Dear friends of IEM,

It has been about one year since we began developing a new strategic plan. I am happy to report that the plan is now complete and available at iem.okstate.edu. We had sought your input on a previous version and will share the final version in a forthcoming bulletin.

The IEM strategic plan has very ambitious educational, research and outreach goals. The educational and research plans call for increasing the number of BS graduates to 60, the number of PhD graduates to 8, faculty size to 20 and annual research expenditures to $5 million per year by 2020. The outreach plan calls for doubling study abroad, co-op and internship opportunities for our students. Our over-arching goal is to make IEM an endowed and highly ranked school in the nation and the world.

We are beginning to make progress on many of these fronts. We recently recruited two young faculty, Dr. Arash Pourhabib from Texas A&M and Dr. Chaoyue Zhao from the University of Florida to two tenure-track positions. We also hired Dr. Jennifer Glenn as Lecturer. She will be teaching core and IEM courses. Our research expenditure continues to grow. The chart on page 9 shows that we have ramped up our annual research expenditures from $800,000 in 2008 to $2,100,000 last year. Two of our faculty received three new NSF awards this year. We recently welcomed 19 new IEM students to the freshman class. Today we have about 120 students in the undergraduate program, 80 students in the IEM Masters program, 166 students in the ETM Masters program, and 26 students in the PhD program. Our students and faculty continue to get University-wide and national awards.

Thanks to new leadership at multiple levels in the University, including the College of Engineering, Architecture and Technology, I believe we are poised to scale new heights.

On November 14th, a new Engineering Student Excellence Center on the lower floor of ATRC will be ready for business. This new space is designed for students to come together, collaborate, relax and enjoy. Engineering North is getting a facelift, one floor at a time. In 2016, the entire third floor and IEM will undergo a large-scale renovation. Plans are underway for the construction of a new undergraduate teaching laboratory. Our students are continuing to be educated in state-of-the-art-facilities by world-class faculty.

In the coming months, you will receive calls from your alma mater to get involved and help us reach our goals. We will soon initiate a mechanism to communicate with you on the happenings in IEM. Your input, feedback and advice are essential. So, please provide them when asked.

I invite you to join us in celebrating these accomplishments, helping us drive change, and taking pride as we begin to accomplish one goal after another.

Go pokes!

Sunderesh S. Heragu, Professor and Head
Donald and Cathey Humphreys Chair
NEW FACULTY SPOTLIGHT

Dr. Chaoyue Zhao

Dr. Chaoyue Zhao received her Ph.D. from the University of Florida in summer 2014 in Industrial and Systems Engineering. Before that, she obtained her B.S. degree in Information and Computing Sciences from the Fudan University, China in 2010. Her research interests include data-driven stochastic optimization and stochastic integer programming with applications in power system security and renewable energy management.

She has collaborated with Sandia and Argonne National Labs for her research and worked at Pacific Gas & Electric Company, one of the largest utilities in US. Her research has led to papers published on the flagship journal for power systems and a best student paper award in the CIS track of ISERC Conference 2012. She won the Graduate Student Council Outstanding Research Award in 2014 for her research accomplishments. In her spare time, she loves reading and traveling. “Traveling helps me meet the world, and read helps me meet myself.”

“Working with smart people here is a wonderful experience. Doing research here makes me feel passionate and sharing my knowledge with students makes me feel proud.”

NEW FACULTY SPOTLIGHT

Dr. Arash Pourhabib

Dr. Arash Pourhabib received his B.S. in Industrial Engineering from Sharif University of Technology in 2008 and his PhD from the department of Industrial and Systems Engineering at Texas A&M University in 2014. He is currently an Assistant Professor in the School of Industrial Engineering and Management at Oklahoma State University. His research interests are in the areas of system informatics and control, and statistical machine learning.

As a student at Texas A&M University, he worked as a Research Assistant in the Advanced Metrology Laboratory. He also served as an instructor for the course Total Quality Engineering. Dr. Pourhabib’s main hobby is practicing Judo, which he has been doing since he was 10 years old. He currently holds a second degree black belt from USA Judo. He was on Texas A&M Judo team and represented the university in many national tournaments. He has just joined the OSU Judo Club and hopes to compete for OSU Judo pretty soon!

