LEVERAGING THE COMPUTATIONAL PERSPECTIVE IN A DATA-DRIVEN WORLD

Boston University Rafik B. Hariri Institute for Computing and Computational Science & Engineering

2017 ANNUAL REPORT

BOSTON UNIVERSITY

Contents

letter from the director

Since opening its doors in 2011, the Hariri Institute for Computing has experienced substantial growth in size, scope, and impact.

More than 10 rounds of seed-funding have incubated innovative research spanning nearly all of the University's schools and colleges. Six cohorts of junior faculty fellows have given rise to a diverse community of researchers who are pushing the boundaries of how computing is transforming their fields. Leveraging this research and an energized community, the Institute has attracted significant funding over the past five years, including the $10 million, NSF-funded Modular Approach to Cloud Security (MACS) project; the multi-institutional, industry-supported Massachusetts Open Cloud (MOC) project; and the Smart-city Cloud-based Open Platform & Ecosystem (SCOPE) project.

These achievements have paved the way for an exciting year at the Institute, as we work to develop new capacities and improve existing resources that catalyze cross-disciplinary research and education. Of particular importance are the Institute's efforts to develop a new funding model driven by external partnerships and a focus on student engagement and entrepreneurship.

As the federal research funding landscape continues to contract, the Institute is increasing collaborations with industry, nonprofits, and public entities, in which partners are viewed not as sponsors but rather as co-investors. Two notable examples are new partnerships with Red Hat Inc. and the Honda Research Institutes (HRI). Leveraging successful MOC relationships, the Institute developed a five-year, $5 million partnership to create the Red Hat Collaboratory @BU with a focus on incubating research on scalable cloud platforms. Drawn to the Institute's recent successes in support of secure smart-city applications, HRI has initiated a three-year collaboration to seed fund research at the nexus of data privacy, consumer personalization, and user control.

Over the past several years, the Institute has invested in student engagement through courses developed as part of major Institute research projects. Expanding on those successes, the Institute introduced several new initiatives this year, including the Experiential Lab in Software Engineering and BU Spark!. Leveraging the Software & Application Innovation Lab (SAIL), the program allows students to complement existing computer science coursework and internships with a directed study in which they execute a project within a professional software engineering context while following community best practices. BU Spark!, funded by a gift from computer science alumna Alicia Mullen, focuses on expanding student-driven innovation by providing access to resources, knowledge, and expert networks.

Along with ramping up the University's Data Science Initiative and helping to establish the BU Digital Health Initiative this year, we're excited to highlight achievements from all of our centers and initiatives in this report. We pride ourselves on being an agile, innovative incubator, and we look forward to hearing from our constituents about how we can support new endeavors as we continue to grow.

Sincerely,

Azer Bestavros
Warren Distinguished Professor of Computer Science
Founding Director, Hariri Institute for Computing

BY THE NUMBERS

50% as direct research support

$1.1M FY17 operating budget

35:1 ROI for 2017*

$94M BU Computing community research expenditures since inception

$19.2M secured for Institute-supported projects since inception

$38M FY17 research expenditures (BU Computing community)

$7.8M FY17 expenditures for Institute-supported projects

$25M gifts, direct and in-kind industrial support since inception

201 faculty affiliates from

53 departments in

12 schools and colleges, including

50+ fellows involved directly with Institute projects

$391,891 in awards given to support incubated research on **20** new projects that represent collaborations between **38** PIs and Co-PIs from **22** departments across **9** schools & colleges

48 proposals submitted for **$40.1M** in extramural funding, including **32** Institute-led proposals for **$27.5M** and **16** Institute-enabled proposals for **$12.5M**

32 media mentions

90 Institute news posts

launched **1st** newsletter

90+ public events and **250** group meetings attended by **2,400+** participants; hosted events for **65** faculty, staff, and student organizers from **30** departments

SAIL

worked with

44 investigators from

16 departments; developed

21 projects with over

$305K of funding, including

15 externally funded projects; and provided

20 student internships

All figures reflect FY17 data, unless otherwise noted.
*ROI calculation reflects ratio of BU Computing Community research expenditures to Institute FY17 operating budget

An Incubator in a University Setting

The Hariri Institute is an incubator through which new initiatives are envisioned, resourced, launched, and grown into self-sustaining endeavors. The Institute leverages seed funding, office and lab space, state-of-the-art conference facilities, local and national partnerships, and staff support to create and sustain a community of scholars who believe in the transformative potential of computational perspectives in research and education.

In addition to being an incubator, the Institute sustains a federation of centers and initiatives, each focusing on a set of strategically-aligned projects and programs. The resulting ecosystem connects computing with everything from undergraduate entrepreneurship to basic and translational research. Accomplishments of the Institute's many entities are integrated throughout this report's *People*, *Research Lifecycle*, *Experiential Learning*, and *Events & Outreach* sections.

existing entities

CENTER FOR COMPUTATIONAL SCIENCE (CCS)

CCS enables cross-fertilization of methodologies through collaborations involving researchers with expertise in model building, simulation, analysis, and HPC.

People | Research Lifecycle | Experiential Learning | Events & Outreach

CLOUD COMPUTING INITIATIVE (CCI)

Home to the Massachusetts Open Cloud (MOC) project, the CCI leads research & development projects at all layers of the cloud computing ecosystem. This year, the CCI expanded through a new $5M, five-year partnership that created the Red Hat Collaboratory @BU.

People | Research Lifecycle | Experiential Learning | Events & Outreach

SOFTWARE & APPLICATION INNOVATION LAB (SAIL)

SAIL is a professional research, software engineering, and consulting lab that acts as both a driver and collaborative partner for computational and data-oriented research efforts across the University. Facing growing demand, SAIL diversified its projects and launched a successful internship program this year.

People | Research Lifecycle | Experiential Learning | Events & Outreach

CENTER FOR RELIABLE INFORMATION SYSTEMS AND CYBER SECURITY (RISCS)

RISCS promotes a multidisciplinary approach to cybersecurity that brings together methodologies from computer science, engineering, economics, ethics, and law. Over the past year, RISCS led the Institute's research efforts to improve and expand a cloud-based, secure multi-party computation platform and initiated the Cyber Security, Law & Society Alliance.

People | Research Lifecycle | Experiential Learning | Events & Outreach

DATA SCIENCE INITIATIVE (DSI)

DSI expands BU's data science footprint through the development of new models for data science programs, faculty recruitment, and additional activities. The DSI initiated the Data Science Fellows program, appointing three faculty to its initial cohort.

People | Experiential Learning | Events & Outreach

"The Hariri Institute serves as a melting pot that connects multiple centers and initiatives in order to generate new cross-cutting research endeavors that connect computer science and engineering with medicine, law, philosophy, sociology, and other research interests across BU."

- Mayank Varia, Co-Director, RISCS

The Institute launched and integrated several new entities this year and continues to support the development of evolving initiatives at the University.

BU SPARK!

Funded by a generous gift from alumna Alicia Mullen, BU Spark! empowers students to pursue next-stage development of their ideas for innovative computing and data-driven technologies as well as access experiential learning opportunities to apply new skills in real-world contexts. In its first six months of existence, BU Spark! has sourced external projects for computer science courses, launched a student advisory council, created a student consulting team, and developed relationships with more than 70 internal and external prospective partners. The initiative has engaged over 100 students in just its first semester.

People | Experiential Learning | Events & Outreach

DIGITAL HEALTH INITIATIVE (DHI)

A collaborative effort between the Hariri Institute and the Institute for Health System Innovation and Policy, the DHI supports research that leverages technologies and methodologies from computing and data sciences to tackle a range of applications related to healthcare systems, from medical informatics to healthcare delivery and administration. In its first six months, the DHI has funded 11 innovative research projects at this nexus of technologies, methodologies, and applications that hold great promise for improving the quality, efficiency, and accessibility of healthcare, with significant benefits to the economy and society.

Research Lifecycle | Events & Outreach

BOSTON WOMEN'S WORKFORCE COUNCIL (BWWC)

The BWWC is a collaboration between the City of Boston and BU that aims to close the wage gap and remove barriers to women's advancement. Using data-driven methods, the BWWC works with businesses in a private-public endeavor to build a more equitable workforce where all talent is cultivated and valued. In collaboration with SAIL, the BWWC collects wage data of 100,000+ employees to construct a comprehensive outlook on the wage gap in Boston. Started in 2013, the BWWC relocated to BU in 2017 to improve and expand the data collection process and research feedback loop.

