

Overview of DIMACS

Fred Roberts
DIMACS

September 12, 2019
Mixer – Microsoft Research - NYC

DIMACS

*Center for Discrete Mathematics & Theoretical Computer Science
Founded as a National Science Foundation Science and
Technology Center*



About DIMACS

- DIMACS catalyzes and conducts research and education in mathematical, computational, and statistical methods, algorithms, modeling, analysis, and applications.
- Founded as an NSF Science and Technology Center in 1989 as a partnership among Rutgers, Princeton, Bell Labs, Bellcore, and the New Jersey Commission on Science and Technology.
- Now 14 partner institutions, including Microsoft

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About DIMACS

- DIMACS was founded as the Center for Discrete Mathematics and Theoretical Computer Science.
- In some sense, this has become a misnomer.
- DIMACS has significantly expanded its scope with continuous mathematics, data science, and all kinds of application areas.
- Still, we like to put some emphasis on our roots.

Who is DIMACS?

- Offices are located at Rutgers in Piscataway, NJ; programs often held elsewhere.
- Management and staff at Rutgers.
- Over 350 members, most (but not all) from DIMACS partner institutions.

DIMACS Activities: Overview

- Special foci
- Seminar series
- International programs
- Research projects
- Women in computing
- K-12 teacher training
- CCICADA Center for data analysis and homeland security
- Implementation challenges
- Curriculum development
- Graduate student support
- Research experiences for undergraduates



Special Focus Programs

- A multi-year program of coordinated activities addressing a research topic that requires expertise from one or more DIMACS areas, that is poised for advances, and that has potential benefit to society.
- Often multi-disciplinary. Always integrate research and education.
- Typical activities:
 - workshops
 - tutorials
 - research working groups
 - seminars
 - visitors



Current Special Foci and Themed Programs

- Cryptography* 2015-2019
- Bridging Continuous and Discrete Optimization* 2018-2020
- Lower Bounds in Computational Complexity* 2019-2021
- NEW: Mechanisms and Algorithms to Augment Human Decision Making 2019-2022
- *Collaboration with Simons Institute at Berkeley

Selection of Past Special Foci and Themed Programs

- Mathematics of Planet Earth 2013-2018
- Energy and Algorithms 2012-2017
- Algorithmic Decision Theory 2010-2013
- Algorithmic Foundations of the Internet 2007-2014
- Discrete Random Systems 2006-2010
- Information Processing in Biology 2004-2011
- Computational and Mathematical Epidemiology 2001-2011

Potential Special Foci

- Computational Foundations of Automation and Robotics
- Socially Responsible Algorithms
- YOUR IDEAS



Implementation Challenges

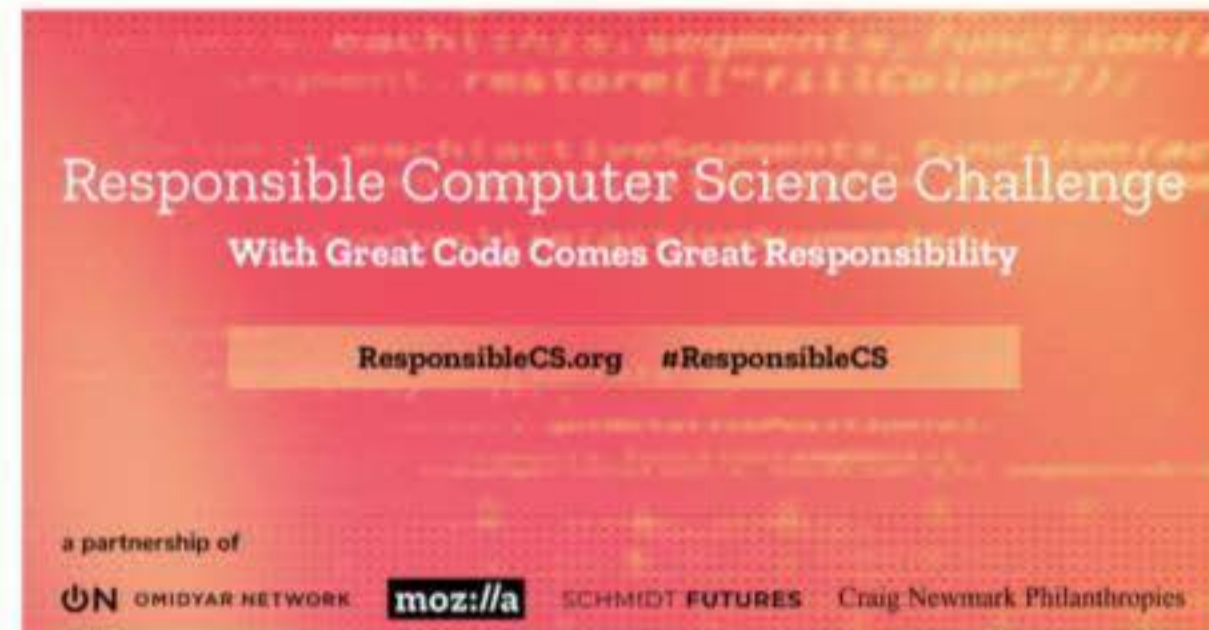
- Complements analysis with experimentation:
 - provides guides to realistic algorithm performance where analysis fails.
 - brings algorithmic questions closer to the motivating problems.
 - tests assumptions about implementation methods and data structures.
 - develops problem instances, instance generators, and other methods of testing and comparing algorithms.
 - provides leading edge implementations of algorithms.
- We have received funding for the 12th Implementation Challenge, on Vehicle Routing Problems.
 - the first since David Johnson's death, held in his honor
 - culminating workshop to be held in Fall 2020