IE&M Faculty and Staff

Dr. Balabhashkar Balasundaram
Associate Professor

Laura Brown
Senior Financial Assistant & Administrative Support Specialist

Dr. J. Cecil
Associate Professor

Dr. Terry Collins
Associate Professor

Dr. Camille DeYong
Associate Professor

Lauren Ferri
Administrative Support Assistant

Dr. Jennifer Glenn
Lecturer

Dr. Sunderesh Heragu
Professor & Department Head

Dr. Ricki G. Ingalls
Associate Professor

Dr. Manjunath Kamath
Professor & Graduate Program Director

Dr. William J. Kolarik
Professor

Dr. Tieming Liu
Associate Professor

Dr. John W. Nazemetz
Associate Professor

Dr. Arash Pourhabib
Assistant Professor

Dr. David Pratt
Associate Professor & Undergraduate Program Director

Dr. Chaoyue Zhao
Assistant Professor

Industrial Advisory Board

Warren Blackmon
Michelin North America

Jason Edward Britton
INTEGRIS Health

Kristin Case
Owner, CaseConsults

Subodh Chitre
Deloitte Consulting

Dan Crawford
Power Costs, Inc.

Matt Freeman
Burns & McDonnell

Jeff McKnight
SCIFIT Systems, Inc.

Andrea Nightingale
ConocoPhillips

Cara Noltensmeyer
Devon Energy

David Reed
Webco Industries

Katie Speakes
Lockheed Martin

Matt Turner
Enbridge
WHO’S WHO IN IE&M

SPOTLIGHT

Nicole Simmons  
UNDERGRADUATE STUDENT SPOTLIGHT

Nicole is a senior in the IEM program graduating in May. She already has a job lined up with Devon Energy in Oklahoma City after she leaves OSU. Over the summer, Nicole interned at Devon and got to know the company and the city and fell in love with all the opportunities in OKC. One particular opportunity Nicole loved was volunteering with Hounds of the Heartland, an adoption program for retired racing greyhounds. She also extends her extracurricular activities into the school year as a member of IIE and the Society of Women Engineers in addition to holding an officer position in Alpha Pi Mu, the industrial honors society. In her free time she enjoys rock climbing at the Colvin Center, volunteering at the Humane Society or flying her kite on the library lawn.

“If I believe in PINK” – Audrey Hepburn
“If it’s not pink, it’s simply not Nicole” – Nicole’s mom, Zella Simmons

Sahil Bhosale  
MASTERS STUDENT SPOTLIGHT

“Do not follow where the path may lead. Go instead where there is no path to trail.”

Education holds top priority to Sahil. He earned his undergraduate degree in Mechanical Engineering from Walchand College of Engineering in India. He was honored with the Best Student Award and he worked with the world’s leading boiler manufacturing company, Thermax Limited as a Regional Manager (Supply Chain) for many years where he was recognized as Best Employee of the Year. At OSU he is working with the Industrial Assessment Center and is a part of Alpha Pi Mu Honor Society and the Golden Key International Honor Society. He eventually hopes to take all of his expertise and knowledge back to India to improve precision in the supply chain decision-making processes. In his free time he enjoys mountaineering and nature photography, he currently serves as an officer for the International Students Organization as the Sports Coordinator.

Akkarapol Sangasoongsong  
DOCTORAL STUDENT SPOTLIGHT

Akkarapol is passionate about the power of data, and has always been fascinated by the concept of predictive modeling and data analytics. His passion has successfully led him to pursue a doctoral study in IEM at OSU. His dissertation research, advised by Dr. Bukkapatnam, involves the development of advanced time series and predictive modeling algorithms for nonlinear time series analysis. During his time at OSU, he has been selected as a recipient of numerous awards and scholarships, including Best Research Paper Awards from IIE and SAS, Outstanding Research and Teaching Assistant Awards from Alpha Pi Mu, and many student scholarships and fellowships from IIE, SAS, MHEFI and OSU. In addition, he was recognized for his contributions to IEM and OSU, and was selected as a recipient of IEM doctoral student award in 2013, and a finalist of OSU Phoenix Award in 2014.

