


Sharing Knowledge without Sharing Data

Platforms for resolving the false dichotomy between privacy and utility of information

Azer Bestavros

Computer Science Department
Hariri Institute for Computing
Boston University




RISE SICS Distributed Computing & Analytics Workshop

Electrum Kista, Stockholm, Sweden
September 26, 2018

The Valentine Question

Want to know if both parties are interested in each other
but, do not want to reveal unrequited love...


She loves me;
she loves me not



Feeld — Dating for couples and singles.


By Feeld Ltd

Open iTunes to download apps


 **Feeld** APP 1.2.1
Hi! I'm Feeld for couples and singles. Your crush come true.
And this is how it works:
1. @mention the person you're interested in. I will keep it a secret.
2. If your crush mentions you, I will let both of you know.
3. Then you can decide if you want to go on a date with them.
[Show more](#)

Help [Privacy Policy](#) [Terms of Service](#) [Not Playing](#)

He loves me;
he loves me not



Can we reveal the answer without revealing the inputs – not even to an app?

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(Yao's) Millionaires' Problem

Want to know who is wealthier



Can we reveal the answer without revealing the inputs – not even to an app?

The Dorm Access Question

Want to know if a student is allowed to access a dorm building



"It kinds of bothers me that the university can find out where students go and how long they stay by interrogating locks."

Can we let students in without knowing who they are?

The Labor Department Question

Want to know if companies like Google/Oracle are paying white men more

Department Of Labor

DOL HOME / NEWSROOM / NEWS RELEASES AND BRIEFS

News Release

01/04/2017

Please note: As of January 20, 2017, information in some news releases may be out of date or not reflect current policies.

US DEPARTMENT OF LABOR SUES GOOGLE INC. FOR COMPENSATION DATA

Data requested as part of routine audit of a federal contractor

SAN FRANCISCO – The U.S. Department of Labor has filed a lawsuit to require Google Inc. to provide requested compensation data and documents for the multinational company's Mountain View headquarters as part of a routine compliance evaluation.

USA TODAY

01/18/2017

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NEWS SPORTS LIFE MONEY TECH TRAVEL OPINION CROSSWORDS WASHINGTON VIDEO MORE

Oracle sued by Labor Department for paying white men more

Jessica Guyon, USA TODAY Published 1:27 p.m. ET Jan. 18, 2017 | Updated 7:44 p.m. ET Jan. 18, 2017

ORACLE

SAN FRANCISCO — Oracle is being sued by the Labor Department for allegedly paying white men more than their counterparts and for favoring Asian workers when recruiting and hiring for technical roles.

TECH Do the earliest adopters. Know what's in, what's out, and what's awesome before anyone else does, Monday/Friday.

NEVER MISS OUT Email address

The administrative lawsuit is the latest from the

“In a statement, Google said it balked at turning over the private information of employees.”

Can DOL prove (non)compliance without access to sensitive employee records?

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The National Hockey League Question

Want to know if donated brains for CTE study belong to a cohort of players

The NHL is taking Boston University to court for their CTE research

And the doctor who inspired the movie Concussion

By Mary Clarke @maryclarke Published 10:18 a.m. ET Jan. 18, 2017

ALL STAR

LA

ALL STAR

LA

ALL STAR

LA

Boston University refuses NHL request for CTE research records

By Rick Weinhard

Boston University

CTE

research records

The National Hockey League is fighting Boston University CTE Center over the research department's refusal to turn over records related to its study on the brains of deceased professional athletes.

Rick Weinhard TSN Senior Correspondent Follow Archive

In a Jan. 19 filing with U.S. federal court in Minneapolis, lawyers for the NHL asked the court to order the school to produce those documents. The dispute is related to a lawsuit filed by more than 100 former NHL players against the league arguing that it has put its profits ahead of their health.

“BU objects to the production of documents concerning the study of the brains of hockey players whose families declined to authorize the release of such information or [those] whose participation was conditioned upon assurances of confidentiality.”

BU letter to NHL, 10/26/2015

Can the court get an answer to NHL query without forcing BU to break its promise?

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Azer Bestavros, Boston University

3

The Admission Racial Bias Question

Want to know if consideration of race in admissions results in reverse racism

U.S. | EDUCATION

Harvard Faces DOJ Probe Over Affirmative-Action Policies

Justice Department accuses university of failing to cooperate in investigation of whether its admission policies discriminate against Asian-Americans

By *Melissa Korn and Nicole Hong*

Updated Nov. 21, 2017 3:12 p.m. ET



NOV. 22 2017 3:11 PM

Justice Department Is Investigating Potential Racial Bias in Harvard's Admission Practices

By Lila Thulin



Can the DoJ get an answer without forcing Harvard to release admission data?

The answer to all these questions is **YES**

We can derive knowledge (K) from data (x_1, x_2, x_3, \dots) without requiring owners of the data to share it or to trust anything other than mathematics under some assumptions about threats

💡 $K = f(\text{TOP SECRET CONFIDENTIAL TOP SECRET}, \text{TOP SECRET CONFIDENTIAL TOP SECRET}, \text{TOP SECRET CONFIDENTIAL TOP SECRET}, \dots)$

Azer in the land of social science with mayors, lawyers, CTOs, CIOs, administrators, politicians, journalists, and lawmakers...

A True Story



July 31, 2014



Katharine Lusk

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

FOR IMMEDIATE RELEASE

CONTACT: Kira Jastive, 617-358-1240 or kjastive@bu.edu

(Boston) – Boston University’s Rafik B. Hariri Institute for Computing and Computational Science & Engineering today announced it has received funding from the National Science Foundation (NSF) to develop a “smart-city” cloud platform designed to streamline and strengthen multiple municipal functions. Called SCOPE: a Smart-city Cloud-based Open Platform & Eco-system, the project is designed to improve transportation, energy, public safety, asset management, and social services in the City of Boston and across Massachusetts.

