SECURE MULTIPARTY COMPUTING FOR MEDICAL RECORD LINKAGE

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OVERVIEW

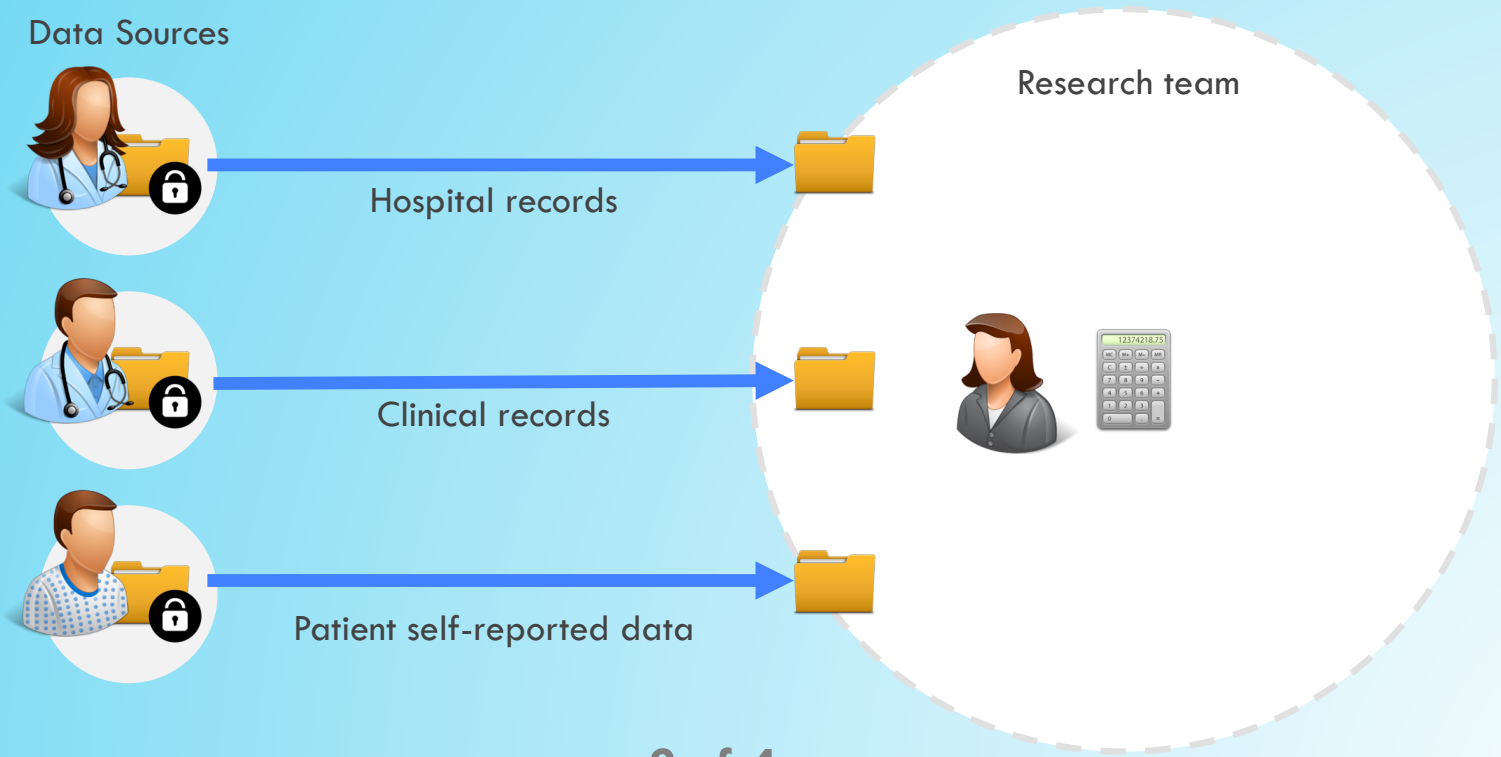
- Ways in which data are stored
- Secure multiparty computation: What is it?
- Set Intersection Method for Secure Computation
- Experiment
- Discussion
- Future Directions and New Applications