Kate Speakes  
INDUSTRIAL ADVISORY BOARD MEMBER SPOTLIGHT

Kate Speakes arrived at her first Board meeting in October 2012 ready to reconnect with her alma mater. Little did she know, big changes on the Board during that meeting would result with her taking the helm for a 2-year term. Ready to test out her strategy, planning, and program execution skills in the Chair role, Kate has successfully implemented structure and executed a strategic plan that aligns the Board’s purpose to the College of Engineering and IEM Department goals. Speakes is currently a Program Manager on the F-35 International team at Lockheed Martin Aeronautics. Her skills and experience are focused on strategy and program execution, as well as optimizing the business processes through risk assessment and negotiations as required to provide her customers a fully capable and operational warfighter. Speakes credits her degree in Industrial Engineering and Management from OSU as the foundation for her success. Speakes also obtained an MBA from the University of Texas at Arlington.

“I have always been fascinated by the international marketplace. The geopolitics and cultural diversity coupled with the challenge of meeting expectations on time and within budget is what drives my work ethic. I really enjoy setting up the strategy, planning, and then implementing the appropriate processes to execute a project to success.”
Lauren Ferri  
STAFF SPOTLIGHT

Lauren is a new member of the IEM department and joined IEM in April 2014 as an Administrative Support Assistant. She moved from Westchester, New York in March where she owned a pet care business. She really misses the wonderful fall foliage, mountains, streams, beaches, and great restaurants, but mostly her family and friends. She graduated from Villanova University in 2010 with a Bachelor’s in Political Science. This is her first time putting out the newsletter and has been planning various IEM events, greeting and helping students, and is the assistant to the department head. Lauren enjoys hanging out with her dogs, Cooper, a Greyhound, and Nuts, a Yellow Lab-German Shepherd mix.

Laura Brown  
STAFF SPOTLIGHT

Laura Brown has been a member of the IEM family since June 2013. She started as Sr. Financial Assistant and just recently added Administrative Support Specialist to her IEM business card. Laura received her Criminal Justice & Technology degree from Cameron University, Lawton, OK. Her love for Stillwater and Oklahoma State University is where her heart has always called home. Laura is also a huge Cowboy fanatic! She tries to get to every football game to show her pride and spirit down to her face tattoos! Go Cowboys!

“As I step out into each new day, I strive to be open, willing and teachable. I am grateful to the faculty and staff at IEM for allowing me to grow and learn at the greatest place on earth, Oklahoma State University."

STUDY ABROAD

France 2014

Dr. Camille DeYong accompanied students on IEM’s summer study abroad trip to Montpellier, France. The program is eight weeks long and students study at the Polytech Montpellier while there. The group visited the Pont du Gard (upper left), Viaduc de Millau (lower left) and the Carcassonne (right) just to name a few places!

For more information on the IEM Study Abroad in France please visit de.ceat.okstate.edu.
WHAT’S GOING ON IN IEM

Farewell to Mindy & Cassidy

The beginning of the school year marked major changes in IEM. Over the summer we lost two of our wonderful staff members, Mindy Bumgarner and Cassidy Young. Mindy was the Senior Administrative Support Specialist for three years and handled numerous tasks for the office. Cassidy was the Senior Administrative Support Assistant and assistant to Dr. Kamath, the Graduate Program Director. Mindy moved to Tulsa to live with her family and Cassidy found a job closer to her home in Cushing, working with children and using her degree in sociology. We will miss them and their contributions to the department very much.

IEM Seminar Series

The IEM Seminar Series is a new installment in the department and is a weekly presentation made by academians and practitioners in industrial engineering. The series is sponsored by the student chapter of INFORMS. The series will run both semesters featuring speakers from OSU’s various departments and companies and also from other universities across the country. Anyone is welcome to attend the sessions which run from 3:30pm-5:00pm on Thursdays in Engineering North 316.