BU Initiative on Cities



Press Release 14-089
Expanding the breadth and impact of cybersecurity and privacy research

NSF announces two Frontier-scale projects, part of a \$74.5 million investment to support foundational cybersecurity research and education

Announced July 31, 2014 Press Release

The National Science Foundation’s (NSF) *Secure and Trustworthy Cyberspace* (STC) program awarded a \$10 million Frontier grant to the Modular Approach to Cloud Security (MACS) project. MACS is one of two new center-scale “Frontier” awards to support large, multi-institution projects that address grand challenges in cybersecurity science and engineering with the potential for broad economic and scientific impact.

The goal of the MACS project is to develop methods for building information systems with meaningful multi-layered security guarantees. Arguably, reasoning about all the security aspects of cyber-“to use” is not feasible. The approach we take is a “modular” one and at systems that are built from smaller and separable functional components, where the security of each component is asserted individually, and where security of the system as a whole can be derived from the security of the components.

The team — made up of researchers from Boston University, Massachusetts Institute of Technology, the University of Connecticut and Northeastern University — comprises experts in different aspects of information security and cryptography. The research is highly collaborative and pools together key areas of expertise in order to provide overall security guarantees. A key component of the project is the Massachusetts Open Cloud, which provides the research team with a platform for designing and testing the developed mechanisms in a production cloud.

Visit the [MACS Project Description](#) for more details.



more than 225 projects

July 31, 2014

As our lives and businesses become ever more intertwined with the Internet and networked technologies, it is crucial to continue to develop and improve cybersecurity practices to keep our data, devices and critical systems safe, secure, private and reliable.

The National Science Foundation’s (NSF) *Secure and Trustworthy Cyberspace* (STC) program announced two new center-scale “Frontier” awards to support large, multi-institution projects that address grand challenges in cybersecurity science and engineering with the potential for broad economic and scientific impact.

April 9, 2013

WOMEN'S WORKFORCE COUNCIL

The Women's Workforce Council was established by Mayor Thomas M. Menino on April 9th, 2013— known nationwide as Equal Pay Day. The day marks how far into 2013 women need to work to earn what men earned in 2012. The first of its kind in the country, the Council's mission is to help transform Boston into the best city in the country for working women.

Members of the Council represent the financial, engineering, medical, law, technology and retail sectors, and include small business owners, entrepreneurs, senior executives, as well as academic, labor and nonprofit leaders.

City of Boston.gov

Official Web Site of the City of Boston

Home 311 Payments Residents Businesses Visitors Students Government

Women's Advancement

- Home
- About Our Office
- Boston Women's Commission
- Boston Women's Workforce Council

Boston Women's Workforce Council

The mission of the Boston Women's Workforce Council, original 2013, is to close the gender wage gap and remove the visible barriers to women's advancement in today's working world. The Council, co-chaired by the Mayor and the Council President, is a public-private partnership of business, academic, labor and nonprofit leaders in the Greater Boston area in a public effort to ensure that 100% of the talent pool is used to make Greater Boston the best city for working women in America.



December 11, 2013



100% TALENT

The Boston Women's Compact

To make Greater Boston the premier place for working women in America, by closing the wage gap and removing the visible and invisible barriers to women's advancement. By doing so, we will build a more equitable workforce where all talent is cultivated and valued.


GOAL 3

Evaluating Success

Employers agree to participate in a biennial review to discuss successes and challenges, as well as contribute data to a report compiled by a third-party on the Compact's success to date. Employer-level data would not be identified in the report. The specific data to be reported will build on data already required by federal and state authorities and should not create an additional reporting burden.



December 11, 2013



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To make Greater Boston the premier place for work by closing the wage gap and removing the visible and invisible barriers to advancement. By doing so, we will build a more equitable economy where talent is cultivated and valued.

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September 4, 2014 ++

A subset of over 120 hours of meetings from Azer's Exchange Calendar with BWWC principals, Company CIOs, HR Officers, ...



Subject	Start	Duration
Cathy Minehan	Fri 9/5/2014 10:30 AM	2 hours
Simmons College	Mon 10/27/2014 3:30 PM	1.5 hours
Data Collection for Pay Equity	Tue 12/2/2014 11:30 AM	30 minutes
Simmons College people	Fri 1/23/2015 1:00 PM	30 minutes
Invitation: 100% Talent Discussion with Data Partners @ Tue Mar 17, 2015 2pm - 3pm (johnstk3@s...	Tue 3/17/2015 2:00 PM	1 hour
Updated Invitation: MassMutual call with Hariri Institute re: Data Collection... @ Thu May 14, 2015 ...	Thu 5/14/2015 3:00 PM	1 hour
Invitation: Mock collection #1 @ Tue May 19, 2015 11am - 12pm (johnstk3@simmons.edu)	Tue 5/19/2015 11:00 AM	1 hour
Invitation: Mock Collection #2 @ Tue May 26, 2015 11am - 12pm (johnstk3@simmons.edu)	Tue 5/26/2015 11:00 AM	1 hour
Invitation: Mock Collection #3 @ Thu May 28, 2015 11am - 12pm (johnstk3@simmons.edu)	Thu 5/28/2015 11:00 AM	1 hour
Invitation: Call with BWWC @ Wed Jun 3, 2015 11:30am - 12pm (johnstk3@simmons.edu)	Wed 6/3/2015 11:30 AM	30 minutes
Updated Invitation: 100% Talent Data Collection: Hariri and Raytheon @ Fri Jun 5, 2015 9am - 10a...	Fri 6/5/2015 9:00 AM	1 hour
Invitation: 100% TALENT DATA COLLECTION @ Mon Jun 8, 2015 9am - 10:30am (johnstk3@sim...	Mon 6/8/2015 9:00 AM	1.5 hours
Invitation: Meeting with Boston Women's Workforce Council @ Tue Aug 11, 2015 10am - 11am (jo...	Tue 8/11/2015 10:00 AM	1 hour



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

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April 14, 2015

THE BOSTON GLOBE

WEDNESDAY, APRIL 10, 2013 \$5.00 (\$6.00 OUTSIDE THE METRO AREA)

Business

TECH | CARS | BUSINESS ACCOUNTS | LIVES OF
Sports

NEWS METRO ARTS **BUSINESS** SPORTS OPINION POLITICS LIFESTYLE MAGAZINE TODAY'S PAPER

MARKETS TECHNOLOGY BOSTONIZATION

Mayor Walsh pushes to gather data on gender wage gap

By Katie Johnson | GLOBE STAFF APRIL 10, 2013



In Boston, white women make 87 cents for every dollar that men make, according to the city.

