TO: The Faculty of the College of Engineering

FROM: Elmore Family School of Electrical and Computer Engineering

RE: New Graduate Course, ECE 60270 Structure and Dynamics of Large-Scale Networks

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 60270 Structure and Dynamics of Large-Scale Networks
Sem. 2 Lecture 3, Cr. 3.
Restrictions: Undergraduate level probability and linear algebra

Description: Large-scale networks are prevalent in both engineered systems (e.g., the Internet, the power grid, industrial control networks, large robotic swarms and sensor networks) and in natural systems (e.g., genetic networks, ecological networks, social and economic networks). While the specific details of such networks will depend on the application, the last few decades have seen the emergence of an underlying "science" of networks, comprised of a common language (graph theory) for representing large-scale networks, along with mathematical models and analytical techniques for studying structure and dynamics. This course will provide a detailed introduction to the field of network science. It will develop common mathematical representations of networks, metrics for identifying important features of networks, generative mechanisms for networks (including both random-graph and strategic network formation perspectives), and tools for studying dynamical processes on networks (such as information cascades, opinion dynamics and interconnected dynamical systems). This is an introductory course that establishes several of the fundamental tools and concepts in network science, and requires only an undergraduate background in probability and linear algebra.

Reason: This course will introduce the fundamentals of the network science, focusing on the topologies of complex networks (random graph models, gametheoretic models, and dynamics on networks). There does not appear to be another course that covers these topics in a self-contained manner. The ECE course on Epidemic Processes Over Networks (offered by Prof. Paré) will cover specific classes of dynamics over networks (namely SIR, SIS, etc.), whereas my course will focus predominantly on how to mathematically model the topology of networks, and briefly cover linear dynamics and diffusion/adoption of discrete-valued quantities.

Milind Kulkarni,
Associate Head for Teaching and Learning
Elmore Family School of Electrical and Computer Engineering

Course History: Fall 2019 – 27, Spring 2022 - 14

ECE 695: Structure and Dynamics of Large-Scale Networks

Instructor Info

_ Name: Prof. Shreyas Sundaram
_ Email: sundara2@purdue.edu
_ Office: EE 322B
_ Office Hours: MW 2:30-3:30pm or by appointment.
Note: Please put \ECE695" at the front of your subject line if you are sending the instructor an email about the course.

Course Info

_ Course: ECE 695: Structure and Dynamics of Large-Scale Networks
_ Semester: Spring 2016
_ Lecture Times: MWF 1:30pm - 2:20pm
_ Location: Physics 110
_ Course webpage and announcements: Blackboard

Reference Textbooks

_ Networks: An Introduction, M. E. J. Newman, Oxford University Press, 2010
_ Social and Economic Networks, M. O. Jackson, Princeton University Press, 2008
_ Complex Graphs and Networks, F. Chung and L. Lu, American Mathematical Society, 2006
_ Graphical Evolution: An Introduction to the Theory of Random Graphs, E. M. Palmer, Wiley & Sons, 1985
_ Epidemics and Rumours in Complex Networks, M. Draief and L. Massoulie, The London Mathematical Society, 2010
_ Networks, Crowds and Markets, D. Easley and J. Kleinberg, Cambridge University Press, 2010
_ Decentralized Control of Complex Systems, D. D. Siljak, Dover, 1991
_ Large-Scale Dynamic Systems: Stability and Structure, D. D. Siljak, Dover, 1978

Prerequisites

_ An undergraduate course in probability and linear algebra is required. Knowledge of stochastic processes, graph theory and/or dynamical systems would be bene_cial, but not required.
_ Access to MATLAB.

Grading Policy

Homework:

_ Homework problems (approximately 5 sets) will be assigned on a periodic basis. All homework assignments and solutions will be posted on Blackboard.

_ You may work with other students to solve the homework problems, but each student must turn in their own homework solution. Students are expected to demonstrate professionalism in doing their assignments; thus, messy or illegible solutions may be penalized. Late homework assignments will not be accepted.

Exam: There will be one midterm exam in the course; this exam will occur towards the end of the semester
and will take place in-class. The date of the exam will be announced during the semester.

Project: The course will contain a _nal project by each student on a topic pertaining to network science. Students are expected to survey the state-of-the-art on their chosen topic, and either formulate new ideas
or describe novel applications of existing ideas to their own research. Students will be expected to present
their projects in class, and turn in a _nal report describing their _ndings.

Final Grade:

_ Midterm: 40%

_ Homework: 20%

_ Course project: 40%

Course Objectives

Large-scale networks are prevalent in both engineered systems (e.g., the Internet, the power grid, industrial control networks, large robotic swarms and sensor networks) and in natural systems (e.g., genetic networks, ecological networks, social and economic networks). While the specific details of such networks will depend on the application, the last few decades have seen the emergence of an underlying \science" of networks, comprised of a common language (graph theory) for representing large-scale networks, along with mathematical models and analytical techniques for studying structure and dynamics. This course will provide a detailed introduction to the field of network science. It will develop common mathematical representations of networks, metrics for identifying important features of networks, generative mechanisms for networks (including both random-graph and strategic network formation perspectives), and tools for studying dynamical processes on networks (such as information cascades, opinion dynamics and interconnected dynamical systems).