Curriculum Development

- Module development projects partner subject matter experts and education experts, working with partner schools, to develop curricular materials on topics of importance.
- Biology and mathematics:
 - 5-day modules for high school biology and mathematics classes.
 - a senior-level biomathematics course.
- Computational thinking across the curriculum:
 - 5-day modules that introduce computational thinking ideas and skills intended for use in a wide variety of high school courses.
 - expected new project on professional development for high school teachers in computational thinking
- Sustainability:
 - 5-day modules for high school in mathematical, computational, and modeling topics related to planning for a sustainable future.

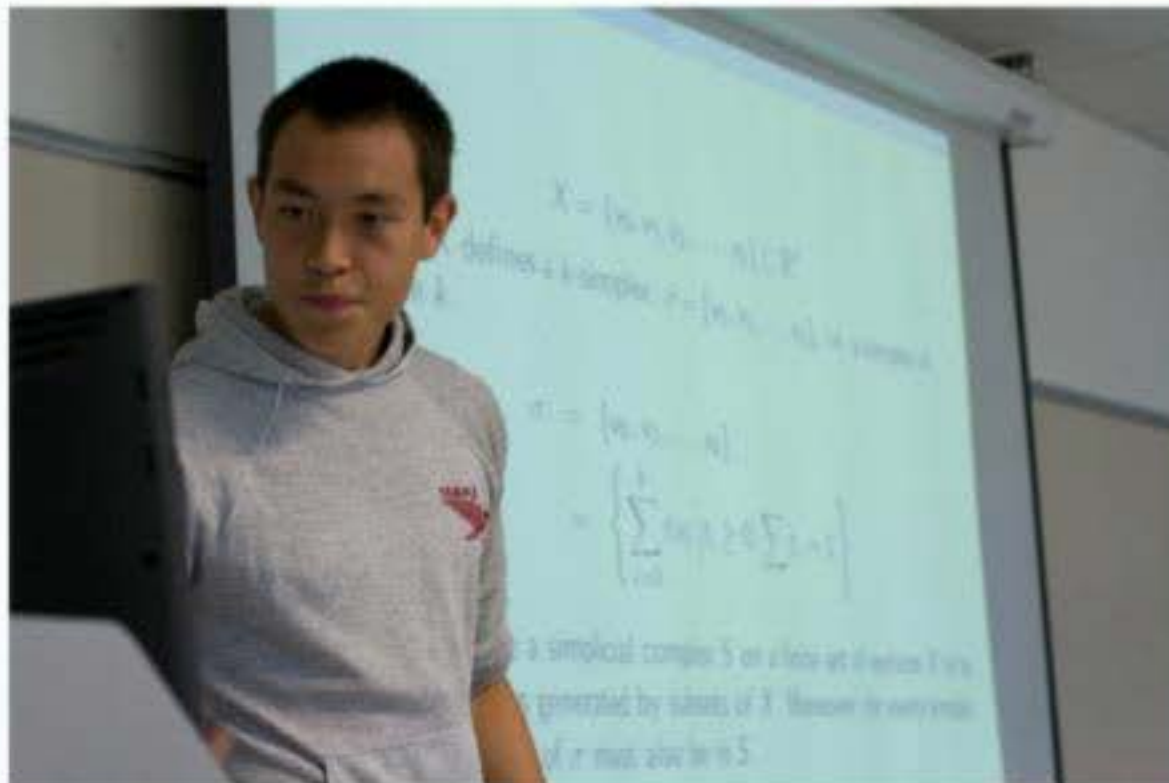
Curriculum Development

- Computational thinking professional development online
 - How to teach computational thinking in your classroom
- Intelligence community center of academic excellence
 - Developing a critical technologies studies program
- Responsible computer science
 - Bringing ethics into data science and machine learning courses
 - Under development



Research Experiences for Undergraduates

- Around 35 students each summer
- Students are matched with faculty mentors for one-on-one or small-group research experiences
- NSF site grant
- International partnership with DIMATIA at Charles University in Prague



Reconnect Program

- Introducing undergraduate faculty to current research topics ripe for their classroom
- Mostly faculty no longer doing research
- Weeklong program at different locations each year
- Not just lectures: Participants develop modules for classroom use
- Modules reached over 35,000 students



Reconnect Program: Recent Topics

- 2019: Cryptography
 - Champlain College
- 2018: Not in My Backyard: Mathematical and Computational Tools for Decision Making
 - Muhlenberg College
- 2017: Energy Efficiency and Reliability of Data Centers and the Electrical Grid
 - Appalachian State University
- 2016: Cyber security
 - West Point
- 2015: Social Networks and Homeland Security
 - Rochester Institute of Technology
- 2020: Topic TBD

Douglass-DIMACS Computing Corps

- A technical, leadership, and outreach program for Rutgers undergraduates interested in computing.
- Students carry out computing activities (including Girls Who Code modules) with Piscataway and other local middle schools and Girl Scout troops.



Computer Science Living-Learning Community for Women



- Students live in a common dorm on the Rutgers Busch campus where the CS department is