Incoming IEM Students

Morgan Stites
Omar Saud Abdulaziz Algannas
Ashley Fouts
Caleb Kliewer
William Barnes
Zechariah Shrum
Hamad Abdulrahman Alazwari
Summor Fields
Timothy Stolle
Morgan Slusher

Oscar Eduardo Veliz
Natalie York
Spencer Jones
Cody Witzkoske
Jessie Morgan
Joshua Mabin
Bosung Kim
Kelli Gauger
Christopher Lacy

Congratulations freshman! We look forward to getting to know all of you and helping you on your way to becoming industrial engineers!
IIE Student Chapter Wins Gold Award

The Institute of Industrial Engineers Student Chapter at OSU has completed the requirements to be recognized as a Gold Chapter for IIE. This is the highest recognition awarded by IIE and recognizes their achievements, progress and improvements in the last year. The OSU Chapter is one of 65 schools across the world receiving the award. The IIE Officers included President Kaitlin Krause, Vice President Ian Giese, Treasurer Morgan Reiner, Events Coordinator Ann Meister, Student Council Representative Carly Reaves, Secretary Claire Van Beek, Public Relations Managers Monik Shah and Kaitlin Kliewer. Dr. Baski Balasundaram served as the faculty advisor for the chapter. Congratulations to the 2013-2014 Officers for all of their hard work and accomplishments!

Letter from the Industrial Advisory Board

Dear OSU IEM Partners,

Greetings from the OSU IEM Industrial Advisory Board (IAB). The IAB serves the OSU IEM community through Student, Faculty, and Alumni outreach, and through providing industry feedback in the ABET Accreditation process. Our board members are organized into three committees to accomplish these objectives.

- The Accreditation Committee works in conjunction with the IEM Department Head to fulfill its role as an important stakeholder for the ABET Accreditation process.
- The Outreach Committee acts as a liaison to the IEM alumni network and associated industry in order to create and recommend a pipeline of candidates to maintain Board membership.
- The Faculty & Student Committee conveys general trends and opportunities within member’s respective industries to provide a better educational experience to the IEM students. The Spring and Fall Board meetings are held in Stillwater to meet with faculty, staff and students. Additionally, the board has monthly conference calls to coordinate efforts toward each committee’s objectives. The IAB is always seeking qualified candidates to fill board positions and to improve the industry breadth of the Board. If interested, please email Andrea Nightingale at Andrea.Nightingale@gmail.com or Dan Crawford at dcrawford@powercosts.com.

Sincerely,

OSU IEM Industrial Advisory Board

**See list of IAB Members on Page 2**

Congratulations Graduates

OSU held its spring commencement ceremony on May 9th and 10th. We would like to congratulate the following IEM students for their hard-work and dedication to finish their degree. These students received either: Bachelor of Science in Industrial Engineering and Management (BSIE), Master of Science (MS), Master of Science in Engineering Technology Management (MSETM), or Doctorate of Philosophy (PhD).

Ammara Ahman
Darnell Bortz
Cinnamon Gerdes
Emily Greer
Nicholas Halpern
Timothy Higgins
Deana Hubert
Andrea Lewis
Katey Luster
Rachel Morgan
Reason Pumphrey
Weikao Wu
Amit Awate
Julian Badillo
Sarang Baviskar
Antonio Calzadilla
Sampath Chintagari
Avilon Dias
Everado Diaz
Siddartha Divecha
Yogesh Doravari
Abhishek Doshi
Abhishek Iyer
Praveen Madhan
Miresah McClendon
Tessa Morgan
Srirama Mutnuri
Sergio Perez
Christopher Plume
Patricia Rodriguez
Dhinesh Selvaraj
Monik Shah
Carolina Sicre
Surender Singireddy
Vishal Tamraparni
Cindy Thuli
Rajesh Velu
Charles Williams
Jingzhi Xue
Swaroop Yellapantula
Praladada Rao
Yingjue Zhou

Congratulations Graduates!
HONORS AND AWARDS

AEE Hall of Fame

Oklahoma State University alumnus Eric Woodroof has been inducted into the Energy Managers Hall of Fame for his lifetime achievements in promoting energy management. Woodroof is the youngest individual with a doctorate to be inducted since the Association of Energy Engineers established the hall of fame 37 years ago. This is the highest form of recognition presented by the association, which is represented in over 90 countries with tens of thousands of members and professional engineers.

A life member of the OSU Alumni Association, Woodroof is known for his leadership in the energy industry in helping businesses save over $100 million in energy expenses by making them more cost-competitive and “green.” He is a recognized authority on energy management, carbon emissions, financing, performance contracting and selling projects.