Research Lifecycle | Events & Outreach

creating synergies in the academic ecosystem
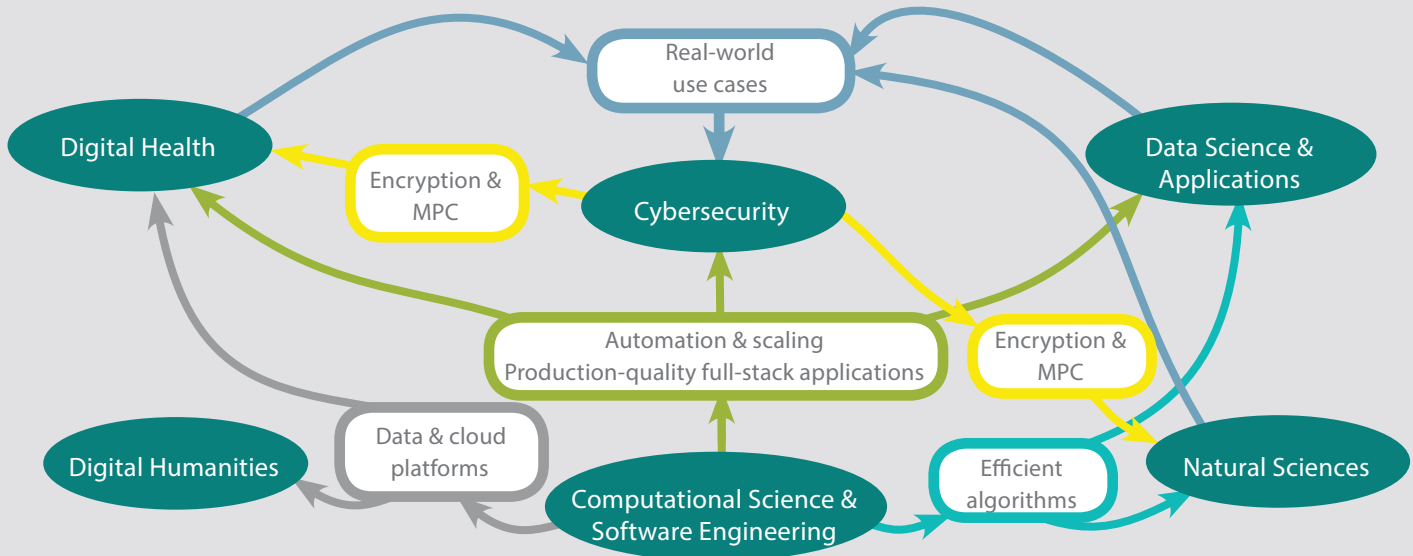
CYBERINFRASTRUCTURE RESEARCH & INNOVATION LAB (CRI)

The CRI Lab is a partnership between the Hariri Institute and IS&T that pursues research and development in support of innovative, open, and deeply programmable end-to-end computing, networking, and storage testbeds. In collaboration with industry partners and regional and national consortia, the Lab will undertake focused projects that leverage BU's expertise and resources to enable key advancements in computational, data-driven science and engineering research, education, and training.

Research Lifecycle

CYBER SECURITY, LAW & SOCIETY ALLIANCE

The Cyber Alliance is a collaboration between computer science researchers, law professors, and social scientists to position BU as a leader in the global discussion on cybersecurity. Led by RISCS, the Alliance leverages BU's disciplinary breadth to create opportunities for cross-disciplinary debate, research, and activities. In its first year, the collaboration hosted a speaker series, invited field experts to give seminars at BU, and supported congressional briefings. Looking forward, faculty are working to create innovative learning opportunities that bring computer science and law students together to tackle challenges of data ethics and cybersecurity law.

Events & Outreach

empowering a community of like-minded scholars

MATHEMATICAL & COMPUTATIONAL SCIENCES (73)

Electrical & Computer Engineering, 27
Computer Science, 23
Mathematics & Statistics, 10
Economics, 7
MET Computer Science, 6

ENGINEERING & PHYSICAL SCIENCES (51)

Physics, 12
Mechanical Engineering, 10
Biomedical Engineering, 10
Astronomy, 6
Chemistry, 6
Earth & Environment, 5
Systems Engineering, 2

BIOLOGICAL & MEDICAL SCIENCES (40)

Medicine, 14
Biology, 3
Speech, Language & Hearing, 3
Bioinformatics , 2
Computational Biomedicine, 2
Global Health, 2
Health Sciences. 2
Neurology, 2
Occupational Therapy, 2
Biostatistics, 1
Epidemiology, 1
Family Medicine, 1
Microbiology, 1
Molecular & Cell Biology, 1
Otolaryngology, 1
Physical Therapy & Training, 1
Surgery, 1

SOCIAL & MANAGEMENT SCIENCES (38)

Political Science, 8
Psychological & Brain Sciences, 8
Information Systems, 5
Psychology, 4
Administrative Sciences, 2
Marketing, 2
Ops & Tech Management, 2
Sociology, 2
Finance, 1
Finance, Law & Policy, 1
International Relations, 1
Linguistics, 1
Health Law, Policy & Management, 1
Health Policy & Services Research, 1
Markets, Public Policy & Law, 1
Social Welfare Policy, 1
Social Work Clinical Practice, 1

LIBERAL ARTS, COMMUNICATION & EDUCATION (8)

Emerging Media Studies. 2
Archaeology, 1
Design & Visual Analytics, 1
History, 1
Humanities, 1
Journalism, 1
Philosophy, 1

People

"I've had a number of terrific experiences interacting with the Institute. Fascinating talks by both BU and outside speakers have exposed me to broadly applicable computational and statistical methods, and my work has directly benefited from Hariri grants and interdisciplinary collaborations." - Dino Christenson, Hariri Faculty Fellow & Steering Committee Member, Associate Professor of Political Science

The Institute focuses on empowering a community of scholars – enabled by rapid advances in computational and data-driven techniques – to advance our collective knowledge. The Institute community consists of 201 faculty affiliates from across 53 departments and 12 schools and colleges. This diversity highlights the importance of computing in nearly every field, and underscores the critical role of the Institute in catalyzing cross-disciplinary research and education.

INSTITUTE FELLOWS

Through a variety of fellowship programs, the Institute facilitates connections between researchers who form the Institute's core community and spark new directions for research and activities.

Faculty Fellows

Faculty Fellows include both faculty whose research projects are funded by the Institute and faculty who have distinguished themselves in contributions to the computational work of the Institute. Currently, more than 50 Faculty Fellows are involved in Institute-led research and projects.

Data Science Faculty Fellows

The new Data Science Faculty Fellows program aims to assemble a cluster of uniquely talented faculty whose expertise transcends traditional boundaries. This year, the Provost appointed the University's first cohort of Data Science Faculty Fellows. The cohort includes John Byers, an existing BU Professor of Computer Science; Ahmed Ghappour and Adam Smith, who join the School of Law and Computer Science Department (respectively) in fall 2017. These fellows are leveraging methodologies from computer science, statistics, and electrical & computer engineering to enable advances across the entire landscape of academic disciplines.

Junior Faculty Fellows (JFF)

The JFF program strengthens the BU research community by recognizing achievements and accelerating the careers of outstanding junior faculty. The 2016 cohort consisted of six faculty members from the global health, emerging media studies, economics, earth & environment, and electrical & computer engineering departments.

*Faculty Affiliate department image accounts for dual appointments

"The JFF program has provided an impetus for a fruitful collaboration with computer science faculty, which has led to an NIH submission to use our research in evaluation of a major HIV policy change. Through the fellowship, I've gained exposure to a large range of intriguing and creative projects, and I've benefited from feedback on my own work. With my faculty appointment based on the medical campus, the Hariri Institute has offered a valuable 'home away from home' and a launching pad for collaborations with CRC faculty."
– Jacob Bor, Hariri JFF, Assistant Professor of Global Health

STUDENTS
The Institute continues to expand engagement with students through fellowships and internship programs.

Graduate Student Fellows (GSF)
The GSF program recognizes outstanding PhD students who pursue computational and data-driven research at BU. Now in its second year, the program has successfully attracted two new PhD students to BU and has awarded 13 continuing students. GSFs are pursuing projects that span from how hospitals can use data to improve quality outcomes to how the development of computational tools can facilitate the drug discovery process.

"As a GSF and SAIL fellow, I've learned how research goes hand in hand with finding practical, real-life solutions to a wide range of problems in different fields. The opportunity to interact with people from different backgrounds has helped me understand various social and economic considerations that guide research in computer science." *– Rawane Issa, Hariri GSF, SAIL Fellow, Computer Science PhD Candidate*

SAIL Interns
In its first year, the SAIL Internship program mentored 20 undergraduate and graduate students. The program provides unique experiences for students to work with professional software engineers and the intersection of research, technology, and software engineering.

"SAIL has taught me how to learn new coding languages and concepts outside of a classroom. My internship has given me direction in my academic and professional pursuits by introducing me to a variety of different career paths." *– Sreeja Keesara, SAIL Intern, Undergraduate Student (CAS '19)*

BU Spark! Interns & Consultants
Spark! engages students in a variety of capacities. Over the past year, the new initiative employed five student interns and engaged 13 technical mentors (including several BU alumni) who provided over 70 consultations for students seeking innovation support. Over 30 students were placed on external project-based learning opportunities.

"Spark! provides students with opportunities for cross-institutional and organizational collaboration. By working with Spark! to develop business and technical skills, I'm confident that I'll graduate from BU with not only a world-class education, but also a strong support network and even a successful business." *– Anna Goncharova, BU Spark! Ignite Student Leadership Council Member, Undergraduate Student (CAS '18)*

Additionally, the Ignite Student Leadership Council was formed to serve as an advisory body to Spark! in support of programs, partnerships, events, and new initiatives. The Council is the first time that leaders from 11 computer science and engineering student clubs have come together in a regular forum for collaboration.

LEADERSHIP
The Steering Committee acts as a think tank, creating a vision for how the Institute can engage researchers and students to enhance BU's position as a world-class institution for research and learning. The Committee includes representation from the College of Arts & Science, College of Engineering, Questrom School of Business, and School of Medicine.

"Learning about the range of projects and people that Hariri supports, which span from the fine arts to economics and computer science, has been a revelation. Moreover, the exceptional leadership and administrative support at the Institute ensures that resources— including the time of committee members and researchers— are leveraged to have the greatest impact on Boston University."
– Barbara Shinn-Cunningham, Hariri Steering Committee, Professor of Biomedical Engineering

STAFF GROWTH & REALIGNMENT
The administrative, research, and technical staff are instrumental in supporting the work of the Institute's many entities. To more effectively serve a growing range of work, the Institute restructured its administrative arm this year and created dedicated operations, finance and administration, and program management teams. Additionally, the SAIL team continues to expand its corps of software engineers, bringing on new staff with talents in areas such as cybersecurity and life sciences.