THE OLD WAY: BRING DATA TO A CENTRAL DATABASE WHERE COMPUTATIONS ARE DONE

Data Sources

Research team

THE OLD WAY: BRING DATA TO A CENTRAL DATABASE WHERE COMPUTATIONS ARE DONE



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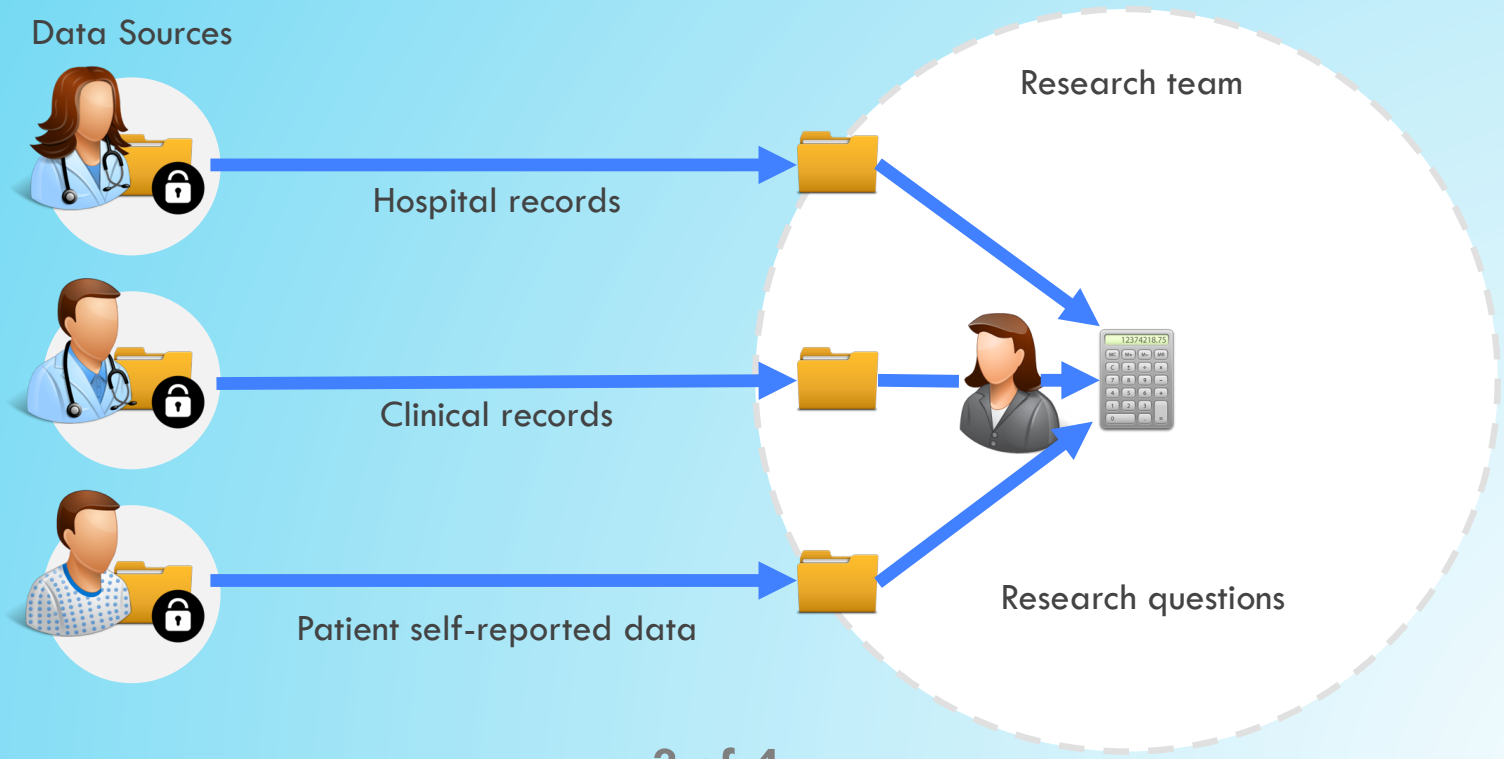

