

White House offers encouragement for cyberphysical systems

SmartAmerica Challenge catalyzes two dozen projects that add further functionality to the Internet of Things.

Imagine you are driving on a deserted downtown street at 2am. Not another car on the road. But that red light you're stuck at seems to last forever. What if there were a smart system that not only turned your light green but also switched the subsequent lights in sequence, letting you breeze through the sleeping town. That would be an example of a cyberphysical system (CPS), the newest incarnation of the evolving internet.

Conceptually, CPSs are a nascent feature of the so-called Internet of Things. Geoff Mulligan was one of two presidential innovation fellows who organized a recent White House-sponsored SmartAmerica Challenge and exposition to draw attention to CPSs. He describes the Internet of Things as being "about sensors attached to the network, shoving data into the cloud, doing data analytics, and figuring out what cool things you can determine from that." CPSs complete that loop, taking actions automatically based on the data and analysis.

To draw attention to CPSs and to help give them a push, Mulligan and associate presidential fellow Sokwoo Rhee last November invited companies, universities, national laboratories, and other entities at the forefront of the emerging field to show off their wares and chal-

lenged them to come up with new applications that could have a big societal impact.

"What we found out is there has been a huge investment, public and private, in CPS research, but everybody is working on their sector-specific stovepipe," Mulligan says. "Health care has blinders on and a tunnel focus. Energy has the same thing, [as do] building control and transportation. They are making breakthroughs and progress, but nobody is thinking about how is this going to have an impact and create jobs."

By increasing the interactions between computer networks and the physical world, CPSs are enabling advances in areas such as personalized health care, emergency response, and autonomous vehicles.

Ronald Ambrosio, chief technology officer for smarter energy research at IBM, says, "CPS[s] will be transformational in transportation, electric grids, gas networks, water management systems, chemical and petroleum [production], manufacturing, you name it."

To find potential attendees, Mulligan and Rhee searched NSF's CPS-VO (virtual organization), a research and education community committed to the study and application of CPS innovations. They also worked their personal contacts. "I think that most of the folks

showed up because they were invited to the White House. I wish it was my magnetic personality," Mulligan jokes. "But then they stayed because it was a chance to show the fruits of their research, and they found kindred spirits and other pieces of the puzzle."

One demonstration project under way in San Jose, California, involves feeding continuous data from air-quality sensors into models to predict when and where pollution hot spots will develop. The next step could be to reroute traffic or to encourage ride sharing or alternate transportation on particularly smoggy days, says Guy Allée at Intel, which is partnering in four SmartAmerica projects.

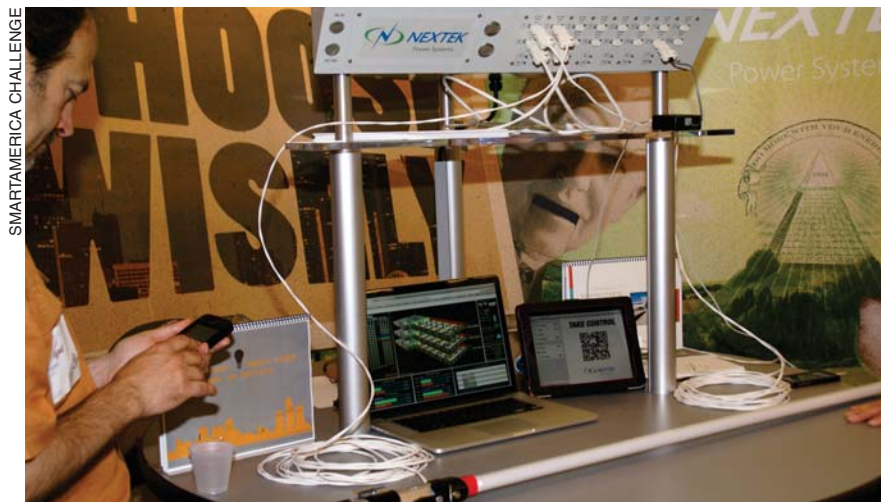
Electricity is a focus

One-third of the 24 SmartAmerica projects are related to smart grids or electricity. In a Smart Rooftop project, an advanced energy sensor and intelligent gateway from Intel were incorporated into commercial HVAC rooftop units made by Daikin Applied. The sensor data are periodically uploaded to the cloud for remote analysis. Energy consumption, end-point voltage, and failure detection and prediction are tracked and analyzed.

