Obscuro: A Bitcoin Mixer using Trusted Execution Environments

Muoi Tran, Loi Luu, Min Suk Kang, Iddo Bentov, and Prateek Saxena
ACSAC 2018 | December 3–7 | San Juan, Puerto Rico, USA

Bitcoin addresses are ***linkable***

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18yFGxy...

16SCgr3...

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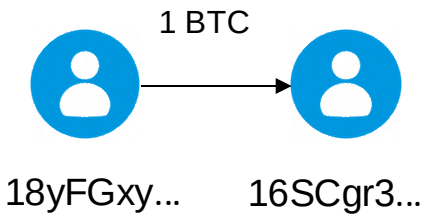

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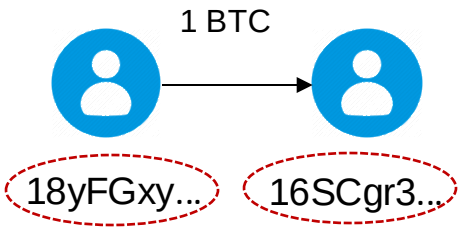

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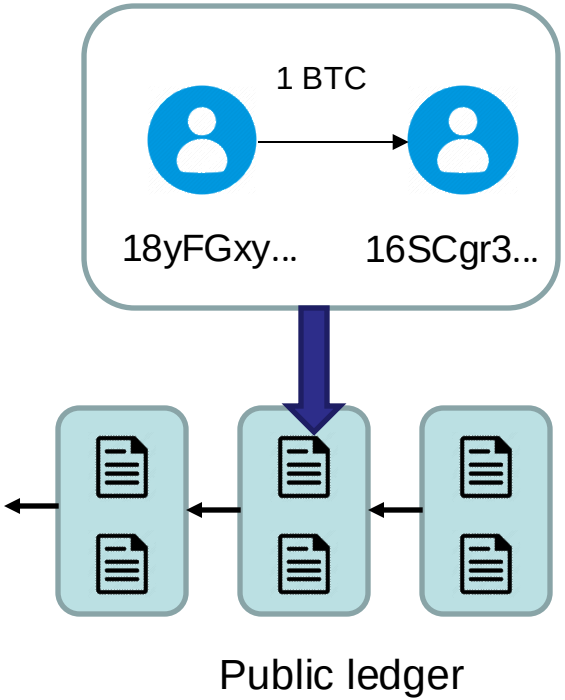

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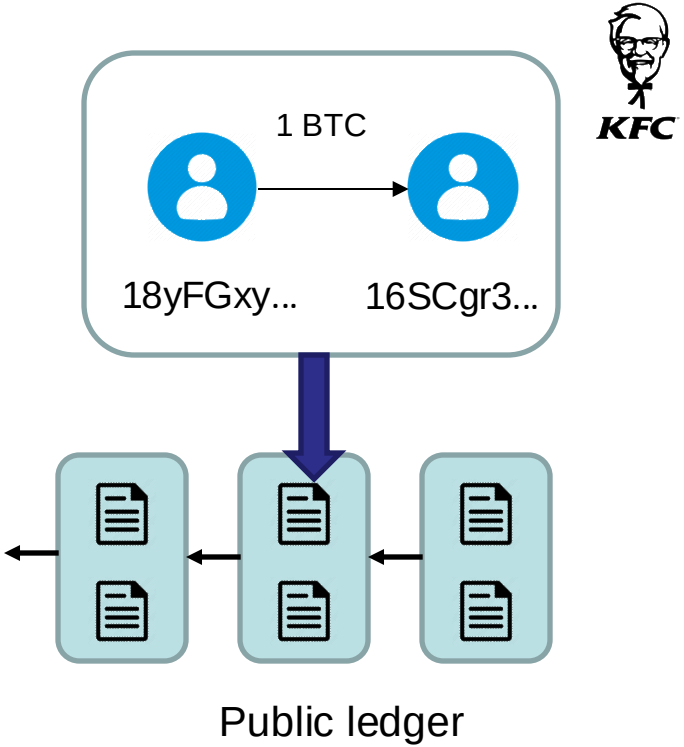

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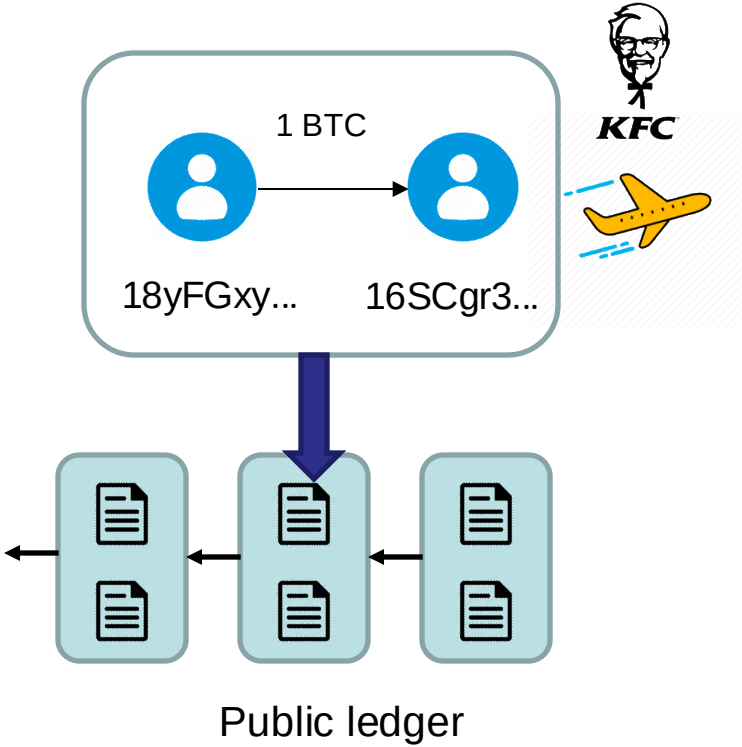