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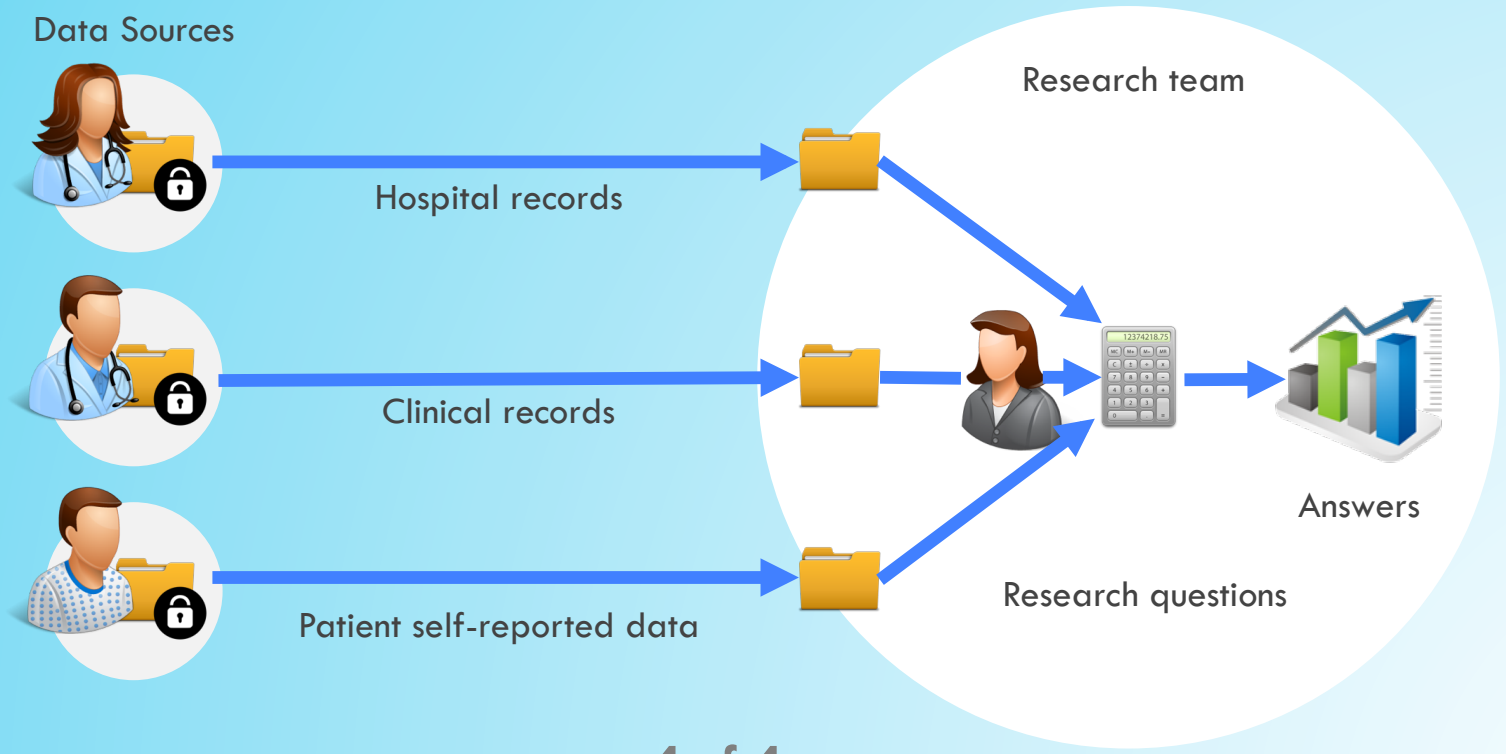

