1. Project Summary

The primary objective of this project is the development of an interdisciplinary project-based course on network modeling for students from virtually all colleges of the university. The main subject of the proposed course will be the analysis of complex systems by using the recently developed network modeling techniques based on graph theory. Examples of complex systems which will be analyzed include but not limited to Internet, World Wide Web, social networks (online or acquaintance), epidemiology, computing systems, metabolic networks, gene-regulation networks, financial systems, etc.

Complex networks research is a new field emerged from interdisciplinary collaborations during the last decade among physicists, mathematicians, information/computer scientists, and scientists from other fields such as sociology, linguistics, business, etc. As shown in Fig. 1, the number of papers published in this field increased rapidly according to the preprint site arxiv.org, the data is from [1]. This course will demonstrate innovation in the university in that a technical course, flavored with the latest cutting-edge research and relevant for almost every student, will be taught. With its student project component and interdisciplinary content, the course has the potential to be offered as part of the Honors program.

Currently, some universities are offering courses on complex networks most of them being at graduate level but unfortunately the lack of a textbook especially at undergraduate level makes it difficult to teach. In these courses review articles [2, 3, 4, 5, 6, 7, 8], graduate-level technical books on networks [9, 10, 11, 12], collection of articles [13, 14], Scientific American-level popular books [15, 16] are being used. The PI will mix the popular science books’ content with some undergraduate-level theoretical framework to present the foundations of the complex networks. The students at the same time will work on their projects relevant to their majors in the network modeling framework.

Recently, the PI gave a talk attended by many students including RIT’s, on network modeling for complex systems at the University of Rochester. He is planning to give the same talk at RIT sometime before the end of the quarter to give a chance to interested students to see some of the content of the proposed course.
2. Targeted Learners or Population

The primary target audience will be primarily upper-division undergraduate students who are interested in discrete mathematical modeling and analysis of real-life systems which can be modeled as entities and the interactions between them, hence networks. Since the course will be designed in such a way that the students will first learn the basics of network science and then work on simple to complicated projects, interested lower-level undergrad and graduate students will benefit from it as well.

When we announced the “complex networks” course last quarter at the School of Mathematical Sciences (SMS) as a special topics course, we received 17 e-mails from students who showed strong interest ranging from College of Science (COS), College of Engineering (COE), and College of Computing and Information Sciences (CCIS). The distribution of the interested students over the programs are: 5 students from Applied Mathematics, 2 students from Computational Mathematics, 1 student from Biotechnology, 4 students from Computer Engineering, 2 students from Computer Science, 2 students from Information Technology and 1 student from Information Security and Forensics. The distribution of the students based on their years are: 1 freshman, 5 sophomore, 4 junior, 5 senior, and 2 graduate students. Although all the attention came from the students of COS, COE, and CCIS, we believe the students of College of Liberal Arts (CLA) and College of Business (COB) might also be interested in this course because of its diverse content.

3. The Number of Students Who Will Be Affected

The course will impact the student population especially in the programs of School of Mathematical Sciences, Computer Science, and Information Technology, making about 300 students. We expect to have interested students from other programs such as Biology, Physics, and other engineering departments as well. The total number of students who will be affected is about 500.
4. Project Rationale

Relevance to college and the department

The proposed “complex networks” course will complement the courses being offered already at SMS: Discrete Mathematics, Graph Theory, Mathematical Modeling, although the course will not have any prerequisite. The necessary technical background will be reviewed in the first part of the course. This course will have the potential to bridge the different disciplines of the COS: mathematics, statistics, physics and biology.

Relevance of the involved faculty

Before joining RIT’s School of Mathematical Sciences as an assistant professor in Fall 2008, PI was a Director’s Funded Postdoctoral Fellow in the Complex Systems Group at Los Alamos National Laboratory for three years. He received his Ph.D. in statistical physics from Rensselaer Polytechnic Institute, Troy, NY, in 2005. He has extensive research expertise in network modeling for complex systems and its applications in parallel computing, social networks, epidemiological modeling, and peer-to-peer networks. He has published more than 20 peer-reviewed papers in leading prestigious journals and conferences such as Science, Nature, IEEE Conferences, etc. He organized workshops and conferences on complex systems and served as reviewer for Physical Review, European Physics Letters, Chaos, Journal of Physics A, Physics Letters A, International Journal of Computer Mathematics, and Journal of Biological Dynamics. Currently, he is teaching Multivariable Calculus at the School of Mathematical Sciences.

5. Impact on Teaching and/or Learning and Student Success

The proposed course will have the same challenges every interdisciplinary course might have. First of all it is hard to find a focus for the course if students are from various programs. Second, as the response to our course advertisement shows that the students will be in different years from freshman to PhD level. One of the major objectives in the development of this course will be converting these challenges into opportunities.

In the foundations part of the course the instructor will present the theoretical background at an understandable level, i.e., simple yet sophisticated enough for both undergrads and graduate students. The level of the project part of the course will depend on the level and background of the students. The PI will collect many data-sets from various disciplines (social, natural, or technological systems) for students to choose from and will follow the progress of the projects by mid-quarter evaluations. Larger projects might also be selected by groups of students contingent upon the instructor’s approval. The students will also have the chance to present their findings in a friendly class environment.

As a tool for analysis and visualization of the networks, a free and easy to learn software package Pajek [17] will be used. The instructor will review the basic capabilities and operations of Pajek in the class. With Pajek one can do abstractions by recursive decomposition of a large network into smaller networks, visualize the large networks easily, and implement efficient (subquadratic) algorithms for analysis.
The course has also the potential to increase student retention with its vibrant and real-life applications to many areas. The instructor will assign fun-to-do homework and in-class activities to attract students’ attention such as a social network game (reaching somebody in the school with the least number of intermediaries by using the acquaintances), creating the facebook social map of RIT students, collaboration network of the faculty and students, mapping the spread of a computer virus, fad, or flu, etc.

7. Measurement of the Impact and Dissemination of the Findings

Student progress in the course and in individual or group projects will be constantly observed by the instructor. During the project presentations in the class the presenters will have the opportunity to invite their department’s faculty members and students so that the impact of the course will be measured properly. The PI will present his overall experience on the development/teaching of an undergrad level complex networks course in the International Conference and Workshop on Network Science 2010 (NetSci2010).

8. Project Timetable

- Summer 2009: Course development (data-set collection, preparing lecture notes on foundations) and advertisement.
- Fall or Winter 2009: The course will be offered as a special topics course for the first time.
- Winter or Spring 2010: Course evaluations will be collected and necessary alterations to the content will be made to convert it into a regular elective course.

References