Don Winter, Daikin Applied's director of marketing communications, says the intelligent rooftop units can be automatically controlled to ramp up and down slowly, which results in much improved energy efficiency and avoidance of power spikes that can greatly increase electricity costs for commercial users. "We understand the importance of working with organizations like the Department of Energy and SmartAmerica in helping communicate that there are better ways to doing things," Winter says.

This year the Smart Rooftop partners plan to demonstrate a local area network consisting of multiple HVAC units on several buildings. "The idea is to operate suites of these rooftop units in concert and look at ways to reduce and manage energy use within the whole building, within a group of related buildings on a campus, or even across a city or a region," says Allée.

In another SmartAmerica project, IBM and AT&T teamed up on "transactive energy management" (TEM). TEM, says Ambrosio, involves "the use of economic value signals to convey the changing needs of the electric system in almost real time." One such signal is the price spike that often results from sharp increases in electricity demand. For some large commercial consumers, that



Two Detroit-area companies, Nexttek Power Systems and Toggled, showed off their modular, scalable DC-powered lighting system at the SmartAmerica Challenge exposition in Washington, DC, in June. The system integrates with existing building management systems, eases the rewiring of lights, and enables remote control.

signal will cause them to reduce their electricity demand in response.

Each of the multiple parties involved in the generation, transmission, and distribution of power has a different set of objectives and constraints, Ambrosio explains. Using economic signals, which he says include more than price alone, “we can capture the value of reaching those operational objectives, we can assign an economic value to achieving those objectives, and we can assign some economic costs, or negative values, to the constraints.”

At a grid scale, transactive control nodes can be placed wherever there is an opportunity to respond to fluctuating conditions. For example, as part of the largest US smart-grid demonstration project to date, GE set up a control node to manage a 5-MW lithium-ion storage battery. When the cost of electricity at any given moment jumps because of a supply shortage, perhaps caused by a drop-off in wind generation, the battery automatically discharges through the CPS process to help ease the deficit. Further, TEM will forecast the upcoming costs so that the battery is charged more efficiently in response. “Whether it’s supplying or charging, the decision is being made automatically by the transactive control node that manages it,” Ambrosio says.

Although AT&T and IBM have collaborated on other applications for the Internet of Things, the SmartAmerica Challenge gave them their first opportunity to work together in the smart-grid arena.

Distributed test bed

The Smart Energy CPS project combined the cybersecurity efforts at five universities, three companies, and a national lab to form a distributed network to assess the security and resiliency of the growing smart grid, says Terry Benzel, deputy director of computer networks and cybersecurity at the University of Southern California’s Information Sciences Institute.

In addition to a 10-year-old USC cybersecurity simulation facility funded by the Department of Homeland Security, the Smart Energy CPS collaboration is using labs at Iowa State University and North Carolina State University to test physical devices used in smart grids.

A major component of the smart grid is the synchrophasor, which provides precise, real-time measurements of the AC voltage and phase at a given point on the grid. Thousands are deployed across the US. The waveform informa-

tion that they gather allows operators to sense what is happening on the grid and take action to stabilize it. Protecting synchrophasors from cyberattacks is the focus of the Cyber Secure Synchrophasor Security Fabric project. Partners include Intel and its McAfee division, National Instruments, Texas Tech University, American Electric Power, and the Electric Reliability Council of Texas, which operates most of the state’s grid.