By Katie Johnson | GLOBE STAFF APRIL 10, 2013

Mayor Martin J. Walsh waded into the controversy surrounding the gender wage p

Tuesday, announcing that he was set to launch an unparalleled effort to collect sala

data from businesses throughout Boston, and that he had boosted the salaries of o

women on his own staff.

The city's findings are part of a report by the U.S. Department of Labor's Bureau of Economic Analysis, which found that white women in the United States earn 87 cents for every dollar that men make, while black women earn 64 cents for every dollar that men make.

Walsh said the city would be the first in the nation to conduct such a study. He said the data would help him identify areas where women are being paid less than men and work to address those disparities.

The city's findings are based on data from 2011, when the city conducted a comprehensive pay survey. The survey found that the average salary for a woman in the city was \$44,000, compared to \$50,000 for a man. The gap was even larger for people of color, with black women earning the lowest average salary at \$38,000.

Walsh said the city would be releasing the full report next month. He said he hoped it would serve as a model for other cities looking to address the gender wage gap.

The report also found that the gender wage gap was largest in the private sector, where women earned 82 cents for every dollar that men made. In the public sector, the gap was smaller, with women earning 91 cents for every dollar that men made.

Walsh said the city would be working to close the gap by ensuring that all employees were paid fairly and equitably. He said he would be reviewing the city's compensation policies and making changes as needed.

The report also found that the gender wage gap was largest for people with lower levels of education. Women with a high school diploma or less earned 78 cents for every dollar that men made, while women with a college degree earned 91 cents for every dollar that men made.

Walsh said the city would be providing training and support for women to help them advance in their careers. He said he would be working to ensure that all women had access to the same opportunities as men.

The report also found that the gender wage gap was largest for people who worked in low-paying jobs. Women who worked in retail or food service earned 74 cents for every dollar that men made, while women who worked in professional occupations earned 91 cents for every dollar that men made.

Walsh said the city would be working to create more high-paying jobs for women. He said he would be supporting businesses that hire and promote women.

The report also found that the gender wage gap was largest for people who worked part-time. Women who worked part-time earned 64 cents for every dollar that men made, while men who worked part-time earned 87 cents for every dollar that men made.

Walsh said the city would be working to provide more benefits and protections for part-time workers. He said he would be advocating for legislation that would require employers to provide the same benefits to part-time workers as they do to full-time workers.

The report also found that the gender wage gap was largest for people who worked in the service industry. Women who worked in the service industry earned 74 cents for every dollar that men made, while men who worked in the service industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to improve wages and conditions in the service industry. He said he would be supporting organizations that advocate for workers' rights.

The report also found that the gender wage gap was largest for people who worked in the manufacturing industry. Women who worked in the manufacturing industry earned 64 cents for every dollar that men made, while men who worked in the manufacturing industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to attract more investment to the manufacturing industry. He said he would be supporting businesses that invest in research and development.

The report also found that the gender wage gap was largest for people who worked in the construction industry. Women who worked in the construction industry earned 64 cents for every dollar that men made, while men who worked in the construction industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to encourage more women to enter the construction industry. He said he would be supporting organizations that provide training and mentorship for women in the field.

The report also found that the gender wage gap was largest for people who worked in the health care industry. Women who worked in the health care industry earned 74 cents for every dollar that men made, while men who worked in the health care industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to ensure that all healthcare workers were paid fairly. He said he would be supporting organizations that advocate for nurses' and other healthcare workers' rights.

The report also found that the gender wage gap was largest for people who worked in the education industry. Women who worked in the education industry earned 74 cents for every dollar that men made, while men who worked in the education industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to ensure that all educators were paid fairly. He said he would be supporting organizations that advocate for teachers' and other educators' rights.

The report also found that the gender wage gap was largest for people who worked in the arts and entertainment industry. Women who worked in the arts and entertainment industry earned 64 cents for every dollar that men made, while men who worked in the arts and entertainment industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the arts and entertainment industry. He said he would be supporting organizations that provide training and mentorship for artists and entertainers.

The report also found that the gender wage gap was largest for people who worked in the nonprofit industry. Women who worked in the nonprofit industry earned 64 cents for every dollar that men made, while men who worked in the nonprofit industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to ensure that all nonprofit workers were paid fairly. He said he would be supporting organizations that advocate for nonprofit workers' rights.

The report also found that the gender wage gap was largest for people who worked in the government industry. Women who worked in the government industry earned 74 cents for every dollar that men made, while men who worked in the government industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to ensure that all government workers were paid fairly. He said he would be supporting organizations that advocate for government workers' rights.

The report also found that the gender wage gap was largest for people who worked in the military industry. Women who worked in the military industry earned 64 cents for every dollar that men made, while men who worked in the military industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to ensure that all military workers were paid fairly. He said he would be supporting organizations that advocate for military workers' rights.

The report also found that the gender wage gap was largest for people who worked in the agriculture industry. Women who worked in the agriculture industry earned 64 cents for every dollar that men made, while men who worked in the agriculture industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the agriculture industry. He said he would be supporting organizations that provide training and mentorship for farmers and ranchers.

The report also found that the gender wage gap was largest for people who worked in the fishing and hunting industry. Women who worked in the fishing and hunting industry earned 64 cents for every dollar that men made, while men who worked in the fishing and hunting industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the fishing and hunting industry. He said he would be supporting organizations that provide training and mentorship for fishermen and hunters.

The report also found that the gender wage gap was largest for people who worked in the mining industry. Women who worked in the mining industry earned 64 cents for every dollar that men made, while men who worked in the mining industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the mining industry. He said he would be supporting organizations that provide training and mentorship for miners.