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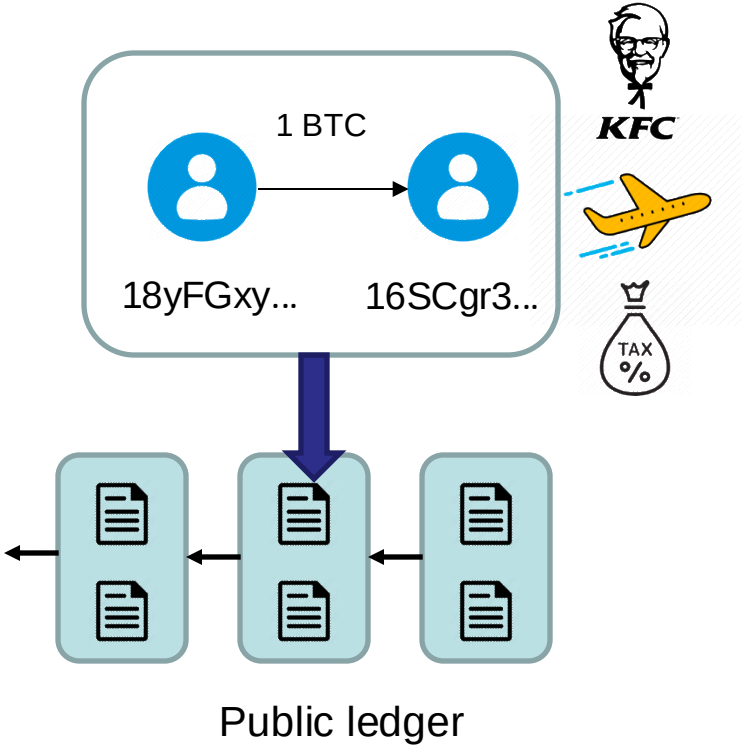

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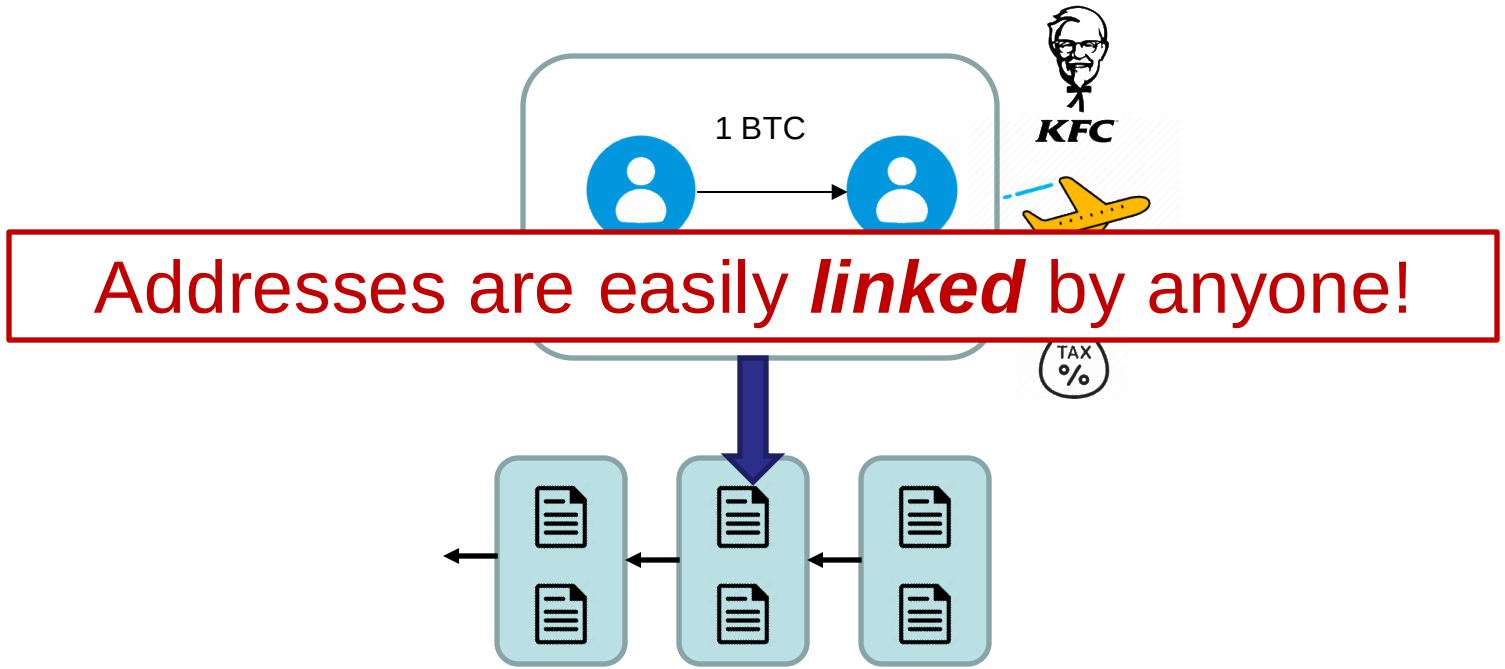

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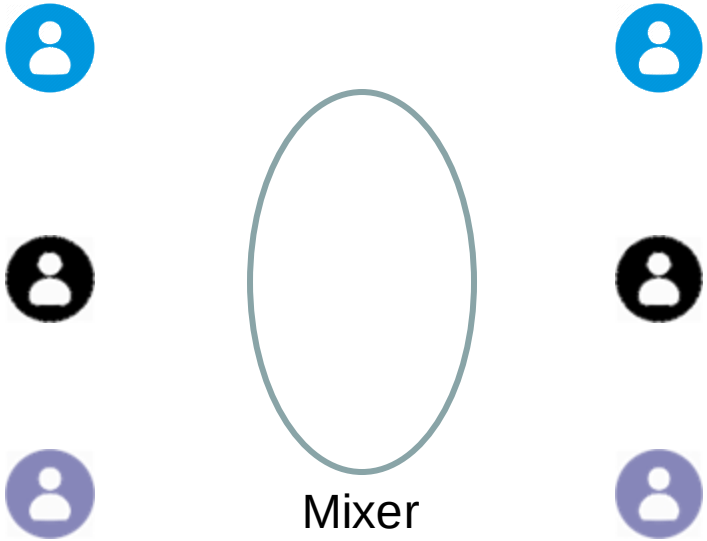

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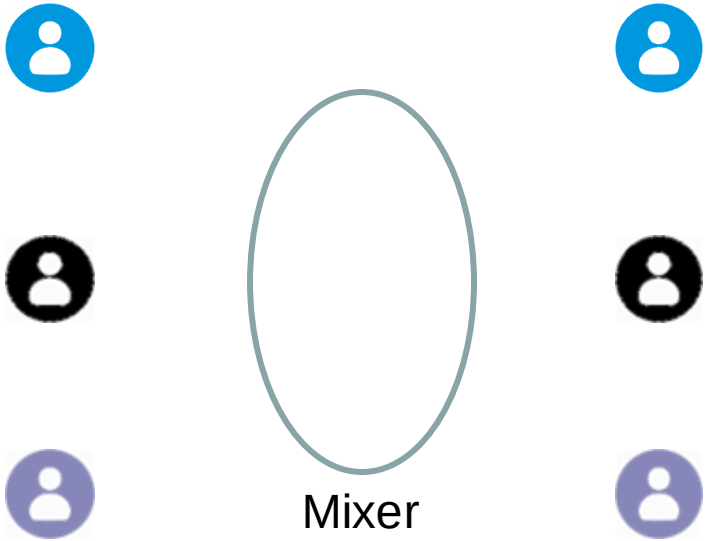