THE NEW WAY: BRING THE COMPUTATION TO THE DATA

Clinical Sites

Research team

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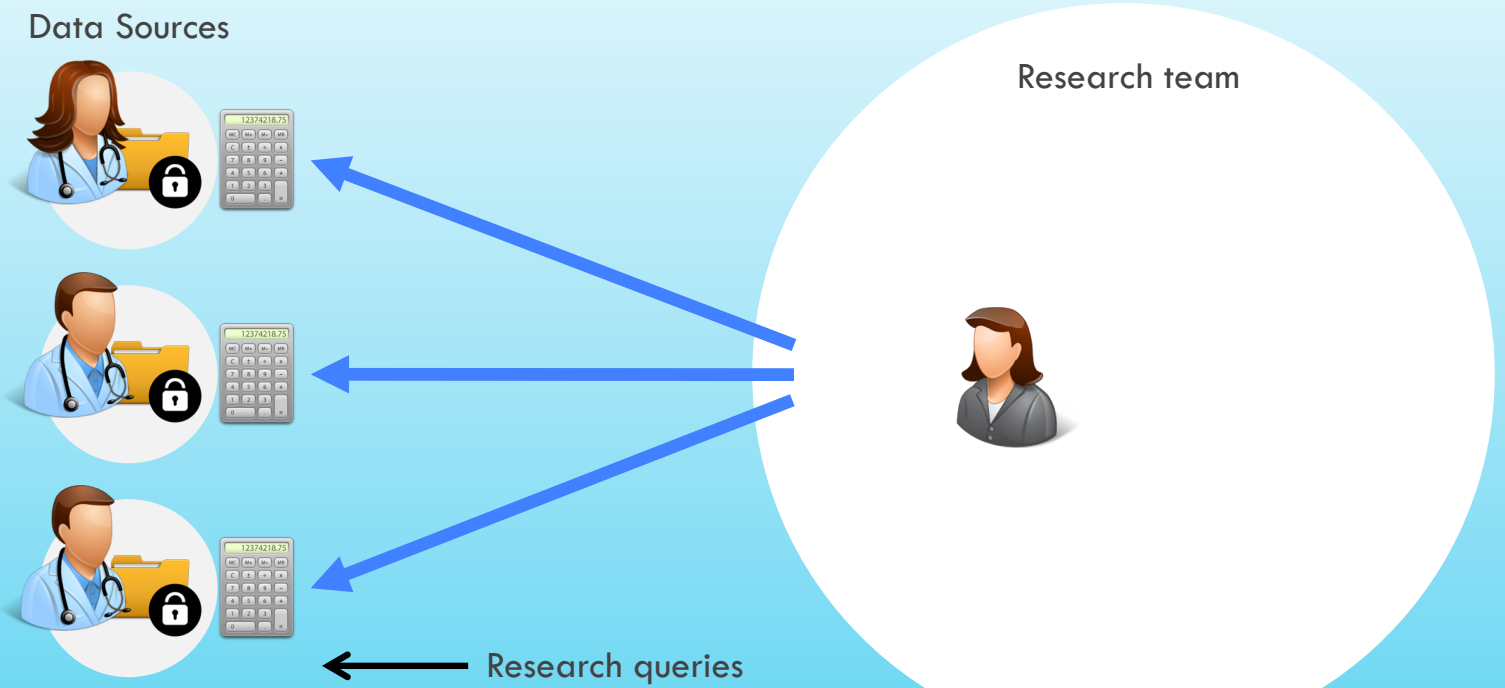
THE NEW WAY: BRING THE COMPUTATION TO THE DATA