The report also found that the gender wage gap was largest for people who worked in the energy industry. Women who worked in the energy industry earned 64 cents for every dollar that men made, while men who worked in the energy industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the energy industry. He said he would be supporting organizations that provide training and mentorship for energy workers.

The report also found that the gender wage gap was largest for people who worked in the transportation industry. Women who worked in the transportation industry earned 64 cents for every dollar that men made, while men who worked in the transportation industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the transportation industry. He said he would be supporting organizations that provide training and mentorship for transportation workers.

The report also found that the gender wage gap was largest for people who worked in the information technology industry. Women who worked in the information technology industry earned 74 cents for every dollar that men made, while men who worked in the information technology industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the information technology industry. He said he would be supporting organizations that provide training and mentorship for IT workers.

The report also found that the gender wage gap was largest for people who worked in the telecommunications industry. Women who worked in the telecommunications industry earned 64 cents for every dollar that men made, while men who worked in the telecommunications industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the telecommunications industry. He said he would be supporting organizations that provide training and mentorship for telecommunications workers.

The report also found that the gender wage gap was largest for people who worked in the media industry. Women who worked in the media industry earned 64 cents for every dollar that men made, while men who worked in the media industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the media industry. He said he would be supporting organizations that provide training and mentorship for media workers.

The report also found that the gender wage gap was largest for people who worked in the publishing industry. Women who worked in the publishing industry earned 64 cents for every dollar that men made, while men who worked in the publishing industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the publishing industry. He said he would be supporting organizations that provide training and mentorship for publishers.

The report also found that the gender wage gap was largest for people who worked in the film and television industry. Women who worked in the film and television industry earned 64 cents for every dollar that men made, while men who worked in the film and television industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the film and television industry. He said he would be supporting organizations that provide training and mentorship for actors and actresses.

The report also found that the gender wage gap was largest for people who worked in the music industry. Women who worked in the music industry earned 64 cents for every dollar that men made, while men who worked in the music industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the music industry. He said he would be supporting organizations that provide training and mentorship for musicians.

The report also found that the gender wage gap was largest for people who worked in the dance industry. Women who worked in the dance industry earned 64 cents for every dollar that men made, while men who worked in the dance industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the dance industry. He said he would be supporting organizations that provide training and mentorship for dancers.

The report also found that the gender wage gap was largest for people who worked in the theater industry. Women who worked in the theater industry earned 64 cents for every dollar that men made, while men who worked in the theater industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the theater industry. He said he would be supporting organizations that provide training and mentorship for actors and actresses.

The report also found that the gender wage gap was largest for people who worked in the opera industry. Women who worked in the opera industry earned 64 cents for every dollar that men made, while men who worked in the opera industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the opera industry. He said he would be supporting organizations that provide training and mentorship for singers.

The report also found that the gender wage gap was largest for people who worked in the ballet industry. Women who worked in the ballet industry earned 64 cents for every dollar that men made, while men who worked in the ballet industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the ballet industry. He said he would be supporting organizations that provide training and mentorship for ballerinas.

The report also found that the gender wage gap was largest for people who worked in the circus industry. Women who worked in the circus industry earned 64 cents for every dollar that men made, while men who worked in the circus industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the circus industry. He said he would be supporting organizations that provide training and mentorship for circus performers.

The report also found that the gender wage gap was largest for people who worked in the rodeo industry. Women who worked in the rodeo industry earned 64 cents for every dollar that men made, while men who worked in the rodeo industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the rodeo industry. He said he would be supporting organizations that provide training and mentorship for rodeo riders.

The report also found that the gender wage gap was largest for people who worked in the sports industry. Women who worked in the sports industry earned 64 cents for every dollar that men made, while men who worked in the sports industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the sports industry. He said he would be supporting organizations that provide training and mentorship for athletes.

The report also found that the gender wage gap was largest for people who worked in the gaming industry. Women who worked in the gaming industry earned 64 cents for every dollar that men made, while men who worked in the gaming industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the gaming industry. He said he would be supporting organizations that provide training and mentorship for gamblers.

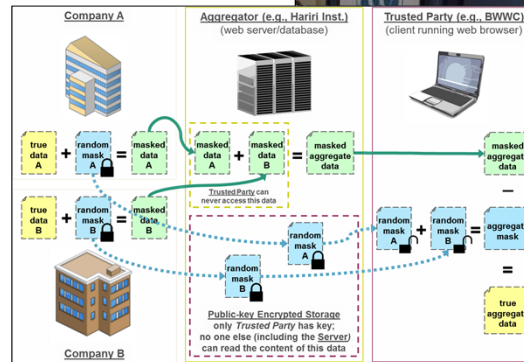
The report also found that the gender wage gap was largest for people who worked in the gambling industry. Women who worked in the gambling industry earned 64 cents for every dollar that men made, while men who worked in the gambling industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the gambling industry. He said he would be supporting organizations that provide training and mentorship for casino workers.

The report also found that the gender wage gap was largest for people who worked in the hotel and tourism industry. Women who worked in the hotel and tourism industry earned 64 cents for every dollar that men made, while men who worked in the hotel and tourism industry earned 87 cents for every dollar that men made.

Walsh said the city would be working to support the hotel and tourism industry. He said he would be supporting organizations that provide training and mentorship for hotel workers

A screenshot of a BU Today article header. The BU Today logo is in the top left, and the text "In the World" is in the top right. The main title is "Computational Thinking Breaks a Logjam" in large, bold black font. Below it is the subtitle "Hariri Institute helps address Boston's male female pay gap" in a smaller black font. At the bottom left of the header area, it says "04/27/2016" and "By Rich Barlow". On the bottom right, there are two small circular icons: a green one with a white plus sign and a red one with a white minus sign.

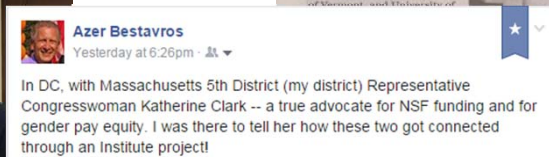


June 6, 2015

[illegible]

**“Dennis and Diane,
what State Street Bank
lawyers should ask for
is a Non Collusion
Agreement!”**

lawyers should ask for is a Non Collusion Agreement!"

