K-State EPICENTER:
Modeling the future of epidemic research

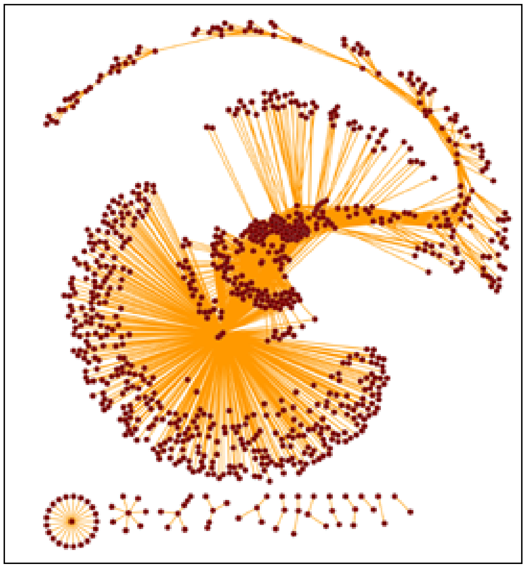
Kansas State University's EPICENTER—Center for Complex Network Approach to Epidemiological, Biological, and Sociological Modeling and Simulation is directed by Dr. Caterina Scoglio, assoc. professor of electrical and computer engineering, and Dr. Morgan Scott, professor of epidemiology. EPICENTER provides those in multidisciplinary research with resources to build, simulate, and analyze mathematical models to determine the spread of phenomena in complex networks.

A main goal of EPICENTER is to provide policy makers with real-time, flexible modeling tools to curtail epidemiological outbreaks, whether such an outbreak occurs in humans, animals, plants, or computers. Given the heightened attention to protecting the U.S. from threats, such modeling may well be essential to mitigating the sociological and economic effects of a potentially out-of-control epidemic, effects such as human death, herd disposal, crop destruction, or the inability to communicate over the Internet. Whether the threat is famine, war, terrorism, or epidemic disease, the goal of EPICENTER researchers is to design efficient, realistic simulations for real-time implementation using models, algorithms, and software for network simulation and topology analysis.

The lynch pin of EPICENTER is its multidisciplinary approach to complex networks; for example, faculty hail from agriculture, veterinary science, biology, medicine, social sciences, and engineering. Additionally, EPICENTER research is enhanced by the contributions of dedicated student researchers. Highlights of several key projects that together demonstrate the versatility of this approach follow.

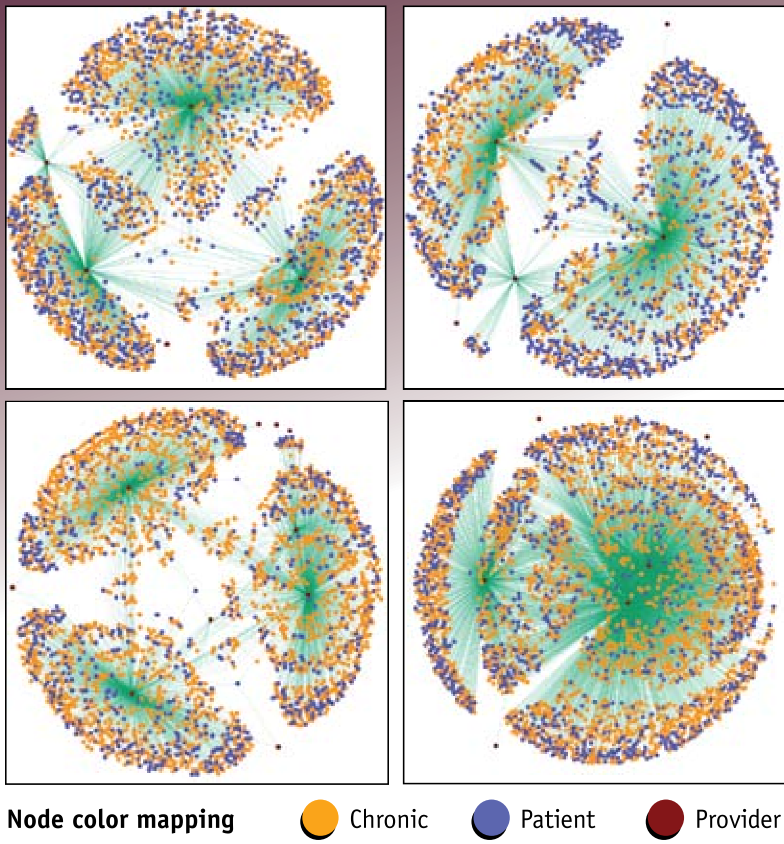
Complex network approach to epidemic spreading in rural regions

