UMass Amherst experts are driving the future of Internet infrastructure

Our current Internet architecture was built for a wired world and has not kept pace with the rapid explosion of technical, business, and social applications. That situation puts users at risk for security breaches and exposes discrepancies between old, outmoded capabilities and an increasingly mobile user-base. Federal initiatives are beginning to address these issues with high-level competitive research efforts, in which two out of the five major projects find UMass Amherst researchers at the helm.

The workup to these efforts began in 2002 at a National Science Foundation–sponsored workshop designed to explore issues surrounding outdated Internet architecture, including the need to explore new technologies. Chaired by UMass computer scientist James Kurose and attended by researchers from around the country, the workshop yielded a report that served as a springboard for federal research programs aimed at addressing next-generation Internet architecture needs. The newest and largest of these is the Future Internet Architecture (FIA) Program, which is funding five multi-million-dollar projects nationwide. In two of these, UMass Amherst computing and engineering experts Kurose, Arun Venkataramani, Tilman Wolf, and Michael Zink are key players. Along with world-renowned UMass operations management expert Anna Nagurney, they are part of a core faction of researchers helping to create the next-generation Internet.

"The fact that our campus was selected to take a leadership role on two of the five FIA projects speaks volumes about our faculty expertise," says Mike Malone, vice chancellor for research and engagement. "We take an interdisciplinary approach to science, which is critical to an initiative of this size."

Kurose, Venkataramani, and Zink are part of FIA's MobilityFirst project, led by a team at Rutgers University and aimed at designing an alternative Internet architecture with mobility and security as the driving goals. When the Internet was standardized there were no mobile devices, yet now such devices are in the majority. Kurose explains that it makes little sense to have such an important network designed to connect with outdated technology.

"If mobility is the norm," he says, "we really want to think about building a network architecture that takes mobility as a first-class concern and organizes the whole architecture around it."

With Venkataramani as lead architect, the UMass team is working with colleagues at Rutgers, the University of Wisconsin-Madison, the University of Michigan Ann Arbor, Duke University, MIT, and the University of Nebraska-Lincoln to build the overall architecture, put protocols in place to substantiate the architecture, and develop working prototype code.

Jim Kurose

Arun Venkataramani

Tilman Wolf

Michael Zink

Anna Nagurney

According to Venkataramani, issues of mobility and security can be addressed simultaneously by separating names, or endpoint identifiers, from their addresses, or network locations. By conflating the two, he says, the current system poorly supports mobility and leaves IP addresses vulnerable to hijacking. A key innovation in MobilityFirst is the Global Name Service, or GNS—software designed specifically to support mobility in a seamless, secure manner. Logically centralized but physically geo-distributed, GNS is a cloud-based infrastructure that maintains information about people and their associated locations and enables "context-based communication," meaning that it generalizes name- or address-based communication. In developing the technology, the team realized its potentially revolutionary implications for notification systems around the globe. Because the software stores basic identification information, can pinpoint one's various mobile devices (phone, iPad, or even a car GPS), and can send contextualized messages, it is easy to imagine how it could alert people traveling in a certain direction of an imminent traffic obstruction or even a developing tornado. It can also customize different messages to different people—for example, one warning to senior citizens and a different one to first responders.

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Wolf and Nagurney are leading another FIA project, ChoiceNet, an Internet "economy plane" designed to provide greater economic incentives for service providers and more options for users. Imagine sitting down to a movie marathon on a rainy Sunday with your family and purchasing, for that day only, high-speed, high-definition streaming options. Or imagine working from home while your office is being renovated, and purchasing high-speed options for just two weeks rather than for a whole month or more. Wolf and Nagurney say that such options would not only be more convenient for users but would force competition between service providers, leading to better technologies overall and more competitive prices. "Our project is about giving people choice," says Wolf. "We're trying to think about how we can restructure Internet architecture so that we can actually incentivize providers to deploy new and innovative protocols and services in the network."

