shifting to EMBEDDED SYSTEMS

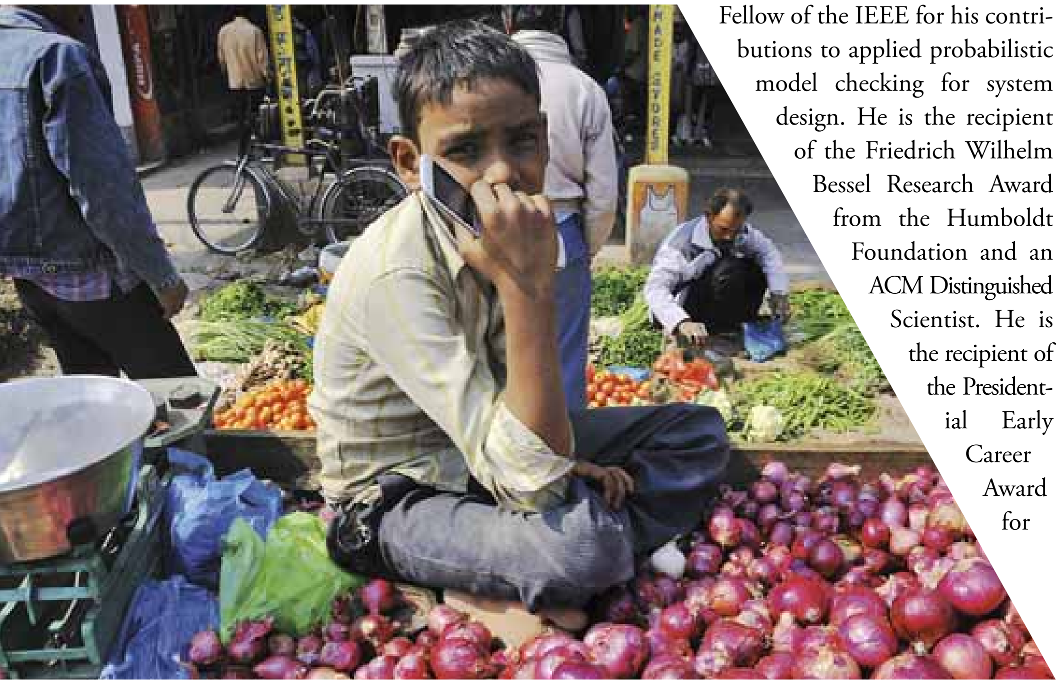
FOR SUSTAINABILITY AND DEVELOPING COMMUNITIES

Throughout his career, Sandeep Shukla, professor of electrical and computer engineering (ECE), has applied formal methods to a wide range of applications, including communication networking for the smart grid and compatibility checking and interfacing for independently developed software components.

It is time, he says, to tackle a different set of problems. It is time electrical and computer engineers apply their expertise to help people and communities that don't have reliable services like electricity, medicine, and education. Today's embedded systems, communications and distributed energy technologies — combined with ingenuity — can help the developing world access services and knowledge to help improve lives.

While it is important to continue developing technology and improving systems, there is a difference, he says, "between being one of many who made an incremental change to a technology and interacting with communities whose lives we can positively impact."

Shukla was recently named a Fellow of the IEEE for his contributions to applied probabilistic model checking for system design. He is the recipient of the Friedrich Wilhelm Bessel Research Award from the Humboldt Foundation and an ACM Distinguished Scientist. He is the recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE) and he serves as editor-in-chief for the ACM Transactions of Embedded Computing Systems journal.



It was while trying to fill ACM editorial positions in embedded systems for sustainability and embedded systems for the developing world, that Shukla formalized his shift in emphasis. Embedded systems for sustainability includes technologies such as solar panels, windmills, and "small gadgets you can use to reduce power consumption," he explains. Embedded systems for the developing world include technologies to help people build their own electricity or have local systems for processing waste, software systems and services for logistic support, policy implementation, tele-health, direct access to banking etc.. Unfortunately, Shukla notes, "not a lot of top researchers seem to be interested in these research topics." This difficulty in finding editors (the positions remain open), led Shukla to look for new applications for his own research.