[illegible]

The congresswoman, who had signed onto a bill addressing income disparity between men and women, was impressed by the relevance he outlined. *"It's linking it back for the members of Congress,"* Clark said. *"Nobody would think, oh, the Paycheck Fairness Act, how is that tied into NSF funding?"* The meeting was slated for 15 minutes. It lasted 25.

April 28, 2016

The Sequel

- Compact doubled in size
- More elaborate analytics
- Hardened user interface
- Provide local sanity checks
- Provide comparative metrics

BU Today

In the World

Calculating Gender Pay Equity

BU computer scientists remove obstacle in Boston's push for wage parity

07.08.2016 By Andrew Thurston

100% TALENT

The Boston Women's Compact

Workforce Survey

Enter Session Key

Email Address to track participation

Female Workforce

Male Workforce

npr wbur 90.3

ON POINT

WITH TOM ASHBROOK

BWWC co-chair Evelyn Murphy on secure multi-party computation: "It's used in computer science applications, but it has never been used for public good. Here, we're beginning to show how to use this sophisticated computer science research for public programs."

BU

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

Azer Bestavros: Sharing Knowledge without Sharing Data -- On the false choice between privacy and utility of information

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January 5, 2017

BOSTON WOMEN'S WORKFORCE COUNCIL REPORT 2016

"We collected data regarding 112,600 employees, which represents 11% of the Greater Boston workforce and almost \$11 billion in annual earnings."

TABLE 3: COMPENSATION COMPARISONS BY GENDER WITHIN JOB CATEGORY

EXECUTIVES

MIDLEVEL

PROFESSIONALS

TECHNICIANS

SALES WORKERS

ADMIN SUPPORT WORKERS

CRAFT WORKERS

OPERATIVES

LABORERS AND HELPERS

SERVICE WORKERS

0 0.2 0.4 0.6 0.8 1 1.2 %

TOTAL ANNUAL COMP (FEMALE/MALE RATIO)

Even in liberal Boston, there's a gender wage gap

Subscribe Starting at 99 cents

Members Sign In

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By Katie Johnston

GLOBE STAFF JANUARY 05, 2017

Working women in Greater Boston make 77 cents on the dollar compared to men — a gender wage gap that echoes the national average — according to a report released Thursday by the Boston Women's Workforce Council.

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Azer Bestavros: Sharing Knowledge without Sharing Data -- On the false choice between privacy and utility of information

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Azer Bestavros, Boston University


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January 27, 2017



BU Today

Tackling the Wage Gap with Code

Hariri software team aids Boston Women's Workforce Council



Hariri Institute director Azer Bestavros at a City Hall press conference on the Boston Women's Workforce Council wage gap report earlier this month, flanked by Katie Conboy, Simmons College provost (from left), former Lt. Governor Evelyn Murphy, Boston Mayor Martin J. Walsh, and Eddie Ahmed, MassMutual Financial Group chief human resources officer. Photo by Cydney Scott.



Membership Brief
Creating Internal Goals
Boston University Hariri Institute
March 27, 2017

Mayor Walsh with members of the Boston Women's Workforce Council and 100% Talent Compact signers. Photo courtesy of the City of Boston.

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January 31, 2018

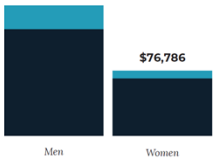
BOSTON WOMEN'S WORKFORCE COUNCIL REPORT 2017



"This year's data submission included 166,705 employees from 114 Compact-signing companies."

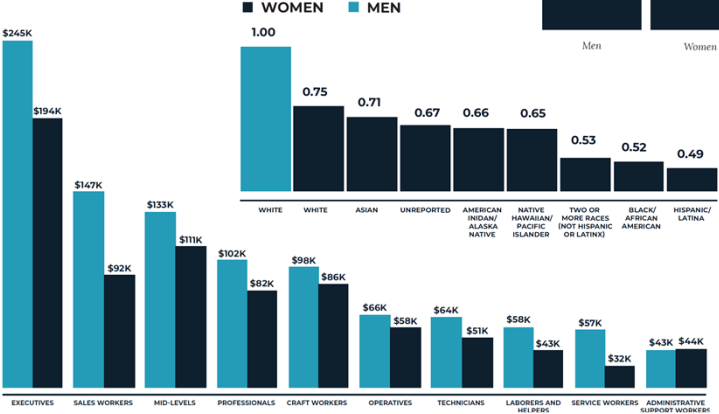
ANNUAL COMPENSATION

CASH PERFORMANCE PAY



WOMEN

MEN



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November 16, 2017

115TH CONGRESS
1ST SESSION

H. R. 4174

IN THE SENATE OF THE UNITED STATES
NOVEMBER 16, 2017
Received; read twice and referred to the Committee on Homeland Security and Governmental Affairs

AN ACT

To amend titles 5 and 44, United States Code, to require Federal evaluation activities, improve Federal data management, and for other purposes.


Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.
(a) SHORT TITLE.—This Act may be cited as the “Foundations for Evidence-Based Policymaking Act of 2017”.

GOVTECH
WORKS
by General Dynamics IT

Evidence-Based Policy Act Could Change How Feds Use, Share Data

by Tobias Naegele | Nov 29, 2017



As government CIOs try to get their arms around how the Modernizing Government Technology (MGT) Act will affect their lives and programs, the next big IT measure to hit Congress is coming into focus: House Speaker Paul Ryan’s (R-Wis.) “Foundations for Evidence-Based Policymaking Act of 2017.”

