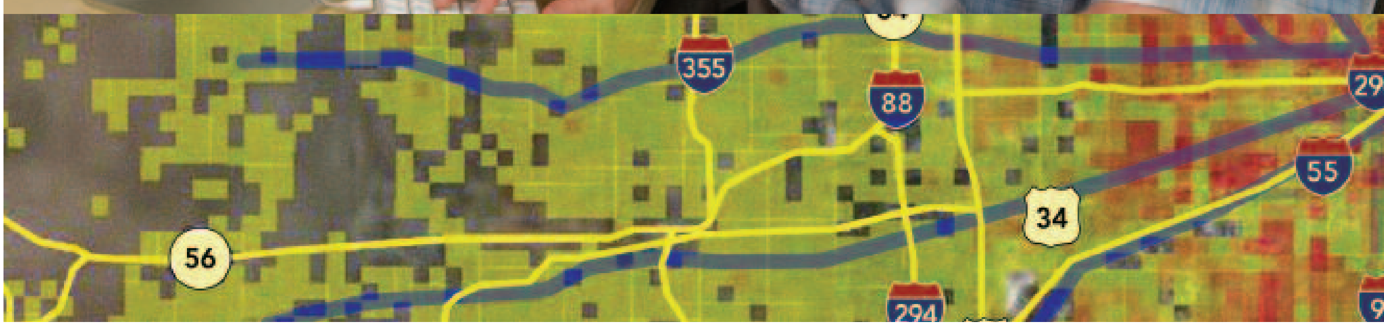
# Social Studies




BOTTOM: STEPHEN EUBANK TOP: JOHN McCORMICK

**BY EMILY CARLSON**

Katie Holmes and Kevin Bacon? According to the popular trivia game, “Six Degrees of Kevin Bacon,” Holmes is tightly linked to the *Footloose* and *Beauty Shop* star. The game asks participants to connect Bacon to any other actor, resulting in a “degree of Bacon” score.

Holmes’ number is two: She starred in *Batman Begins* with Sarah Wateridge, who was in a movie with Bacon.

College students at the University of Virginia in Charlottesville developed a Web site, http://oracleofbacon.org/, to compute the Bacon degree of just about any Hollywood personality. Tom Cruise, for instance, is one degree. The average number is 2.96.

While the game and its results may seem like idle fun, they demonstrate an inherent feature not just of Tinseltown, but of communities in general: We are linked to each other through intricate social networks.

## More Than Friends

Stephen Eubank, a physicist at Virginia Tech University in Blacksburg, studies these complex networks. Right now, he's using the networks to understand how diseases, like a deadly flu, could spread through communities.

"Most people think of their social networks as their friends," says Eubank. "But our networks include all the people who help us accomplish what we need to do."

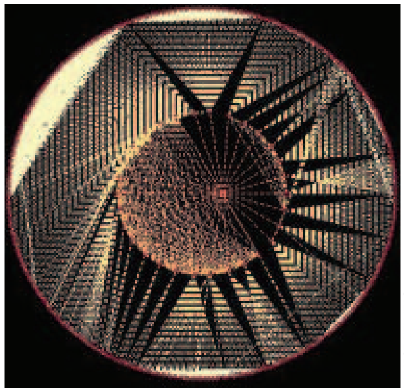
Your circle, for instance, could include clerks at the mall, ushers at movie theaters, students in your math class, and the person who delivers your latest online order.

Eubank uses public surveys, census reports, and transportation data to piece together the general schedules of thousands of people leading very different lives.

In one such scenario, for instance, he knows that a dad drops off his daughter at daycare at 7:30 a.m. and, after an evening meeting, picks the girl up at grandma's around 9 p.m. Or, that a retired electrician goes fishing with his buddies at 1 p.m. every Friday and then eats out with his wife.

With this information, Eubank begins to link an individual to personal contacts, those contacts to their contacts, and so on until he has mapped an entire community that represents how people move around and interact.

But as you can imagine, people interact in nearly infinite ways. Maybe lightning knocks out power at the daycare center, forcing the dad or his wife to change their routine. Perhaps one of them stays home or all three go to a movie.



