



Title

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by
NIKLAS ISERMANN

submitted to:
Prof. Dr. Johannes Blömer
and
???

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1 Abstract

2 Introduction

2.1 MPC and Databases

A famous problem in the context of MPC is Yao's millionaire's problem. In Yao's millionaire's problem there are two millionaires Alice and Bob. We will call Alice's wealth x and Bob's wealth y . Alice and Bob want to know who of them has more money. i.e. they want to compute the function $F(x,y) := \begin{cases} \text{Alice is richer} & y \leq x \\ \text{Bob is richer} & y > x \end{cases}$. Yet neither of them is willing to trust the other and tell him how much money he has. Yao's millionaire's problem can be generalised into the general MPC problem. Instead of Bob and Alice, we now consider n parties p_0, \dots, p_{n-1} and each party i holds an arbitrary input x_i for an arbitrary function $F(x_0, \dots, x_{n-1})$, that all parties have agreed upon. A MPC protocol π is protocol, that allows p_0, \dots, p_{n-1} to compute $F(x_0, \dots, x_{n-1})$ without revealing any information about x_0, \dots, x_{n-1} .

Andrew Yao proposed a solution for Yao's millionaire's problem in 1982 [1]. It has also been shown that MPC is Turing-complete[2]. This means that for any function f that can be computed with a Turing machine. There exists a MPC protocol π that can compute f . -Databases ...

2.2 related work

2.2.1 From Keys to Databases—Real-World Applications of Secure Multi-Party Computation

2.3 goals

In this section we describe the goals of our work.

2.4 structure

In this section we outline the structure this document.

3 preliminary

3.0.1 MPC definition

- n parties p_0, \dots, p_{n-1}
- agreed functionality $F(x_0, \dots, x_{n-1})$
- functionality is function with internal randomness - party p_i holds input value x_i
- protocol π that enables the parties to compute $F(x_0, \dots, x_{n-1})$ without revealing inputs

3.0.2 the adversary and its capability's.

An adversary has the ability to corrupt one or more party's. There exists an upper bound $0 < t < n$. This t limits how many parties the adversary can corrupt and is an important parameter of the setting. A common setting is $t = \lfloor \frac{n}{2} \rfloor$, which is called the honest majority. For example and for $n=3$ the presence of an honest majority means, that it is assumed that the adversary can corrupt at most 1 party. Once a party is corrupted the adversary gets full information about every message the party sends or receives, this also includes the messages from the time before the party had been corrupted. There are multiple categorizations of adversary's and their capabilities. On such categorization is the distinction between passive and active adversary's. A passive adversary can not force a corrupted party to deviate from the protocol in any way. An active adversary has the power to force a corrupted party to deviate from the protocol in an arbitrary way. So if for example the protocol would at some point require that each party chooses an integer between 1 and n uniformly at random. Then a passive adversary would have no choice but to choose the integer between 1 and n uniformly at random. On the contrary an active adversary would be able to force a corrupted party to choose the value 42 or any other value that the adversary considers to be advantageous for him. Another important distinction is the distinction between static and adaptive adversary's. A static adversary is bound to choose which parties he wants to corrupt before the execution of π starts. An adaptive adversary can corrupt a party during the execution of the protocol. This makes the adaptive adversary much more powerful as he can try to identify "weak links" during the execution of the protocol and corrupt those.

3.0.3 real world vs ideal world

For semi-honest adversary's we can now formalise the question if a protocol π achieves our security goal of "not revealing x_0, \dots, x_{n-1} ", this is done by describing an ideal world where there exists a perfect solution for the MPC problem and then comparing the execution of π to this ideal world. In an ideal world there exists an incorruptible

third party P that all parties trust. In the real world there is no such incorruptible third party. Instead the parties execute the protocol π by exchanging messages. In the ideal world evaluating $F(x_0, \dots, x_{n-1})$ can be done in two steps. In a first round of communication party p_i send x_i to P . This gives P all the information required for computing $F(x_0, \dots, x_{n-1})$. In a second round of communication P send each party $F(x_0, \dots, x_{n-1})$. If $F(x_0, \dots, x_{n-1})$ is computed this way the ability of the adversary to gain new knowledge about x_0, \dots, x_{n-1} is minimized. We say that π is secure against adversary A if A cannot learn more information by attacking π in the real world than by attacking the ideal world. This can be shown using simulation based proof. The View of a party consist of its input, the state of its memory which includes its internal randomness i and all messages it received. We say π is secure against A , if there exists a probabilistic polynomial-time simulator S that given the ideal world views of all parties A corrupts can compute the corresponding views in the real world. We require that the output of S has an identical distribution of values as the views that A would see when A attacks π in the real world. Given such S exists, A could instead of attacking the real world, simply attack the ideal world and then run S to get views that are identically distributed as the views A would have obtained by attacking the real world. So there is no advantage for A in attacking the real world compared to attacking the ideal world. Furthermore π is secure, if π is secure against all A .

4 framework description

4.1 conclave

- published in 2019,
 - combining MPC operations and cleartext processing
 - moving operations outside of MPC to maximise performance
 - allows to explicitly annotate trust between parties
 - utilises trust through hybrid operations for additional performance increase
 - maintaining same end-to-end security as "pure" MPC
 - relying on Obliv-C and Sharemind as MPC backend
 - backend theoretic exchangeable through generic interface
- Query optimization aims to move as work outside of mpc
- contrary to conventional sql operations that aims to minimize the total amount of work
e.g. filters before join
- secure against semi-honest adversary
 - adversary is statically
 - no secure channel setting
 - inherits security guarantees of backend -> honest majority
 - compares to "SMCQL most similar existing system"
 - jiff dependency
 - requires python 3.5
 - ...

4.2 aby3

- In [MRR20] .. -3 Party setting
- , - honest majority
 - passiv adversary
 - all protocols constant rounds of communication
 - $O(n)$ overhead in for join where n is number of rows
 - supports inner left ,full join, set union, set minus, single table operation like where or aggregate. prototype - does feature a LAN VS WAN comparison in benchmarks

4.3 smcql

- prototype for 2 parties can be expanded for more parties - honest adversary

5 implementation

6 evaluation

Bibliography

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