A bipartisan measure now pending in both the House and Senate, the bill has profound implications for how federal agencies manage and organize data – the keys to being able to put data for informed policy decisions into the public domain in the future. Sponsored by Ryan in the House and by Sen. Patty Murray (D-Wash.) in the Senate, the measure would:

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November 29, 2017

115TH CONGRESS
1ST SESSION

S. _____

IN THE SENATE OF THE UNITED STATES

Mr. WYDEN (for himself, Mr. RUBIO, and Mr. WARNER) introduced the following bill; which was read twice and referred to the Committee on _____

A BILL

To establish a new higher education data system to allow for more accurate, complete, and secure data on student retention, graduation, and earnings outcomes, at all levels of postsecondary enrollment, and for other purposes.

1Be it enacted by the Senate and House of Representa-

2tives of the United States of America in Congress assembled,

Home > News > Press Releases

Wyden, Rubio, Warner Introduce “Student Right to Know Before You Go Act” to Empower Students as Consumers and Showcase New Privacy-Protecting Technology

Updated Legislation Allows Students and Families to Make Informed Decisions about How to Spend Their Higher Education Dollars; Protects Student Privacy By Featuring Encrypted, Secure Multi-party Computation

“We are excited to see legislation promoting the use of multi-party computation (MPC) in formulating sound public policy. Boston University’s successful collaboration with the City of Boston and the Boston Women’s Workforce Council brought this technology into practice to maintain data privacy while gaining insight into an important societal issue -- potential wage inequality in private industry. Such applications demonstrate that MPC can bring enormous value to policymakers at all levels of government.”

-- Azer Bestavros (on behalf of the team from BU)

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August 21, 2018

"the bills have been stalled in the Senate, caught in the tension between two constituencies that mean well. One wants to improve consumer awareness and one wants to protect the privacy of individuals in an age when there isn't much privacy left. It's an increasingly familiar conflict between privacy and the public good, and because of a little-used cryptographic technology that has been used to solve similar clashes, it need not exist."

-- Azer Bestavros
Washington Post Op-Ed, August 21, 2018

The Washington Post

Democracy Dies in Darkness

Grade Point • Perspective

It's time to tell students what they need to know

By Azer Bestavros
August 21

What's the real value of a college education? For some people, that is calculated by the earning power that comes with a particular college degree. For others, it's more about the satisfaction of a particular career, or about the social skills or intellectual rewards gained from the college experience. In every case, it is a life-altering decision with little data to inform it. Less data, in fact, than many other types of major long-term expenses and commitments, such as purchasing a home or buying a car.

Prospective students and their parents deserve a better look at what they are signing on for, and they could get exactly that with either of two bipartisan bills in the Senate. The Wyden-Rubio Student Right to Know Before You Go Act and the College Transparency Act would require colleges to collect and share data about such things as college costs, post-graduation salaries, the percentage of students that go on to graduate school and how long it takes to graduate. The initiatives would give prospective students a great deal of information that could help many decide what college to attend.

No one thinks that's a bad idea, but many people — privacy advocates, congressional Republicans and private colleges — point out that the collection and dissemination of such student-level data could violate a ban written into the 2008 reauthorization of the Higher Education Act. Consequently, the bills have been stalled in the Senate, caught in the tension between two constituencies that mean well. One wants to improve consumer awareness and one wants to protect the privacy of individuals in an age when there isn't much privacy left. It's an increasingly familiar conflict between privacy and the public good, and because of a little-used cryptographic technology that has been used to solve similar clashes, it need not exist.

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Multi-Party Computation (MPC)

What is it?

- Given multiple parties p_1, p_2, \dots, p_n each with private data x_1, x_2, \dots, x_n
- Parties engage in computing a function $f(x_1, x_2, \dots, x_n)$
- Nothing is revealed about the inputs beyond what the output of f reveals
- What f leaks is an orthogonal question, e.g., the realm of “differential privacy”

State of the Art

- Theory known since 1979, with Shamir’s “How to share a secret”
- Frameworks and libraries increasingly available over the last few years ...
- Experience with real use cases at scale is limited ← We are changing that
- Deployments are not easily portable ← We are changing that

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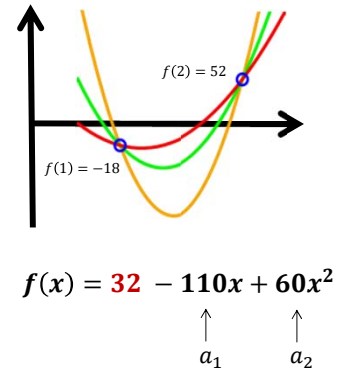
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Shamir Secret Sharing (1979): The Basic Math

→ Need $k + 1$ points to define polynomial of degree k

- To share a “secret” among k parties, make it the free coefficient of a polynomial $f(x)$ of degree k
- Select coefficients a_1, a_2, \dots, a_k of $f(x)$ at random
- Give party P_i a “share” of the secret – namely, $f(i)$
- To reconstruct the “secret” all parties need to combine their shares to find the secret – namely $f(0)$



Notes

- Need to use finite field arithmetic to provably avoid any leakage
- Approach allows secret sharing among any number of parties; any subset k can uncover the secret
- Other approaches have been proposed, most notably the use of garbled circuits

Multiparty Computing on Secret Shares

Any arbitrary function is a circuit of additions & multiplications

→ Addition is easy!

- Sum of secrets is represented by $f(x) = f_1(x) + f_2(x)$
- To compute $f(x)$, each party adds its shares of $f_1(x)$ and $f_2(x)$
- Using one round of k messages, sum of secrets can be revealed

→ Multiplication is not that easy...

- Multiplication of secrets is represented by $f(x) = f_1(x) * f_2(x)$
- Requires $O(k)$ rounds of communications – could be very expensive!