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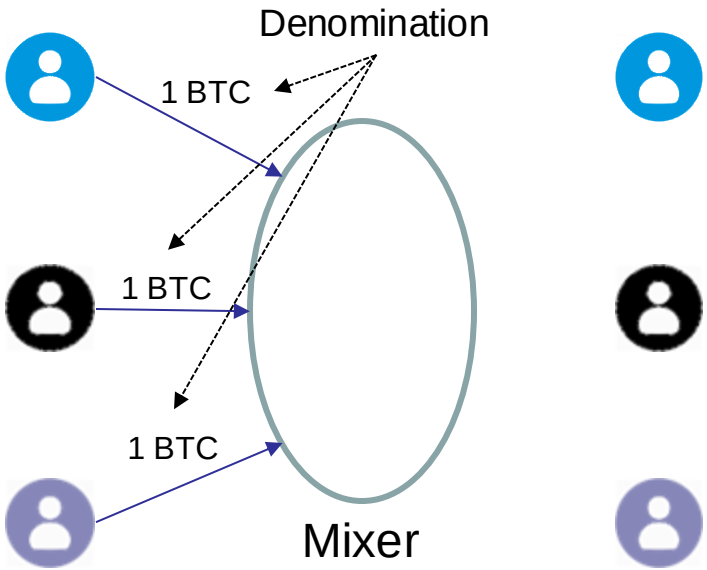

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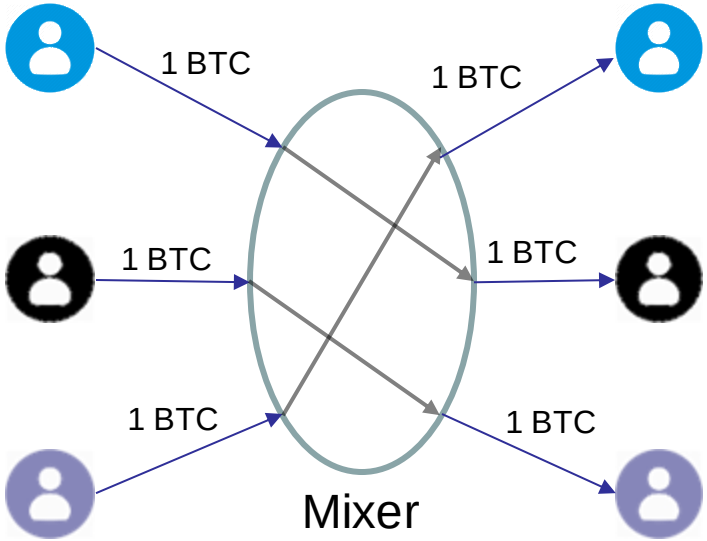

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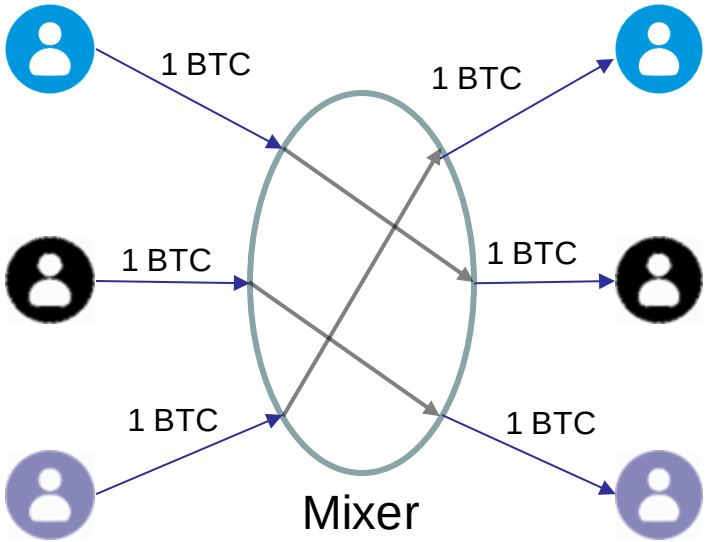

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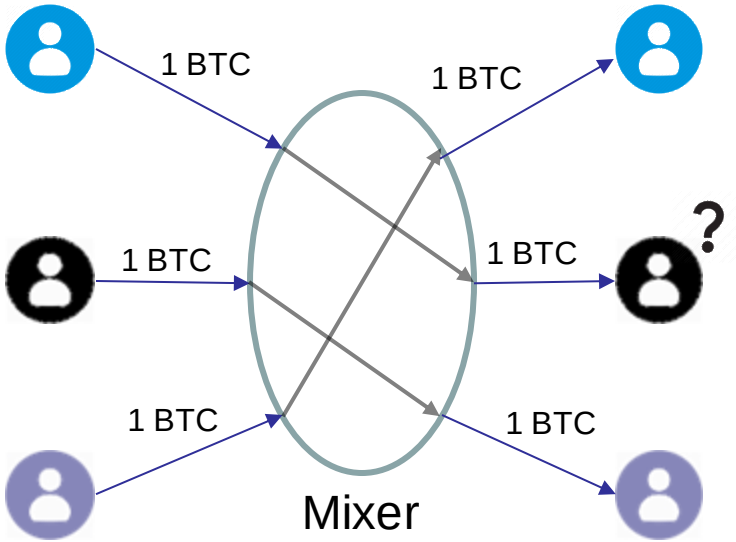

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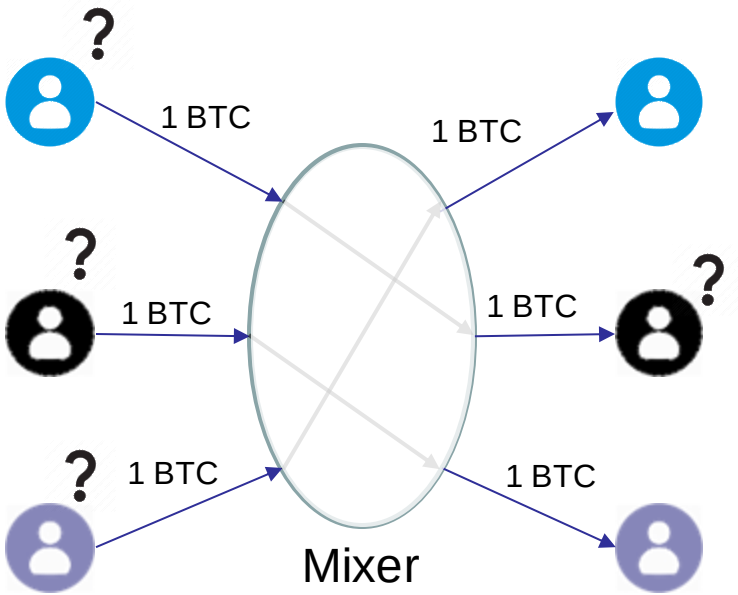

