

Syllabus - Fall 2017

Course CSCI-6250/4250 4cr: Frontier of Network Science

Monday - Thursday 12pm-1:40pm, MRC 334

Office Hours: Tuesday 14:00 – 15:00; Thursday 10:30 – 11:30am, MRC335A

Class Web-site

<http://www.cs.rpi.edu/~szymansk/fns.17/index.php>

Instructor

Prof. Boleslaw K. Szymanski, e-mail: szymansk@cs.rpi.edu, MRC335A

Textbooks

Albert Laszlo Barabasi *Network Science*,

Cambridge University Press, 2016

On-line version is available at <http://barabasi.com/networksciencebook/>

In addition, class notes will be used.

Course Description

This course offers the introduction to network science and review of current research in this area. Classes will interchangeably present chapters from the textbook and the related current research. The emphasis will be on mathematical background of network science: graphs and networks; random networks and various types of scale-free networks; network properties such as assortativity, mobility, robustness, social networks and communities; and dynamics of spreading in networks.

Prerequisites

CSCI-2300; a 4000 level algorithms-based CSCI (e.g. 4020, 4050, 4260, 4800), or MATH (4100, 4150, 4200, 4210, 4800) course; junior or senior level standing; some familiarity with probability, linear algebra, and calculus; or permission of the instructor.

Course Content

- Mathematical background of network science: graphs and networks.
- Random networks and their properties.
- Scale-free networks, small world networks and Barabasi-Albert model.
- Mobility and networks
- Network robustness
- Social networks and communities
- Assortativity of networks
- Spreading processes

Grading Criteria

One individual project (50%) for both graduate and undergraduate students, followed by one individual homework assignment for undergraduates (40%), and one 25 min presentation on network science topic of student's choice for graduates (40%) are due throughout the semester. The project will be handed out approximately after the end of the 4th week, while the assignment in the 9th week of the course. The project requires using network analysis tools (or programming) and analysis of the results obtained for the real and synthetic networks. The undergraduate students can replace the assignment with presentation. The remaining 10% of the grade will be assigned based on participation in discussions of project, assignment and presentations.

Graded projects/homework will be returned approximately one week after they are handed in; students will have these grades as their means to determine progress in the course by mid-semester and undergraduate student will be able to decide then to choose or not a presentation.

Student Learning Outcomes

Upon completion of this course, all students will be able to:

1. Apply fundamental network science ideas to create models and understand dynamics of networked systems;
2. Compare, contrast, and describe the similarities and differences of different kinds of networks and processes modeled on networks;
3. Critique the strengths and weaknesses of each of the models and types of networks base on them as applied to diverse network science applications;
4. Understand the principles of applying network science to disciplinary science and design and set up basic models for some specific applications.

Additionally, graduate students, will also be able to:

5. Read, analyze, and critique published literature in the field of network science and social network
6. Assess novelty of network science research projects and their relation to the state of the art

Course Assessment Measures

The student performance will be measured via four different methods: (i) project assignment for the entire class, (ii) homework assignments for undergraduate class, (iii) presentation that will include evaluation of slides and notes prepared for presentations, and (iii) contributions to in-class discussions.

The assignments will measure the ability to apply concepts of network science to network analysis.

The slides and notes prepared for presentation will measure student skills in preparing summary material on fundamental scientific concepts. The presentation will measure ability to communicate the concept and notions related to the research projects the student is involved in.

The discussion in class will measure the skills in evaluating and objectively assessing the results of others.

Academic Integrity

Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses they teach, and teachers must trust that the assignments that students turn in are their own. Acts, which violate this trust, undermine the educational process. The Rensselaer Handbook of Student Rights and Responsibilities defines various forms of Academic Dishonesty and all students should make themselves familiar with these.

In this class, all assignments that are turned in for a grade must represent the student's own work. Submission of any assignment that is in violation of this policy will result in a penalty of 0 points for assignment and failing of the course in case of repetition.

If you have any question concerning this policy, please ask for clarification before preparing or submitting an assignment.