STEPHEN EUBANK

What looks like a Native American dream catcher is really a network of social interactions within a community.

Maybe the same storm forces the fisherman to go to a matinee instead. Maybe they all end up at the same theater.

## Twists and Turns

Plans change, leading us to different people and places all the time. Sometimes, external factors like weather or world events compel us to make certain choices. Other times, chance happenings shape our actions. Either way, how we move around and come together can vary the course of events.

Eubank's own course has involved many twists and turns.

"I thread my way through life," laughs Eubank.

The son of an Army officer who fought in World War II, Eubank graduated from Swarthmore College in Pennsylvania knowing he wanted to be a scientist, but that he didn't want to go back to school right away.

So he headed to Florida to hitch rides on sailboats. He crewed boats to Cape Cod and the Bahamas. He even bought his own boat, but he shipwrecked it on his first long cruise.

Better at science than captaining, Eubank left the sea for graduate school in Austin, Texas, a city he likens to an island isolated from the world. He studied physics—and baked bread, made beer, and rode his bike.

"Graduate school was a great time in my life."

Eubank still visited the ocean, often when he went home to see his parents in South Carolina. On these sandy shores, he met his future wife, Helen.

**"I thread my way through life."**

Seemingly random, this first encounter actually was fated by their social network: His parents lived across the street from her grandparents!

The couple, married for 23 years, have two children, Jonathan, 15, and Elizabeth, 8.

## Complexity Made Easy

Eubank is an expert on "complex systems." A complex system has several components that interact in more ways than you can count. Exactly how those components interact can change the behavior of the whole system.

Social networks are only one type of complex system. Another type is the earth's climate. Static components such as the lay of the land, and more dynamic ones like ocean currents, distribution of heat, rainfall, and greenhouse gases, can mix in different ways to cause floods, tornadoes, and even global warming.

If the components of a complex system can interact in any combination, how do you begin to calculate the temperature in the year 2150 . . . or a country's response to a widespread outbreak of a contagious disease?

The answer is simple, says Eubank.

"Math rules!"

Eubank and others studying complex systems primarily use statistics and advanced algebra to figure out the likely outcomes. The science may be ancient, but the tools are quite modern.

"It used to be that you could write down some equation on paper and come up with solutions," says Eubank, who still likes solving equations by hand.

## "Math rules!"

Social networks are far too complex to work out on restaurant napkins, where Eubank often jots down ideas. They need to be sorted out through computer simulations, he says.

Eubank and computer scientists enter the interactions among components of a particular complex system into a software program. The program does the calculations to create a model of the entire system, say the transportation network of a large city. The model then can simulate probable outcomes—morning gridlock at a downtown intersection, for example—over a period of days, weeks, or months.

Since outcomes are also dependent on random interactions, Eubank and other modelers will simulate a single day 100 times to produce a collection of the possible outcomes. It's kind of like the movie *Groundhog Day*, where the main character wakes up over and over again to February 2, explains Eubank.

The simulations run on high-performance computers that generate massive amounts of calculations, which could show the number of tractor-trailers on an interstate at 4 p.m. or the alternate routes that a city's drivers take in response to an accident.

Statisticians study the data to make sure it all makes sense. If it doesn't, they'll figure out why. The answer can help Eubank retool the models to make them more accurate.

Components of complex systems like climate or traffic interact in many different ways. Computer simulations can model potential outcomes, such as traffic jams or storms.