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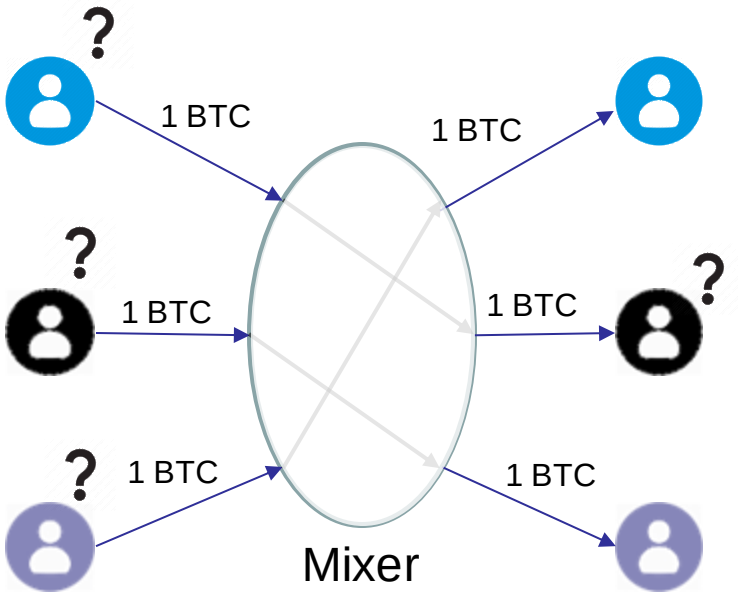

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Security parameter:
Anonymity set size, or the number of users per mixing round

Two categories of existing mixers

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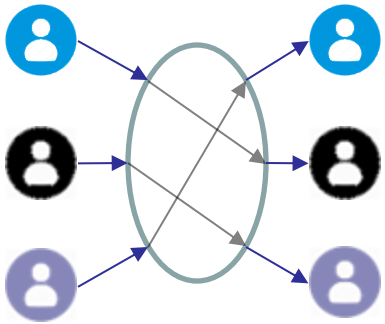

Centralized mixer

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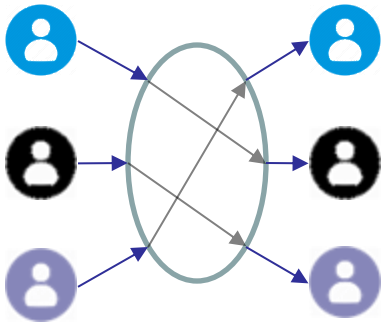

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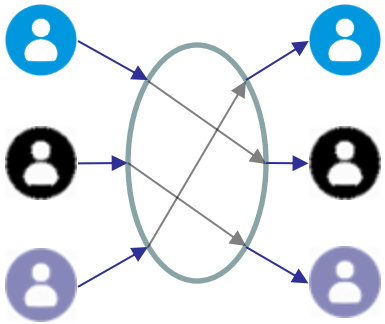

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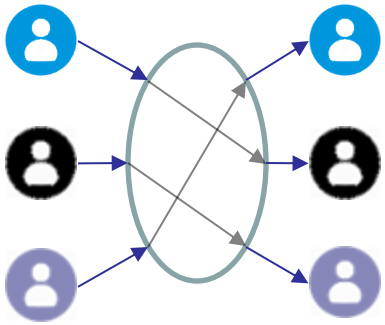

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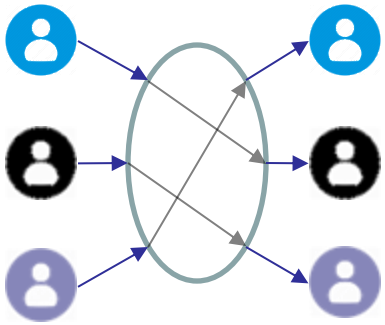

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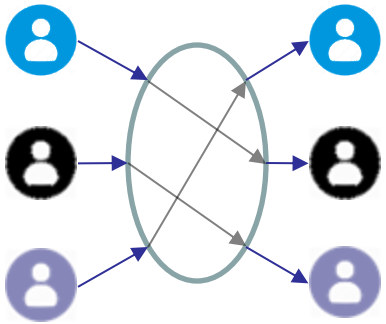

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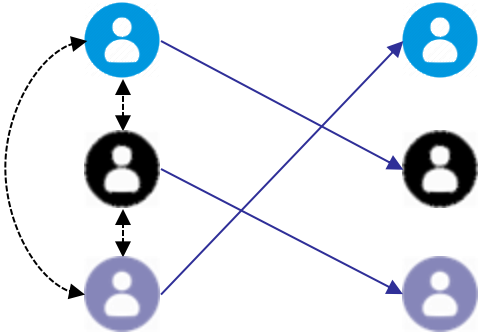

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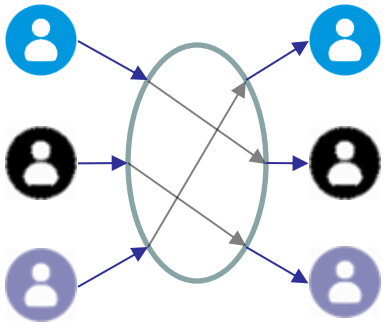

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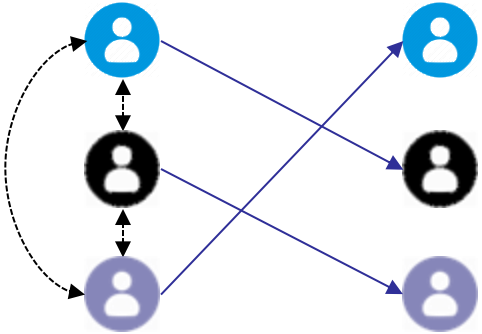

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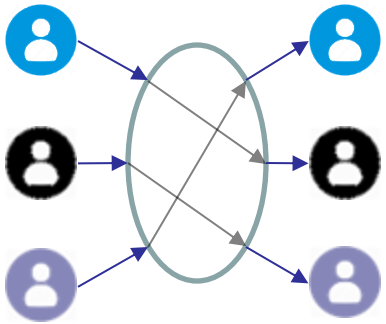