People

highlights

BU RISCS
Bolstered by a grant from Cisco and a gift from Verizon, Sharon Goldberg (CS) and her students contributed four Internet Drafts to the Internet Engineering Task Force, gaining media attention for uncovering two critical security vulnerabilities. Goldberg also authored a policy paper, published by the Century Foundation, that discusses surveillance oversight mechanisms.

BU RISCS
Tanya Zlateva (CS, MET) increased the visibility of BU cybersecurity education and research by serving as the point of contact for BU to the Center of Academic Excellence program, representing BU at the Executive Academic Forum at the National Cyber Summit on behalf of President Brown, and serving as member of the Board of Directors for the Colloquium for Information System Security Education.

BU CCI
Orran Krieger (ECE) was interviewed by The Cube to discuss the vision and potential of the MOC project at the OpenStack Summit.

BU CCS
David Coker (Chemistry) was selected to a team of 15 international academic experts to participate in Xi'an Jiaotong University's 2017 Discipline Innovation and Intelligence Importation Project providing funds to develop collaborative research activities on new electronic materials and materials for energy applications.

BU Hariri Institute
Azer Bestavros (CS) and a group of other experts participated in a panel discussion on smart cities hosted by BU and the Information Technology & Innovation Foundation in Washington D.C.

BU Hariri Institute
Steering Committee member and Faculty Fellow Doug Densmore (ECE) was honored as one of five "Outstanding Innovators Under 40" honored at the 54th Design Automation Conference.

SAIL
Senior Engineer Frederick Jansen and the SAIL team's work to develop a software platform for privacy-preserving analytics was featured in various media outlets when the BWWC issued its 2016 Gender Wage Report.

BU Hariri Institute
Noora Lori (International Relations) has received international media attention for her Urban Refuge project. The project, which is seed-funded by a Hariri Research Award, is creating an online dashboard that allows refugees to connect with local aid providers.

ATTRACTING TOP TALENT TO BU

The Institute plays an important role in efforts to attract extraordinary new faculty members, with a focus on supporting the University's strategic plan to emphasize interdisciplinary research and scholarship in areas in which BU is uniquely excellent.

- The Data Science Initiative (DSI) successfully recruited Adam Smith, a top data privacy and cryptography expert, to join the Department of Computer Science with a Data Science Faculty Fellow appointment.
- Through the DSI and Cyber Alliance efforts, Ahmed Ghappour will join the School of Law as an Associate Professor. Ghappour's research bridges computer science and the law to address contemporary challenges with a focus on cybersecurity.
- CCS helped realize the hire of Qiang Cui, whose research interests span computational chemistry, biology, and material science. With a large, well-funded computational science research group, this appointment will be pivotal in developing collaborative training grants and large-scale HPC infrastructure proposals.

PLACING STUDENTS

In addition to recruiting top talent, the Institute strives to offer students experiences that bolster their research portfolios and contribute to successful placements at top universities upon completion of their BU degree programs.

- Jonathan Hersh (Economics, CAS) was recruited to join the highly-ranked Chapman University Argyros School of Business as an associate professor. Hersh credits his experience as a Hariri Graduate Student Fellow (GSF) with contributing to his placement.
- Yicheng Song (Information Systems, QST), another member of the Institute's first cohort of GSFs, will join the University of Minnesota's Carlson School of Management as associate professor.
- Sarah Zheng (Operations Management, QST) has received placement as an Assistant Professor in Business Analytics/Decision Science at Ithaca College. As a GSF, Zheng focused on using data to improve hospital outcomes.
- After developing a new object caching architecture that has demonstrated 900% improvement in performance during client testing, a team of three MOC PhD researchers were hired as summer interns by Red Hat to upstream the work.
- After spending several semesters working with RISCS and CCI researchers, Kyle Hogan (CAS '16) credits her undergraduate research in cryptography and cloud computing with contributing to her placement as a graduate student at MIT.

Research Lifecycle
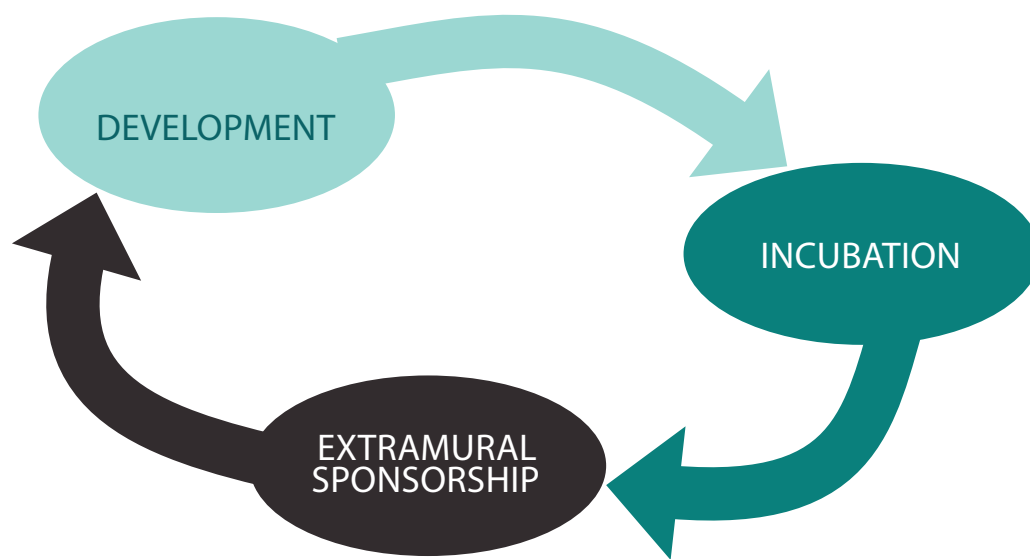
The Institute's research lifecycle has three interdependent phases: research development, in which the Institute devotes significant resources to the development of key relationships and new research ideas; research incubation, the seed funding of BU faculty-led research that catalyzes new collaborations and crosses typical disciplinary boundaries; and extramural sponsorship, which leverages ongoing, incubated research to support new inquiry and attract major funding.

Research Development
priming the research pipeline

The Institute's success in securing extramural funding relies on its ability to develop high-risk, high-reward research ideas, leverage a multi-sector partner network, and cultivate unique resources. Efforts in this area include assisting faculty with the development of high-quality research proposals, identification of new funding opportunities, and cultivation of strategic industry partnerships.

proposals

Over the past year, the Institute supported 48 proposals towards a total of $44M in extramural funding (up from 32 proposals for $16.2M in FY16). The Institute both led and enabled efforts with BU's College of Arts & Sciences, College of Engineering, Information & Services Technology unit, Metropolitan College, Pardee School of Global Studies, School of Medicine, School of Public Health, Sargent College, and Questrom School of Business.

To develop new research ideas and bring together diverse collaborators, the Institute devotes significant resources to proposal development and submission. Many of these are multi-year efforts and include several rounds of revisions before securing funding. Examples from the past include the large-scale MACS, MOC, and SCOPE projects, which continue to be leveraged in support of new inquiry.

proposals

Institute-led Sponsored Research Submissions
Total: $31.4M

Institute-led proposals include all research submissions that were submitted by the Institute and for which the Institute serves as the funding award base. Over the past year, the Institute led proposal submission for 20 different PIs and Co-PIs from computer science (CAS), electrical & computer engineering (ENG), mechanical engineering (ENG), counseling psychology (SED), administrative studies (MET), as well as the Center for Polymer Studies, CRI Lab, RISCS, and IS&T.

| Award Status	# Awards	Funding
Awarded	8	$2,599,741
Pending	23	$18,824,074
Declined	1	$9,997,627
Total	32	$31,421,442

Awarded 25%

Declined 3%

Pending 72%
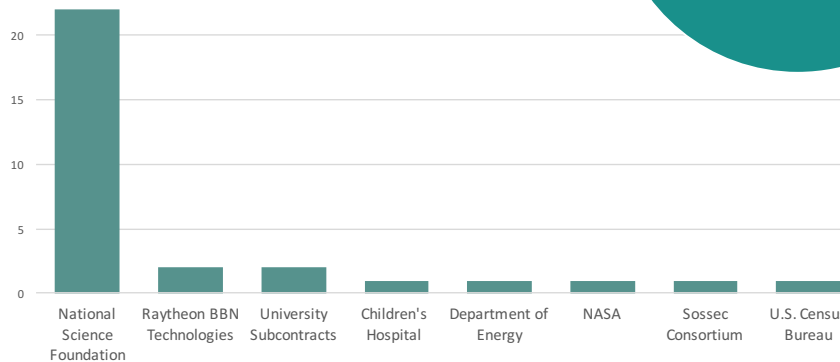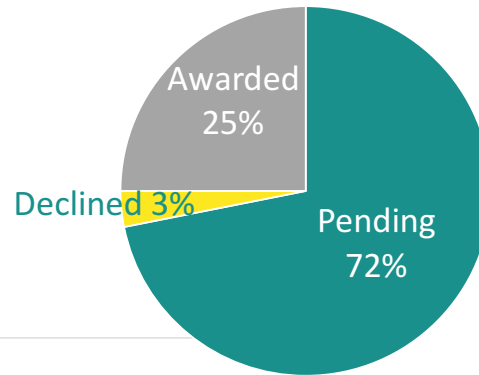
Institute-enabled Sponsored Research Submissions
Total: $12.5M

Institute-enabled proposals include projects for which the Institute provided support during the proposal process, but does not serve as the award base. The role of the Institute varies with these projects, and can include letters of support, consultations, and software development (SAIL). Over the past year, the Institute enabled 16 projects, led by 25 different PIs and Co-PIs from 20 departments.