Beyond his own business, Woodroof has shared best practices via books, articles and over 100 seminars on six continents. Since 1999, he has served on three professional certification boards and has been involved with training thousands, who are now collectively saving billions while reducing global pollution. During the past decade, he has personally helped over 250 college students get scholarships and exposure to employers. He served as president of the Association of Energy Engineers in 2011.

Woodroof earned a master’s degree in Environmental Sciences in 1995, and a doctorate in Industrial Engineering and Management in 1998 both from OSU. He currently lives in Somerset, Kentucky, with his wife Andrea and two children.

Faculty & Students Recognized at IIE Annual Conference in Montreal

Faculty and students from the OSU School of Industrial Engineering and Management participated in the 2014 Institute of Industrial Engineers Annual Conference on June 2nd in Montreal, Canada and garnered numerous awards.

Dr. David Pratt received the prestigious Innovations in Curriculum Award for his accomplishments in creating an extremely efficient course preparation system for OSU IEM graduate school students. The courses are designed to highlight major topics within IEM subjects, but not delve deeply. These single credit courses are taught online and allow a more diverse group of students to enter into the IEM graduate school.

Numerous Spring 2014 graduates, current students and faculty were recognized for their excellence. Erin Lee, a recent graduate placed first in in the South-Central Regional Student Paper Competition sponsored by John Deere for her senior design project which was mentored by Dr. Baski Balasundaram. Her project for Dr. John Nazemetz’s class, entitled “Process Improvement in Stillwater Medical Center’s Same Day Surgery Department” was one of nine final papers selected for the paper competition.

Emily Greer and Zachary Kelch, recent graduates, both received the James W. Barany Student Award of Excellence. Ian Giese, IEM senior received the Process Industries Division's Best Student Paper Award for his summer internship paper entitled “Michelin Recyclable Material Planning Tool.” Giese, mentored by Dr. Baski Balasundaram. IEM Graduate student Diana Rodriguez received the John L. Imhoff scholarship, her advisors are Dr. Kamath and Dr. Ingalls.
President’s Leadership & Service Recognition

Two undergraduate Industrial Engineering and Management students were honored at the President’s Leadership and Service Recognition Reception in April. Cinnamon Gerdes received special recognition as a CORD Recipient. CORD, Creating Opportunities for Responsible Development, recognizes individuals showing an exemplary commitment to community service by serving 400 hours of service in their time at OSU. Kaitlin Krause received special recognition as a Service Learning Ambassador Executive and also was honored with the Outstanding Student Leader Award for the 2013-2014 academic year. SLVC Ambassadors serve as representatives of the university and actively promote volunteerism through many channels and communities. The Outstanding Student Leader Award is given to students showing great initiative in community service and high academic honors.

Scholarships Awarded to IEM Students

Five IEM students were awarded scholarships for the 2014-2015 school year. Diana Rodriguez, Esmaeel Moradi, Sam Cannon, Daniel Anderson and Connor Mojo were all recipients of awards from various national industrial engineering organizations. Rodriguez, a graduate student from Colombia, received the John L. Imhoff Scholarship from the Institute of Industrial Engineers. Moradi, who is also a graduate student from Tehran, Iran, received the Lift Manufacturers Product Section Honor Scholarship from the Material Handling Industry of America’s Education Foundation. Both Cannon and Anderson are undergraduate students, who received the Howard Bernstein Industrial Distribution Scholarship sponsored by TVH Americas from the Material Handling Education Foundation. Mojo, also an undergraduate, was recognized by the Material Handling Education Foundation as well for distinction in material handling and logistics.

EVENTS

2014 Annual IIE Picnic

Fall marked the beginning of the school year as well as the Annual IIE Welcome Back Picnic. The picnic was held on Gundersen Lawn in August and was sponsored by the Institute of Industrial Engineers. The end of August also marked the time of the ALS Ice Bucket Challenges of which two IEM professors were nominated for, Dr. DeYong and Dr. Heragu. Both professors elected to perform the challenge at the event. It was a great start to the year!