Course Outcome: A student who successfully fulfills the course requirements will have demonstrated:

1. The ability to characterize networks based on degree distributions, clustering coefficients, diameter etc.
2. The ability to identify influential nodes via centrality metrics
3. The ability to analyze random and strategic (game-theoretic) models for large-scale networks
4. The ability to analyze dynamical processes and stability of interconnected dynamical systems on Networks

Course Outline (tentative):

# of weeks	Topics
1	Introduction, examples of large-scale networks and networked systems
1	Mathematics of networks: matrix representations, graph theory, network classifications

1 Network metrics: node centralities, PageRank, degree distributions
3 Random graph models for large networks: Erdos-Renyi graphs, power-law graphs, small world graphs, phase transitions
2 Strategic/game-theoretic models for large networks: distance-based utilities, pairwise stability
3 Dynamical processes on networks: contagion and cascades, bootstrap percolation, viral marketing and epidemic processes, opinion dynamics
2 Networked dynamical systems: connective stability, vector Lyapunov functions, structural controllability and observability
2 Project presentations

General Policies

Academic Dishonesty

Purdue prohibits \dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, University Regulations] Furthermore, the University Senate has stipulated that \the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]
Please refer to Purdue's student guide for academic integrity:
http://www.purdue.edu/odos/aboutodos/academicintegrity.php
The ECE faculty expect every member of the Purdue community to practice honorable and ethical behavior
both inside and outside the classroom. Any actions that might unfairly improve a student's score on homework, quizzes, or examinations will be considered cheating and will not be tolerated. Examples of cheating include (but are not limited to):
_ Sharing results or other information during an examination
_ Bringing forbidden material or devices to an examination.
_ Working on an exam before or after the o_cial time allowed.
_ Requesting a regrade of answers or work that has been altered.
_ Submitting homework that is not your own work or engaging in forbidden homework collaborations.
At the instructor's discretion, cheating on an assignment or examination will result in a reduced score, a zero score, or a failing grade for the course. All occurrences of academic dishonesty will be reported to the
Assistant Dean of Students and copied to the ECE Associate Head for Education. If there is any question as to whether a given action might be construed as cheating, please see the instructor or the teaching assistant before you engage in any such action.

Grief Absence Policy for Students

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes
for missed assignments or assessments in the event of the death of a member of the student's family.

Violent Behavior Policy

Purdue University is committed to providing a safe and secure campus environment for members of the

university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.
Additional information can be found at:
http://www.purdue.edu/policies/pages/facilities_lands/i_2_3.shtml

Students with Disabilities

Purdue University will respond to the needs of students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services,
and activities at Purdue University.
If you have a disability that requires special academic accommodation, please make an appointment to speak with the instructor within the _rst two (2) weeks of the semester in order to discuss any adjustments.
It is the student's responsibility to notify the Disability Resource Center (http://www.purdue.edu/drc) of an impairment/condition that may require accommodations and/or classroom modifications.

Emergencies

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond
the instructor's control. Relevant changes to this course will be posted onto the course website (Blackboard) or can be obtained by contacting the instructors or TAs via email. You are expected to read your @purdue.edu email on a frequent basis.

Nondiscrimination

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among
its members; and encourages each individual to strive to reach her or his own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes
that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.
Purdue University prohibits discrimination against any member of the University community on the basis
of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University
will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes
they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

Emergency Preparedness Syllabus Attachment

Emergency Notification Procedures are based on a simple concept: if you hear a _re alarm inside,

proceed outside. If you hear a siren outside, proceed inside.
_ Indoor Fire Alarms mean to stop class or research and immediately evacuate the building.
{ Proceed to your Emergency Assembly Area away from building doors. Remain outside until police, _re, or other emergency response personnel provide additional guidance or tell you it is safe to leave.
_ All Hazards Outdoor Emergency Warning Sirens mean to immediately seek shelter (Shelter in Place) in a safe location within the closest building.
{ \Shelter in place" means seeking immediate shelter inside a building or University residence. This course of action may need to be taken during a tornado, a civil disturbance including a shooting or release of hazardous materials in the outside air. Once safely inside, _nd out more details about the emergency. Remain in place until police, _re, or other emergency response personnel provide additional guidance or tell you it is safe to leave.
In both cases, you should seek additional clarifying information by all means possible (Purdue Emergency
Status page, text message, email alert, TV, radio, etc.). Review the Purdue Emergency Warning Noti_cation System multi-communication layers at:
http://www.purdue.edu/ehps/emergency_preparedness/warning-system.html

Emergency Response Procedures

_ Review the Emergency Procedures Guidelines:
https://www.purdue.edu/emergency_preparedness/flipchart/index.html
_ Review the Building Emergency Plan (available on the Emergency Preparedness website or from the building deputy) for:
{ evacuation routes, exit points, and emergency assembly area
{ when and how to evacuate the building
{ shelter in place procedures and locations
{ additional building specific procedures and requirements.

Emergency Preparedness Awareness Videos

\Shots Fired on Campus: When Lightning Strikes," is a 20-minute active shooter awareness video that illustrates what to look for and how to prepare and react to this type of incident. See the link on the Emergency Preparedness website.

More Information

Reference the Emergency Preparedness web site for additional information:
https://www.purdue.edu/ehps/emergency_preparedness/