The penalty for not adhering to these academic integrity rules is a failing grade for the assignment on the first offense, then failing the course and potential disciplinary actions by the Institute on any subsequent offenses.

Preliminary Schedule

The list indicates the basic topics and points which will be covered in classes, **brown** are lectures based on **textbook**, **blue** are research presentations.

Aug. 31: L01 **Introduction and Overview**

Research 16:00: Community structure in complex networks (*Prof. Fortunato*);

Sept. 07: L02 Introduction to Gephi and other tools for assignments (*Konstantin Kuzmin*);

Sept. 11: L03 Tools for assignment, advanced (*Konstantin Kuzmin*);

Sept. 14: L04 **Introduction to Network Science** (textbook, chapter 1)

Sept. 18: L05 **Research: Naming Game and Burstiness** (*Casey Doyle*); Matching in Networks (*Stephen Dipple*)

Sept. 21: L06 **Graph Theory** (textbook chapter 2)

Sept. 25: L07 **Random Networks** (textbook chapter 3)

Sept. 28: L08 **Small World Networks** (textbook chapter 3)

Oct. 02: L09 **Scale-free Networks** (textbook chapter 4) **Homework 1 out**

Oct. 05: L10 Q&A session for H1; **Barabasi-Albert Model-Part I** (textbook chapter 5);

Oct. 10: L11 **Research: Dominating Sets** (*Noemi Derzsy*); Social Net Co-evolution (*Ashwin Bahulkar*)

Oct. 12: L12 **Barabasi-Albert Model-Part II** (textbook chapter 5)

Oct. 16: L13 **Evolving Networks** (textbook chapter 6);

Oct. 19: L14 **Degree Correlation Part I** (textbook chapter 7)

Oct. 23: L15 **Degree Correlation Part II** (textbook chapter 7)

Oct. 26: L16 **Network Robustness** (textbook chapter 8)

Oct. 30: L17 **Network Robustness II** (textbook chapter 8); **Topic selection starts;**

Homework 1 due;

Nov. 02: L18 **Research: Crime Networks** (*Dr. Noemi Derzsy*); News Media Cascades (*X. Lu*);

Nov. 06: L19 **Homework 2 out; Homework 1 discussion; Community Structure;**

Nov. 09: L20 Limits of human mobility, *Jihui Nie*; Video as a Spatio-Temporal Network, *Spencer Whitehead*; Giant Component and Component Sizes, *Yeming Shen*

Nov. 13: L21 Epidemic modeling and Network Epidemic, *Connor Foody*; Estimating the Degree Exponent, *Jie Cheng*; A network framework of cultural history, *Max Llewellyn*

Nov. 16: L22 Quantifying Long-Term Scientific Impact, *Ian Gross*; Links between Companies and Venture Capital, *Zijiang Yang*; IoT Honeypots as Distributed Network Defenses, *Ed McCorry*

Nov. 20: L23 Greedy Algorithm for Community Detection, *Matthew Mohr*; A new type of neurons for machine learning, *Fenglei Fan*; Disease Network, *Connor Hadley*

Nov. 27: L24 Beyond the Degree Distribution, *Miao Qi*; Immunization, *Michael Yang*; News Reliability, *Sara Khedr*

Nov. 30: L25 **Research: Power Grids; WEF Global Risk Model** (*Alaa Mousawi*); Risk Evolution (*Xiang Niu*)

Dec. 04: L26 Network Analysis of Convertible Debt Systemic Risk, *Yueliang Lu*; Link Prediction on Hacker Networks, *Samantha Lee*; Analysis of Popularity Patterns of Games, *Justin Buerger*;

Hints for Homework 2 Solution

Dec. 07: L27 Agglomerative vs. Divisive Community Detection, *Jacob Fucci*; Partisan bubbles: Political bias of Reddit Users, *Diego Cepeda*; Measuring fitness of evolving networks, *Mauricio Gouva*

Homework2 due (noon)

Dec. 11: L28 Milgram Experiment, *Shruthi Chari*; Quantifying the evolution of individual scientific impact, *Tommy Fang*; Integrating Supply Chain and Network Analysis, *Yue Yin*;

Homework2 discussion