S&T SNAPSHOTS

Homeland Security
Science and Technology

Science Stories for the Homeland Security Enterprise

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User Guide

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This issue of S&T Snapshots *features work of the DHS Centers of Excellence (COEs), which are based at colleges and universities across the country and managed by the Science and Technology (S&T) Directorate. The COEs conduct multidisciplinary research and develop education initiatives in several areas of importance for homeland security.*

Click here to listen to a recent interview (a 4.9 MB MP3 file) about the COEs with Matt Clark, Director of the DHS Office of University Programs. The interview was conducted by Homeland Security Inside & Out*, a weekly public radio program affiliated with Texas A&M University.*

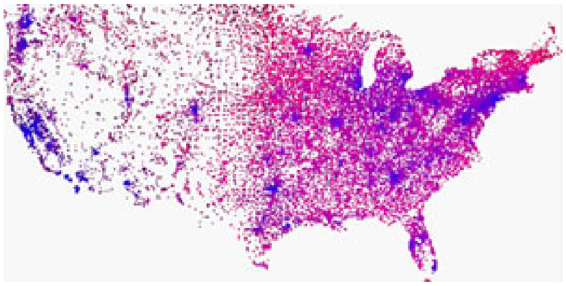
All Over the Map

A Washington, D.C., think tank says it has pioneered a way to simulate, through advanced computer technology, the spread of an infectious disease on a national scale using both biological *and* sociological data.

PACER
A HOMELAND SECURITY CENTER OF EXCELLENCE

Information about how the disease is transmitted can be combined with statistics from the census on 300 million–plus Americans in more than 31,000 ZIP codes—all into one image. These data—compiled in compliance with relevant privacy laws—include traits such as age, income, and the proximity of people to others. As a result, homeland security and other policymakers could be able to actually see the overall effect that preventive measures, such as school closings and limited quarantines, could have in reducing illnesses or deaths.

The Large-Scale Agent Model (LSAM) is developed by the Brookings Institution and can be used to plot and plan for insect-borne and sexually transmitted diseases, industrial accidents that can produce harmful chemical plumes, and even trends such as obesity and teenage smoking. Eventually, LSAM will be able to expand to encompass data on schools, workplaces, and every hospital and medical facility in the country. It could even be integrated with travel and sociological data from other countries to predict disease spread and emergency response around the globe.



Click here to view a demo (a 3.4 MB animation) of the PACER-Brookings model. This scenario shows the spread of a flu-like disease as it travels across the United States, over the course of 200 days (every second equals about 2 days). The epidemic begins in Los Angeles and spreads first to San Francisco, then Sacramento and Phoenix. Once the epidemic has spread this far, it reaches all U.S. population centers almost simultaneously.

A pixel turns a deeper shade of red as more citizens have the disease, and a deeper shade of blue as more citizens recover from their illness. Consequently, a city in the middle of its epidemic will appear purple.

"We build artificial communities of cyber people who represent the real population," said Joshua Epstein, the project lead at Brookings. "Basically, we grow large-scale social dynamics of central importance to policy."

LSAM is a major initiative of the National Center for the Study of Preparedness and Catastrophic Event Response (PACER), a DHS Center of Excellence based at Johns Hopkins University. PACER partners with other schools and organizations such as the American Red Cross to find ways to improve the Nation's ability to prepare for and respond to high-consequence natural or man-made disasters.

The Brookings model fits into PACER's focus on surge capacity, which deals with the challenge of accounting for enough medical care in the event of a catastrophe. Epstein and his colleague Jon Parker—who built the computer program for LSAM—will input over the next year information about the location of every staffed hospital bed in the country. Then, they'll run a simulation that shows where shortages in medical care can be expected if there's ever an epidemic or disaster.

In the same scenario, public health experts and policymakers would be able to use LSAM to map out and "observe" the effectiveness of vaccine distribution and other measures that could, for example, stop the spread of contagious diseases. These other measures could range from simple health advisories to moratoriums on travel.