Wolf began thinking along these lines during a previous NSF project in which he attempted to improve the functionality of routers within the Internet network. He and his team felt discouraged knowing that their work would not readily be deployed under the current model because providers had no incentives to spend the money to improve the technology. ChoiceNet, he explains, opens new doors for network-based services and builds economic relationships for services across various time scales.

Wolf, the project's PI, is leading a team across the UMass Amherst, UKentucky, NC State, and UNC campuses. An engineer, he partnered with Nagurney to ensure that the technology he is developing includes the right economic incentives. Nagurney and her graduate students are investigating the behavior of various stakeholders in order to better understand the competitive environment and its pricing, service-quality, and provider-profit implications.

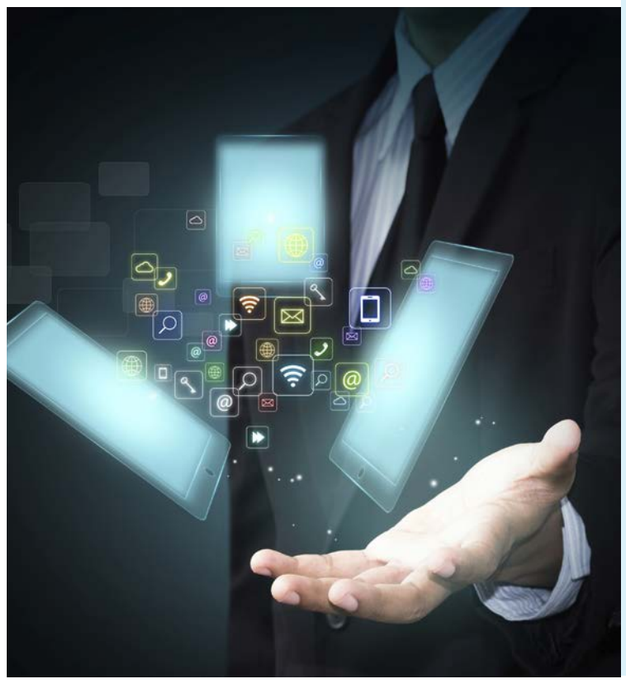
Zink, also a co-director on the campus's CASA (Collaborative Adaptive Sensing of the Atmosphere) Engineering Research Center, is working with other colleagues on a subsequent grant to layer their advanced radar technology over the GNS to enhance its capabilities. As a planned field trial, Zink and his colleagues will work in coordination with the National Weather Service and the CASA radar test-bed in Texas to demonstrate the effectiveness of context-based hazardous-weather warning apps.

One important aspect of the network being worked on in all FIA projects is "caching" —finding ways to more efficiently utilize storage. In the current model, the vast majority of storage and computation happens at the edge of the network, while the hardware inside the network is relatively slow and storage-poor. To that point, NSF's Global Environment for Network Innovation (GENI) program was launched along with FIA as a way to test new architectures with a more cutting-edge network that implements advanced hardware. Because the Internet serves billions daily, it has been difficult to experiment with alternative Internet architectures while in "production mode," which Kurose likens to "changing the engine of an airplane while it's flying."

The GENI program addresses that issue by funding projects to help build a smarter, faster experimental platform on which to test the FIA projects and other Internet-advancing projects around the globe. The platform is a working infrastructure strictly for research traffic, not commercial. In a project closely aligned to GENI through an NSF CC-NIE (Campus Cyberinfrastructure – Network Infrastructure and Engineering) grant, Zink says that he and his colleagues will soon install new switches to connect UMass Amherst with the Massachusetts Green High Performance Computing Center in nearby Holyoke, a data center dedicated to research computing.

A platform called NSF-Net predates GENI, having been used since the 1980s, before the Internet was commercialized in 1993. Now that the Internet is used by so many on a day-to-day basis, Zink explains, the industry is more likely to insert the GENI platform's more advanced aspects into the current model than to switch to an entirely new system.