“You’ve got a whole grid that is struggling to modernize, and as we do that we will introduce these new threat

potentials in the cyber domain,” says AILee. Facilities that are owned by local utilities and not accessible by internet in the past are becoming more vulnerable to cyberthreats as they move more to the Internet of Things, he says.

Detroit-based Nextek Power Systems and LED innovator Toggled developed a modular, scalable, DC-powered lighting system. As building needs change, the system lets facility managers rewire and move lights more safely and cost effectively than with conventional systems. It also features a dashboard that integrates with existing

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Next steps?

Mulligan and Rhee “achieved to a fair extent what they were hoping to accomplish: drawing more attention and visibility to cyberphysical systems and how they are going to help us transform a lot of industries in the future,” Ambrosio says. “The SmartAmerica initiative really pulled people together,” adds Benzel. “Our group didn’t know each other before December 2013.”

Mulligan, who recently completed his yearlong fellowship, says that talks are under way with the White House about a possible follow-up, SmartAmerica Challenge 2.0. “We’re excited about the community it created,” he says. “We don’t want to lose that.” He adds that some of the teams have realized their technologies could be used in other sectors: “Some of the major players want to do new projects and find other partners.”

Possible new applications could be in air quality or water conservation systems, both of which he says could be managed better with lower-cost feedback control. Mulligan hopes the White

House will decide soon on whether to sponsor a second exposition. “We have momentum,” he says.

Separately, NSF in June awarded a five-year, \$4 million grant to address the challenge of synchronizing time in CPSs. Researchers at five universities will share the grant, with a goal of improving the accuracy, efficiency, robustness, and security with which computers maintain knowledge of time and synchronize it with other networked devices. CPSs depend on precise knowledge of time to infer location, control communication, and coordinate activities.

David Kramer

Report urges more planning to cope with Fukushima-like event

Industry and the NRC maintain that US reactor safety has greatly improved in the three years since Japan’s nuclear catastrophe.

The US nuclear industry and the Nuclear Regulatory Commission (NRC) should be more proactive about hazards that could affect the safety of nuclear plants, says a new report from the National Research Council.

The committee that wrote the report acknowledged the additional safety measures that were ordered by the NRC and are being implemented by the nuclear industry since the 2011 Fukushima nuclear accident (see *PHYSICS TODAY*, May 2011, page 18, and January 2013, page 20), but the committee did not assess their adequacy. The steps include installing hardened vents in the containment vessels of boiling-water reactors; adding thermometers to spent-fuel pools; and stationing generators, fuel, and other emergency response equipment nearby to cope with a potential loss of power to the plant as occurred at Fukushima.

The industry and the NRC should give specific attention to improving plant systems operation and training for catastrophic events, said committee member Robert Bari, senior physicist at Brookhaven National Laboratory. He added that procedural changes arising from that recommendation should be peer reviewed.

The committee, whose report was requested by Congress in 2012, urged the nuclear industry and emergency responders to assess their preparedness for large-scale nuclear accidents that could result from natural disasters. Emergency response plans, including

communicating with affected populations, should be revised as necessary to ensure that they are scalable and effective. In addition, well-trained personnel and adequate resources for responding to long-duration accident scenarios need to be in place.

While acknowledging that the committee hadn’t the time or resources to perform an in-depth analysis of US preparedness for severe nuclear accidents, the report nonetheless expressed doubts that the country is prepared to cope

with a disaster on the scale of Fukushima. “We also recommend that the nuclear industry and emergency responders assess the value of protective actions, such as sheltering in place, evacuation, relocation, and distribution of potassium iodide,” said committee member Barbara Hamrick, radiation safety officer at the University of California, Irvine Medical Center. “Particular attention should be given to protection for special populations—children, the elderly, and the ill; longer-term impacts of evacuation; shelter in place, including the social, psychological, and economic impacts; and decision making for resettlement in areas



To avoid a Fukushima-like accident (the aftermath of which is shown in this 2011 photo), the US nuclear industry should seek out and act on newly available information about reactor safety hazards, says a National Research Council report.