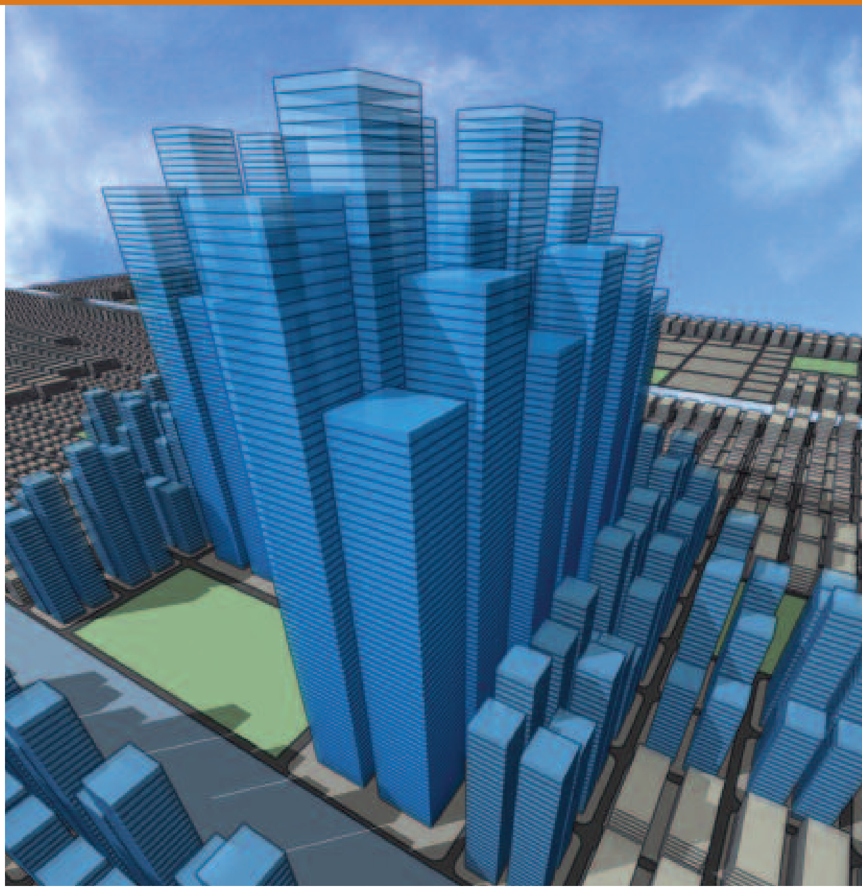
### Simple Pleasures

Eubank's antidote to complex research is a simple lifestyle.

Just because his family recently bought its first DVD player, cell phone, and cable TV connection doesn't mean they actually use them! They only watch one show—on DVD. They all enjoy the simple pleasures music can bring: Jonathan plays piano and Elizabeth plays violin. Eubank strums his mandolin.

Or, they head for the hills to camp in their green 1984 Volkswagen van. Eubank says its main feature is a "pop-top," or expandable roof. The van has more problems than Eubank can fix, so he has focused his energy on figuring out how he can use Jonathan's new iPod to rock out the van. Expectedly, it has no radio.

Living in a town of 40,000 people tucked along the Blue Ridge Mountains, the family spends a lot of time outdoors. Eubank often starts the day by strolling the Virginia Tech campus with his dog Goldberry, a hefty retriever



In Eubank's simulated version of Portland, Oregon, there are six or fewer degrees of separation between any two people.

named after a *Lord of the Rings* character.

If the weather's bad, like when a blanket of snow spreads across the campus, Eubank will stay home with Jonathan and Elizabeth. They spent the last snow days building a 4-foot-tall obstacle course through which balls drop, spin, and slide.

Although the family members spend time together disconnected from their own individual worlds, they're continuously touched by Eubank's social network.

A job studying the complex system of human language took them to Japan for 2 years. For nearly 15 years, they lived in the rocky desert of New Mexico, where Eubank studied complex systems at the Santa Fe Institute and started his own company to predict the ups and downs of financial markets.

Such adventures, too, have expanded the family network to include people like the Harry Potter series author, J.K. Rowling. When the family traveled to England with Eubank for a business trip, a cab driver pointed out Rowling's house and said she knew the author.

At that very moment, Jonathan was sitting in the back reading the latest Potter adventure. Because the Eubanks met the taxi driver with connections to the creator of the fictional hero, they can now say they're "three degrees of Potter!"

## Threading Science

Eubank, who hasn't taken biology since eighth grade, had never planned on studying the spread of infectious disease.

"When I was in school, the big advertisement for physics was that if you got a degree in it you could do just about anything," he says. Physics even taught him where to put the power in his swimming stroke. "I've learned how to apply my particular skills to solve any problem."

In New Mexico, Eubank also worked for the Los Alamos National Laboratory with a group developing the transportation analysis system TRANSIMS. The goal was to simulate the second-by-second movements of 1.6 million virtual people living in Portland, Oregon.

