular warfare -- such as the ongoing conflicts in Iraq, Colombia and Afghanistan -- and global terrorism. Our work suggests that these conflicts are being carried out in a generic way, irrespective of the individual conflict's specific origin, geographic location, ideology, and religious issues. In each case, the insurgency resembles a similar soup of continually evolving attack units. Our findings suggest that the observed dynamics emerge as a consequence of how humans naturally 'do' asymmetric warfare. Having established the quantitative power of our model, we use it to predict the duration of wars, and test out the consequences of different intervention strategies. We then turn to look at the connection with transnational 'maras', street gangs, and online gangs which form around Internet role-playing games such as World of Warcraft.

*Done in collaboration with: Z. Zhao and J. Bohorquez, Physics Department, University of Miami, Florida; P.M. Hui and X. Chu, Physics Department, Chinese University of Hong Kong; G. Tita, Department of Criminology, University of California, Irvine; N. Ducheneaut, Computer Science, Palo Alto Research Center, California; M. Spagat, Royal Holloway College, London U.K.; S. Gourley, Oxford University; E.M. Restrepo, International Studies, University of Miami.

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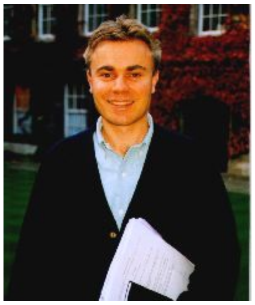


Neil Johnson *heads up a new interdisciplinary research group in Complexity at University of Miami (Physics Department) looking at collective behavior and emergent properties in a wide range of real- world Complex Systems. Until summer 2007, Neil was Professor of Physics at Oxford University (U.K.), having first joined the faculty in 1992. He did his BA at Cambridge University (U.K.) and PhD at Harvard University as a Kennedy Scholar. In addition to research articles, he has published two books: Financial Market Complexity (Oxford University Press, 2003) and 'Two's Company, Three is Complexity' (Oneworld Publishing, 2007). He is Series Editor for the book series 'Complex Systems and Interdisciplinary Science' by World Scientific Press, and is the Physics Section Editor for the journal 'Advances in Complex Systems'.*

Modularity: Mechanisms and Measurements
I will discuss models for producing modulary or community structure in social networks -- natural divisions of networks into densely connected subgroups. These models rest upon the notion that there exists a coevolution of opinions and network connections, with individuals wanting to be connected to those with similar opinions, while maintaining a certain degree of diversity. I will also discuss methods for finding layered community structure in networks. These methods go beyond current techniques which find only a single set of division of nodes into communities. In this case, we find multiple possible divisions which give us insights into the possible different kinds of communities in the network. For instance a network might be divided into a professional network and a social network. Our algorithm aims to detect this kind of structure with no information about the nodes or edges.

Michelle Girvan *is an assistant professor at the University of Maryland, joint between the department of physics and the Institute for Physical Sciences and Technology. Her research exists at the intersection of statistical physics, nonlinear dynamics, computer science, and the social sciences. She applies techniques from these areas toward the understanding of complex network problems. These involve systems for which the intricate tangle that connects interacting elements must explicitly be taken into account. Girvan's research addresses interdisciplinary, network-related problems by tackling broad theoretical issues, like the optimal deconstruction of complex networks and the detection of communities in overlapping networks, and then applying these insights toward the understanding of problems like social network construction, contagion processes, norm formation, and community fission. Girvan did her undergraduate work at MIT, majoring in math and physics. From there, she went on to Cornell where she got her Ph.D in theoretical physics. She then took a postdoctoral fellowship at the Santa Fe Institute. Following that, she joined the faculty at the University of Maryland.*