Award Status	# Awards	Funding
Awarded	8	$1,497,754
Pending	6	$8,549,431
Declined	2	$2,494,417
Total	16	$12,541,602

Pending 37%

Awarded 50%

Declined 13%
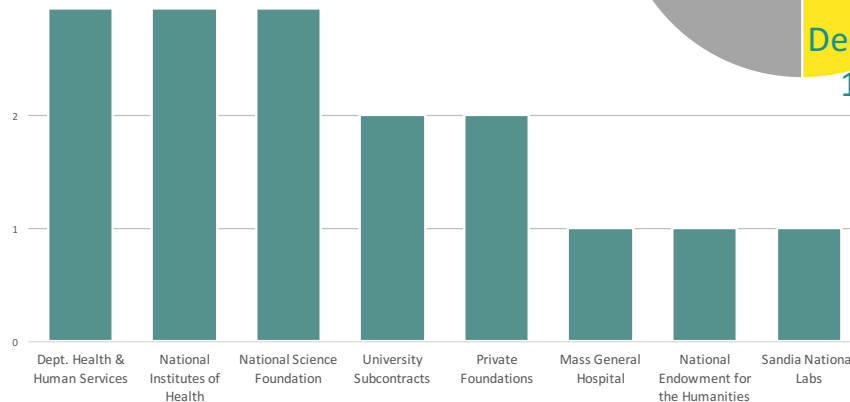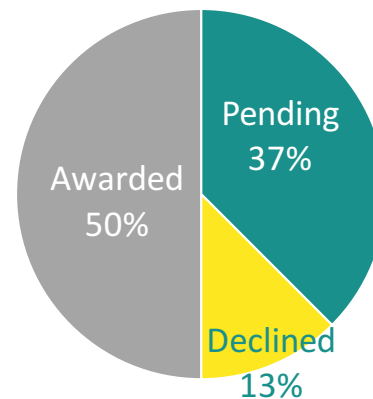
Proposal development efforts are constantly evolving; some have already successfully received funding, e.g. research on secure multi-party computation (MPC), while others require further development. These highlights reflect the Institute's investment in strategic research thrusts that support BU's long-term vision for excellence in research.

proposal highlights

BU CRI Lab

RESEARCH TESTBEDS

Developing robust testbeds is critical to Institute's ability to support new inquiry. Led by Abraham Matta (CS), Director of the CRI Lab, the Institute has initiated a number of efforts in cyberinfrastructure research and innovation. This work of connecting researchers and domain scientists (who need testbeds) with computer scientists (who design and develop the testbeds) and IS&T experts (who operate and maintain the testbeds) is establishing the Institute as a leader in setting up national software-defined infrastructures and has already resulted in an invitation to submit a proposal to host the NSF's *Tomorrow's Internet Project Office*.

BU RISCS

SCHOLARSHIP FUNDING

In order to continue to attract extramural funding, the University must also secure scholarship funding in areas of academic strength. In line with that goal, Tanya Zlateva (MET CS) and RISCS researchers developed a grant proposal for the NSF *CyberCorps Scholarships for Service Program* to support a cohort of full-time students through a "Cyber Security Education in a Multi-Disciplinary, Dynamic, and Inclusive Learning Environment" initiative. Though not funded, the efforts gave faculty critical feedback on their framework for an innovative educational program that has the potential to position BU at the forefront of cyber security education.

BU CCS

MULTI-INSTITUTIONAL STRENGTH

Recognizing that multi-institutional collaborations enable unique funding opportunities, the Institute continues to leverage the Massachusetts Green High Performance Computing Center (MGHPCC) in research development. For example, David Coker (Chemistry) and CCS colleagues joined forces with Northeastern, UMass, and MIT to submit an NSF *Major Research Instrumentation (MRI)* proposal in support of a regional HPC infrastructure initiative, titled "MRI Consortium: Acquisition of a Regional Simulation and Analysis Engine to Accelerate Research in Materials Science, Chemistry, and Nano Science."
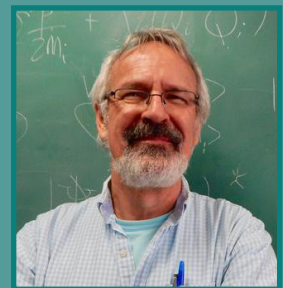
new partnerships

The Institute has invested significant time developing a new funding model that is driven by partnerships with industry, nonprofits, and public entities. Institute leadership continues to work with partners to identify new opportunities for research development and fruitful collaborations.

NEW PARTNERSHIPS

BU RISCS

RISCS leadership interfaced with scientists from the Honda Research Institutes (HRI) to develop a new research partnership. HRI has committed $680k in support of BU research at the intersection of privacy and automation. In addition to sponsoring research, the partnership will provide BU researchers with the opportunity to learn about HRI's emerging technology and envisioned applications.
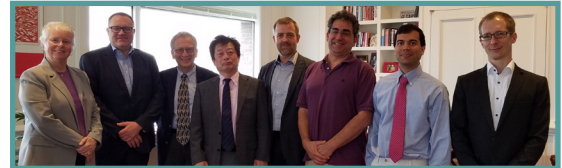
University Provost Jean Morrison is joined by Hariri Institute directors and representatives from the Honda Research Institutes.

"The synergy between BU's world-class research in data security and privacy and our approach and experience in Cooperative Intelligence will enable significant progress to provide people with both confidence and trust in intelligent systems of the future"
— Bernhard Sendhoff, Head of Global Operations, HRI & President, HRI Europe

BU CCI

Building on a successful partnership through the Massachusetts Open Cloud , the CCI has developed a new research collaboration with Red Hat. The five-year, $5M partnership has created the Red Hat Collaboratory @BU to incubate research projects, provide fellowship opportunities, and support visiting scientists.

Associate Provost for Research Gloria Waters speaks at the grand opening of Red Hat's Boston office.

PROSPECTIVE OPPORTUNITIES

BU Hariri Institute

On behalf of the University, Azer Bestavros organized a series of meetings to bring together key personnel from GE Research with BU faculty and administrators. The meetings included presentations and white papers and identified areas of mutual research interest, which may lead to expanded future collaboration down the road.

BU CCI

Building on the existing MOC partnership with the U.S. Air Force, the Hanscom Academic Cloud Team (HACT) program is being developed to create new opportunities for collaboration in pursuit of shared goals on research and development on cloud computing, with a specific focus on cloud security.

BU RISCS

Led by Mayank Varia and George Kosar (Director of BU Foundation Relations), RISCS researchers designed a series of activities and seminars at the intersection of technology and policy that will enable the center to forge relationships, bridge gaps in communications and understanding, and enrich knowledge in this space. Efforts to cultivate new opportunities will continue into the next year. Varia also participated in a series of congressional meetings to discuss ongoing work with the BWWC that uses MPC to identify, and help close, the gender wage gap in Boston. Initial meetings led to extended discussion with Senator Wyden's (D-Oregon) office on future usage of this research.

Incubated Research
seeding collaborations that extend research horizons

Through seed funding, the Institute supports high-risk, high-reward research and forward-looking education initiatives that catalyze new directions and collaborations in computational and data-driven research.

HARIRI RESEARCH AWARDS

This year, the Institute provided funding for 20 new research projects through the Hariri Research Award program. Eleven of these projects are funded through a special Digital Health Initiative research call, and are co-funded by the Institute for Health System Innovation & Policy. Descriptions of all awarded projects can be found on the Institute's website.

2017 Hariri Research Award
PI and Co-PI Departments
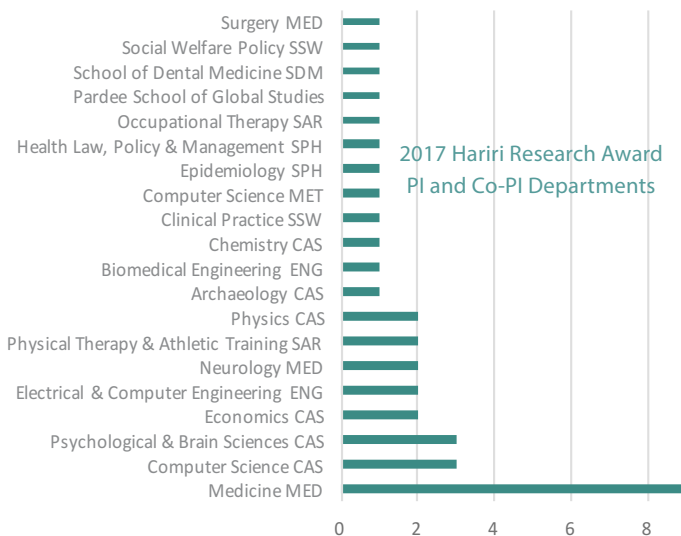
Fiscal Year	# of Awards	Total Funding
FY12	5	$144,560
FY13	8	$215,309
FY14	4	$110,900
FY15	9	$195,767
FY16	7	$181,250
FY17	20*	$391,891
To Date	53	$1,239,677

*2017 awards include 11 DHI awards jointly funded by Hariri Institute and IHSIP. **Funding Amount reflects Hariri contribution.

SAIL

During FY17, SAIL provided software development support for six ongoing projects sponsored by Hariri Research Awards and collaborated with seven PIs from the economics, computer science, archaeology, emerging media studies, international relations, and political science departments. With a growing demand for research software engineering across the CRC and MED campuses, SAIL is developing solutions and expertise that cross disciplinary boundaries and multiply the benefits of research efforts to bring greater value to the BU research community.