For a complete video of the ALS Ice Bucket Challenge with Dr. Heragu & Dr. DeYong, check out our Facebook page at Oklahoma State IE&M!!
Mission

The School of Industrial Engineering and Mangement at Oklahoma State University’s mission is to develop professionals and leaders in industrial engineering and management by being a leader in education, research, and outreach.

Vision

Our vision is to place more industrial engineers in a wide variety of industries including manufacturing, service, energy, healthcare, humanitarian, and others, so that our society at large can benefit from systems that efficiently produce goods or provide services effectively, use an optimal set of resources - physical or virtual, natural or man-made and enrich the quality of life for all.

Educational Goals

Educate and produce a new generation of IEM students proficient in theoretical, applied and technology relevant concepts and practices which will have a global reach and global impact while continuing to improve, monitor and enhance the student learning, recruiting, retention, advising, mentoring, internship and placement process.

Research Goals

Engage in cutting edge research of global importance to produce innovators and next generation engineering, education and societal leaders.

Community Goal

Actively engage in community projects, economic development and service for the greater good. Enhance IEM’s image internally within CEAT and OSU, and externally – the world at large.
INFORMS (Institute For Operations Research and Management Sciences) is one of the most prestigious professional organizations in the world which brings together professors, students, industrial practitioners and researchers in the fields of Operations research, analytics and many more specializations. It is a common platform in which people share the opportunities of research and career with the fellow members. The student chapter representing INFORMS was formed in OSU with nine students from Industrial Engineering and Management departments as the chapter’s officers. We, the members of INFORMS student chapter have been conducting numerous activities each year in order to benefit the students. Our activities include brown bag seminars, software workshops for students, field trips and interaction sessions with Industrial people. INFORMS recognizes the efforts of this student chapter every year by presenting their prestigious awards including Cum Laude and Magna Cum Laude awards. INFORMS- OSU has attained national recognition with its continuing efforts towards students development. We seek new applicants for officer position at INFORMS by sending application form at the beginning of each semester. Interested students are more than welcome to apply and be a part of this wonderful student chapter.

Alpha Pi Mu
Industrial Engineering Honor Society

The purpose of Alpha Pi Mu is to bring distinction to those who have achieved academic excellence, to promote scholarly activities, and to foster an atmosphere for social interaction between students and faculty. Being a part of Alpha Pi Mu gives an individual scholarship and volunteer opportunities. This semester, Alpha Pi Mu is planning a tailgate and a food drive. The society is open to juniors, seniors, and graduate students who meet the membership requirements. For more information about Alpha Pi Mu you can contact Morgan Reiner at morgan.reiner@okstate.edu or Nicole Simmons at nicole.simmons@okstate.edu.

IIE is the student organization dedicated to professional development through education and networking opportunities. OSU’s student chapter hosts social activities such as a picnic every semester, information sessions for companies seeking students for internships and full time jobs, and continuing education including Six Sigma Green Belt Certification through IIE Headquarters. The organization also takes field trips to companies to learn what Industrial Engineers will do in each respective field, and attends regional and national conferences for competitions and to network with professionals. Membership is through the national organization and comes with a subscription to IE Magazine which highlights current trends in Industrial Engineering. Please be sure to like us on Facebook (IIE Oklahoma State) for more information, or contact us directly at iie.okstate@gmail.com
RESEARCH GRANTS


**NSF Grant Awarded to Dr. Baski**


The objective of this collaborative research award is to establish a comprehensive knowledge-base for detecting low-diameter clusters in network models of social and biological big-data that are subject to measurement errors and incomplete information. This research study focuses on a novel model for detecting clusters in social and biological networks called a “k-club.” Some key innovations pursued as part of this study include the use of a risk measure from financial engineering that is used to quantify losses in cluster cohesiveness that results from the measurement errors and uncertainty that underlies such network models of big data. This measure represents the downside risk of high losses in the worst-case scenarios leading to risk-averse mathematical models that facilitate the detection of clusters that are more likely to be application significant. If successful, this work can enable biologists to better understand complex biological networks, accelerate discoveries and reduce experimental costs. The research has the potential to spur fundamental discoveries that can lead to advancements in biomedicine, agriculture and bioenergy with positive societal impacts.