Monday, May 19: Outbreaks

The Dynamic Spread of Happiness in a Large Social Network
The study of happiness is receiving increasing attention in economics, psychology, neuroscience, and evolutionary biology, and a broad range of stimuli to human happiness and unhappiness have been explored, including lottery wins, income, job loss, socioeconomic inequality, divorce, commuting time, illness, bereavement, and genes. However, these studies have not addressed a key stimulus to human happiness: the happiness of others. Past work has shown that people imitate facial expressions, and that one person's mood might fleetingly determine the mood of others. However, whether happiness spreads broadly and more permanently across social networks is unknown. Here, we measure the happiness of 5,019 individuals over 18 years in the Framingham Heart Study Social Network (FHS-Net) to examine how network characteristics affect a person's happiness and how happiness spreads between friends, spouses, siblings, and neighbors. Clusters of happy and unhappy people are visible in the network, and the effect of one person's happiness appears to extend up to three degrees of separation (to one's friends' friends' friends). Moreover, network characteristics predict which individuals will be happy in the future, particularly those who are surrounded by many happy people and those who are highly central in their local networks. We also find that the spread of happiness decays with both physical distance and time. Finally, longitudinal statistical models suggest that happiness clusters result from the spread of happiness and not just a tendency for people to associate with those who exhibit similar emotional states.

James H. Fowler *is Associate Professor of Political Science at the University of California in San Diego. He earned a BA from Harvard in 1992, served in the US Peace Corps from 1992-1994, earned an MA from Yale in 1997, and a PhD from Harvard in 2003. He is best known for his scholarly research on social networks, particularly his study of the social spread of obesity in the Framingham Heart Study that was published in the New England Journal of Medicine. James is also known for his research on egalitarianism and the evolution of cooperation that has appeared in the journals Nature, Science, and Proceedings of the National Academy of Sciences. Most recently, James has published in Journal of Politics the first-ever link between specific genes and voter behavior, bringing to the attention of political scientists the need to incorporate biological theories into their study of political behavior. James is currently working on a book for a general audience about social networks in everyday life (Connected! -- with Nicholas Christakis) that will be published by Little Brown, probably in early 2010.*

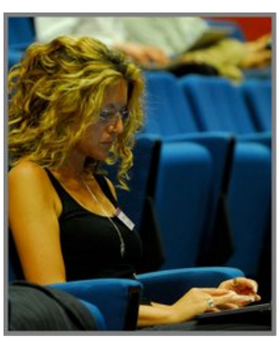
The Impact of Mobility Networks on the Worldwide Spread of Epidemics
Networks which trace the activities and interactions of individuals, transportation fluxes and population movements on local and global scale have been analyzed and found to exhibit large scale heterogeneity, self-organization and other properties typical of complex systems. Here we analyze the impact of the complexity of mobility networks on the global spreading of emerging infectious diseases. We define a computational model for the large scale spread of infectious diseases that integrates the air transportation network with demographic data. The model is used to study the specific case of the SARS epidemic and to provide scenario forecasts for pandemic influenza. The effect of the network complexity is then analyzed by exploiting the analogy of epidemic models with stochastic reaction-diffusion processes on heterogeneous networks.

Monday, May 19: Outbreaks

Alessandro Vespignani *is currently a professor of Informatics and Cognitive Science and adjunct professor of Physics and Statistics at Indiana University. He has obtained his Ph.D. at the University of Rome "La Sapienza." After holding research positions at Yale University and Leiden University, he has been a member of the condensed matter research group at the International Center for Theoretical Physics (UNESCO) in Trieste. Before joining Indiana University Vespignani has been a faculty of the Laboratoire de Physique Theorique at the University of Paris-Sud working for the French National Council for Scientific Research (CNRS) of which he is still member at large. Vespignani is also scientific supervisor of the Complex Network Lagrange Laboratory (CNLL) at the Institute for Scientific Interchange in Torino, Italy. Recently Vespignani's research activity focuses on the interdisciplinary application of statistical and numerical simulation methods in the analysis of epidemic and spreading phenomena and the study of biological, social and technological networks. Vespignani is author of the books Evolution and Structure of the Internet and Dynamical Processes on Complex Networks, both published by Cambridge University Press.*

Wireless Router Weaknesses: The Next Crimeware Epidemic

The use of WiFi routers is becoming close to mainstream in the US and Europe, with 8.4% and 7.9% of all such respective households having deployed such routers by 2006, and a WiFi market expected to grow quickly in the next few years as more new digital home devices are being shipped with WiFi technology. As the WiFi deployment becomes more and more pervasive, the larger is the risk that massive attacks exploiting the WiFi security weaknesses could affect large numbers of users. Indeed, many WiFi security threats have been downplayed based on the belief that the physical proximity needed for the potential attack to occur would represent an obstacle for attackers. The presence nowadays of large ad-hoc networks of routers make these vulnerabilities considerably more risky than previously believed. In this talk, I will consider the ability of malware to propagate from wireless router to wireless router over the wireless channel, infecting large urban areas where such routers are deployed relatively densely. Introducing an SIR epidemiological model, in analogy with biological epidemics, I will present simulations of the contagion process on real-world data for geo-referenced wireless routers. Worrisome scenarios and suggestions to minimize the threat will be presented and discussed.