"My brother lives in Portland," said Eubank, the youngest of five children. "I tried to figure out who represented him in the simulated population." He admitted with some relief that synthetic people only *represent* real people and don't resemble individuals closely enough to identify them.

The model showed that there really are six or fewer degrees of separation between Portlanders. Transportation planners now use TRANSIMS to examine everything from traffic safety to energy consumption.

With many questions looming about the impact of biological warfare, the group used TRANSIMS as a foundation for modeling how diseases could move through communities and what interventions might slow or stop that spread. They started by unleashing virtual smallpox in the virtual Portland.

After the first simulated smallpox cases emerged—and spread quickly as people carried on with their daily activities—the researchers introduced various interventions, such as mass vaccination or quarantine, at different times. Patterns that emerged from the data showed that acting fast was the most crucial strategy for saving lives.

Eubank started attending scientific talks related to infectious disease spread. He met a new crowd of scientists, who encouraged him to get involved in a research project called Models of Infectious Disease Agent Study, or MIDAS, funded by the

National Institute of General Medical Sciences.

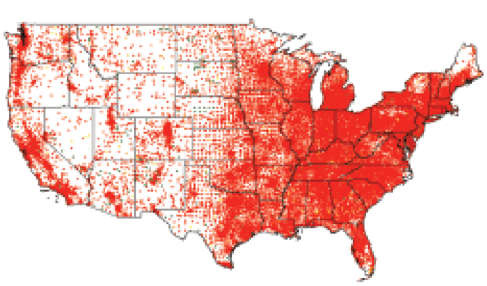
MIDAS researchers use different types of models to address a variety of questions about communicable diseases. But they've also teamed their expertise to focus on one in particular: pandemic flu.

## Cause for Concern

Beginning in December 2003, reports of a deadly flu in poultry emerged from several Asian countries. By early the next year, more than 100 million birds had died from the disease or were killed to control outbreaks. After a short lull, new cases appeared in European and African poultry, wild birds, and other animals like pigs. Some people caught it, too. As of May 2007, there have been more than 300 human cases and nearly 200 deaths.

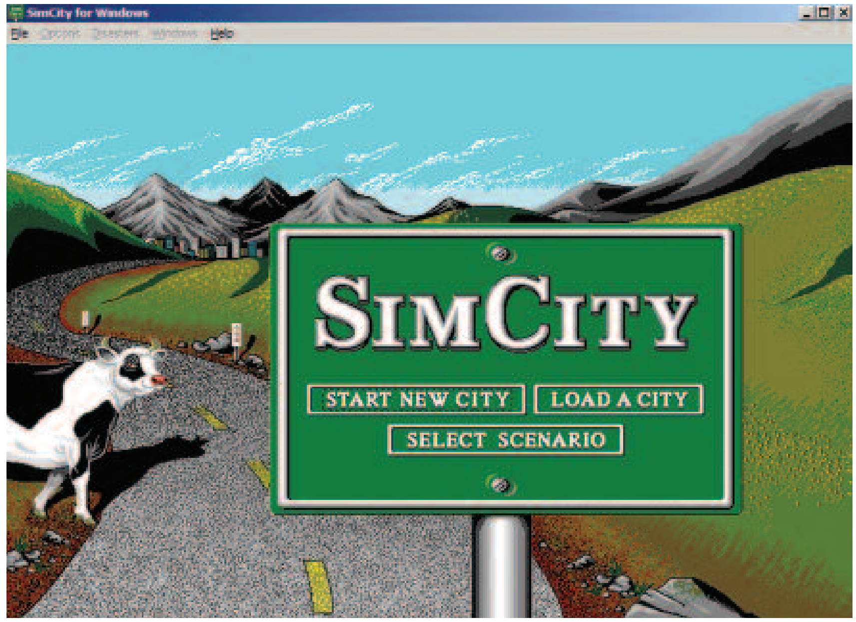
Nearly all the evidence suggested that people caught the virus by directly handling sick birds.

But what if avian influenza started spreading easily between people? Health officials worried that if such a scenario ever occurred, millions of people worldwide would be at risk.



PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES

This map of a simulated pandemic flu outbreak (red) shows how it could spread quickly across the nation without interventions like vaccination or quarantines.




