

# **Eisenbud Lecture Series in Mathematics and Physics**

## **November 29 & December 1, 2011**

**Speaker: Jennifer Chayes, Managing Director of Microsoft Research New England**

### **THE MATHEMATICS OF DYNAMIC RANDOM NETWORKS**

During the past decade, dynamic random networks have become increasingly important in communication and information technology. Vast, self-engineered networks, like the Internet, the World Wide Web, and online social networks, have facilitated the flow of information, and served as media for social and economic interaction. I will discuss both the mathematical challenges and opportunities that exist in describing these networks: How do we model these networks – taking into account both observed features and incentives? What processes occur on these networks, again motivated by strategic interactions and incentives, and how can we influence or control these processes? What algorithms can we construct on these networks to make them more valuable to the participants? In this talk, I will review the general classes of mathematical problems which arise on these networks, and present a few results which take into account mathematical, computer science and economic considerations. I will also present a general theory of limits of sequences of networks, and discuss what this theory may tell us about dynamically growing networks.

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**Lecture I: Tuesday, November 29, 2011**  
**(4:00pm, Abelson 131)**

***Reception will follow after this talk***

### **LECTURE 1: Models and Behavior of the Internet, the World Wide Web and Online Social Networks**

Although the Internet, the World Wide Web and online social networks have many distinct features, all have a self-organized structure, rather than the engineered architecture of previous networks, such as phone or transportation systems. As a consequence of this self-organization, these networks have a host of properties which differ from those encountered in engineered structures: a broad "power-law" distribution of connections (so-called "scale-invariance"), short paths between two given points (so-called "small world phenomena" like "six degrees of separation"), strong clustering (leading to so-called "communities and subcultures"), robustness to random errors, but vulnerability to malicious attack, etc. During this lecture, I will first review some of the distinguishing observed features of these networks, and then discuss some of the models which have been devised to explain these features. I will also discuss processes and algorithms on these networks, focusing on a few particular examples.

**Lecture II: Thursday December 1, 2011  
(4:30pm, Abelson 131)**

**LECTURE 2: Convergent Sequences of Networks**

In the second lecture of this series, I will abstract some of the lessons of the first lecture. Inspired by dynamically growing networks, I will ask how we can characterize general sequences of graphs in which the number of nodes grows without bound. In particular, I will define various natural notions of convergence for a sequence of graphs, and show that, in the case of dense graphs and even some sparse graphs, many of these notions are equivalent. I will also give a construction for a function representing the limit of a sequence of graphs. I'll review examples of some simple growing network models, and illustrate the corresponding limit functions. I will also discuss the relationship between these convergent sequences and some notions from mathematical statistical physics.

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