Epstein said PACER and Brookings see a host of potential uses for LSAM, which could apply to government agencies in the United States and, eventually, around the world. "We're trying to have a very big picture of things," he said, "and so far, we've had a lot of success."

To request more information about this story, click here

Security from Chaos

There's safety (and security) in numbers … especially when those numbers are random. That's the lesson learned from a DHS-sponsored research project out of the University of Southern California (USC). The research is already helping to beef up security at LAX airport in Los Angeles, and it could soon be used across the country to predict and minimize risk.

CREATE HOMELAND SECURITY CENTER

Here's how it works: Basically, computer software records the locations of routine, random vehicle checkpoints and canine searches at the airport. Police then provide data on possible terrorist targets and their relative importance. These data may change from one day to the next, or if there have been any security breaches or suspicious activity. A button is pushed, the computer runs, and—*voilà*—police get a model of where to go, and when. The software comes up with random decisions that are based on calculated probabilities of a terrorist attack at those locations, using mathematical algorithms.

The result: Security with airtight unpredictability. With the software, it's extremely difficult to predict police operations.

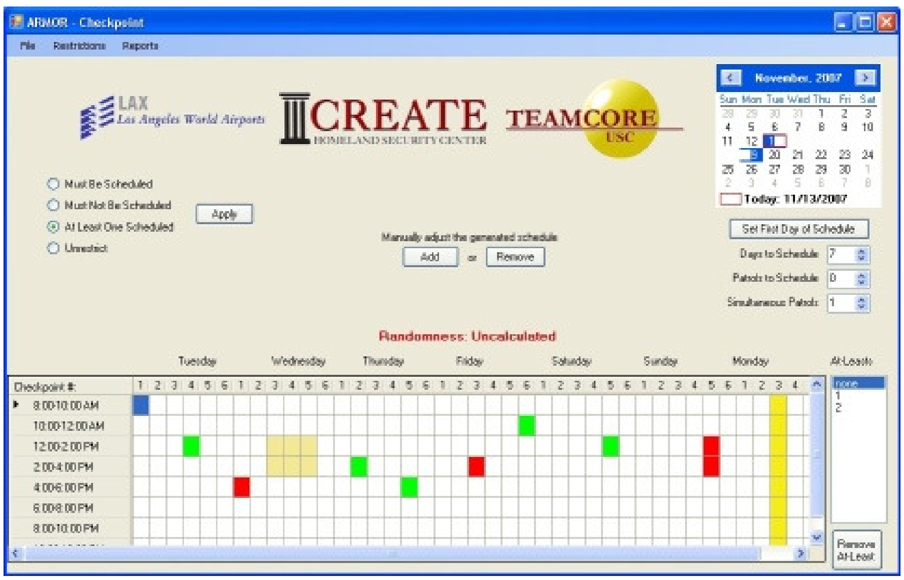
The ARMOR project, funded by DHS, is under way at LAX airport.

"What the airport was doing before was not truly statistically random; it was simply mixing things up," said computer science professor Milind Tambe. "What they have now is systematized, true randomization."

Tambe is with the [Center for Risk and Economic Analysis of Terrorism Events](#) (CREATE), a DHS Center of Excellence based at USC. CREATE works with government agencies and other researchers to evaluate the risks, the costs, and the consequences of terrorism. The center helps policymakers set priorities and find the best, most efficient ways to counter threats and prevent attacks.

It was Tambe who had an "ah-*ha* moment" in 2004 that led to the LAX project. He and his team use math and computers to study "multi-agent systems"—in other words, systems in which different software applications, robots, and people interact. By nature, Tambe contends, humans cannot oversee purely random systems for an extended period. Invariably, they'll make decisions based on prior decisions. He recognized the parallels between this field and counterterrorism.

Security uses a software interface (below) to ensure 'true randomization' for vehicle checkpoints and canine searches.



