M375T/M396C (56825/57015)
Topics in Complex Networks, Spring 2013
Course syllabus (last revised: 01/30/2013)

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Lecture: RLM 7.112
Class website: http://www.ma.utexas.edu/users/rav/ComplexNetworks/

Prerequisites and degree relevance:
A grade of C or better in M362K and M340L/M341 (or equivalent courses), or consent of the instructor, is required. A strong working knowledge of probability and linear algebra (at the level of M346) will certainly be helpful, as is some mathematical maturity and the ability to write code.

Course description and content:
Network science is a rapidly developing field that is of significant interest in both theoretical and applied settings. The advent of large data sets derived from social, economic, and biological networks, along with modern computational power, has fueled much of this interest in recent years. The goal of this advanced undergraduate/introductory graduate course is to provide a mathematical foundation for analyzing the structure of complex networks. The subject material is quite interdisciplinary, sitting at the intersection of graph theory, probability theory, statistical physics, and computer science. In covering these topics we aim for a mix of rigor and intuition.

A preliminary outline of topics is given below. Some topics will be added in, while other will be taken away, in the coming weeks. Note that due to time constraints we will likely only be able to cover parts of III(a) or III(b). Furthermore, topics will be chosen in part to reflect student interest.

I. Introduction

* Review of topics in probability, linear algebra
* Examples of real-world networks and their properties

II. Empirical tools for studying networks

* Clustering, centrality, spectral properties of adjacency matrix, degree distributions, scale-free and power laws, degree correlations, community structure, diameter

III. Random graphs and network formation

* Erdos-Renyi random graphs, tree structure, giant component
* Fixed degree distributions, configuration model
* Small-world (Watts-Strogatz) model
* Exponential random graphs, Markov graphs
* Network growth, preferential attachment, Barabasi-Albert model, power-law networks

III(a). Computational and statistical tools

* Algorithms for computing degree distributions and clustering coefficients
* Extremal paths and breadth-first search, maximum flows and minimum cuts, spanning trees
* Graph partitioning, community detection
* Search on networks
* Inference of network structure

III(b). Dynamics on networks

* Random walks on graphs, diffusion
* Epidemics/contagion, mean-field models
* Learning and games on networks

Suggested references (many articles of interest are not yet listed):
(1) ``Networks: An Introduction'' by M. Newman
(2) ``Social and Economic Networks'' by M. Jackson
(3) ``Random Graph Dynamics,'' by R. Durrett
(4) ``Complex Graphs and Networks,'' by F. Chung and L. Lu
(5) ``A Course on the Web Graph,'' by A. Bonato

Notice:
The University of Texas provides appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-6441 TTY. If you plan on using accommodations, you need to notify your instructors early in the semester.

Important dates:
Thu., Jan. 17, 2013 -- Last day of official add/drop period
Wed., Jan. 30, 2013 -- Last day to drop a course for possible refund (can only Q-drop after this date)
Mon., Apr. 01, 2013 -- Last day to withdraw/drop a class with Dean's approval, change status to or from a pass/fail basis

Grading:
Grades will be determined from problem sets, scribing, and a course project (**Note: Weighting of each of these is subject to change as the course progresses.**). Course grades will be computed on a +/- basis according to a scheme at least as generous as this (rounded to the closest integer):

A : 92-100
A-: 90-91
B+: 88-89
B : 82-87
B-: 80-81
C+: 78-79
C : 72-77
C-: 70-71
D+: 68-69
D : 62-67
D-: 60-61
F : < 60

1. Problem sets: 50%
Problem sets will be posted weekly or bi-weekly on the class website. The purpose of these problem sets is to learn the material. You are encouraged to discuss the concepts behind these problems with others (including during office hours), but your submitted solutions should be your own. Only a select set of problems will be graded each week, and you will get a minimal amount of credit simply for handing in your completed solutions. Late submissions will not be accepted. If you happen to skip an assignment, make sure to complete the problems at some point in order to prepare for future assignments.
[Note: Those taking M396C will be given homework sets with more mathematically intensive problems, perhaps requiring some knowledge of graduate probability.]

2. Scribing: 20%
Every student is expected to scribe a lecture in LaTeX. Scribing will be done in groups of two. The goal is to produce a high-quality, complete record of the material covered in class. Students that scribe a Tuesday lecture are expected to e-mail a polished and complete draft by Friday of the same week. Students scribing a Thursday lecture should submit this by Monday. This leaves time for some iteration if required, with the goal of posting the scribed notes within a week of the class scribed. Scribing templates will be available on the class website. Please reference completely and fully as if writing a publication. Also, as with any paper, all the writing should be your own.

3. Course project: 30%
The course project involves the reading of a set of articles on a particular topic (to be approved by the instructor) and producing a high-quality article--written in LaTeX--that

summarizes this information. Topics must center on a mathematical issue concerning networks (social or otherwise), and suggestions will be made by the instructor. More will be said about this as the course progresses.
[Note: Those taking M396C will be required to write a detailed research proposal that presents previous work and a summary of work you would conduct: basic motivation, approach, methods, and some preliminary analysis, along with an outline of what steps would be taken to complete the analysis.]

Some tips:
- Ask questions: In lecture, office hours, and by e-mail. Don't be shy--if you have a question it's likely someone else does as well. Class participation makes lectures more interesting and fun for both you and me.
- Do the homework: No one can learn mathematics without working examples themselves. The most important driver of success in virtually every math course is doing practice exercises carefully and completely.
- Read the text: To get the most benefit from the lectures and problem sessions, you should read relevant sections of the text as they are covered in class. The supplementary texts listed can also be useful references at particular times in the course.
- Come to office hours: Office hours offer valuable opportunities to reinforce concepts, clarify confusing issues, work more examples, and get individualized feedback.
- Study together: You are encouraged to study together with your peers enrolled in the class. Get to know your classmates, and make arrangements to share notes in case you miss class due to illness.
- Learn to work problems without a calculator: You may use a calculator on homework problems but not during quizzes or exams. In any case, a calculator will not be useful for the vast majority of problems encountered during the semester.
- Be honest: Any academic dishonesty will be severely penalized.