**Dr. Cecil Obtains Two NSF Grants as Principal Investigator**

Research Experiences in Information Centric Engineering, July 2014-June 2017, $338,288

The overall goal of this Research Experiences for Undergraduates (REU) Site project is to introduce undergraduate engineering and computer science students to research activities in Information Centric Engineering and Digital Manufacturing. Information Technology (IT) continues to revolutionize engineering practices worldwide. One of the unique objectives of this project is to encourage students with physical challenges to be exposed to ICE research areas and kindle their interest in IT oriented engineering careers. Other emphasis is on exposing minority undergraduate students (African American, Hispanic, Native American and Women) to ICE research activities.


This grant focuses on creating a cyber physical framework for advanced manufacturing (using the Next Internet). This Next Internet based framework will enable globally distributed software and manufacturing resources to be accessed using gigabit networks and lay the foundation for next generation digital manufacturing approaches. The primary objective of this research effort is to develop a cyber framework to support the rapid assembly of micro/meso scale devices using gigabit networks and distributed physical resources. A part of this grant involves integrating cyber physical resources in the US with other resources in the European Union and other countries. Funding for this grant is from the CNS program (CISE) at NSF.

Detecting “clusters” in data-sets is a fundamental problem in data mining with a variety of approaches based on statistics, machine learning, and mathematical optimization available in the research literature. Cluster detection, depending on the nature and source of the data, yields different insights into a massive data-set. If the data is non-numerical and unstructured, then modeling it as a graph (aka network) can provide a perspective not offered by other techniques. This article discusses general concepts and issues in this regard, that motivate the use of combinatorial optimization techniques to detect patterns and structures in graph models of massive, complex data-sets.

Graph Models
A simple graph is described by its nodes and its edges, where the nodes represent a finite set of entities and the edges represent pairwise relationships between nodes. Figure 1 illustrates the famous (in some circles!) Petersen graph. The blob in Figure 2 is the illustration of a real-life biological network, the protein interaction map of Helicobacter pylori—a gastric pathogen. Clearly, this is not a “toy” graph! Here, the nodes represent proteins in an organism, and an edge indicates that the corresponding pair of proteins are known to interact, a relationship that is usually discovered via biological experiments.

The Big-Data Challenge
A deeper understanding of complex biological networks which control cellular functions is critical to identify and manipulate the mechanisms of diseases such as neurodegenerative disorders, cancers, and diabetes, which occur when cellular processes are dysregulated [1]. For instance, cluster detection in protein interaction networks is used to discover protein complexes and functional modules which are macro-molecular machines that carry out critical cellular functions. A biologist studying such networks to discover new protein complexes faces a massive big-data challenge. Firstly, the scale of the interactome, the complete set of proteins and their molecular interactions, is huge, with several thousands of proteins even in the simplest organism. Secondly, the interaction information is collected using multiple, heterogenous sources, and subject to significant levels of erroneous and missing information. For instance, the recently discovered PIN of the “model” plant Arabidopsis has 27,000 known proteins, the largest-ever known for a plant [2]. However, only 6,205 pairwise interactions are presently known among approximately 10% of the proteins. Suspected interactions and protein complexes are confirmed by costly higher confidence laboratory experiments, while noisy lower confidence assays are also available.

Cluster Models
Apart from the massive scale of many biological networks, the types of cluster models employed also influ-
ences both the biological potential of the detected clusters, and the computational (in)tractability of finding such clusters. While the scale of the graph in Figure 2 is visually over-whelming, with roughly 1500 nodes, this is a medium sized graph. From a computational perspective, detecting the largest connected component is much easier (in general) than detecting a largest clique. However, from a practical modeling perspective, both are unsatisfactory as cluster models as demonstrated by the H. pylori example. This graph has a connected component with approx. 700 nodes, which is too big to analyze any further. Even more surprisingly, the largest clique in this graph has 3 nodes! So our choice of a mathematical/graph-theoretic definition of a cluster must take into consideration the application of interest and the computational demand. It is important to recognize that such complex networks are far from perfect—these are subject to both incomplete and erroneous measurements that translate to missing and false edges in the graph model. So a cluster model like a clique, while ideal as a concept, is not practical.