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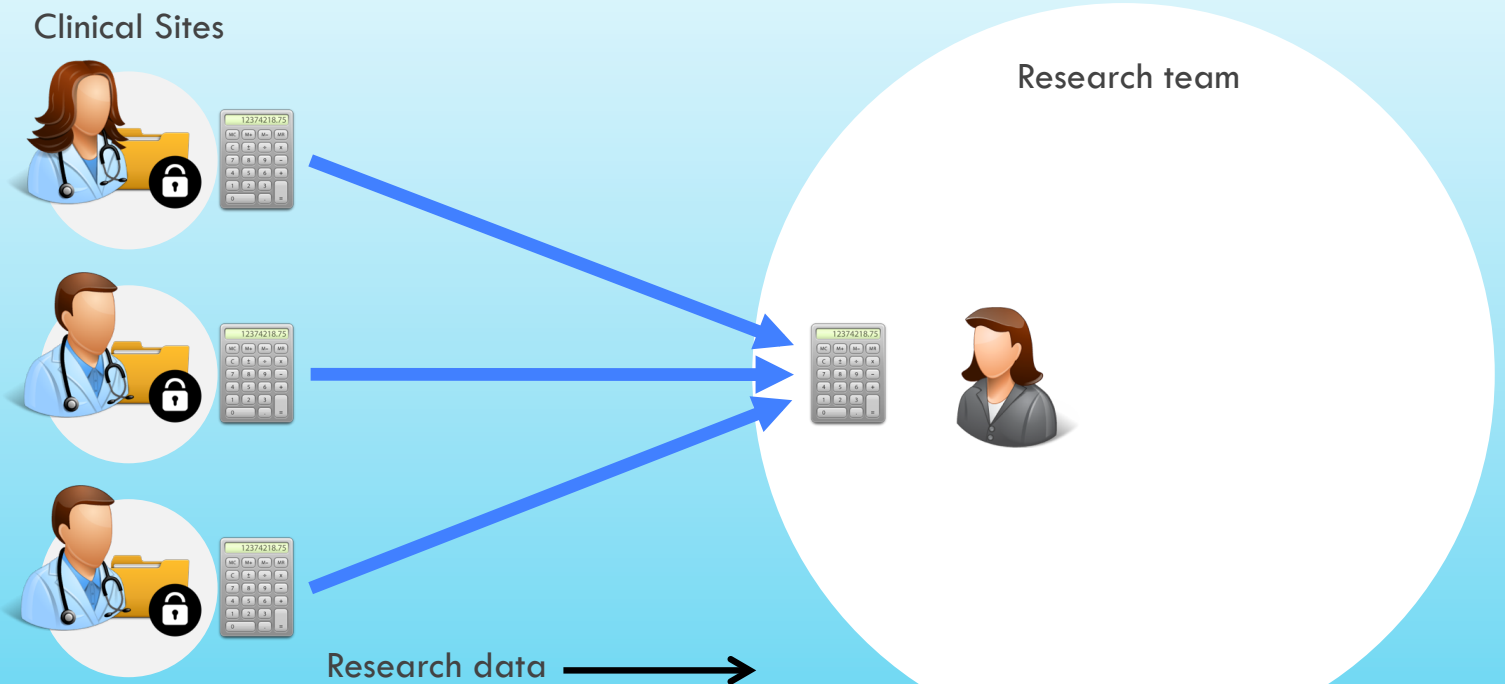