- A first-year seminar course on “Great Ideas and Applications in Computer Science.”
- Multi-layered mentoring including a graduate mentor, an undergraduate peer leader, a faculty advisor, and dedicated Douglass Project staff members.
- Community-building programs and events to promote student-faculty engagement.



New Initiative on Women in CS

- Curricular Revision: starting with introductory CS course.
 - Topics that might appeal to women, keep them engaged
- Co-curricular programs: Living-Learning Community
- Outreach to Middle and High Schools
- Collaboration with Big Ten universities and others
- Research on what appeals to women, what turns them away

CCICADA

- Command, Control, and Interoperability Center for Advanced Data Analysis
- Founded as a DHS University Center of Excellence
- 11 years of DHS funding
- Builds mathematical and computational foundations for data science to extract both knowledge and practical consequences from massive, complex or unstructured data.
- Mostly multidisciplinary research
- Focus on results for near-term transfer and close collaboration with agencies
- 17 academic and industrial partners
 - CMU, USC, RPI, Howard, Morgan State, Bell Labs, etc.



CCICADA

- Algorithms for efficient allocation of Coast Guard boats and aircraft
 - Large mixed integer programming problem
- Best practices for stadium security
 - Collaboration with NFL, NBA, MLB, and all major sports leagues
- Web scraping tools to counter human trafficking
 - Collaboration with FBI
- Resource allocation to prepare for oil spills in the Arctic
 - Collaboration with Coast Guard
- Voice forensics to catch serial hoax callers
 - Collaboration with Coast Guard Investigative Service
- Maritime cyber security
 - Pioneered in developing this field
- Crowd management simulation
 - For Port Authority Bus Terminal NYC



CCICADA

- Development of new fundamental tools:
 - Natural language processing
 - Higher order learning
 - Information based testing
 - Social media analytics
 - Split and conquer for penalized regression
- Education and workforce development programs
 - Fellowships/Internships
 - Reconnect
 - REU
 - Modules
 - Minority serving institution program



CCICADA: Current Projects

- With TSA: algorithms to adjudicate criminal history records in applications for transport worker identification card
- With DHS Criminal Investigations University Center of Excellence: Cyber Forensics
- Drones
- Future of Work at the Human-Technology interface in the Security Arena
- Could CCICADA be a model for another DIMACS research-oriented activity?