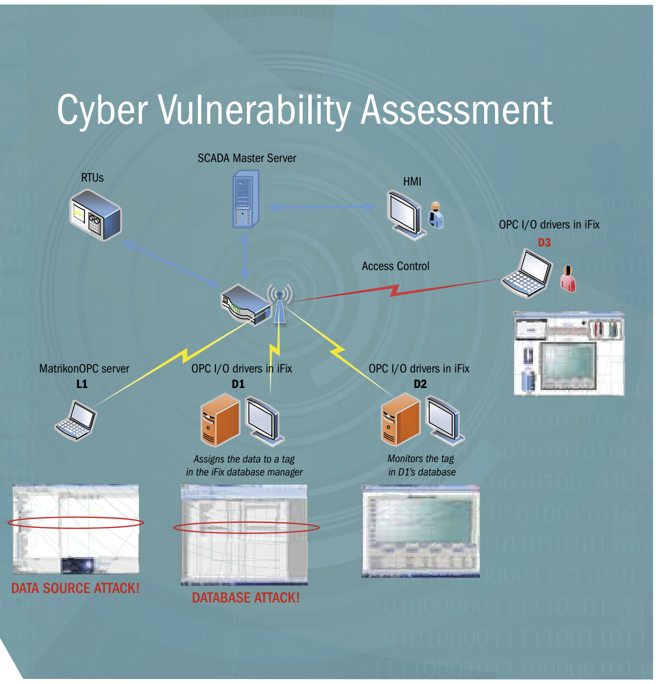
Some projects Shukla is considering will bring affordable, sustainable electricity or virtual medical care to remote villages. For example, "in India, many villages don't have doctors," according to Shukla, but with cell phone and sustainable energy technology "we could actually create telemedicine portals." Shukla envisions a facility with a local nurse who could connect a patient to

SYSTEMS FOR DEVELOPING COMMUNITIES

There are villages in India and many other parts of the world that have no electricity for 10-15 hours each day, but they do have cell phones, according to Sandeep Shukla. This situation is ripe for engineering solutions that can directly impact lives, he says.

SYSTEMS FOR UAVS AND SCADA TRAINING

Sandeep Shukla (right) has worked with formal methods in a variety of applications, including hardware-software co-design for advanced control of unmanned aerial vehicles. He is also working on a SCADA virtual lab to train engineers (left).



medical monitoring equipment. This data would then be transmitted to a distant doctor who would communicate with the patient via video.

Some of the greatest challenges of this kind of work are not technical, he says. "We will need help from administrative bodies who might think we are encroaching on their territories."

While Shukla is shifting direction for some of his work, he continues his research in formal verification, software synthesis, and security. One current project is to create formal verification software to help Toyota's systems engineers provide formal requirements for components they need for a vehicle. Toyota uses components from many suppliers for parts such as cruise control systems and brakes.

"The systems engineers need to look at the entire system, then at the overall requirements, then decompose those requirements in such a way that each supplier provides specific parts conforming to specific formal requirements. Finally, they need to make sure that all parts provided by different providers compose together to satisfy overall system requirements," explains Shukla. "It's a big systems engineering problem to put them all together in a correctly functioning car." Toyota has asked for a way to easily decompose system level properties into formal component level properties, and then prove system level properties are satisfied by the composition of acquired components, and Shukla's team is developing contract based component composition techniques for multi-vendor software acquisition and system development.

Shukla and his students have recently created a prototype tool for the U.S. Air Force to manage software synthesis for safety-critical systems such as unmanned aircraft. This tool helps ensure that the software for such critical systems are safe by construction, and thus avoiding expensive post-development verification.

Shukla also is creating a Supervisory Control and Data Acquisition (SCADA) virtual laboratory. SCADA systems for power, telecomm, transportation and sewage collect data from various locations in real-time to see what is happening in the network. However, "the SCADA systems are vulnerable to cyber attacks," Shukla says. "Someone can spoof the data so that the controllers can see something that's not happening in the real system. The operators will then react to the wrong data and hurt the system."

Shukla emphasizes that to avoid such damage, engineers must understand how SCADA systems work and students must be trained in SCADA technology and issues. "Our virtual laboratory provides an ideal environment for such training," he says. ▲