Vittoria Colizza *is a Research Scientist at the Complex Networks Lagrange Laboratory at the Institute for Scientific Interchange (ISI Foundation) in Turin, Italy. Integrating methods of complex systems with statistical physics approaches, computational sciences, geographic information systems, and informatics tools, her main research activity focuses on the characterization and modeling of the spread of emerging infectious diseases. Current research explores cyber epidemics, the effect of travel on the worldwide propagation of human epidemics, forecasts for the next pandemic flu, innovative epidemic surveillance systems. Her work also addresses the analysis of networks' organization in relation to their function and performance, in the fields of transportation, scientific collaboration, biology, social systems. Vittoria obtained her PhD at the International School for Advanced Studies (SISSA) in Trieste, Italy, in 2004. After holding a research position at the Indiana University School of Informatics in Bloomington, IN, she spent a year as Visiting Assistant Professor at IU and joined the ISI Foundation in Turin. She was recently awarded a Starting Independent Career Grant by the European Research Council.*

Superstar Extinction *

We estimate the magnitude of spillovers generated by 137 academic “superstars” in the life sciences onto their coauthors’ research productivity. These researchers died while still being actively engaged in science, thus providing an exogenous source of variation in the structure of their collaborators’ coauthorship networks. Following the death of a superstar, we find that coauthors suffer a lasting 8 to 18% decline in their quality-adjusted publication output. These findings are surprisingly homogenous across a wide range of coauthor and coauthor/superstar dyad characteristics. Together, they suggest that part of the scientific field embodied in the “invisible college” of coauthors working in that area dies along with the star — that the extinction of a star represents a genuine and irreplaceable loss of human capital.

*Done in collaboration with J. G. Zivin, Columbia University and NBER; and J.Wang, MIT.

Professor Azoulay *joined the MIT Sloan School faculty in July 2006. In his research, he investigates how organizational design and social networks influence the productivity of R&D in the health care sector. Currently, he is studying the impact of superstar researchers on the research productivity of their colleagues in the academic life sciences. He is also interested in the topic of academic entrepreneurship, having recently concluded a major study of the antecedents and consequences of academic patenting. In the past, he has researched the outsourcing strategies of pharmaceutical firms, in particular the role played by contract research organizations (CROs) in the clinical trials process. He teaches courses on strategy and technology strategy. Professor Azoulay is also a faculty Research Fellow at the National Bureau of Economic Research. From 2001 and 2006, he was Assistant and then Associate Professor of Management at Columbia University's Graduate School of Business. A native of France, he received his doctoral degree from MIT in 2001.*

The Structure and Dynamics of Social Communication Networks

Social networks have attracted great interest in recent years, largely on the account of their relevance to information processing in organizations, distributed search, and diffusion of social influence. Networks evolve in time, driven by the shared activities and affiliations of their members; by similarity of individuals' attributes; and by the closure of short network cycles. I will discuss a study of a dynamic social network comprising students, faculty, and staff at a large university, in which interactions between individuals are inferred from time-stamped e-mail headers recorded over one academic year, and are matched with affiliations and attributes. The results show that in the absence of global perturbations, network-level properties appear stable, whereas individual properties fluctuate, and the network evolution is driven by a combination of effects arising from network topology itself and the organizational structure in which the network is embedded.

Gueorgi Kossinets *is a postdoctoral associate in the Department of Sociology at Cornell University. He received his PhD from Columbia in 2006 and prior to that studied physics and worked in IT in Russia. His research interests are centered on large-scale social networks: how networks evolve, and how they affect diffusion of information, decision making, and success of distributed collaborations.*