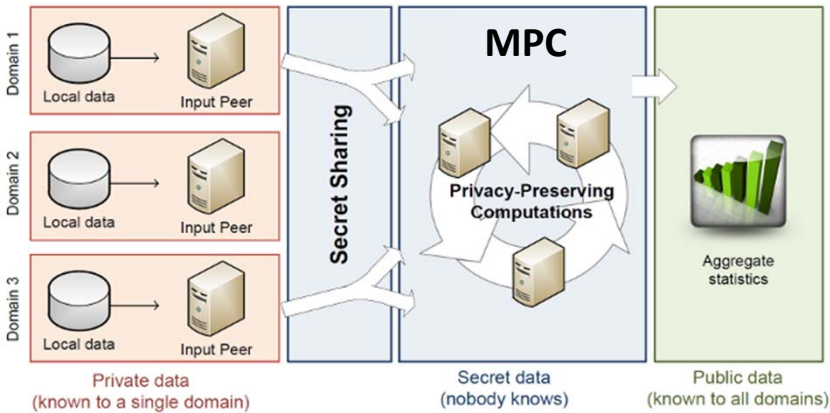
Another Flavor: Yao Garbled Circuits (1986)

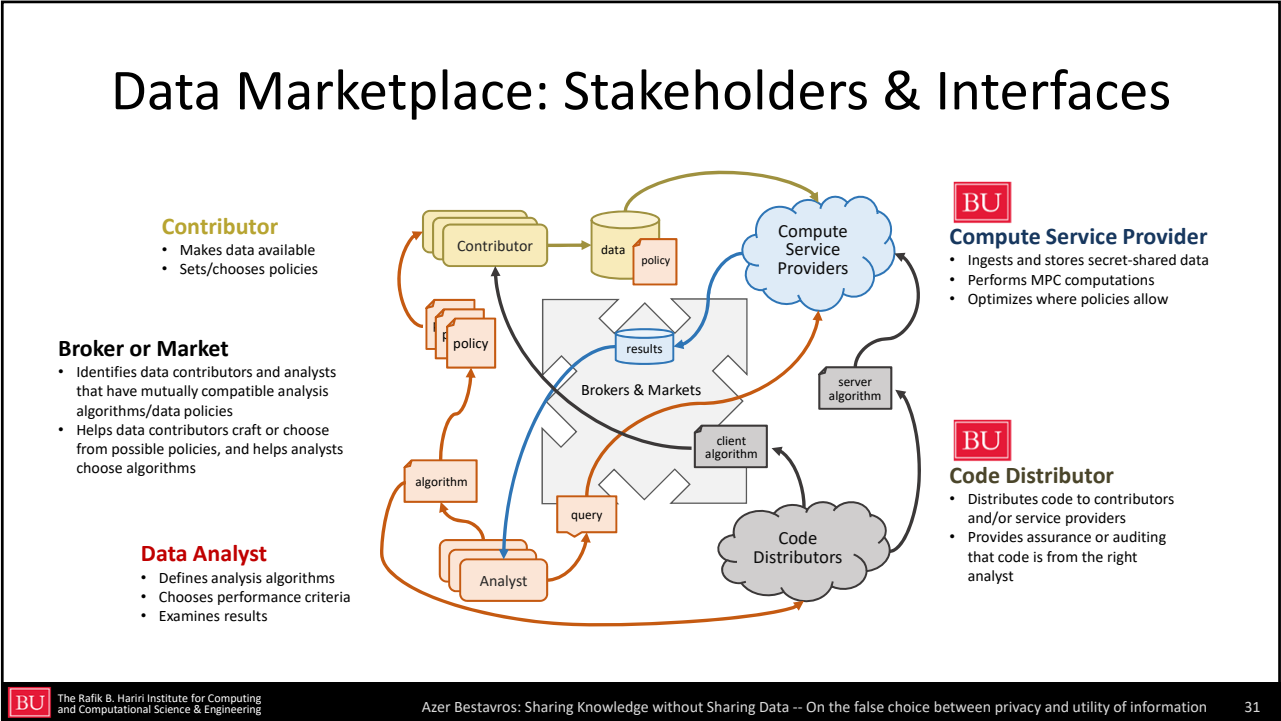
- Motivated by Yao’s Millionaires Problem (who is wealthier)
- Enables two mistrusting parties to jointly evaluate a function over private inputs using “oblivious transfer” (OT) primitive
 - P_1 replaces inputs of a truth table (gate in circuit) with random labels
 - P_1 encrypts truth table outputs using corresponding input labels
 - P_1 permutes the table and sends the encrypted “garbeled” table to P_2
 - P_1 sends the labels corresponding to its private input to P_2
 - P_1 also sends the labels corresponding to P_2 ’s inputs to P_2 using OT
 - P_2 uses labels corresponding to private inputs to compute output label
 - P_2 communicates output label to P_1 who decrypts it and reveals result

Secret Sharing: How?

$$f(x) = \textcolor{red}{s} + r_1x^1 + r_2x^2 + r_3x^3 + ... + r_ix^i + ...$$

$$\begin{aligned} s_1 &= f(1) \\ s_2 &= f(2) \\ s_3 &= f(3) \\ &\dots = \dots\dots \\ s_i &= f(i) \\ &\dots = \dots\dots \end{aligned}$$





Modeling threats and adversaries

Crypto MPC researchers consider four types of adversaries

- **Semi-honest adversary:**
 - Follows rules but may attempt to glean information along the way
- **Covert adversary:**
 - Cheats only if unlikely to be caught
- **Rational adversary:**
 - Cheats as long as expected payout is larger than expected penalty if caught
- **Malicious adversary:**
 - Performs any action needed to breach system integrity

The Parties in our MPC Setting

Contributors (100% Talent Companies)

- Have private data needed for computing the analytic
- Number of contributors is unknown in advance

Broker + Analyzer (BWWC)

- Ultimate recipient of the output of the analytic
- May also participate in computing the analytic

Service Provider + Code Distributor (BU)

- Connects/coordinate largely decoupled parties
- Has capacity to (partially) compute the analytic

Threat Modeling & Trust Assumptions

Contributors & analyzers place some trust in each other

- Analyzers trust that contributors will submit valid data
- Contributors trust that analyzers will protect aggregate output
- Contributors trust that analyzers will not collude with others

... but place no trust in service provider

- Service provider cannot be entrusted with data or with the results
- Assume that service provider is incentivized to perform the computation on behalf of the contributors and analyzers

Multi Party Computation: State of the Art

Very active R&D to make MPC accessible to programmers:

