A Course on Network Science at UAlbany

S. S. Ravi

Department of Computer Science
College of Computing and Information
University at Albany – State University of NY
Albany, NY 12222

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Information About UAlbany

- **Official name:** University at Albany – State University of New York.
- Part of the State University of New York (SUNY) system.
  - SUNY system has 64 campus across New York State.
  - No. of full-time students: 465,000
- Four SUNY Centers:
  - Albany
  - Binghamton
  - Buffalo
  - Stony Brook

Information About UAlbany (continued)

- Established as a Teacher's College in 1844.
- No. of full-time students: 17,500 (12,000 undergraduate and 5,500 graduate students).
- No. of full-time faculty: 940
- **Focus:** Physical Science, Social Science, Humanities, Public Policy, Education and Criminal Justice.
- No Engineering school (except Nanoscale Sciences and Engineering).

Computer Science Department at UAlbany

- Established in 1965 by Professor Edwin Reilly.
- Was part of the College of Sciences and Mathematics until 1992 and College of Arts and Sciences until 2005.
- Became part of the College of Computing and Information (CCI) in 2005.
- Other departments in CCI:
  - Department of Information Studies.
  - Department of Informatics.

Computer Science Department at UAlbany (continued)

- Offers Bachelor's, Master's and Ph.D. degrees.
- 11 full-time faculty. (A new faculty member will join in January 2014.)
- About 275 majors.
- About 110 graduate students (80 M.S. students and 30 Ph.D. students).

Network Science Class – Spring 2012

- **Course Number:** ICSI 660
- **Duration:** Jan. 19, 2012 to May 8, 2012.
- **Level:** Graduate.
- **No. of students:** 11
  - Eight of 11 the students were graduate students in Computer Science.
  - The other three were from Informatics.
- **Prerequisite:** Background in Algorithms.
- **Focus:** Algorithmic aspects of network science.

Learning Objectives

- Understand definitions of structural properties and measures of networks.
- Learn algorithms for testing properties and computing measures.
- Understand the impact of structural properties/measures on the behavior of a network.
- Develop an appreciation for the usefulness of network science in other disciplines (e.g. Social Science).
- Understand basic game theoretic concepts and how they are used in modeling practical problems involving networks.

Required Text and Some Reference Material

Required text: D. Easley and J. Kleinberg, *Networks, Crowds and Markets: Reasoning About a Highly Connected World*, Cambridge University Press, New York, NY, 2010.

Some References:

- C. Aggarwal (Editor), *Social Network Data Analytics*, Springer, 2011.
- Lecture slides by Madhav Marathe, Anil Kumar and Chris Kuhlman for the course at Lawrence Livermore National Labs, 2011.
- D. Kempe, "Structure and Dynamics of Networked Information", Lecture Notes, Computer Science Department, University of Southern California, 2008.
- A number of survey papers on Network Science (e.g. Newman's survey in SIAM Review).

Software Tool Used

- CINET (Cyber Infrastructure for Network Science).
- Designed and developed by the NDSSL group at Virginia Bioinformatics Institute (VBI) at Virginia Tech.
- Supports computations of many graph parameters on fairly large networks.
- Provides many sample networks.
- Additional enhancements are being done by NDSSL.

List of Topics Covered

Note: Chapters mentioned below correspond to the text by Easley and Kleinberg [EK].

- Overview, basic topics in graph theory (definitions of various graph parameters, BFS, DFS, etc.).

  Ref: Chapters 1 and 2 of [EK].

- Network data sets, strong and weak ties.

  Ref: Chapters 2 and 3 of [EK].

- Networks in their surrounding contexts: concepts such as homophily and triadic closure and Schelling's segregation model.

  Ref: Chapter 4 of [EK].

List of Topics (continued)

- Positive and negative relationships: notion of structural balance, algorithms for testing balance conditions.

  Ref: Chapter 5 of [EK].

- Centrality measures for networks (e.g. degree centrality, closeness centrality, betweenness, eigen vector centrality and page rank) and algorithms for computing these measures.

  Ref:

  1. L. Freeman, "Centrality in Social Networks: A Conceptual Clarification", *Social Networks*, Vol. 1, 1978/1979, pp. 215–219.
  2. Chapter 14 of [EK].

List of Topics (continued)

- Models of Random Graphs (e.g. Erdös-Renyi random graphs, Chung-Lu random graphs, power-law graphs, Watts-Strogatz small-world graphs) and algorithms for generating such graphs.

  Ref: R. Albert and A. Barabasi, "Statistical Mechanics of Complex Networks", *Reviews of Modern Physics*, Vol. 74, Jan. 2002, pp. 47–97.

- Basic ideas of game theory and applications in modeling network traffic; relating cost of Nash Equilibrium to social optimum in network games.

  Ref: Chapters 6 and 8 of [EK].

List of Topics (continued)

- Structure of the web: student presentation.
  Ref: Chapter 13 of [EK].
- Diffusion in networks (brief coverage).
  Ref: Chapter 19 of [EK].

Work Assigned

- Paper and pencil assignments (3).
- Paper presentations (two per student; each presentation was 20 minutes long).
- CINET Assignments (2).
- Term project or paper (up to two students per project or term paper).

Some Projects and Term Papers

Projects:

- The collaboration network of researchers in CCI and its centrality measures. (This work was presented as a poster at a Workshop on Social Networks in Canada.)
- An experimental study of an approximation algorithm for closeness centrality.

Term Papers:

- A survey on centrality measures.
- Trust propagation models in social networks.
- Algorithms for finding community structure in networks.

Student Feedback About the Course

- Students were very happy with the text by Easley & Kleinberg.
- They liked the material on strong/weak ties, centrality measures, web structure and random graph models.
- Many students did not like the game theory component; it was hard for them to see the relevance of the concepts.
- Students had difficulty completing CINET assignments. (The system was under development at that time and the user interface needed improvement.)

Fall 2013 Version – Some Thoughts

- Introduce students to NetworkX.
- Cover more material on diffusion (Part VI of [EK]).
- Design additional paper and pencil xercises; many exercises in [EK] are too simple.
- Work closely with NDSSL folks so that CINET becomes a useful learning tool.
- Make the material on game theory more appealing.