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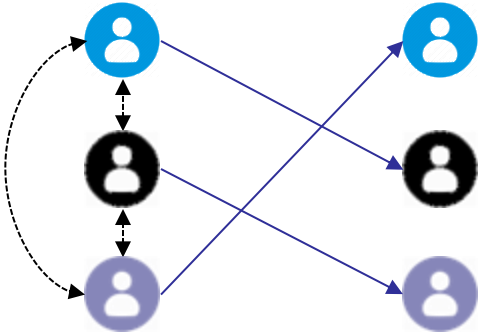

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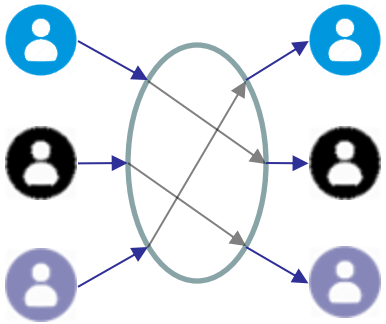

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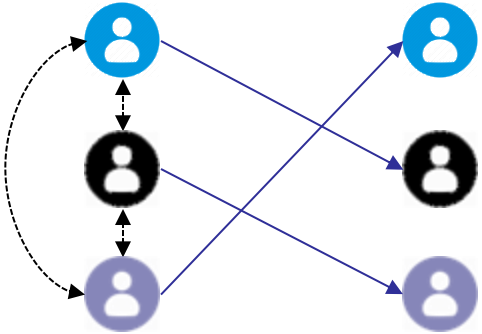

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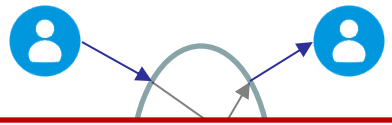

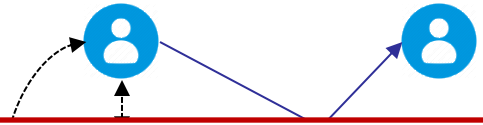

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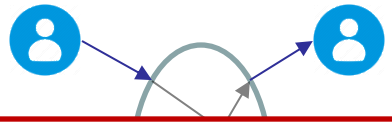

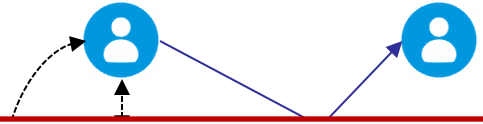

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Centralized mixer

De-centralized mixer

Can we have a Bitcoin mixer that is both ***secure*** and ***efficient?***

- ***Steal*** coin or ***leak*** permutation

✓ Partial solutions exist (e.g., TumbleBit [NDSS'17])

- ***hints (or even longer)*** to mix

using CoinShuffle++ [NDSS'17]

Obscuro: centralized mixer protected by ***Trusted Execution Environments***

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Verifier

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Trusted software

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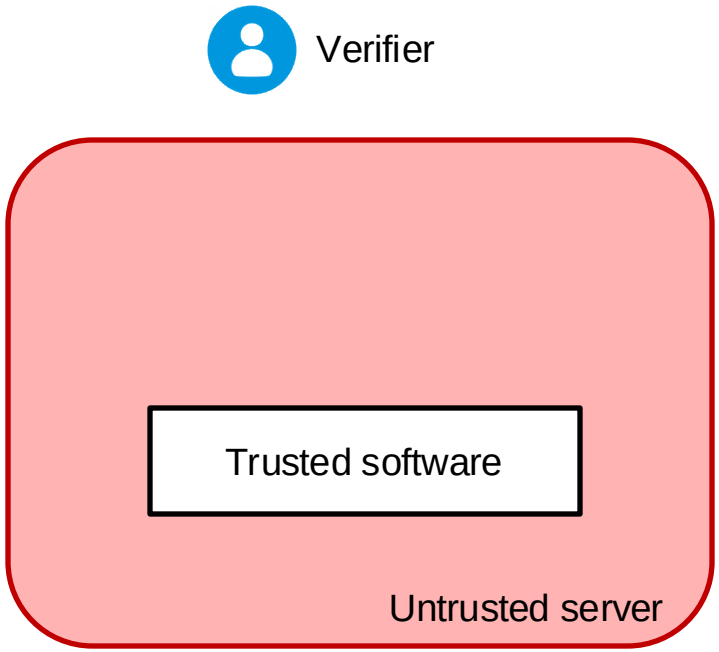

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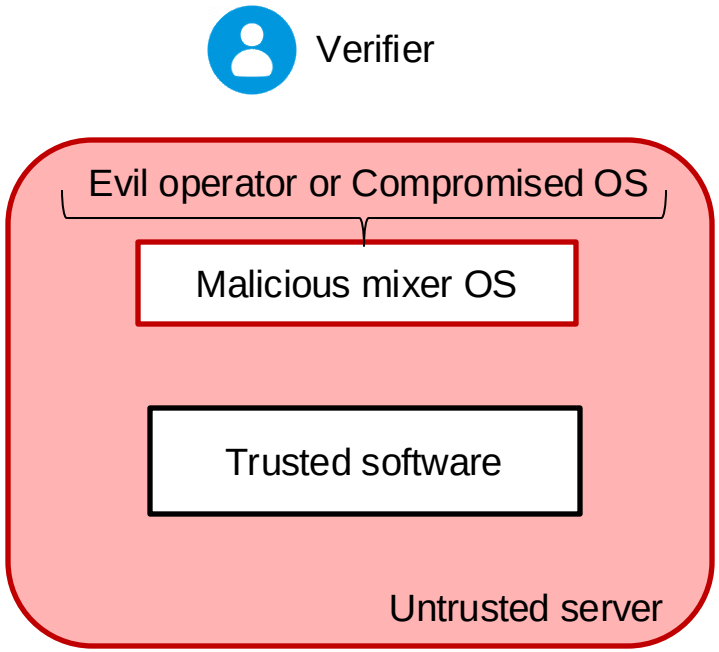

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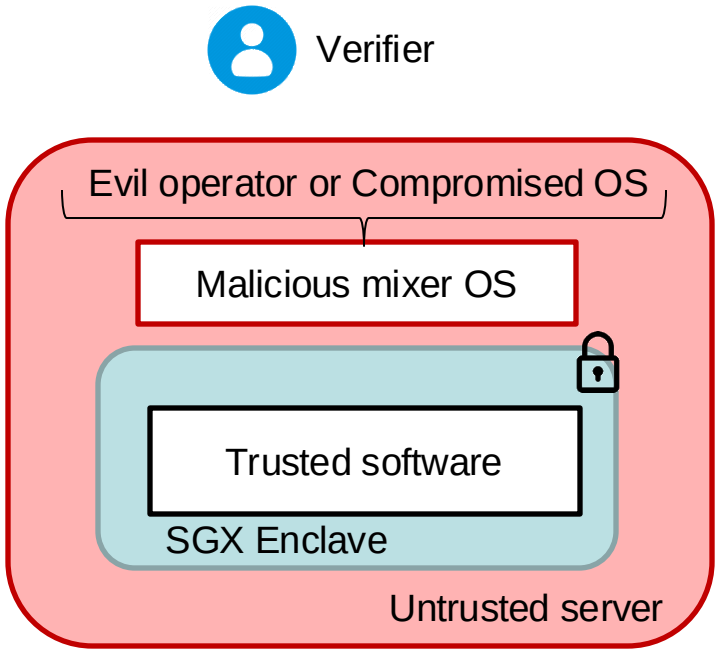