"The capacity to analyze big data has allowed me to implement a wonderful sea change in my research agenda. The SAIL team has been creative, responsive, patient, and illuminating. I've gone from being dismissed at professional conferences as 'conventional wisdom' to being 'ahead of the curve,' and who can ask for more?" — Cathie Jo Martin, Hariri Research Fellow, Professor of Political Science

Noora Lori (Pardee) is working with the SAIL team to create a smartphone app that provides refugees with tools for navigating insecurity and collects data on aid distribution. The project has the potential to catalyze future efforts to develop a more reliable income metric that can revise the expenditure-based model currently used by the United Nations High Commissioner for Refugees to allocate aid to refugees.

Led by Gerald Denis (MED), one seed-funded project brings together personnel from RISCS, SAIL, and the BU Medical Campus to create a secure data-sharing platform for medicine. The $40k grant enables researchers to develop common data formats in order to facilitate data sharing among research labs in the U.S. and India.

Gerald Denis
(Medicine, MED)

Naomi Ko
(Medicine, MED)

Mayank Varia
(RISCS)

PI Ksenia Bravaya (Chemistry, CAS) is developing an eMap web-based application capable of predicting and visualizing electron transfer channels in proteins based on the X-ray structure. The application will be available free of charge for public use and distributed as an open source software.

Ioannis Paschalidis (ECE, ENG) and George Kasotakis (Surgery, MED) are developing predictive analytics to forecast hospital re-admissions within 30 days from discharge after surgery. Starting with a dataset of 5,769 Boston Medical Center patients, the PIs plan to expand the project's scope to over two million patients in order to improve prediction accuracy. Ultimately the researchers hope to offer specific recommendations to optimize the trade-off between the cost of extended stay and the cost of a readmission.
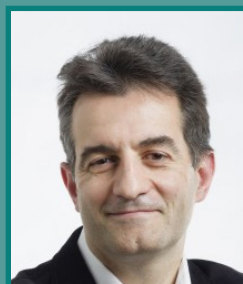
Ioannis Paschalidis
(ECE, ENG)

George Kasotakis
(Surgery, MED)

incubated research highlights
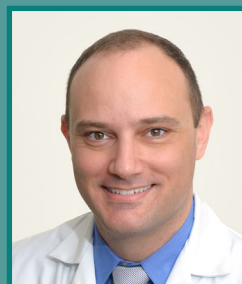
CO-INVESTING WITH INDUSTRY

Through new partnerships with the Honda Research Institute and Red Hat, the Institute has developed innovative funding channels that incubate translational research. In their first six months, both of these new partnerships have enabled cutting-edge, computational research.

highlights

BU - HRI Research Collaboration   **BU** RISCS   SAIL

The first HRI-funded project, "Personalized Policy-Based Privacy-Preserving Geospatial and Temporal Data-Driven Services," is led by Andrei Lapets (Hariri, SAIL, CS), Assaf Kfoury (CS), and Frederick Jansen (SAIL). It provides a unique opportunity to develop research with real-world applicability. Using secure multi-party computation (MPC), researchers are creating a platform that extends the capabilities of web services (such as route planning) that rely on sensitive user data in order to provide secure, personalized information. The platform will allow users to control how their data can be shared – and how other users' data can influence their results – while securely analyzing a multitude of contributed data to offer user-specific suggestions.
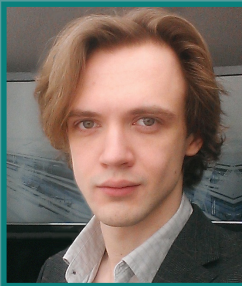
Andrei Lapets
(Computer Science, CAS)
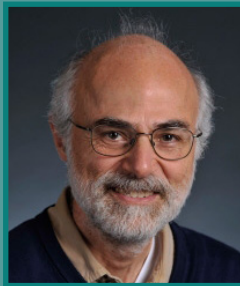
Assaf Kfoury
(Computer Science, CAS)

Frederick Jansen
(SAIL)

BU Red Hat Collaboratory   **BU** CCI

Sponsored by the Red Hat Collaboratory @BU, Martin Herbordt (ECE) is developing new forms of workload acceleration, including High Performance Computing applications, through the use of field-programmable gate arrays (FPGAs) as "bump-in-the-wire" accelerators for network functions. This work has significant potential implications for creating development environments that make these accelerators easily accessible to application programmers.

Martin Herbordt
(ECE, ENG)

impact of incubated research

BU Hariri Institute   BU RISCS   BU Data Science Initiative

One of the earliest Hariri Research Awards provided funding for the 2013-2014 Privacy Year project. Led by Sharon Goldberg (CS), the project brought three top researchers to BU to conduct joint research on data privacy.

As a direct result of that small investment and the Institute's development of the university-wide Data Science Initiative (DSI), BU was able to attract Adam Smith to join the computer science department in fall 2017. Smith is a data privacy expert and was one of the visiting researchers from the Privacy Year project. The Institute facilitated the recruitment process for Smith, including hosting him for a DSI Distinguished Lecture and several meetings with faculty.

Additionally, the seed-funded project helped spur the formation of the new Cyber Alliance, which led to the Law School's successful recruitment of Ahmed Ghappour. Both Smith and Ghappour are members of the inaugural cohort of Data Science Faculty Fellows, a critical component of the DSI.

Adam Smith joins BU with a primary appointment in the Computer Science Department, secondary appointment in ECE, and affiliation in Math & Stats.

Ahmed Ghappour joins BU School of Law as an associate professor of law.

Extramural Sponsored Research

incubating transformative projects at the nexus of cloud computing, cyber security, and data science for a better society

Imagine a world in which self-driving cars and robots offer highly personalized services while completely protecting a user's privacy. Imagine a world that allows medical data to be shared across nations and continents, allowing researchers to find cures for dangerous diseases without legal and geopolitical obstacles. Imagine a world where we can correlate school absences, social media networks, and arrests among friend groups to identify early indicators of substance abuse and confront ongoing drug epidemics.

At the Hariri Institute for Computing, we're combining privacy-preserving MPC with an open cloud computing system to leverage cutting-edge data science, develop new and trustworthy security guarantees, and create opportunities for scalability.

FY15-FY17 research expenditures

In addition to spearheading large, multi-collaborator projects, the Institute serves as an amplifier for the work of the entire BU computing community.

BU Computing Community Research Expenditures	
FY15	$25,838,705
FY16	$29,957,750
FY17	$38,156,756
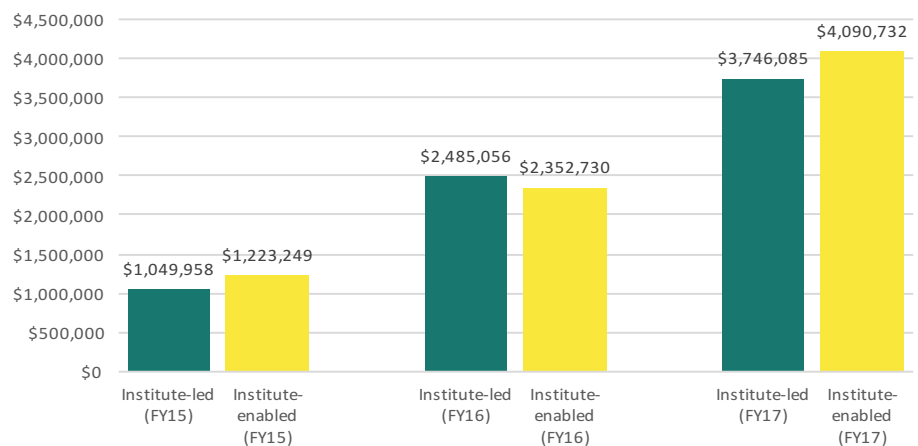
*The BU Computing Community includes all of the Institute's fellows and affiliates; computing community expenditures reported here include only those expenditures related to computational and data-driven research.

**Institute-led projects include all research submissions that were submitted by the Institute and for which the Institute serves as the funding award base.

*** Institute-enabled projects include all projects for which the Institute provided support for the project but does not serve as the funding award base.

Funded by a $10M, five-year NSF Frontier grant, the Modular Approach to Cloud Security (MACS) project seeks to develop techniques and tools for building information systems whose security guarantees can be individually personalized and jointly composed. A multi-institution, multi-disciplinary project, MACS is housed within RISCS and researchers collaborate closely with the MOC team, leveraging the platform as a testbed.

MODULAR APPROACH TO CLOUD SECURITY   **BU** RISCS

Ran Canetti (RISCS; CS) and Mayank Varia (RISCS) provided a composable security analysis of OpenStack, a popular open-source software package used by the MOC and others to manage cloud computing services. The analysis is user-centric and modular (built from analyses of individual components), and it provides defense in depth (OpenStack retains partial security even if some components are compromised).

After exposing flaws in the security of the Network Time Protocol (NTP) in 2015, Sharon Goldberg (CS) led a deeper investigation into NTP security and developed a secure protocol to share time information over a network.

Goldberg is working with Canetti to address the circularity of trust involving time: we rely on time to validate cryptographic certificates, and we also use crypto to protect the transmission of time itself.

Azer Bestavros and SAIL engineers improved the scalability and usability of secure, multi-party computation (MPC). Their Conclave system enables secure joint analytics queries over private data with optimizations that improve performance and scale by 10-100x factors. Additionally, the improved web-based system at 100talent.org has been successfully used to calculate the average gender wage gap from payroll data of 112,600 employees in the Greater Boston Area.

Jonathan Appavoo (CS) integrated EbbRT, an operating system he custom-built for cloud computing, into the MOC. This approach allows cloud application software to be constructed through a framework that decomposes operating system functionality into components, which can be tailored to optimize scale, performance, and security.