Praveen Paruchuri was a CREATE student at the time, and he, too, saw the connection. Then, in 2007, Paruchuri's Ph.D. dissertation on the subject caught the eye of CREATE Associate Director Erroll Southers. Southers serves as Chief of Intelligence and Counterterrorism with the Los Angeles World Airports Police Department, which supports LAX.

Soon thereafter, Tambe and Paruchuri tested the software, and the project was born as a six-month trial period. And it was given a snappy name, of course: Assistant for Randomized Monitoring over Routes, a.k.a. ARMOR.

ARMOR has recently completed its six-month trial, and airport officials have given the university the "thumbs up" to transfer the software over to LAX on a more permanent basis. Meanwhile, other airports, agencies, and even businesses are starting to notice, Tambe said. It's a project that's attracting attention from coast to coast.

But, wait: What if terrorists get hold of ARMOR and use the same information? Couldn't they solve the predictability puzzle? Not really, Tambe said. "Even if they got the software and all the inputs, it'd be like rolling 50 different dice and expecting to correctly roll one combination of all 50 pairs."

To request more information about this story, click [here](#)

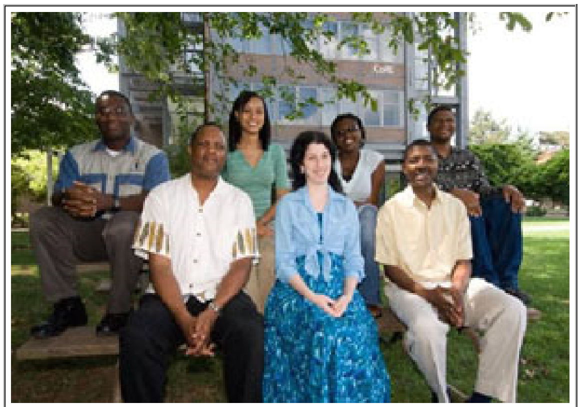
Reading by Numbers

Last summer, five mathematicians and one public health student converged on Rutgers University. Their mission: Develop an early-warning model that can "see" an epidemic before it claims many victims.

The visiting researchers worked with members of the Rutgers Center for Dynamic Data Analysis (DyDAn), the lead on a DHS Center of Excellence that creates ways to see patterns and relationships hidden in massive amounts of data. "Our goal is to find evidence of an epidemic as early as possible, even before public health officials recognize it," said Nina Fefferman, a research professor at the university's Center for Discrete Mathematics and Theoretical Computer Science. Fefferman, an applied mathematician, served as her visitors' research mentor and joint team leader

The six researchers came from two historically black universities: Howard in Washington, D.C., and Morgan State in Baltimore. Each school sent a graduate student, an undergrad, and a faculty member. They were part of the DHS Summer Research Team Program for Minority Serving Institutions (MSIs), in which the department's S&T Directorate fosters collaborative research between MSIs and the Centers of Excellence.

Epidemiologists study health reports and compare them to chart a disease's course—the earlier, the better. But report data can seldom be compared "apples for apples." For example, two neighboring counties may report an illness by ZIP code or by street, by week or by month. And to respect privacy laws, some of the most telling health data—such as a victim's contact information, age, or race—may remain off-limits.

