Research Strategies in Informatics at NSF

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11th SCJ Symposium on Informatics
http://www.nsf.gov/CISE
Agenda

I. NSF & CISE Context
II. Focus: Smart & Connected Communities
III. Focus: Secure & Trustworthy Cyberspace
IV. Research Strategy: Partnerships
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Mission of the National Science Foundation

“To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...”
NSF by the Numbers

- $7.72 billion FY 2016 budget request
- 94% funds research, education and related activities
- 50,000 proposals
- 11,000 awards funded
- 2,000 NSF-funded institutions
- 300,000 NSF-supported researchers
- 217 Nobel Prize winners

Fund research in all S&E disciplines
Fund STEM education & workforce
NSF: Seven Directorates
Covering all fields of science and engineering
NSF Big Ideas for Future Investment
(announced 2 May 2016)

- Harnessing Data for 21st Century Science & Engineering
- Shaping the Human-Technology Frontier
- Understanding the Rules of Life: Predicting Phenotype
- The Quantum Leap: Leading the Next Quantum Revolution
- Navigating the New Arctic
- Windows on the Universe: The Era of Multi-messenger Astrophysics

- Growing Convergent Research at NSF
- Mid-Scale Research Infrastructure
- NSF 2050
The Data Revolution

Experimental  Theoretical  Computational  Data
NSF Big Data & Data Science Programs

**BIGDATA** (foundations)
**CDS&E** (Computational and Data Science and Engineering)
**QuBBD** (Quantitative Approaches in Biomedical Big Data)
**BDD** (Big Data and Disaster Research)
**FutureCloud** (CISE/CNS)...

**CC**: Campus Cyberinfrastructure
**DIBBS**: Data Infrastructure Building Blocks
**RIDIR**: SBE resource building
**BCC**: EHR resource building...

**NRT**: NSF Research Traineeship (with emphasis on Data-Enabled Science & Engineering)

**Big Data** Regional Hubs and Spokes
**Workshops** (National Academy, WH, NSF)
NSF Support of Academic Basic Research
(as a percentage of total federal support)

- All Science and Engineering Fields: 24%
- Physical Sciences: 40%
- Engineering: 41%
- Environmental Sciences: 59%
- Mathematics: 61%
- Social Sciences: 67%
- Biology: 68%
- Computer Science: 83%

Source: NSF/NCSES, Survey of Federal Funds for Research & Development
Focus: CISE

Office of the Director

- Biological Sciences
- Computer & Info Science and Engineering
- Education and Human Resources
- Engineering
- Geoscience
- Mathematical and Physical Sciences
- Social, Behavioral and Economic Sciences
CISE Research Investments

Exploring the frontiers of computing

- Strong commitment to core/fundamental research – the heart of what we do.
- Cast a broad net & let the best ideas surface.
- Engage with our community to develop new research directions.
Engaging the CISE Research Community

*NSF uses many ways to interact*

“Rotating” scientific staff
Academics spend 2-4 years at NSF in science leadership positions (~45% of CISE science staff)

Proposal Review Panels
(372 panels in 2016)

Research Workshops
(91 workshops in 2016)

CISE Advisory Committee
(~20 leaders: academia, industry)

Requests for Input, Dear Colleague Letters
Formal requests for input

Committee of Visitors
Quadrennial review of merit review process, portfolio

Collaborative Research Solicitations with Industry
SRC, Intel, VMWare
CISE by the Numbers: FY 2017

- **$936 M** research budget
- **8,723** proposals
- **390** panels
- **1,819** awards
- **17,778** people supported
- **21% success rate**
- **7,230** senior researchers
- **1,086** other professionals
- **489** postdoctoral associates
- **6,539** graduate students
- **2,624** undergraduate students
Computer & Network Systems Programs

Exploring Systems, Building Research Infrastructure, Preparing Future Generations, Encouraging Innovation

Research

Core:
- Computer Systems Research (CSR)
- Network Technology & Systems (NeTS)

Crosscutting:
- Secure & Trustworthy Cyberspace (SaTC)
- Cyber-physical Systems (CPS)
- Smart & Connected Communities (S&CC)

Infrastructure for Systems Research

Education & Workforce Development

Industry & Entrepreneurship (Joint with ENG)
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Cyber-Physical Systems (CPS)