Clique Relaxations

The modeling challenge in defining a cluster formally can be addressed by using a hierarchy of models called “clique relaxations” that systematically relax the definition of a clique based on pairwise distances, degree, edge density, vertex connectivity etc. Each family of parameterized models allows for missing edges while still guaranteeing meaningful structural cohesiveness properties in the cluster. For instance, rather than find a clique in the H. pylori network, we could find a “3-club”, a group of proteins with pairwise distances at most three. Figure 3 is such a cluster detected in H. pylori, and it is a structure that is interesting for the following reason. We have identified a group of approximately 100 proteins containing a two node kernel with which the other proteins interact. This is very encouraging since structures where interactions of proteins occur through a central protein kernel are likely to be found in similar biological processes [3].

Combinatorial Optimization & Complex Networks

While we limited our attention to protein interaction networks in this discussion, numerous other graph models are used in practice: acquaintance graphs in social network analysis, wire-transfer graphs used to investigate money laundering, call graphs used to investigate criminal networks, stock market graphs used in computational finance, document graphs used in text-mining, web graphs used in internet search and retrieval, intersection graphs used in wireless telecommunication, Hamming graphs are used to identify error-correcting codes, and other types of biological networks like gene co-expression and metabolic networks. Furthermore, cluster detection is not the only type of problem that is of interest in this setting. All-maximal-cluster enumeration, coloring, covering/partitioning, generalized domination and critical node detection are some of the other problems of interest. The opportunities for research in combinatorial optimization theory and methodology related to clique relaxations are vast. Deploying scalable algorithms for use by practitioners is another important avenue for advancement and impact. While the classical optimization problems over a graph are very challenging, the graphs themselves model a high-level snapshot of a complex dynamic system. Defining and detecting “graph signatures” that help signal/predict anomalies or other critical events in the time evolution of graphs is an open area. Research establishing the mathematical foundations and combinatorial optimization approaches associated with the evolution and dynamics of complex networks is also of immense interest. Readers interested in a more technical discussion on clique relaxations are encouraged to consult the references listed at the end [4, 5].


5. Balasundaram, Balabhaskar, and Foad Mahdavi Pajouh. "Graph theoretic clique relaxations and applications." In Handbook of Combinatorial Optimization,


J. Cecil, M. Pirela-Cruz, Virtual Environment for Micro Surgery, accepted for publication, *International Journal of Virtual Reality*.


The School of Industrial Engineering and Management at Oklahoma State University seeks talented and motivated candidates for two tenure-track positions, starting in Fall 2015. Appointment level and salary will be commensurate with qualifications and accomplishments. The candidates are expected to complement and enhance the School’s current research and education performance. Candidates must have a Ph.D. in industrial engineering or a related discipline. Performance expectations include leadership and creativity in undergraduate and graduate education, funded research, scholarship, and professional service. The School has an ambitious plan for growth, recognition and visibility in the industrial engineering and management field. We seek candidates with curricular interests and experience as well as a strong methodological background and potential to attract funded research in:

- Healthcare systems engineering
- Quality, statistics and reliability.

Candidates with interests in manufacturing systems and processes, production planning and control, logistics and supply chain management, ergonomics and human factors, energy and engineering management, service systems, optimization, stochastic modeling, or simulation will also be considered.

Interested applicants should apply online at https://jobs.okstate.edu. Applicants should submit a curriculum vitae, a list of three to five references, a cover letter and a statement of capabilities, qualifications, and interest. Any inquiries may be sent to Sunderesh Heragu, Professor and Head, School of Industrial Engineering and Management, Oklahoma State University, Stillwater, OK 74078 (sunderesh.heragu@okstate.edu). More information about the School can be found at iem.okstate.edu.

OSU is an Affirmative Action/Equal Employment Opportunity/E-verify Employer committed to diversity.
Industrial Engineering and Management at OSU was ranked in the top 10 “Best Buys” for engineering professionals pursuing higher education master’s degrees online, based on a national survey by GetEducated.com.

WHAT’S NEW IN IE&M

IEM will be getting a new sign for the office! Your feedback is greatly appreciated, so let us know what you think by emailing sunderesh.heragu@okstate.edu