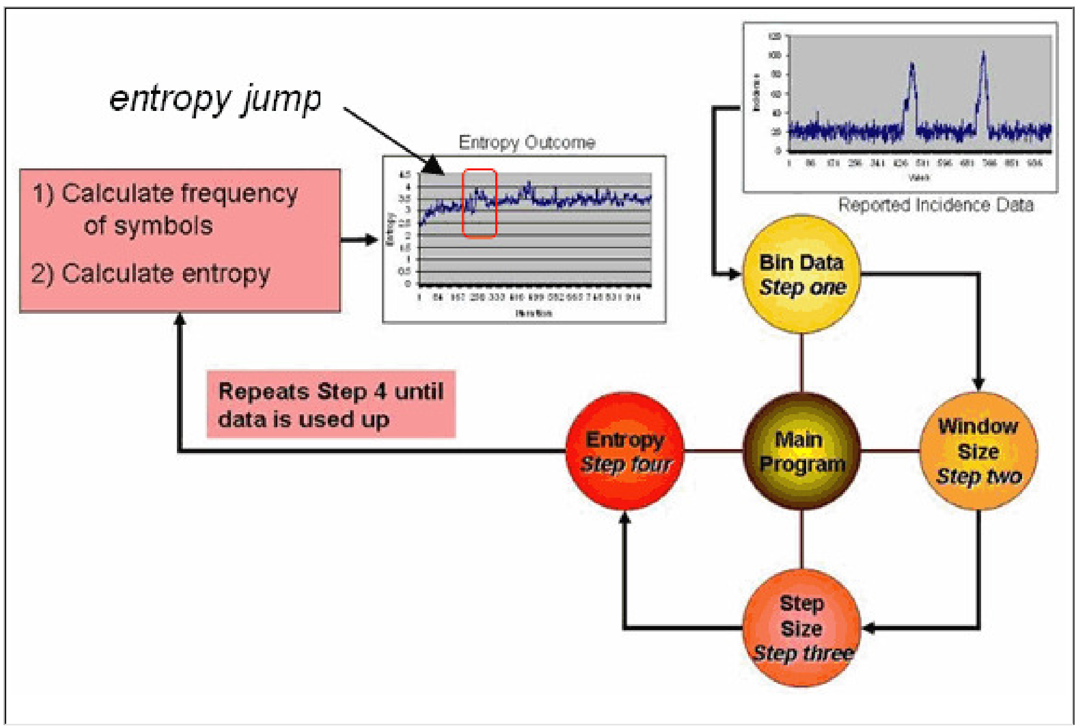


The Howard and Morgan State researchers with DyDAn mentor Nina Fefferman (center).

Therefore, epidemiologists often must interpolate, reading between the lines, even when they are eyeing an illness that has already claimed scores of victims. So imagine the challenge of charting an illness whose numbers seem to be growing in no discernible pattern. The earliest victims may fall ill sporadically—too sporadically to signal a pattern or raise an alarm. Are their illnesses the start of a mushrooming trend? Or are they just statistical "noise"—isolated accidents that foretell nothing?

Could the DyDAn researchers sort the noise from the signal? Using math, could they "see" a budding epidemic … before its death toll reached epidemic proportions?

Yes, they could—using a principle called *information entropy*, which is a measure of the uncertainty associated with a random variable. A single event that's totally random—say, a coin toss or dice roll—has the greatest possible entropy. Its outcome is completely uncertain. But add weight to the coin or load the die, and the outcome is now less random, more predictable; it has less entropy.



The research teams exploited these properties to study disease. They first analyzed data that indicate the start of a possible disease spread (*"Step one" in the diagram*), selected just the right time-window for analysis ("*Step two*"), and grouped the disease's daily incidence figures into just the right categories ("*Step three*"). In this way, they were able to tease out an unmistakable jump in entropy (or spike) early into the outbreak —earlier than disease watchers could have noticed using standard

A diagram of the new algorithm for calculating the amount of entropy in disease surveillance data.

detection methods. Equally important, such a jump did not occur at any other time.

The researchers then tested how well their model "detected" actual historical outbreaks. They scored a bulls-eye, accurately detecting when each disease shifted from low, normal levels to become an epidemic, days in advance.

If DyDAn can maximize the model's warning time, while retaining its accuracy, public health officials could intervene early, saving hundreds or even thousands of lives, Fefferman said. "We know what we want to accomplish, but we don't know how long it will take," she added. "But one thing is for sure: These students are up for the challenge."

To request more information about this story, click here

S&T Snapshots is a monthly newsletter produced by the DHS Science and Technology Directorate in partnership with the Homeland Security Institute. HSI is a Studies and Analysis Federally Funded Research and Development Center.