TRIPODS Program:

- New NSF grant; 3 year program
- Transdisciplinary Institute on Data Science
- Institute on Data Science for INtelligent Systems and People Interaction = DATA-INSPIRE.
- Math-CS-Stat
- Theoretical Foundations of Data Science
- Premise: advances in data science principles are needed to impact the emerging paradigm of intelligent machines and their convergence with human society



TRIPODS INSTITUTE

- Research Groups
- Workshops
- “Boot Camps”
- Seminars
 - Including with industrial partners
- Interaction with other TRIPODS Institutes
- REU program



Some New Initiatives/Directions for DIMACS

- Data science
- AI/ML
- Future of work at the human-technology
Interface
- Ethics in algorithms
- Cyber security
- Resilience of ecosystems, urban systems, food
systems

How to Get Involved

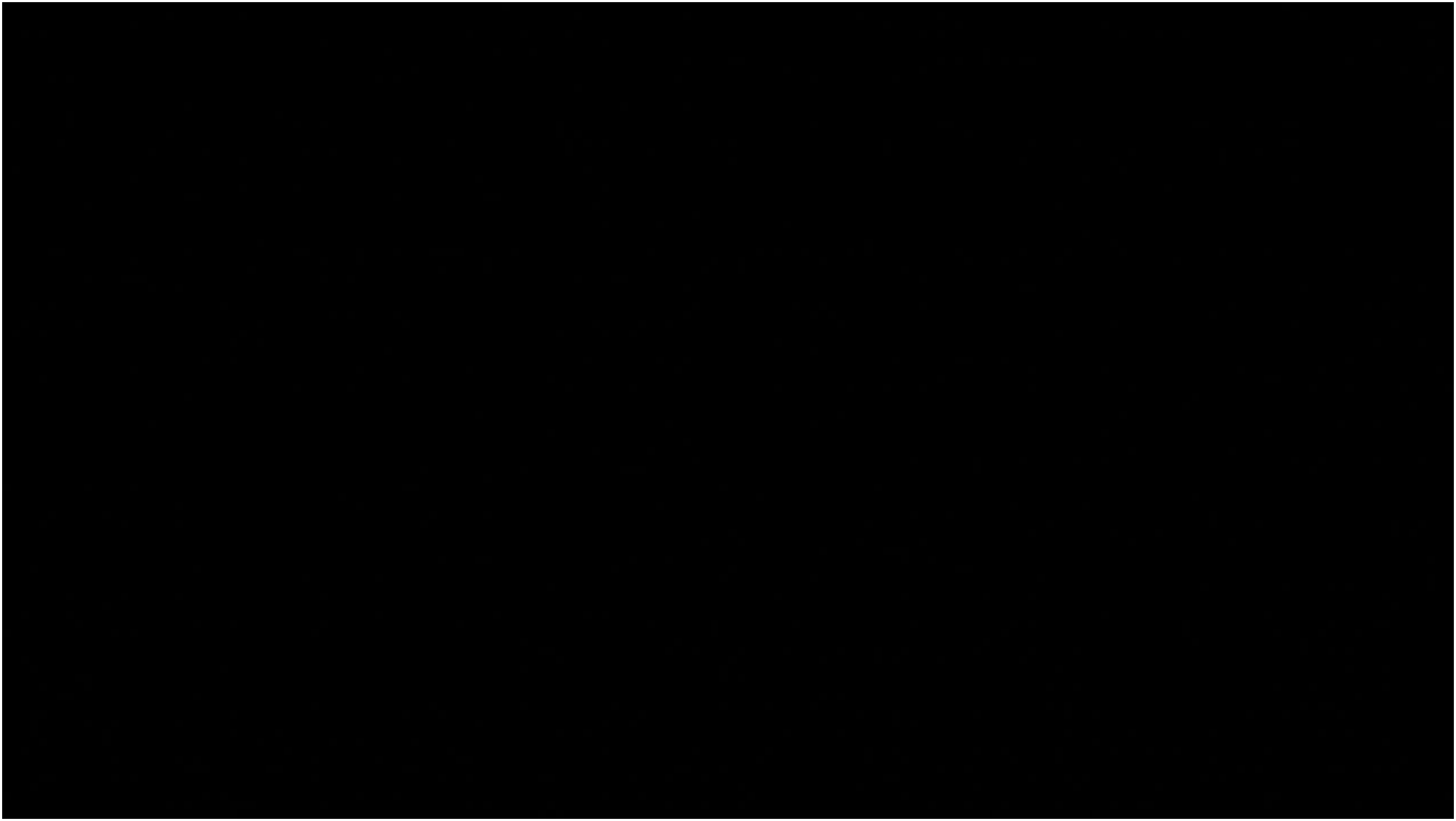
- Organize a workshop
- Suggest a workshop or special focus or research project
- Attend workshop or seminar
- Mentor REU student
- Co-sponsor a postdoc
- Organize/teach tutorials
- Write an educational module
- Serve on a DIMACS committee