George Kollios (CS) designed outsourced database systems that balance security and performance. His work utilizes differential privacy to protect data at the record level against an untrusted or malicious server that controls data and queries.

Built upon a unique academic, industry, and government partnership, the Massachusetts Open Cloud (MOC) is comprised of deeply interconnected projects with the same goal: to develop an open, production-quality cloud computing system that enables research and provides leading-edge services for scientific computing.

MOC   **BU** CCI

The Cloud Dataverse project brings together the power and scalability of cloud computing and storage with access to thousands of feature-rich datasets. Led by Orran Krieger (CCI Director; MOC; ECE) Piyanai Saowarattitada (MOC); and Mercè Crosas, (Chief Data Science & Technology Officer at Harvard University; Hariri Visiting Fellow), researchers are enhancing Dataverse to run on an OpenStack cloud and allow users to operate on data sets from compute tightly connected to the storage.

MOC contributors are working to make data access efficient for large "Datalakes," low-cost storage systems for massive collections of data sets. MOC graduate students Ugur Kaynar of BU and Northeastern University teammates MaNia Abdi and Mohammad Hajkazimi developed and demonstrated a successful, "caching" approach, where data is copied into fast solid state storage as it's accessed. The work has been accepted by the upstream Ceph community as an experimental feature.

MOC researchers are working on a new project, the Cloud Analysis Model Prototype, to enhance and develop technologies identified as relevant to the evolving U.S. Air Force cloud requirements and then integrate those technologies into the MOC. Collaborators are also creating documentation for the broader academic and industrial cloud community to encourage the development of dual-use technologies.

The Center for Computational Science secured NSF funding for several projects that advance computational research in a variety of areas, including physics, chemistry, and high performance computing.

BU CCS

Ksenia Bravaya (Chemistry) received NSF funding to develop new computational methods to study the chemistry of meta-stable, electron-attached molecules that are key in many high-energy processes, such as radiation damage of biomolecules. David Coker (Chemistry) received NSF funding to develop quantum dynamical methods to study energy transfer in light harvesting materials.

CCS researchers developed new theoretical tools to explore electron-molecule interactions and electron attachment-induced chemical reactions, processes that play a pivotal role in interstellar medium chemistry and chemistry initiated by ionizing radiation. The new methods are implemented in two major quantum-chemistry packages (Q-Chem and Firefly) and available to academia and industry.

Saul Youssef (Physics) secured continued funding for the U.S. ATLAS, Large Hadron Collider "Northeast Tier 2" (NET2) facility at MGHPCC, one of four facilities in the U.S that provides computing for international particle physicists and the U.S. national science community. Youssef also began development of the Northeast Storage Exchange (NESE), a regional storage facility at the MGHPCC.

research lifecycle in action:
secure multi-party computation (MPC)

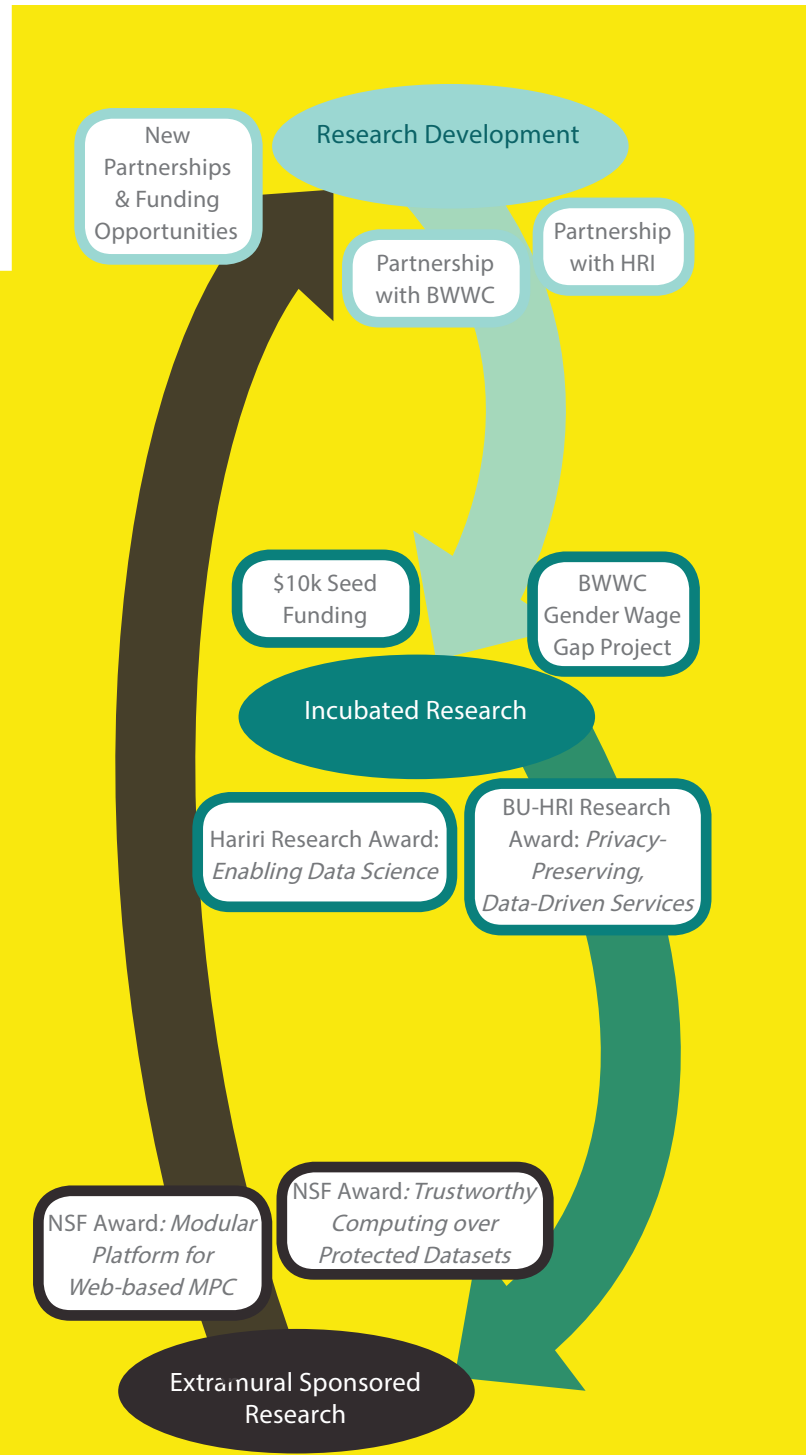BU Hariri Institute   BU RISCS   BU CCI

SAIL

100% TALENT
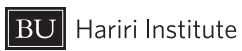
In 2014, the Institute developed a partnership with the Boston Women's Workforce Council (BWWC) to seed fund a small research project related to the organization's work around pay equity. With just a $10k investment, the Institute hosted two undergraduate interns to work on developing an algorithm that aggregates private datasets.

Since then, Institute researchers have expanded on this work through the development a multi-party computation platform (MPC) and implementation of a web-based version of the application. Researchers continue to refine the technology through research incubated by Hariri Research Awards, including projects with the BU Medical Campus and Honda Research Institute.

Bolstered by these successes, Azer Bestavros, Andrei Lapets, and Mayank Varia have submitted four proposals for extramural funding; two of which have already received funding. The "Modular Platform for Web-based Secure Multi-Party Analytics" project will enable researchers to develop libraries and services for MPC in order to make secure computing more usable for the world. The cyberinfrastructure award for "Trustworthy Computing over Protected Datasets" will exploit the synergy behind several prior Hariri efforts. Researchers will deploy their Conclave system for MPC at scale on the MOC to bring secure computing to the Dataverse repositories where social scientists house sensitive information.

With additional proposals in the works, secure MPC has emerged as a key research thrust of the Institute, with applications across medicine, business, law, social sciences, and many more fields.

New Partnerships & Funding Opportunities

Research Development

Partnership with HRI

Partnership with BWWC

$10k Seed Funding

BWWC Gender Wage Gap Project

Incubated Research

Hariri Research Award: *Enabling Data Science*

BU-HRI Research Award: *Privacy-Preserving, Data-Driven Services*

NSF Award: *Modular Platform for Web-based MPC*

NSF Award: *Trustworthy Computing over Protected Datasets*

Extramural Sponsored Research

Experiential Learning

The Institute's research profile provides broader impact by enabling researchers to test and implement new ideas while offering exclusive experiential learning opportunities to BU students.

CLOUD COMPUTING · BU CCI

Designed to give students an understanding of cloud computing, open stack, big data problems, and agile methods, the course provides mentorship by industry collaborators and researchers from companies such as Red Hat, IBM, Cisco, and Microsoft.

This year, Rudolph Pienaar (Boston Children's Hospital), and Dan McPherson (Red Hat) mentored a team of students to use Red Hat's OpenShift platform on the MOC as a computational resource for the hospital's image processing service. The resulting project demonstrated the platform's ability to solve complex image processing problems in real time, which could dramatically reduce image processing time and improve patient care. What began as a student project has now opened the door for a formal collaboration with Boston Children's Hospital.

DATA MECHANICS · SAIL · BU CCI

Offered in both the fall and spring semesters, students apply data science tools and methods to build platforms and applications that work with data sets related to aspects of urban environments, such as mobility, employment, traffic and parking, emissions, energy consumption, and public safety. The course is supported through the SCOPE and MOC projects.