Deeply integrating computation, communication, and control into physical systems

- Developing the core system science to engineer complex, “smart” systems that interact with the physical world
- Joint program with ENG directorate, other federal agencies
  - DHS, DoT, USDA, NIH
- About $31.5M in FY2017

Transportation
- Faster and safer aircraft
- Improved use of airspace
- Safer, more efficient cars

Energy and Industrial Automation
- Homes and offices that are more energy efficient and cheaper to operate
- Distributed micro-generation for the grid

Healthcare and Biomedical
- Increased use of effective in-home care
- More capable devices for diagnosis
- New internal and external prosthetics

Critical Infrastructure
- More reliable power grid
- Highways that allow denser traffic with increased safety
NSF Cyber Physical Systems Research Model

• Abstract from sectors to more general principles – and apply these to problems in new sectors
• Thriving CPS community – over 350+ current funded researchers
• Multiple agency participation (DHS, DoT, NASA, NIFA, and NIH)
• Investment
  – Over $300M cumulative
  – 350+ awards
• Over $40M in awards for each of FY14 - FY17
• Program and research of global Interest
  – Multiple emerging collaborations
Smart & Connected Communities

Planning for the Future, Building on CNS and NSF Investments

• Goal: “accelerate the creation of the scientific and engineering foundations that will enable smart and connected communities to bring about new levels of economic opportunity and growth, safety and security, health and wellness, and overall quality of life.”

• Partnership among CISE, ENG, EHR, GEO and SBE directorates

• Current solicitation is open: NSF 18-520
Smart & Connected Communities
Program Research Model

• Scientific & Engineering Foundations to enable cities/communities to bring about new levels of economic opportunity & growth, safety & security, health & wellness
• Build research community
• Integrative research projects that pair advances in technical and social dimensions with community engagement
1. Integrative Research
   – Technical + Social aspects
Pillars of the Program
Proposal Requirements for FY 2018

2. Meaningful Community Engagement
   – Community stakeholders involved in project
3. Management Plan

- Ensure collaboration across disciplines, sectors
Pillars of the Program
Proposal Requirements for FY 2018

4. Evaluation Plan
   – How success is defined & progress measured
Pillars of the Program
Proposal Requirements for FY 2018

- Award size: $750K-$3M
- FY18 is 2nd year of program
- Anticipated total: $19M (all directorates)
Iterative Science and Engineering Research in Partnership with Communities

Partnerships enable piloting, testing, and future research in communities to improve community functioning and quality of life.
Data-Informed Modeling and Correct-by-Design Control Protocols for Personal Mobility in Intelligent Urban Transportation Systems

Lillian J. Ratliff (PI, UW); Behcet Ackimese (Co-PI, UW); Samuel Coogan (Co-PI GaTech); Juan Matute (Sen. Per., UCLA)

Challenge:
• Unified, data-driven approach to modeling and control of parking, ride-sharing, and traffic flow in urban areas, incorporating incentives & demand-based pricing for parking, incentives for ride-sharing, and traffic light control.

Integrative Research:
1) Data-informed stochastic system mobility models including Markov Decision Processes and Stochastic Games
2) Correct-by-design optimal decision policy synthesis using formal methods and convex optimization.
3) Verification and validation of decision-making algorithms through rigorous simulation and living lab experiments

Community Engagement & Impact:
• Stakeholders include commercial districts in the partner cities (Seattle, Santa Monica, LA) and serve very diverse communities.
• Goal: identify real-world conditions and policy objectives to inform the research
• Mobility Policy/Engineering Bootcamps to engage students & community

Collaborators:
Overcoming Social And Technical Barriers For The Broad Adoption Of Smart Stormwater Systems

Research Team: Branko Kerkez (PI)\(^1\), Jon Hathaway\(^2\), Jon Goodall\(^3\), Teresa Culver\(^2\), Lisa Reyes Mason\(^2\), Noah Webster\(^2\), Joan Nassauer\(^1\), Ruben Kertesz\(^4\)

Community Team: Evan Pratt\(^5\), Ric Lawson\(^6\), Santiago Garces\(^7\), Chris Howley\(^8\), Dawson Garrod\(^9\)

