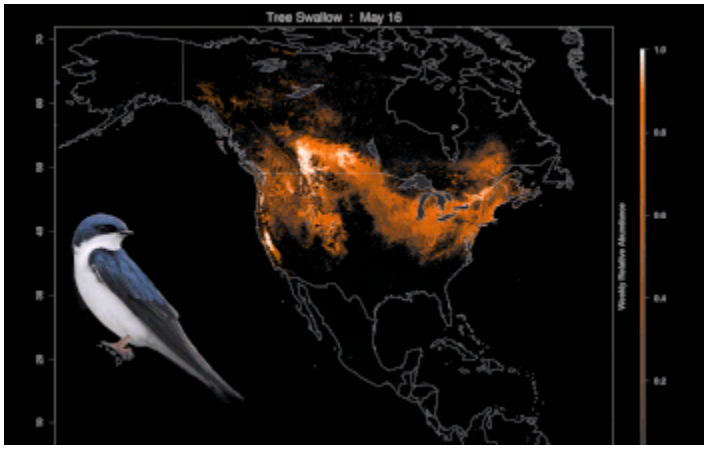
National Science Foundation
WHERE DISCOVERIES BEGIN

News Release 16-003

NSF commits $30 million to expand the frontiers of computing

Expeditions in Computing grants span theoretical computer science, synthetic biology and computational sustainability



One expedition will study computational sustainability. Shown: Annual abundance of the tree swallow.

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January 7, 2016

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The National Science Foundation (NSF) today announced $30 million in funding to three Expeditions in Computing projects. Each grant will provide $10 million over five years to interdisciplinary, multi-investigator research teams to support transformative computing and information technology research. The Expeditions projects constitute the largest single investments in computer and information science research NSF has made.

The three projects are led by researchers at Princeton University, Boston University and Cornell University, and include scholars at 14 colleges, universities and labs across a wide range of disciplines. The projects aim to explore the frontiers of theoretical computer

science, synthetic biology and computational sustainability. They will pursue new formal methods for software development, a novel toolkit for computational bio-design and a large national and international network of computational sustainability researchers.

The Expeditions in Computing program catalyzes far-reaching research motived by deep scientific questions that have the potential for significant societal benefit. Examples include the development of robotic bees, advances in software-defined networking and new programming models that make data analytics faster. The grants enable concurrent research advances in multiple disciplines, which is often necessary to stimulate deep, enduring outcomes.

"The Expeditions in Computing program enables the computing research community to pursue complex problems by supporting large project teams over a longer period of time," said Jim Kurose, NSF's head for Computer and Information Science and Engineering. "This allows these researchers to pursue bold, ambitious research that moves the needle for not only computer science disciplines, but often many other disciplines as well."

Initiated in 2008, the Expeditions program has funded 19 projects to date, with a total investment of approximately $190 million. The program has had transformative impacts on numerous fields ranging from robotics to next-generation networking to hardware circuit design. Earlier projects are beginning to transition their innovations to practice through follow-on funding from industry. (Learn more about past Expeditions projects <http://www.nsf.gov/cise/ccf/expeditions_awds.jsp> .)

The new Expeditions projects announced today are:

The Science of Deep Specification -- Principal Investigator: Andrew Appel, Princeton University; partnering institutions: University of Pennsylvania, Yale University, Massachusetts Institute of Technology

This new NSF grant aims to eliminate software "bugs" that can lead to security vulnerabilities and computing errors by improving the formal methods -- or the mathematically based techniques -- by which software is developed and verified.

The researchers' initial challenge will involve dissecting the complexity of modern hardware and software to uncover factors that determine how various computer components work together. The next step entails developing "deep specifications" — precise descriptions of the behavior of software elements based on formal logic. These deep specifications will enable engineers not only to build bug-free programs, but to verify that their programs behave exactly as they intend.

"In our interconnected world, software bugs and security vulnerabilities pose enormous costs and risks," Appel said. "When you press the accelerator pedal or the brake in a modern car, for instance, you're really just suggesting to some computer program that you want to speed up or slow down. The computer had better get it right."

The team will also develop new courses and curricular materials at their universities to train the next generation of software developers to use the new, improved methods.