Minteng Xie, Yue Lei, and Zhi Dou developed a solution that quantifies the best living areas in Boston. By analyzing City of Boston datasets, they used rent costs, transportation accessibility, food establishments and crime records to create a system that allows users to find their preferred living area. Their platform allows each user to rate personal preferences, and their algorithm provides a list of the top five recommended neighborhoods for that user.
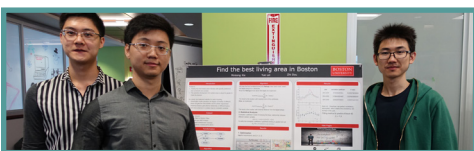
Xie, Lei & Dou present their work at the Institute during a student poster session.

SECURE MPC AT SCALE · BU RISCS

Azer Bestavros, Ran Canetti, Andrei Lapets, and Mayank Varia created and co-taught *Secure Multi-Party Computation (MPC) at Scale*, which examines the crypto and systems security aspects of MPC. Fifteen graduate students completed the inaugural edition of this course, which will be repeated in Fall 2017.

"Being part of the Hariri Institute community and the Secure Multi-Party Computation at Scale course not only allowed me to gain a solid grasp of MPC and carry out research, it also changed my understanding of the social science behind MPC and cryptography, as well as how computer science affects and is affected by society, law, and politics at large." – Kinan Bab, Computer Science PhD Candidate

DEVELOPMENT OF NEW COURSES

Institute staff and affiliates are continually working to develop new experiential opportunities for BU students. With curricula developed over the past year, the Institute will support four new courses this coming fall.

BU Spark! Product Innovation (CS course taught by Ziba Cranmer) course will provide a structured process and technical support for students to advance an original innovation project. Starting with a project concept, students will engage in a structured product development experience accompanied by self-directed study.

Experiential Lab in Software Engineering (CS course taught by Andrei Lapets) will allow students to work on case studies and real-world projects in an industry-standard software engineering environment and under the supervision of experienced instructors and professional software engineers.

IoT Security (ECE course taught by David Starobinski), a graduate-level course, will cover software-defined radios, credential management for connected devices, and blockchains.

Computational Chemistry of Materials introduces students to advanced computational chemistry software with labs that give students experience running powerful simulation codes in a HPC cluster environment. Developed by David Coker (Chemistry), the graduate and advanced undergraduate course is cross-listed in ENG, GRS, and CAS.

PROJECT SOURCING

Spark! partnered with Evimaria Terzi (CS) to source real-world projects for the Computer Science Department's Computational Tools for Data Science course (CS 506), which teaches students techniques for collecting and analyzing data in order to create innovative tech solutions. BU Spark! developed partnerships with several local companies and organizations, including Microsoft, Converse, and the ACLU to identify and cultivate projects for students to work on as part of their final projects.

"Projects from companies and NGOs outside of BU have provided the students with real-world challenging data problems that they could not have encountered otherwise. Moreover, the real-life impact of the projects' results motivated the students considerably as they felt they were part of a greater cause." – Evimaria Terzi, Associate Professor of Computer Science
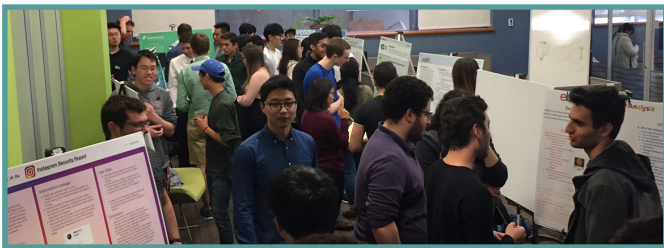
Students present work at one of the six poster sessions hosted at the Institute this past year.

EXTRACURRICULAR CONSULTING PROJECTS

Spark! has developed a student consulting team and initiated three extracurricular projects with external partners. One particularly exciting project is an ongoing collaboration with the Boston Public Schools. The Spark! student consultant team is building an app, called "More than a Mile," that aims to increase BPS students' access to the City of Boston as a classroom. The app will link students to a variety of learning and enrichment opportunities in Boston, with the ultimate goal of expanding their horizons and exposing them to employers and career pathways.

Spark! student consultants and Director Ziba Cranmer meet with Chad Payel, CEO of Thoughtbot, to work on the BPS app project, "More than a Mile."

"The BPS project has allowed me to utilize my skills to give life to an idea that tangibly benefits society. Beyond hard work and perseverance, the experience has shown me the importance of communication, trust and honesty, both intra-team, and inter-team. I've learned what it takes to be a leader in the real world." – Vardaan Aashish, Undergraduate Student (CAS '18)

DIGITAL HUMANITIES

Led by Steering Committee member Andrea Berlin (Archaeology), the initiative is co-sponsored by the Institute and brings together faculty and graduate students interested in developing digital humanities projects. Over the past year, SAIL engineers served as technical advisors and provided one-on-one tutorials for faculty. Seminar participants presented final project proposals in December 2016 at the Hariri Institute.

BU SAN FRANCISCO

BU Spark! played a crucial role in the development of BU Study Abroad's San Francisco Bay Area Internship Program, which piloted this summer and offers students the opportunity to intern in a thriving global center of technological innovation. Six computer science students are participating in the program's inaugural run, during which they complete internships with companies such as BBVA Compass, Narvar, and Bot Central. Spark! Director Ziba Cranmer contributed to both the internship sourcing and program launch.

CAS Dean Ann Cudd and Steve Kean (BU Alumni Relations/Development) visit the first cohort of BU in San Francisco students.

STORYTELLING WITH DATA WORKSHOPS

Founded and directed by Maggie Mulvihill (Journalism), Hariri Faculty Fellow, the Storytelling with Data Workshop is co-sponsored by the Hariri Institute and brings in professionals from a variety of fields, including law, government, science, finance, and healthcare, for week-long trainings on how to interpret and showcase vast amounts of data to efficiently unearth key insights and inform decision-makers. This year, based on feedback from workshop alumni, the program kicked off the country's first university-based Digital Badge program in data storytelling, where attendees can earn a virtual certificate to demonstrate proficiency in three levels of this evolving discipline.

Events & Outreach

Innovation happens when people mix and conversations go beyond disciplinary silos. From weekly reading groups to large-scale conferences, the Institute hosted and sponsored a variety of events throughout the year. Additionally, the Institute supported numerous outreach efforts beyond BU, which are crucial to supporting the research pipeline. A few of activities from each of the Institute's entities are highlighted here.

"The support of the Hariri Institute helped me tremendously with organizing an NSF program on mid-scale cyberinfrastructure. After this success, I continue to count on the Hariri staff to help me with more cyberinfrastructure activities and international collaborations in that space." –Abraham Matta, CRI Lab Director, Professor of Computer Science

The Institute's many entities hosted over 90 public events and 250 group meetings, with more than 2,400 participants. Serving 65 faculty, student, and staff event organizers, the Institute provided support to over 30 different departments and student groups. Roundtables and workshops focused on emerging areas such as fake news, the ethics of algorithms, and privacy, while informal Wednesday@Hariri/Meet Our Fellows talks ranged from record linkage for medical data to how computer automation affects jobs and wages. The BUILDS student hackathon brought in over 50 students who connected with local hacker communities from all over the world during a 12-hour event that focused on building innovative technology. The Institute hosted five student poster sessions, providing over 300 BU students opportunities to present research projects to peers, faculty members and industry guests.

BU Hariri Institute

The Institute co-sponsored the *Journalism and the Search for Truth in an Age of Social Media* symposium, the first in a series of Mellon Foundation Sawyer Seminars led by Juliet Floyd (Philosophy), James Katz (Emerging Media Studies), and Russell Powell (Philosophy). The series brings together humanists, social scientists, computer scientists, and big data experts to discuss intersections of humans, values, and society. The Institute will support additional series' events, and is the lead organizer for the 2018 "Accountability in an Age of Algorithms" symposium, which will focus on how ethics and technology should converse.

One stand-out event was an impromptu international student dinner, hosted by the Institute in the wake of new immigration orders, which raised concerns about student mobility. Over 75 students, staff and faculty gathered to show support and solidarity in the midst of so much uncertainty.

BU Data Science Initiative

Following a successful event in 2016, the DSI hosted the 2nd annual BU Data Science (BUDS) Day in January. This year's event was co-chaired by Institute Junior Faculty Fellow Dylan Walker (Information Systems, QST) and Institute Affiliate W. Evan Johnson (Biostatistics, MED).

Event co-chairs W. Evan Johnson and Dylan Walker kick-off BUDS Day 2017. Photo credit: Dave Green.

More than 250 participants attended the event, hailing from 42 BU departments, 20 external organizations, and nine other academic institutions. Featuring both BU researchers and external data scientists, the symposium included research panels, private and public sector panels, a student poster session, and a presentation by NSF Assistant Director, Jim Kurose.

Hariri Graduate Student Fellow Sarah Zheng presents research at BUDS Day 2017. Photo credit: Dave Green.

In addition to BUDS Day, the DSI hosted two distinguished lectures and nine special colloquia that brought in prominent scholars to discuss exciting advances in data-driven research.

community-building events

community-building events

BU CCI

The CCI hosted the 2nd annual MOC Workshop, which was attended by 140 participants, including students, faculty, staff and representatives from the project's industry and public sector partners. The two-day workshop featured technical presentations, insights from MOC users, working group sessions, an industry partner roundtable, and a hands-on MOC session.

Spurred by the new partnership with Red Hat, the CCI launched the Red Hat Colloquium Series and hosted four events, featuring speakers from Red Hat, Google, and OpenNebula.

MOC students and researchers had the opportunity to showcase their achievements at two major external events, the Red Hat Summit and the Boston OpenStack Summit. With each event drawing an audience of more than 5,000 attendees, the MOC team contributed 10 featured talks and participated in numerous technical meetings and discussions.