This research develops optimized guidelines for administrators to establish procedures and allocate resources to help mitigate the effects of the spread of infectious diseases in rural regions whether by malicious attack or natural causes. Dedicated projects assess the particular contact network of rural regions and develop a simulation tool with multiple compartments running on the contact network. For example, Dr. Scoglio, Dr. Todd Easton, assoc. professor of Industrial and manufacturing systems engineering, and Dr. Walter Schumm, professor of family studies and human services, are researching strategies that will work specifically in rural areas to deal with disease outbreaks.



"We found that person-to-person contact is most important," Easton said. "Having a population with two times as many interpersonal contacts is more dangerous than a disease that is twice as virulent. This shows that the government's ability to limit travel during an epidemic is very important."

Scoglio also points out that research confirms it would be equally important to vaccinate people who don't have many contacts themselves but who are a common link between two people with many connections.



Quality of Care and Network Properties of Outpatient Health Care Delivery

As healthcare systems become more complex, there has been little or no work describing the topology of the complex network of patient care within these systems. In collaboration with Dr. Michael Parchman, professor, with the Veterans Health Administration (VA), the largest integrated health care delivery system in the U.S., this study intends to explore the topology of networks of patient-provider relationships derived from VA records. The purpose of this study is to examine the feasibility of using the network topology to determine the quality of care provided to patients in the network.

The networks we are examining are bipartite graphs with nodes being either patients or providers. The graphs at left are taken from four VA Hospital clinics over the course of a single year. each with different providers and patients. A connection exists between a patient and a provider if a patient has had an appointment with that provider at any point during the four years. Because a patient often sees the same provider multiple times, the edges in the graphs are weighted by the number of recurring appointments between the patient and the provider. Patients are marked “Chronic” if they have been diagnosed with diabetes or hypertension.

Network models for soybean rust epidemics: adapting to aerially-dispersed pathogens

“Collaboration with Professor Caterina Scoglio as part of EPICENTER has helped our group move forward in implementing novel modeling approaches that advance plant disease epidemiology,” said Dr. Karen Garrett, assoc. professor of plant pathology. Modeling large-scale plant disease epidemics calls for network model adaptation; for example, information about soybean rust is available typically from sentinel plots that function to represent a larger area such as a county. Also, since many plant pathogens are capable of long-distance aerial dispersal, distant nodes may be connected with a small but non-zero probability. Currently, research focus is on developing network models to forecast soybean rust in the U.S. using sentinel plot data for model construction and validation.

Predicting rabies exposure risk with spatially explicit, dynamic contact networks

In exploring the ecology of disease, research efforts of those like Dr. Samantha Wisely, asst. professor of biology, concentrate on testing hypotheses of how ecological patterns of urbanization shape the epizootiological processes of rabies for predicting health risk and determining the effect of disease-intervention methods. Specifically, Dr. Wisely said she and her colleagues “…use an integrated approach combining epidemiology and host ecology. Collaborating with EPICENTER has allowed us to model how these aspects of disease emergence work synergistically to create epizootics on the landscape.” EPICENTER’S contribution to this collaboration is dynamic contact network modeling.

Conclusion

While each discipline has its own research objectives and perspective, their collective endeavors unite in pursuit of the study of epidemics, a major research feature of the forthcoming National Biological and Agricultural Facility (NBAF) at Kansas State. EPICENTER’S adaptive mathematical modeling tools enable these various disciplines and researchers to expedite their projects and professional goals. For a complete list of all the research participants and projects, consult the EPICENTER wiki at www.eece.ksu.edu/epicenter_wiki.