Framework for Semi-Private Function Evaluation with Application to Secure Insurance Rate Calculation

ENCRYPTO CRYPTOGRAPHY AND PRIVACY ENGINEERING

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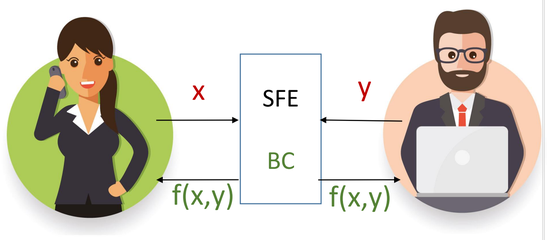
Semi-Private Function Evaluation (SPFE)

Secure Function Evaluation (SFE)

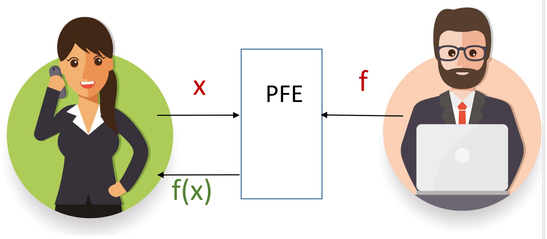
SFE [Yao86] allows 2 parties to jointly compute a public function f represented as Boolean Circuit (BC) on their private inputs x, y and obtain no information but f(x, y).



Alice and Bob learn f(x,y) without revealing x, y to each other.

Private Function Evaluation (PFE)

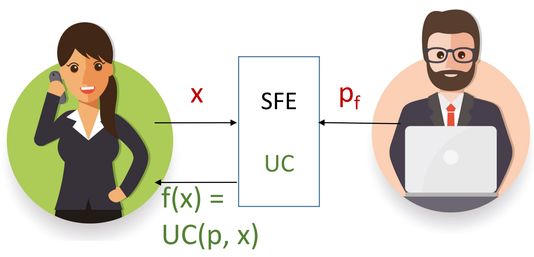
PFE allows Alice and Bob to jointly compute Bob‘s private function f on the private input x of Alice without revealing anything but the output



Alice learns f(x) without revealing x. f is hidden to Bob.

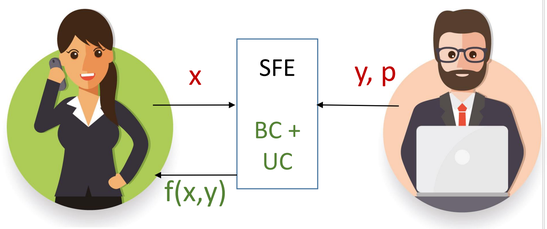
PFE can be reduced to SFE using a Universal Circuit (UC)

A Universal Circuit [Val76, KS16, GKS17] is a BC that can compute any Boolean function f of a given size n by specifying programming bits p, s.t. UC(p,x) = f(x).



Semi-Private Function Evaluation (SPFE)

In many applications not the whole function must be kept private. Dividing the function in sub-functions which are private and public leads to SPFE which results in a smaller total circuit.



Previous Works

[BK17]: N. Büscher, S. Katzenbeisser. Compilation for Secure Multi-party Computation. Springer
[DSZ15]: D. Demmler, T. Schneider, M. Zohner. ABY- A Framework for Efficient Mixed-Protocol Secure Two-Party Computation. In NDSS‘15.
[GKS17]: D. Günther, Á. Kiss, T. Schneider: More Efficient Universal Circuit Constructions. In ASIACRYPT‘17.
[KS16]: Á. Kiss, T. Schneider. Valiant‘s Universal Circuit is Practical. In EUROCRYPT‘16.
[Val76]: L.G. Valiant. Universal Circuits (Preliminary Report). In STOC‘76.
[Yao86]: A. C.-C. Yao. How to Generate and Exchange Secrets (Extended Abstract). In *FOCS‘86*.

Our SPFE Framework

- Our SPFE framework can be used on functions f that can be split into a set of sub-functions specified in the C programming language.
- Every sub-function must be declared either private or public.
- We use CBMC-GC [BK17] to compile each sub-function into a BC.
- Private sub-functions are further processed to UCs [GKS17] and the corresponding programming bits are deviated.
- BCs and UCs are merged using our merger to build one semi-private BC that can then be processed by the SFE framework ABY [DSZ15].

Applications of SPFE

Car Insurance

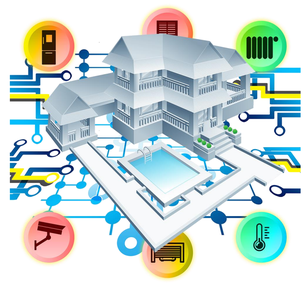
Car insurance companies can calculate different tariffs based on customer‘s private data

Smart Metering

Energy providers can calculate user-specific tariffs based on customer‘s secret data

Credit Worthiness Checking

Protect loanee‘s data and loaner‘s function to decide if the loanee can get a credit

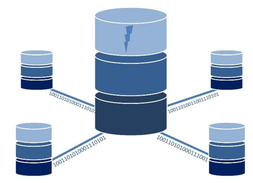


Confidential Information

Companies can check confidential information of customers without revealing any internal processes

Database Management System (DBMS)

Queries in a DBMS can be hidden and the processing function is kept private

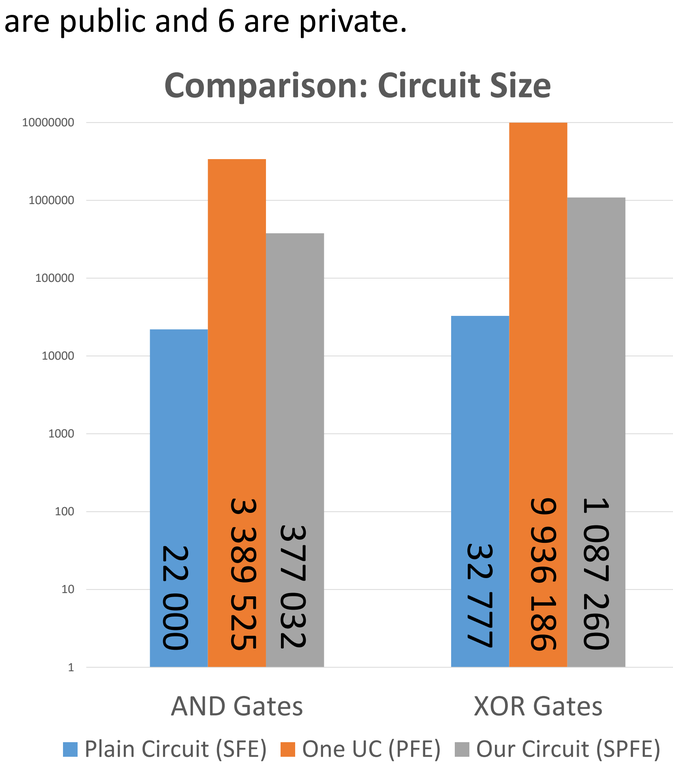


Benchmarks

Car Insurance Application

- Researched insurance rate calculation function to get f.
- Some information (e.g., higher prices for young people) is publicly known, i.e., this information does not have to be hidden in the function.
- Other information (e.g., how tariffs are surcharged for living in a specific location) has to be kept private in UCs.
- Our practice-oriented insurance rate calculation function is split into 15 sub-functions of which 9 are public and 6 are private.

SPFE circuit is up to 9x smaller than one large UC



SPFE is Practical

The resulting performance using Yao‘s garbled circuit protocol is **2,5 seconds** on a LAN and **17,5 MB**.

Architecture