Frameworks

- [ABY](#) - 2PC with secret sharing and GC; semi-honest adversaries
- [batchDualEx](#) - 2PC with GC; malicious adversaries
- [Duplo](#) - 2PC GC; malicious adversaries
- [Obliv-C](#) - 2PC with gGC; semi-honest adversaries
- [Sharemind](#) - 2PC or 3PC with secret sharing; semi-honest adversaries
- [SPDZ](#) - General MPC with secret sharing; malicious adversaries
- [TinyLEGO](#) - 2PC with GC; malicious adversaries
- [Viff](#) - General MPC with secret sharing; semi-honest adversaries

Tools

- [CBMC-GC](#) - Creates Boolean circuits (GC) from ANSI-C code
- [UC Compiler](#) - Valiant's Universal Circuit Compiler

Primitives

- [APRICOT](#) - OT Extension secure against malicious adversaries
- [libOTe](#) - Library with various OT Extensions.
- [OT Extension](#) - OT Extension secure against malicious adversaries
- [SCAPI](#) - Various secure computation API's
- [SplitCommit](#) - Additively homomorphic commitment scheme
- [TSS](#) - Pure-Rust implementation of threshold secret sharing schemes

Protocols

- [BaRK-OPRF](#) - Private Set Intersection
- [Linreg](#) - Privacy preserving linear regression
- [ORAM \(Obliv-C\)](#) - Oblivious RAM
- [PSI](#) - Private Set Intersection

Commentary on State of Art

Adversarial models are too simplistic

- Need to match crypto threat models with economic, reputation, and legal incentives
- Design of privacy-preserving platforms should take advantage of more realistic models
- Plausible deniability (e.g., participation in MPC) goes beyond keeping data private
- Need to account for the weakest link – the human in the loop!

All parties are not created equal

- Parties may have significantly different backend systems and technical sophistication
- Parties interested in output of MPC may not be the owner of the private data
- Privacy concerns are not uniform across all parties

➔ **Need to design solutions that match stakeholders & roles**

Research Projects @ Boston University

Develop new MPC primitives, toolkits, and optimizations

- Efficient shortest-path algorithms operating over private subgraphs
- Efficient analytics/personalization over private geo-temporal data
- PL and compiler frameworks to expose privacy-utility tradeoffs

Develop MPC “as a service” solutions in various settings

- Web/browser-based MPC as a service platform
- Spark-based MPC platform for Map-Reduce analytics
- Incorporate MPC in big-data cloud workflow management

Open-source MPC Libraries

JIFF: JavaScript Implementation of Federated Functionalities

Library for building web-based applications using secure multi-party computation

<https://github.com/multiparty/jiff>

Web-MPC

JavaScript application for user-friendly privacy-preserving web-based data aggregation

<https://github.com/multiparty/web-mpc>

Conclave Workflow Manager

Compiler that optimizes relational queries to be executed under MPC by factoring it into (1) scalable, local, cleartext processing workflows using backends such as Apache Spark, and (2) isolated MPC workflows that utilize existing MPC backend frameworks

<https://github.com/multiparty/conclave>

MPC as a Service – killer apps...

Systemic Threat Analytics in Federated Settings

- Banking and Finance
- Data Network Operations

Collective Intelligence in Competitive Settings

- Information Brokerage for Business/Marketing Intelligence
- E-Commerce Analytics over Segmented Proprietary Data Assets
- Personalization and Sharing Economy Applications

Public Good Settings

- Privacy-preserving Sensus and Surveys
- Healthcare, Education, and Academic Research
- Compliance Testing/Reporting for Trade Associations
- Private/Fair Reporting of Sexual Harrasement/Abuse in Workplace





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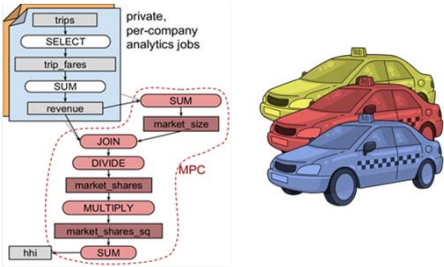
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MPC for big-data cloud workflow management


Our Solution

- **SQL-like DSL Programming**
 - ➔ No MPC experience necessary
 - ➔ Separate InfoTech from InfoSec
- **Compiler does MPC transforms**
 - ➔ No need for privacy experts
 - ➔ No need for systems experts
- **Dispatcher for local deployment**
 - ➔ No need for new backend
 - ➔ No cross-platform integration



Herfindahl-Hirschman Index on 156GB NYC trip data

Setup	Runtime
Insecure, trusted Hadoop (8 nodes)	16 min 10 s (970s)
Musketeer with MPC (5 parties, 1+1+1+1+4 nodes)	17 min 31 s (1,051s)
Secure MPC framework only (VIFF only, 5 parties, 5 nodes)	>2 hours (7,200s)



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Takeaway: We can have it both ways

We can derive knowledge (K) from data (x_1, x_2, x_3, \dots) without requiring owners of the data to share it or to trust anything other than mathematics under some assumptions about threats

$$K = f(\text{TOP SECRET CONFIDENTIAL TOP SECRET}, \text{TOP SECRET CONFIDENTIAL TOP SECRET}, \text{TOP SECRET CONFIDENTIAL TOP SECRET}, \dots)$$

When it comes to data and computation over data, we need to rethink our notions of ownership, custody, jurisdiction, sharing, disclosure, liability, and introduce new ones such as collusion.

Takeaway: Societal Implications

- Privacy/confidentiality concerns should not be used as excuses to deny society the right to answer important questions
- Privacy/confidentiality should not be sacrificed in the name of doing the right thing, or advancing science, or applying the law
- Private data should not be a tradable commodity; computation over private data should be what we offer “as a service”
- Substantial social/financial value can be gained in contexts imposing legal or policy restrictions on sharing raw data

Acknowledgments: It takes a village!

www.multiparty.org



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leveraging the computational perspective

BOSTON UNIVERSITY

Hariri Institute for Computing

"Leveraging the Computational Perspective in a Data-Driven World for a Better Society"

Website: www.bu.edu/HIC
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