First released in 1989, *SimCity*™ is a simulation and city-building personal computer game.

So, Eubank and other MIDAS researchers got to work building models of pandemic flu. On top of the social network, they added whatever information they could gather about the avian influenza virus.

Using historical data, they estimated that a contagious person would infect at least one person in his or her social network—just enough to allow infection to spread. The researchers watched a simulated pandemic flu spread across countries and continents.

About 60 of Eubank's high-performance computers spent 10 hours modeling the spread of pandemic flu in Chicago. The simulated city, like the real one, has about 8.5 million people, and Eubank knew exactly when each person got sick and showed symptoms.

## Preparedness Planning

The great thing about models, Eubank says, is that you can try out different scenarios not easily studied in real life.

"If the social network in the model is right, we can estimate pretty closely if a targeted intervention like closing a particular school will slow down the spread of flu."

The MIDAS researchers have used the pandemic flu models to answer questions—many times from policymakers—about the potential effectiveness of different interventions and their timing of implementation. For instance, the models suggest that if people get vaccinated, the virus will spread more slowly. The results have helped shape national preparedness plans.

The next challenge is modeling how people will react during an outbreak. "A lot of models don't take into account people's behavior," Eubank explains. "This makes determining the probability of outcomes harder."

Whether someone gets a flu shot, for example, depends on a bunch of things: personal convenience, cost, risk, and whether the person has had one before.

To help figure out how to model human decisionmaking processes, Eubank has joined forces with an economist who studies game theory, a method for analyzing strategic behavior.


"We know what needs to go into the model, but not how to do it—that's what makes it fun!" Eubank says.

He also has started working with an entomologist, a scientist who studies insects, to develop models of how diseases carried by organisms like mosquitoes are transmitted through social networks. These simulations could lead to practical measures for reducing the spread of dengue, malaria, and other diseases.

## Real Life or Model?

As Eubank creates models in his Blacksburg office, a teenager in Fargo, North Dakota, may be building his own synthetic town. With the click of the mouse, he can build bridges, change tax rates, and zone buildings. His town may face disasters, like fires or monster attacks.

Actual computer games like *SimCity*™ let people simulate cause and effect.

Even though these games don't begin to capture the complex dynamics at play in research models, Eubank says they offer a teaching tool that illustrates main concepts about social networks.

In fact, anyone can play Eubank's videogame version of a MIDAS model at the Marian Koshland Science Museum in Washington, DC. With the push of a button, you can infect just a handful of virtual Chicagoans with measles or flu.

In seconds, the city map is covered in red, showing thousands of sick residents. Acting as the mayor of the city, you push another button that administers vaccines to as many people as possible very quickly.

You've prevented thousands from the virtual outbreak, and the map goes back to mostly green, representing healthy individuals.

And in the process, you've become two degrees of Eubank. ■

# Spreading the Word

From horrific footage captured on cell phones to frantic messages from people under lockdown, the country learned of an unimaginable event unfolding on the ordinarily quiet campus of Virginia Tech University in Blacksburg.

In two separate attacks on April 16, 2007, a student opened fire on other students and faculty, brutally killing 32.

But many on campus didn't know what was happening.

Stephen Eubank, a physicist at Virginia Tech, found out about the second attack during a conference call with colleagues at other campuses.

"Everyone said, 'We saw the news and can't believe it,'" he remembers. Eubank specializes in studying how future events might unfold.

"I want to develop models that help people prepare for and understand situations more quickly," he says.

Right now, his research team focuses on understanding how infectious diseases can spread through cities and what interventions might slow or stop that spread. Understanding how communication spreads, he explains, is no different.


RICK GRIFFITHS


RICK GRIFFITHS

Information, much like a contagious infection, must be disseminated from person to person. Eubank has found that limiting social interactions can curb the number of people who get sick.

Could increasing social interactions speed the spread of news?

Studies at Virginia Tech are under way to examine how the campus responded to the events and to identify modes of communication, such as e-mail or phone trees, that circulate urgent news the fastest, farthest, and with the greatest impact.

Eubank, forever touched by the tragedy, may be among the researchers answering these questions.—*E.C.*