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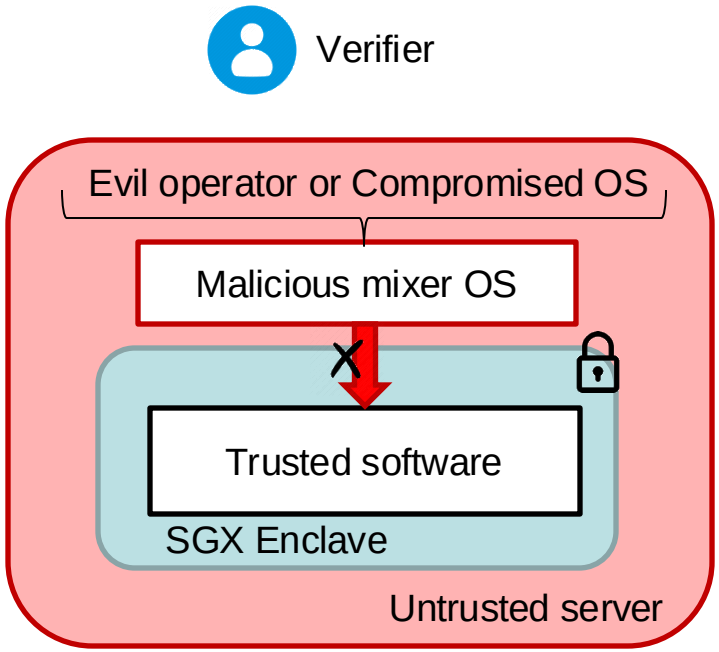

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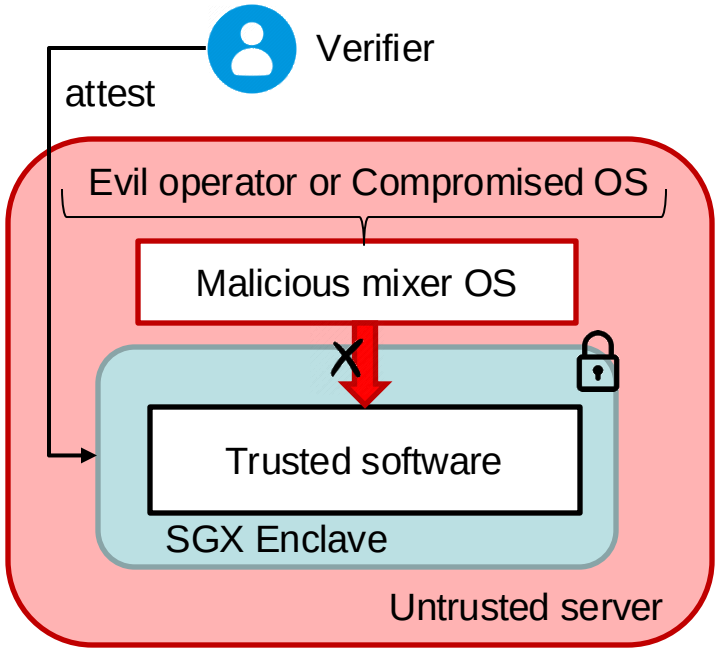

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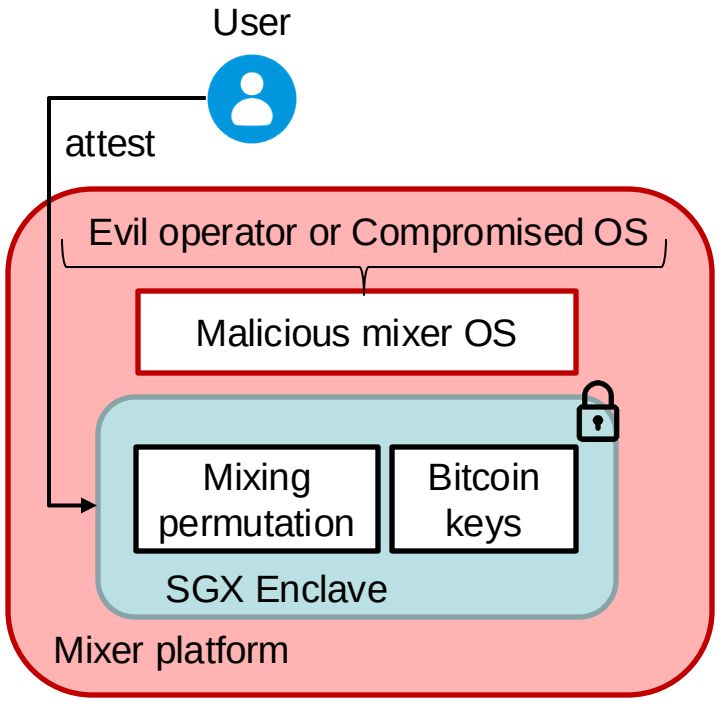

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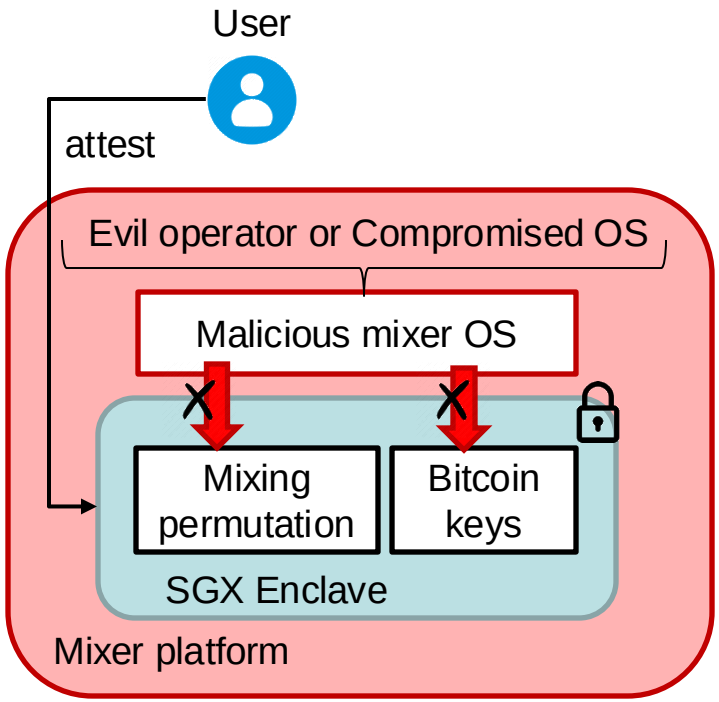