Evolvable Living Computing -- Understanding and Quantifying Synthetic Biological Systems' Applicability, Performance, and Limits -- Principal Investigator: Douglas Densmore, Boston University; partnering institutions: Massachusetts Institute of Technology, Lincoln Labs

The field of synthetic biology has made great strides and yielded tremendous benefits in recent years. For example, early synthetic biology efforts led to the production of antimalarial drug precursors in quantities not seen in nature. Using biological building blocks to engineer biological systems, however, has been difficult without a clear design methodology and supporting quantitative metrics that researchers can use to make decisions.

This NSF grant will support efforts to create a systematic set of guidelines to carefully measure and catalogue biological parts that can be used to engineer biological systems with predictable results. These guidelines will allow researchers to better understand what computing principles can be applied repeatedly and reliably to synthetic biology.

"This puts a stake in the ground to make synthetic biology more rigorous," said Douglas Densmore, associate professor at Boston University. "We want to build a foundation that's well understood and that can serve as an open-source starting place for many advanced applications."

The grant marks the first time researchers will explicitly explore computing principles in multiple living organisms and will openly archive the results.

CompSustNet: Expanding the Horizons of Computational Sustainability -- Principal Investigator: Carla Gomes, Cornell University; partnering institutions: Bowdoin College, California Institute of Technology, Carnegie Mellon University, Georgia Institute of Technology, Howard University, Oregon State University, Princeton University, Stanford University, University of Massachusetts-Amherst, University of Southern California, Vanderbilt University

Computational sustainability aims to apply computational techniques to balance environmental, economic and societal needs to support sustainable development and a sustainable future.

CompSustNet will act as a large national and international multi-institutional research and education network, collaborating with key governmental and non-governmental organizations in the areas of conservation, poverty mitigation and renewable energy. The researchers will use computational techniques and methodologies to increase the effectiveness of the management and allocation of natural and societal resources.

"Our NSF Expedition brings together computer scientists and engineers, environmental and social scientists, physicists, and materials scientists charged with growing and expanding the horizons of the nascent field of Computational Sustainability," Gomes said. "Advances in computational sustainability will lead, for example, to novel strategies to help herders and farmers in Africa improve their way of life, save endangered species and scale renewables up to meet 21st century energy demand."

Gomes led a team that received one of the first Expeditions grants in 2008. Initial funding from NSF led to more than $80 million in support from other agencies and organizations and helped stimulate the field of computational sustainability. As a result of the pioneering efforts of the original Expeditions grant, universities are starting to teach computational sustainability as a discipline in its own right.

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The Living Computing Project will create a systematic set of guidelines for synthetic biology.
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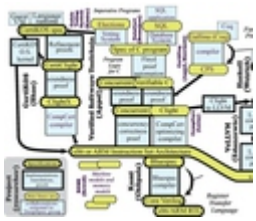

A diagram of the network of deep specifications and the artifacts connecting them.
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See some of the research carried out by past Expeditions in Computing awardees.
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Media Contacts
Aaron Dubrow, NSF, 703-292-4489, adubrow@nsf.gov (mailto:adubrow@nsf.gov)

Program Contacts
Mitra Basu, NSF, 703-292-8910, mbasu@nsf.gov (mailto:mbasu@nsf.gov)

Principal Investigators
Andrew Appel, Princeton University, 609-258-4627, appel@princeton.edu (mailto:appel@princeton.edu)
Douglas Densmore, Boston University, 617-358-6238, dougd@bu.edu (mailto:dougd@bu.edu)
Carla Gomes, Cornell University, 607-255-9189, gomes@cs.cornell.edu (mailto:gomes@cs.cornell.edu)

Related Websites
The Science of Deep Specification: http://deepspec.org/ (/cgi-bin/good-bye?http://deepspec.org/)
Living Computing Project: http://programmingbiology.org/ (/cgi-bin/good-bye?http://programmingbiology.org/)
Computational Sustainability Network: http://www.compsust.net/ (/cgi-bin/good-bye?http://www.compsust.net/)
Expeditions in Computing program page: http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503169 <http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503169>

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National Science Foundation, 2415 Eisenhower Avenue, Alexandria, Virginia 22314, USA Tel: (703) 292-5111, FIRS: (800) 877-8339 | TDD: (800) 281-8749