BU RISCS

The BU Security Group, which pursues research in cryptography and network security, hosted 11 seminars throughout the year and held the summer Seminar on Practical Security series. Series talks discussed the latest topics in cybersecurity attacks and defenses.

Supported by MACS project researchers, RISCS hosted the 11th Charles River Crypto Day (the second time the event has been hosted at BU), which is a recurring networking opportunity for faculty, postdocs, graduate students, and research scientists pursuing basic cryptography research in the Greater Boston Area.

The Cyber Security, Law & Society Alliance held monthly lunch meetings to establish a common language and shared understanding of priorities and concerns between RISCS and the BU Law School. In addition to presentations by both RISCS researchers and BU Law professors, the group brought in several external speakers. Additionally, Sharon Goldberg and Mayank Varia took part in two congressional briefings to discuss issues of privacy and security with elected officials and government agencies.

SPARK!

Spark! hosted several events, including the first edition of the initiative's Technovation Speaker series. An interactive roundtable, the event hosted Rebecca Norlander, a BU alumna and the CEO of Samepage Health; Alexandrea Mellen, founder of Terrapin Computing LLC; Durjoy Bhattacharjya, founder of Medical Records; and Ricky Engelberg, VP of Digital Innovation at Converse/Nike. Panelists shared their experiences and answered questions about starting innovation ventures and introduced attendees to the process of creating minimum viable products through iteration.

BU Digital Health Initiative

Hosted at the Institute and led by DHI Co-Director Jonathan Woodson, the Digital Health Initiative kicked-off with a roundtable featuring three visiting guests, Dr. Patrick McNellie, MD, physician and researcher for IBM's Genomics team; Dr. Belinda Borelli, MD, Lead Co-Director of the Mobile-Electronic Health Arc at BU; and Dr. Meera Kanhouwa, MD, MHA, and Managing Director of Systems Integration at Deloitte. The day-long event successfully chronicled a variety of evolving areas of digital health, including how to use cognitive computing to recommend treatment options, digital methods for improving care for minority populations, and strategies for bridging the gap between health data and patient care.

Outreach activities pursued by Institute fellows and affiliates are critical to strengthening the overall research pipeline as well as expanding access for students of all ages to engage in technology and computing.

BU Hariri Institute   BU CCI

Leveraging the Institute's existing relationship with Red Hat, Hariri Fellow Paul Trunfio worked with BU Corporate Relations, BU Girls Who Code student group members, and Red Hat engineers to design and deliver Co.Lab. The project taught 25 middle school girls how to build and code a digital camera over the course of a three-day workshop held in a Red Hat mobile trailer outside of City Hall Plaza. Events such as this one aim to get more girls interested in pursuing STEM and STEM-related work and careers while teaching them collaboration skills they can use in future projects and pursuits.

BU RISCS

Azer Bestavros continues his support of an ongoing collaboration with Holyoke Public Schools to increase education and excitement about cybersecurity. This year, the Institute sponsored two day-long workshops; the first invited teachers and students to participate in hands-on activities, and the second gave students a tour of the MGHPCC so they could learn how high performance computing supports university research.

Mayank Varia is leading the expansion of the PRIMES program (initially from MIT) to BU. The program provides gifted high school students with the opportunity to conduct original research. BU postdocs and graduate students mentored four high school students this year, and their work has been submitted to peer-reviewed academic conferences for publication.

The Codebreakers outreach program has been renewed for a second year. Led by Cynthia Brossman and supported by Manuel Egele, Sharon Goldberg, and Mayank Varia, this four-week summer program provides 24 high school girls the opportunity to learn about cryptography and network security. The program is a follow-on to the successful Artemis outreach program, which Brossman and Goldberg also supported.

Azer Bestavros, Sharon Goldberg, and Leo Reyzin continue to support the PROMYS program. This year, they worked with Glenn Stevens (PROMYS Co-Founder and Director) to create a new Crypto Institute that targets second year teacher participants and introduces cryptography in a manner that is accessible and enjoyable to high schoolers. The first iteration engaged 14 teachers, who met regularly to discuss topics related to cryptography and computational complexity.

BU CCS

Ksenia Bravaya organized a computational chemistry workshop to provide exposure to cutting-edge research and promote scientific curiosity among high-school students. The workshop includes a lecture, which highlighted the role of computational chemistry in modern biochemical research, and a computational lab, in which the students performed independent quantum-chemical calculations. The annual workshop attracted more than 70 high school participants from BU Summer Term's RISE internship and High School Honors programs.

SPARK!

Ziba Cranmer engaged in extensive outreach to organizations in the corporate, public, and nonprofit spheres to develop new partnerships. Cranmer continues to build relationships with nonprofits across the globe, from the National Democratic Institute to the International Labour Organization (a UN agency) to open doors for Spark! students to contribute to broader social impact. One notable new partner is the Boston Public Schools, for whom Spark! student consultants are creating a new web-based app. In addition to making significant inroads in partnership development, she also coordinated a roundtable with Val Richey, a senior deputy prosecuting attorney for King County, to discuss the intersection of technology with sex trafficking, policing, and gun control.

Hariri Institute researchers (left to right) Mayank Varia (RISCS), Andrei Lapets (SAIL), Frederick Jansen (SAIL), and Azer Bestavros (Hariri Institute) with Boston Mayor Martin J. Walsh (center) at the BWWC data collection training. Photo credit: Isabel Leon, City of Boston.

SAIL   100% TALENT

In order for secure multi-party computation research to be successfully implemented to confront Boston's wage gap, SAIL engineers worked with MaryRose Mazzola (BWWC) and her staff to deliver data collection trainings to the Boston Women's Workforce 100% Talent Compact signers. The trainings both prepare participants for the biannual data collection as well as provide greater understanding of the technologies being used and the privacy guarantees of MPC.

outreach beyond BU

Looking Forward

Entering its seventh year, the Institute continues to focus on activities that play to our strengths as an amplifier of ongoing work and incubator for fledgling ideas with significant potential. Looking to the future, we will continue to make strategic investments that enable the Institute's continued growth and commitment to research and education.

DRIVING INTERDISCIPLINARITY

Our ability to bring unique resources to researchers across the University has increased awareness of how computing can interact with social sciences, such as addressing issues of equity and exploring the role of ethics in algorithms. By continuing to work in partnership with the BWWC and invest in MPC research, researchers are broadening the scope of how and where secure MPC can be deployed for social impact in fields such as financial services and healthcare. Additionally, we're supporting Juliet Floyd's (Philosophy) ongoing Mellon Foundation-funded seminar series, Philosophy of Emerging Computational Technologies. The Institute is the lead organizer for the "Accountability in an Age of Algorithms: How Should Ethics and Technology Converse?" symposium, which will take place in 2018 and focus on connecting humanities to technology.

The expansion of the Cybersecurity, Law, and Society Alliance will be another focus over the next year. First, a joint workshop with the School of Law will bring together experts in computer science, economics, law, and other domains to discuss and debate cross-cutting social questions like ethical hacking and secure voting. Second, we will continue to explore opportunities to bring external foundations and nonprofit entities onboard to support this growing initiative.

SUPPORTING FACULTY-LED INITIATIVES

We're currently in discussion with a number of faculty members to develop roadmaps for how the Institute can help them launch new initiatives. Led by Kate Saenko (CS), efforts are underway to formalize a cross-disciplinary research initiative focused on artificial intelligence through the application of machine learning in various settings. The Artificial Intelligence Research (AIR) initiative will bring together researchers whose work aims to create intelligent systems that learn to make decisions, reason about data, and communicate with humans. Led by Abraham Matta (CS), the CRI Lab is developing plans to support research, planning and outreach efforts on smart applications and services over virtualized cyberinfrastructures. With NSF funding, the lab will support several 2018 GENI (Global Environment for Network Innovations) community events.

ACCOMMODATING GROWTH

To date, the Institute has been very effective in maximizing resources, including space and personnel. However, as we reach full utilization, we need to plan for expansion. Over the next year, Institute leadership will work to creatively use existing space and expand the Institute's footprint to accommodate research teams and new faculty fellows. As we increase capacity to support a growing number of centers and initiatives, we also anticipate a need to increase our administrative and technical teams.

UNEARTHING NEW SYNERGIES

Moving forward, the Institute will continue to act as a catalyst that discovers potential connections across ongoing and often unrelated research. Due to our reach across disciplines and faculty, we're uniquely positioned to leverage data, knowledge, or applications developed in support of one investigator for other projects that otherwise would have no direct connection points. This synergistic capacity allows for a sharing of data and tools across disciplines and in ways previously unimaginable. For example, as SAIL software engineers engage in new collaborations, they are identifying opportunities to repurpose automation and scaling capabilities, validation techniques, and open source frameworks from past and ongoing projects to advance new research.

Another area of synergy comes from our ability to connect research with opportunities for educational programming. As we uncover these opportunities, the Institute is uniquely positioned to support experiential learning through courses, internships, and new programming, such as the new directed study programs created by SAIL and Spark!. Over the next year, Institute fellows and researchers will continue to design new courses in areas such as data ethics and digital health. With the Data Science Initiative entering its first full year with named faculty, DS faculty fellows will have the opportunity to develop new curricula for cross-listed courses with the support of the Institute. In addition to the new experiential learning courses piloting in fall 2017, Institute Fellows John Byers (CS), Chris Dellarocas (Information Systems), and Andrei Lapets (CS) are in the development stage for a massive open online course (MOOC). The MOOC, titled "Business Analytics for Data-Driven Decision Making," is slated to be part of Questrom's new, online MicroMasters program.

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