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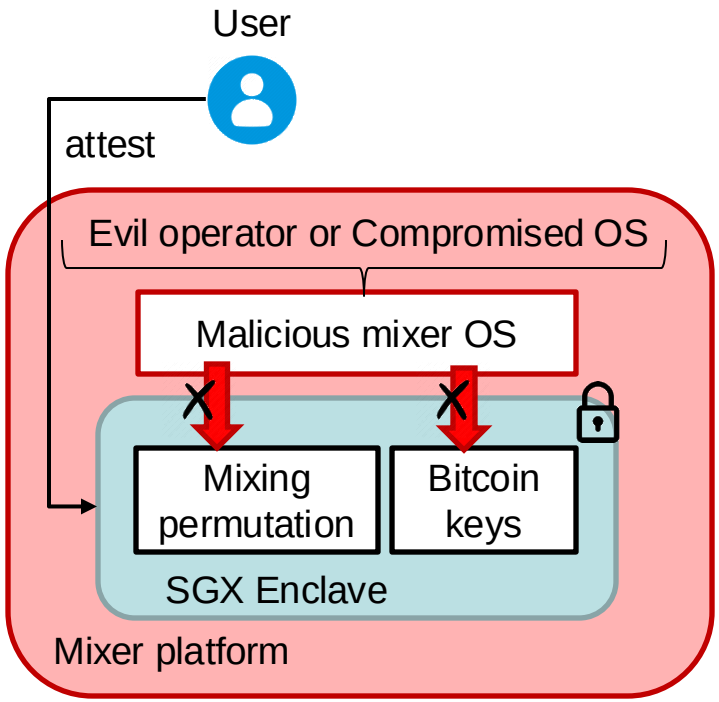

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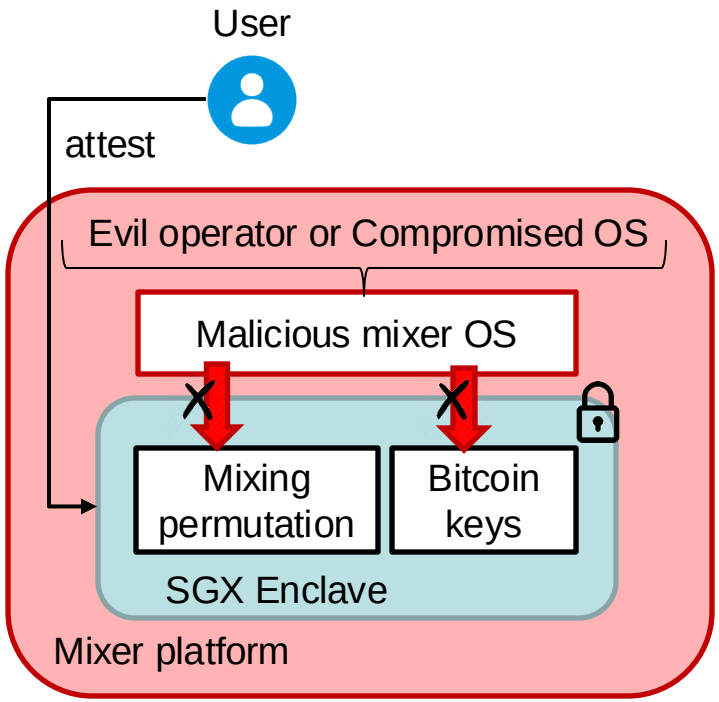

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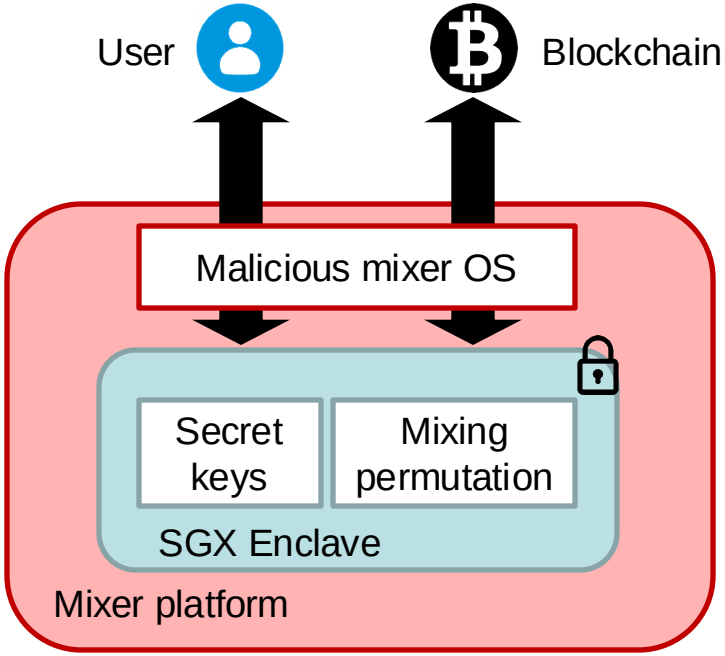
Sophisticated attacks against ***naïve*** Obscuro design



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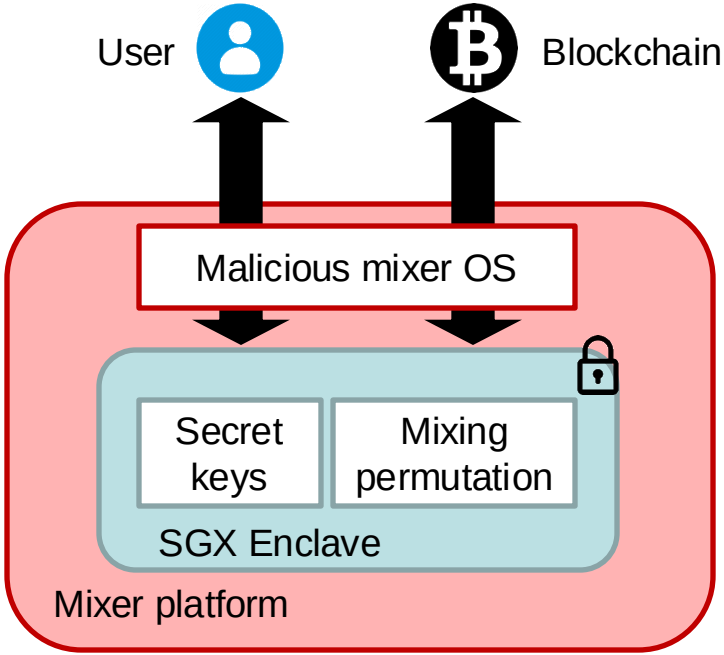