DIMACS is Turning 30

- Major birthday conference
- Looking to the future in fields of DIMACS
 - Future challenges for DM/TCS
 - Future challenges for algorithms
 - Connections to AI/ML
 - Connections to Applications
 - Statistical physics, sustainability, epidemiology, security
 - Bias/Fairness
 - New educational initiatives
 - Broadening participation in STEM
 - What is the future of centers?



Nov. 21-22, 2019



Parallels between MSR-NYC and DIMACS

David M. Pennock

Principal Researcher, MSR-NYC -> Director, DIMACS in January 2020

MSR-NYC

Microsoft Research Mission

- ▶ Expand the state of the art
- ▶ Rapidly transfer innovations
- ▶ Ensure Microsoft's vibrancy and future

New York City Research Areas

- ▶ Machine learning
- ▶ Computational social science
- ▶ Digital economy
- ▶ Computer systems
- ▶ Ethical machines

DIMACS Philosophy

- ▶ DIMACS believes that progress will come at the **intersection of disciplinary boundaries**, motivated by problems in fields like chemistry, ecology, economics, engineering, environmental science, medicine, neuroscience, physics, and sociology
- ▶ DIMACS cherishes its academic and **corporate partners** who both advance and guide its mission
- ▶ DIMACS believes in **quantifying** problems and addressing them using math, statistics, and computer science tools, including algorithms, models, **competitions**, and analysis
- ▶ DIMACS seeks to **educate** a diverse cross section of students, from high school to grad school, about both the wonders and the **limitations** of technology

Some Items of Common Interest

- ▶ DIMACS Special Focus on Mechanisms & Algorithms to Augment Human Decision Making
 1. Eliciting Complex Information
 2. Algorithmic Social Choice
 3. Eliciting Beyond Labels from the Crowd
 4. Preference Aggregation
 5. Learning from Partially Reliable Data
- ▶ DIMACS funding under one of NSF's "10 Big Ideas": Harnessing the Data Revolution
 - ▶ Transdisciplinary Research In Principles Of Data Science (TRIPODS)
 - ▶ Interaction of people and intelligent machines
- ▶ DIMACS [Research Experience for Undergraduates](#) | MSR [Data Science Summer School](#)
- ▶ Rutgers Computer Science Living-Learning Community of undergraduate women interested in majoring in CS

Some Items of Common Interest

- ▶ Fairness, Accountability, Transparency, and Ethics in algorithms
 - ▶ MSR-NYC and Tri-Labs now leaders in the field, organically
 - ▶ Proposed DIMACS Special Focus on Algorithms and Society
 - ▶ Rutgers committed to adding FATE to data science and ML courses
- ▶ Optimization
 - ▶ DIMACS/Simons Collaboration on Bridging Continuous and Discrete Optimization
 - ▶ Sep 16-18, 2019: DIMACS Workshop on Randomized Numerical Linear Algebra, Statistics, & Optimization, New Brunswick - 4 people from MSR registered already!
 - ▶ Oct 7-10, 2019: CRM/DIMACS Workshop on Mixed-Integer Nonlinear Programming, Montreal
 - ▶ May 18-21, 2020: [Mixed Integer Programming Workshop & DANniversary](#), New Brunswick
 - ▶ Oct 5-7, 2020: 12th DIMACS Implementation Challenge: Vehicle Routing Problems, New Brunswick
 - ▶ March, 2021: Frontiers of Optimization Research Conference, New Brunswick
 - ▶ More: Polynomial Optimization; Continuous Approaches to Computing Discrete Partition Functions

Biggest Commonality: Great People

- ▶ MSR-NYC is the best place in the world to do research
- ▶ MSR-NYC has some of the most amazing researchers who are brilliant, tireless, and nice
- ▶ I recognized some of the same kinds of people at DIMACS: smart, effective, and kind