\(^1\)University of Michigan, \(^2\)University of Tennessee, \(^3\)University of Virginia, \(^4\)EmNet, \(^5\)Washtenaw County, \(^6\)Huron River Watershed Council, \(^7\)City of South Bend, \(^8\)City of Knoxville, \(^9\)Facilities Engineer
US Smart Cities/Communities Focus

Activities Across the US Government Gain Momentum in 2015

Coordination efforts began in June 2016

Smart Cities and Communities Task Force (SCC)
US Federal Smart Cities and Communities Task Force

- Multi-agency group chartered (under NITRD) in 2016 to develop Resource Guide and Federal Strategic Plan
  - Led by NSF, NIST, DoT
- Draft released for public comment, January 2017
**Smart Cities & Communities Strategic Plan (draft 1/2017)**

**Strategic Goals**
- Understand local needs
- Accelerate innovation & infrastructure improvement
- Facilitate cross-sector collaboration, bridge silos
- Boost exports, promote US leadership
- Support people-centered solutions that support job growth

**Strategic Priorities**
- Accelerate Fundamental R&D
- Facilitate secure & resilient infrastructure, systems & services
- Foster data sharing, best practices, and collaboration
- Enable evaluation of progress and long-term growth
Example: NSF Support for GCTC Project Team & DOT Smart City Challenge Researchers

**EAGER: Electric Shuttles for Safe and Reliable First-Mile, Last-Mile Mobility**

- Developing scalable and adaptable architecture and control system for first-mile, last-mile autonomous shuttle solution, part of DOT Smart City Challenge winning team
- Partnerships with Easton Town Center, the proof-of concept demo site; the City of Columbus to replicate results in other parts of the city; and Innova UEV, manufacturer of the electric vehicles
- Partnering to scale and replicate technology to several U.S. cities

Image Credit: Meghan Murphy  
photo: Meghan Houghton

(Guvenc, et al., Ohio State University)
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Overview of NSF's Secure and Trustworthy Cyberspace (SaTC) Program

- NSF's flagship research program for research in cybersecurity & privacy
- Supports an interdisciplinary community of security & privacy researchers
- One of the largest science programs in NSF
  \[ \sim \$80M \text{ total in FY17} \]
Secure and Trustworthy Cyberspace (SaTC)

Securing Our Nation’s Cyberspace

• Promoting cybersecurity research and development to "change the game"
  – Establish a science of cybersecurity
  – Minimize the misuses of cyber technology
  – Bolster education and training in cybersecurity
  – Transition promising cybersecurity research into practice

• Aligned with national cybersecurity strategy*

*Federal Cybersecurity R&D Strategic Plan and National Privacy Research Strategy
SaTC Research Areas

Access Control  Authentication  Biometrics  Cloud  Cyber Physical Systems

Cryptography  Economics  Engineering  Data Science  Forensics

Formal Methods  Hardware Security  Human Aspects  Internet of Things  Intrusion Detection

Mathematical Sciences  Network Security  Privacy  Programming Languages  Social & Behavioral Sciences

Social Networks  Software Security  Statistics  System Security  Usability
SATC Frontiers Portfolio: 2012-2016

**Data Privacy**
- Harvard University
- $4.8M for 4 years

**Socio-economic**
- UCSD, Berkeley, GMU
- $10M for 5 years

**Healthcare**
- Enabling Trustworthy Cybersystems for Health and Wellness (2013)
- Dartmouth, UIUC, JHU, Michigan
- $10M for 5 years

**Web Privacy**
- CMU, Fordham, Stanford
- $3.75M for 4 years

**Trust in Cloud**
- UNC, NCSU, Stony Brook, Duke, Wisconsin-Madison
- $6M for 5 years

**Outsourced Computation**
- Modular Approach to Cloud Security (2014)
- BU, MIT, Northeastern, U. Connecticut
- $10M for 5 years

**Program Obfuscation**
- Center for Encrypted Functionalities (2014)
- UCLA, Stanford, Columbia, UT Austin, JHU
- $4.9M for 5 years
Reprogramming Automobiles

Tadayoshi Kohno & Shwetak Patel (U Washington) and Stefan Savage & Ingolf Krueger (UCSD)