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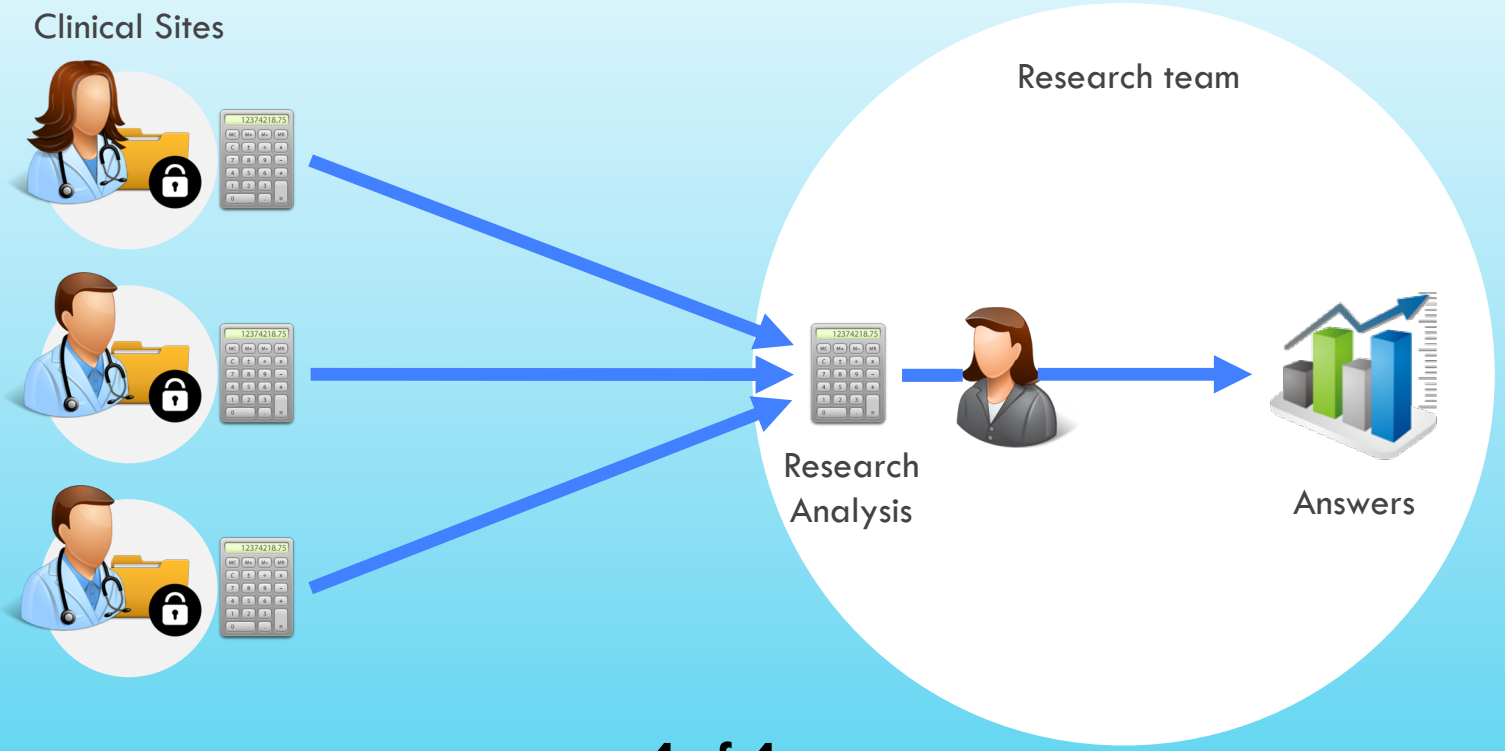
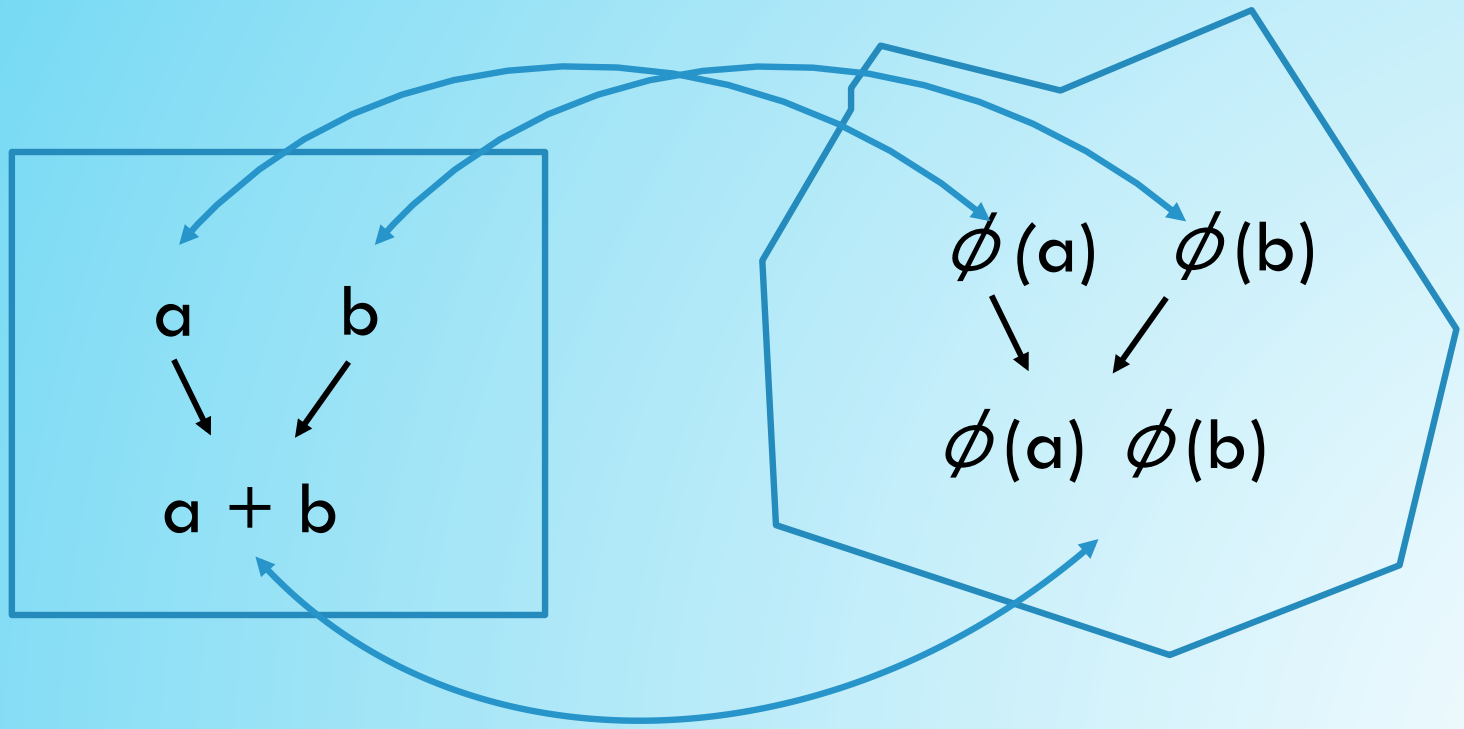