"I think they'll adopt whatever's interesting for them," Zink says.



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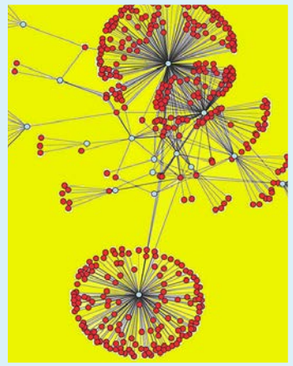

Top left: Procerusternarchus pixuna, the new electric fish species collected in shallow tributaries of the upper Negro river, a tributary of in Amazon River in Brazil.

Top right: A sheet of 'green geckskin' (left) alongside its inspiration, the gecko lizard. The renewable adhesive is made with natural rubber impregnated into stiff natural fiber fabrics such as cotton, hemp and jute. (Photo: Mike Bartlett, Al Crosby, Duncan Irschick)

Bottom: A graphic depiction of the citation networks of two federal agencies – the Environmental Protection Agency/EPA (on right) and Health and Human Services/HHS (middle far left), comparing their use of science in policy decision-making. (Photo: ScERG Research Group)

Electric Fish Genus and Species Discovered

As reported in the Proceedings of the Academy of Natural Sciences of Philadelphia, UMass Amherst biologist Cristina Cox Fernandes and colleagues at Brazil's Instituto Nacional de Pesquisas da Amazônia have discovered a new genus and species of electric knifefish in tributaries of the Rio Negro in Amazonia. True to their name, these fish produce electric discharges in distinct pulses that can be detected by other fish. Cox Fernandes says the discovery is leading to a new interpretation of classifications and interrelationships among closely related groups. She adds that as the diversity of electric fishes becomes more thoroughly documented, researchers will be able to explore possible causes of their adaptive radiation over evolutionary time.

Super Adhesive Gets Trademark, Goes Green

Traditional adhesives, usually petroleum-based and often single-use, are a sustainability challenge. At UMass Amherst, however, the inventors of flexible, reusable Geckskin—of which an index-card-sized swatch can support hundreds of pounds—have now redesigned it using renewable materials.

"Green Geckskin" has been trademarked by the university from the polymer science and engineering team of Professor Al Crosby and researcher Michael Bartlett. They, along with such others as biology Professor Duncan Irschick, introduced Geckskin in 2012. The adhesive mimics a gecko's ability to strongly and repeatedly attach its toes to surfaces yet easily detach them.

Bartlett and Crosby say that the shift toward sustainable adhesives could both have a significant impact on the environment and increase the adhesive's effectiveness. They anticipate exciting applications for the product, including using it to easily apply and detach solar panels to provide a portable charge for electronic devices at several locations over the course of a day.

UMass Scientists Among the World's Most Influential

Eight University of Massachusetts Amherst faculty members are among "the world's leading scientific minds of our times," according to a survey by multinational media and information firm Thomson Reuters.

The Thomson Reuters list recognizes as "2014 Highly Cited Researchers" food scientists Eric Decker, David Julian McClements and Yeonhwa Park; chemist Vincent Rotello; polymer scientist Thomas Russell; soil chemist Baoshan Xing; microbiologist Derek Lovley, and astronomer Mauro Giavaliso. They are all College of Natural Sciences faculty members.

"No matter what methodology we apply, we know that all eight of these researchers are engaged in incredibly high-quality science and are having truly significant impacts on their fields of study," notes College of Natural Sciences Dean Steve Goodwin.

Faculty to Study Research Impacts on Regulatory Policy

UMass Amherst political scientists Bruce Desmarais and John Hird have been awarded $527,233 from the National Science Foundation to study how scientific research informs regulatory policymaking.

Using the best available science is an important component of effective rulemaking and is legally required by executive orders signed by U.S. presidents from Reagan through Obama. The scientific basis