Welcome to the FORCES newsletter

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Welcome to the inaugural FORCES newsletter! We're excited to share with you updates and news from our team of researchers at Berkeley, Michigan, MIT, and Vanderbilt.

The advancement of cyber-physical systems (CPS) represents enormous potential for progress in the way humans interact with the world in the 21^{st} century and beyond. At the same time, the deployment and use of these technologies increases security risks and privacy concerns. Thanks to support from the National Science Foundation, FORCES researchers aim to increase the resilience of large-scale networked CPS in the key areas of energy delivery and air and ground transportation.

Our research is designed to help protect the nation's critical infrastructure from attack and to ensure its robust, secure and efficient operation—for example by developing tools that increase coordination and reliability of controls and data in power grids and that address security challenges in next-generation transportation systems.

I hope you find these newsletters informative and interesting—each a timely synopsis of stories that keep you up-to-date on our latest accomplishments and activities—and the information excites you about our work. On behalf of the entire FORCES team, I welcome your feedback, comments, and suggestions.

Sincerely,

S. Shankar Sastry
Professor and Dean of Engineering
University of California, Berkeley

RESEARCH SPOTLIGHT

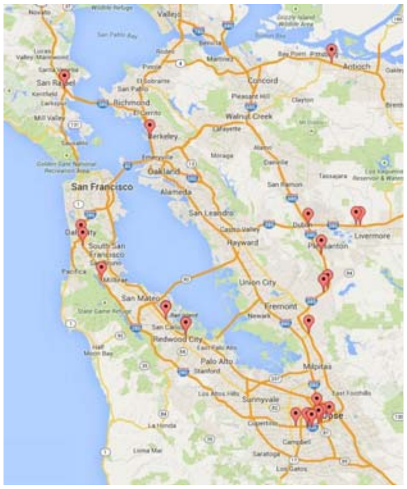
Resilient Monitoring of Large-Scale Cyber-Physical Systems

by Xenofon Koutsoukos

One of the broad areas of concern for researchers in the FORCES project is the ability to distill and study a large amount of information gathered from systems that are constantly changing.

Naturally, the ability to dynamically control any system hinges on having accurate information about its evolving state. This can be obtained through persistent system monitoring. In many applications, such as traffic and water distribution networks, the system to be monitored can extend over a vast area, with many possible points of observation.

Although these areas are often very large, the number of sensors that can be deployed is limited by financial and/or technological constraints. Additionally, system monitors must take steps to guard against adversaries, who may disable some of the deployed sensors.



Traffic sensors in the San Francisco Bay Area

Thanks to funding from the FORCES project, researchers are studying approaches to promote resiliency among large-scale monitoring systems. When systems are resilient, they are able to quickly recover and resume normal operations. FORCES researchers used data from a subset of sensors from real traffic networks to develop efficient approximation algorithms for denial-of-service attacks.

In addition, researchers are developing an approach for sensor placement for fault location and identification in water distribution networks. Resilient water networks aided by real-time sensing and analytics are crucial to ensure water security. Working together in teams, researchers have designed a network of sensors for pipe failure location identification. The goal is to develop a network that will detect faults in system components and implement corrective actions in response to the specific fault. Towards this end, researchers have designed efficient algorithms for computing the minimum number of sensors and provided a detailed analysis of their approach.

Responding to Changes in Electricity Markets

by Demos Teneketzis

As part of the FORCES project, researchers are addressing problems in energy markets and cyber-security. Their work responds to ongoing changes and restructuring of electricity markets, including changes in market mechanisms, integration of renewable energy, and management of security risks.

The U.S. Department of Energy recently listed “development of rules for market evolution that enable system flexibility” among the key strategic elements for a successful integration of renewable energy into the electrical grid.

Motivated by the desire to respond to this stated priority and specifically seeking to develop ways to integrate renewable energy into the grid, FORCES-funded researchers formulated and analyzed mechanism design problems for strategic agents with multi-dimensional private information and uncertainty in their utility functions. The group proved that the optimal mechanism design includes menus of contracts that can be implemented as nonlinear pricing schemes.

Researchers also simulated attacks that influence aggregate demand and developed scalable algorithms, based on dynamic programming, to determine defense policies. This approach modeled a computer network’s operation and replicated progressive attacks on the electrical system, addressing several key issues in cybersecurity systems. Eventually, this will help industry manage threats, using a dynamic and adaptive defense that will be applicable to a growing number of computers in various states of activity.

Managing Urban Traffic

by Alex Bayen

Traffic management systems are increasingly becoming areas of security risk, particularly in densely populated urban areas. Thanks to support from the FORCES program, a group of researchers are working to find solutions by developing a game theoretic framework for modeling, estimation, and control of urban traffic.

Researchers have identified vulnerabilities at all levels of a traffic network: sensing, regulation, and reaction of humans. To address the problem, a research team of faculty and students created an economic incentive scheme for transportation networks by modeling the decision of drivers as a routing game, given information about the congestion (or cost) of each road segment. This model then combines resilient control with the design of an inference scheme that is responsive to noise and attacks.

While designing the economic incentive model of route choice, the goal was to define a version that is easy to implement by drivers and that has provable convergence guarantees that accommodate choice of parameters. Another objective was to make the inference problem robust to sensor faults or attacks.

Resilient control scheme in transportation networks requires reliable estimation of travel costs on each link of the network since inaccurate or corrupted measurements lead to inefficient control strategies. Future plans include further refinement of the economic incentive by launching a routing game experiment where participants will compete against each other to minimize their travel cost and get a reward. The goal is to simulate the behavior of drivers to test the prediction of the model.

Although the accelerated growth of modern cities fundamentally contradicts sustainability, pervasive urban sensing has brought unprecedented opportunities to make cities of the future more efficient, resilient, and adaptive in a data-driven way. By reaching different communities, the project raises awareness for the need of smarter cities.

PROJECT NEWS

Upcoming Events

FORCES All Hands Meeting
November 4-5, 2015
Hyatt Arlington

CPS PI Meeting
November 16-17, 2015
Renaissance Arlington Capital View

FORCES In the News

PUBLIC TRANSPORTATION NEEDS RESILIENT SYSTEMS

FORCES researcher Saurabh Amin at MIT weighed in on NPR in a story about outdated transportation systems in Boston that have been crippled by the region's record-breaking snowfall. Dr. Amin pointed out the vulnerability of public transportation systems, such as Boston's subway, that rely on antiquated electrical motors which are known to fail during extreme weather conditions.

The problem is related to the focus on resilient cyber-physical systems endorsed by researchers in the FORCES project, as it highlights the interdependency of transit systems and the need not only for better equipment but also for the need to develop contingency plans for emergency situations.