“The secret to strong security: less reliance on secrets.”

-Whitfield Diffie

SECURE MULTI-PARTY COMPUTATION: PUBLIC FUNCTION WITH PRIVATE INPUTS

HOMOMORPHIC ENCRYPTION



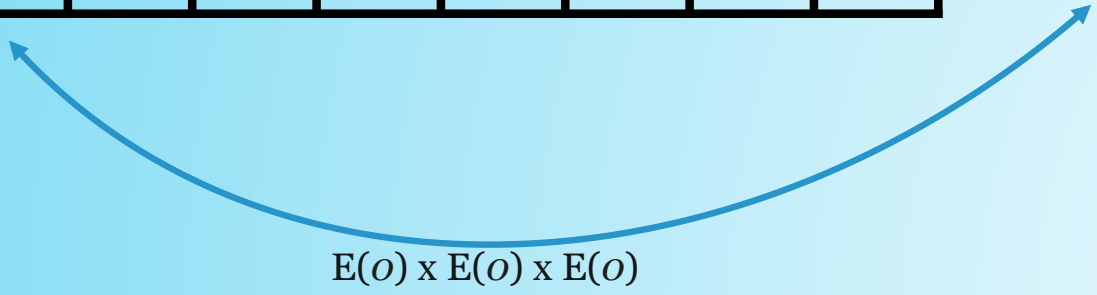
SET INTERSECTION (LIN & TZENG, 2005)