Figure 6. Displaying an arbitrary message and a false speedometer reading on the Driver Information Center. Note that the car is in Park.
Secure Telerobotics

Howard Jay Chizeck & Tadayoshi Kohno (U Washington)

- Telerobotics have human operators interacting with robots through a computer network
  - Ex: remote battlefield surgery by robot
- How can malicious activities against the robot be prevented (and corrected)?
- Project adapts and extends security methods to these systems
  - Remote navigation and control of robotic systems
  - Real-time verification of operator’s requests vs. robot’s actions
  - Timely, reliable detection of discrepancies that suggest spoofed operator movements

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Partnerships: Important Strategy Component

Why partner?
Partnerships: Important Strategy Component

Why partner?
• Build capacity
Partnerships: Important Strategy Component

Why partner?

• Build capacity
• Leverage resources, strengths
Partnerships: Important Strategy Component

Why partner?

- Build capacity
- Leverage resources, strengths
- Share knowledge & best practices
Partnerships: Important Strategy Component

Why partner?

• Build capacity
• Leverage resources, strengths
• Share knowledge & best practices
• Increase speed of translation from discovery to practice
Partnerships at NSF: Many Dimensions

- industry
- universities
- local gov'ts
- societal org's
- federal agencies
- international

NSF CISE

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Partnerships at NSF: Many Dimensions

- NSF-BSF (Israel): CCF+CNS Core, SaTC
- NSF-Finland: WiFiUS
- NSF-Japan: BDD, JUNO, TransPAC 100G
- NSF-Netherlands: Privacy
- NSF-Brazil: Cybersecurity
- NSF-EU (& others): research infrastructure federation
Partnerships at NSF: Many Dimensions

- Cyber-Physical Systems:
  - DHS, DOT, NASA, USDA
- National Robotics Initiative (NRI):
  - DARPA, NASA, NIH, USDA
- Collaborative Research in Computational Neuroscience:
  - NIH
- NITRD:
  - Working Groups
  - R&D Strategic Plan activities
Partnerships at NSF: Many Dimensions

- Joint NSF-industry solicitations:
  - Intel (5)
  - VMware (1)
  - SRC (5)

- Research Infrastructure:
  - PAWR
  - Cloud credits (AWS, Google, Microsoft)

- University-based:
  - IUCRC
  - Intrans
  - GOALI
US-Japan Big Data and Disasters

BDD: NSF 14-575

• Joint NSF-JST program
• Grew out of earlier SAVI (GRAIT-DM) & May 2013 workshop
• Focus areas:
  – Capturing and processing data associated with disasters
  – Improving resilience/responsiveness of computers and networks in disaster zones
• Six collaborative projects funded, PI meetings
Japan-US Networking Opportunity

**JUNO2: NSF 17-586**

- Third Joint NICT-NSF program
- Grew out of March 2016 Workshop
  - Trustworthy Networking for Smart & Connected Communities
- Focus areas:
  - Trustworthy IoT/CPS Networking
  - Trustworthy Optical Networking
- Proposals now under review
Platforms for Advanced Wireless Research

• **Public-private partnership** to deploy an array of mid-scale research platforms on various topics
  – “Pre-competitive” research areas (3-8 years out)
  – Proposed by community-University teams
  – Industry involvement a key component

• **Four experimental platforms over next five years**
  – “City-scale” (not necessarily city-size)
  – 10-20 antenna sites, backhaul
  – ~100 SDR-based clients (experimental, not production)

• **Investment:** $100M over next 5-7 years
  – $50M NSF + $50M from Industry Consortium
  – Expected 7+ year lifetime
PAWR Structure

Industry Consortium

NSF

PAWR Project Office

Platform Proposals

Research Community
PAWR Leverage

• Companies and NSF pool resources
• Expanded capabilities for academic researchers
• Companies access NSF’s community of 400+ wireless researchers
• Academics access industry's know-how and real-world challenges
• Communities "live in the future"
Takeaways

• Secure Smart Connected Communities are an important focus area at NSF.
• Technology is not enough – community involvement is required at many levels.
• There is still a great deal of research to be done.
• Partnering is an amplifier.
• Partnerships are a key part of NSF strategy going forward.
Thank You!

Questions?
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