922312511 > 712312311

Binary:1011000...0 Binary: 0101111...1

	32	31	30	29	28	27	26	...	1
0	*r*	E(*o*)	*r*	*r*	E(*o*)	E(*o*)	E(*o*)	...	E(*o*)
1	E(*o*)	*r*	E(*o*)	E(*o*)	*r*	*r*	*r*	...	*r*

{011,01}



SET INTERSECTION (LIN & TZENG, 2005)

922312511 > 712312311

Binary:1011000…0

Binary: 0101111…1

Specialized encoding

{011,01}

	32	31	30	29	28	27	26	…	1
0	*r*	E(*o*)	*r*	*r*	E(*o*)	E(*o*)	E(*o*)	…	E(*o*)
1	E(*o*)	*r*	E(*o*)	E(*o*)	*r*	*r*	*r*	…	*r*

Decrypt(E(*o*) x E(*o*) x E(*o*))= 0 + 0+ 0 = 0 implies 922312511 > 712312311

SET INTERSECTION EQUIVALENCE

- Matching has more applications
  - Buying and selling prices in market transactions
  - Authentication in Communication
  - Medical Record Linkage
- Developing an application would have many uses

OUR MAIN RESULT

- If Bob returns messages on Z (target identifier) and Z – 1, then we can match identifiers

Case 1 (null set): $Y < Z$; $Y < Z - 1$	Case 2 (nonempty on both): $Y > Z$; $Y > Z - 1$
Case 3 (null set): $Y < Z$; $Y = Z - 1$	Case 4 (nonempty on 1): $Y = Z$; $Y > Z - 1$

EXPERIMENT

DATA SET

- Data represent 20,000 cases, 10,000 at each of two clinical sites (6,000 of which match)
- Metro Community Provider Network in Denver, Colorado between January 1, 2007 and January 31, 2013.

COMPUTING ENVIRONMENT

- The algorithm was carried out on a Apple, inc. MacIntosh computer with a 2.4 Ghz Intel Core i5 processor and 8 GB (1699 MHz DDR3) of memory (My Laptop).
- Software was written in the statistical computing language R, Version 3.3.0, released May 3rd, 2016 (Ihaka, Ross, & Robert, 1996) and utilized the package HomomorpheR for additive homomorphic encryption.

SORTING

We utilized a sorting algorithm to reduce the number of necessary comparisons from a x b to a + b.

RESULTS

- It took 63 minutes for Alice to encrypt her data
- Alice's single vector of encrypted IDs required 462.5 MB of space (about 46.3 GB per million lives)
- Bob's dynamic multiplication of messages, Alice's decryption of Bob's Messages took 6 hours, 32 minutes and 27 seconds.

RESULTS (HH:MM:SS)

Time	Alice encryptions	Bob's Message Generation	Decryption by Alice
User	*00:00:04*	*00:09:57*	*00:00:05*
System	*00:00:02*	*00:00:13*	*00:00:02*
Elapsed	*00:00:05*	*00:11:06*	*00:00:05*

DISCUSSION

- Secure Multiparty Record Linkage is Feasible
- Alice's encryptions can be done offline which adds efficiency
- Methods for generating global identifiers are well-known (Kho et al. 2015)
- Two-party example can be extended easily to multiple parties

FUTURE DIRECTIONS AND NEW APPLICATIONS

- Apply this method across a distributed data network
- Clinical medical record sharing peer-to-peer (through certification matching)
- Authentication in secure communication between clinicians (e.g., Secure texting)
- Genetic marker matching for the protection of personal genetic data

ACKNOWLEDGMENTS

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