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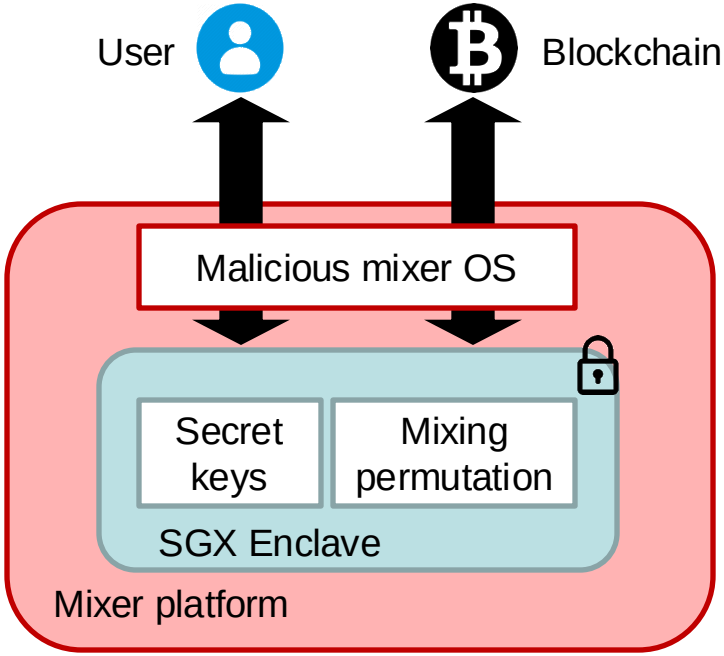

Naïve Obscuro Model

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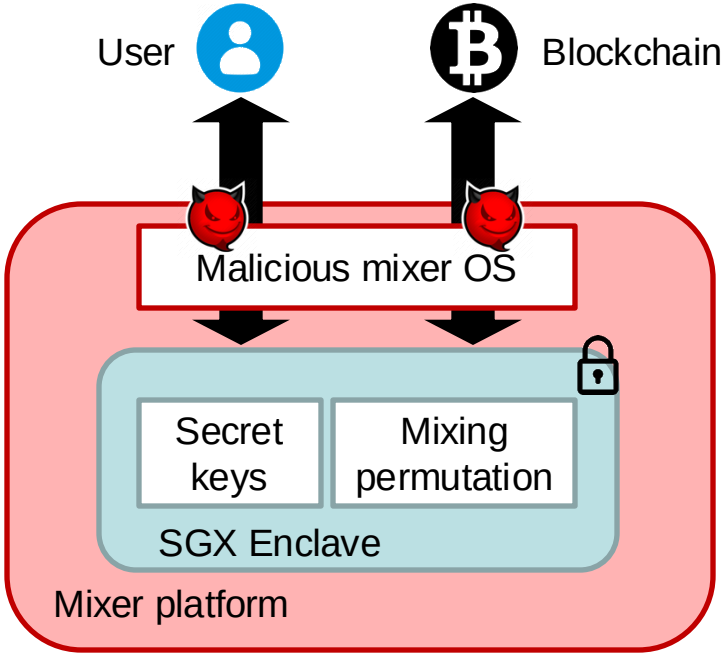

Naïve Obscuro Model

Adversary model

- **Capabilities**:
  - ✓ Mixer OS can read/write all messages

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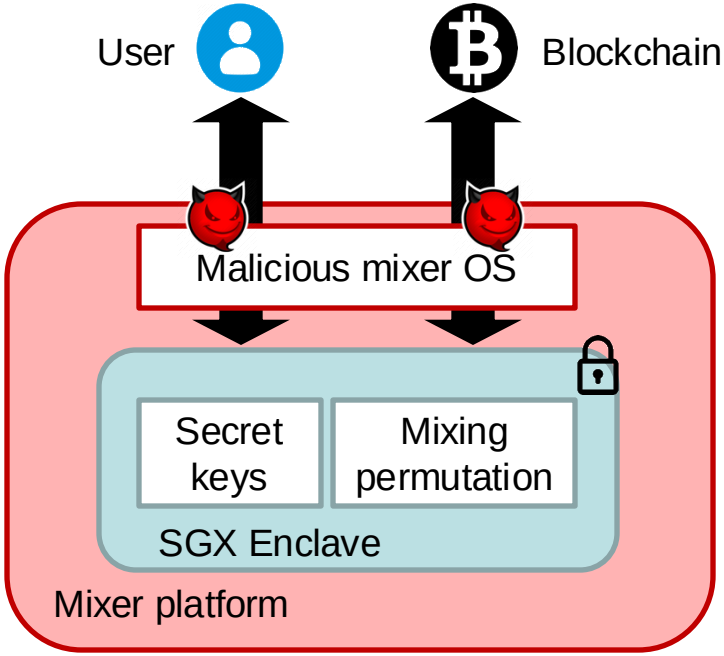

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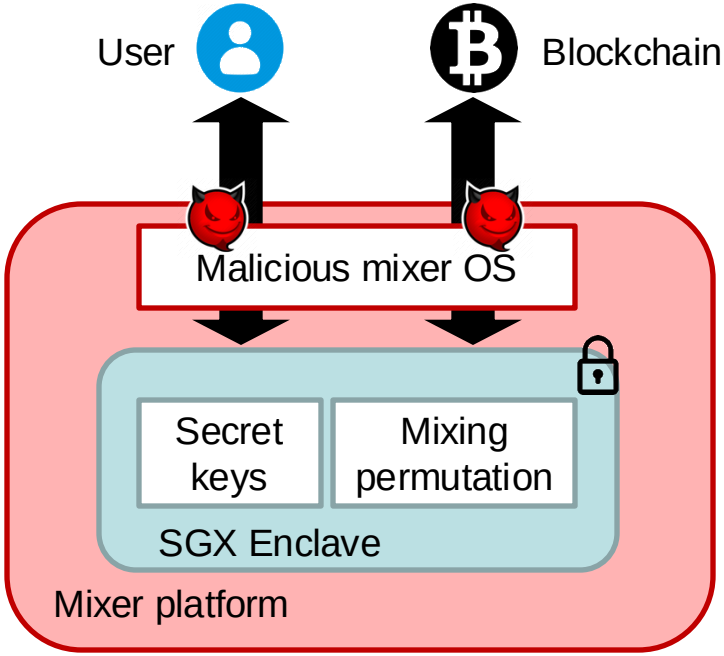

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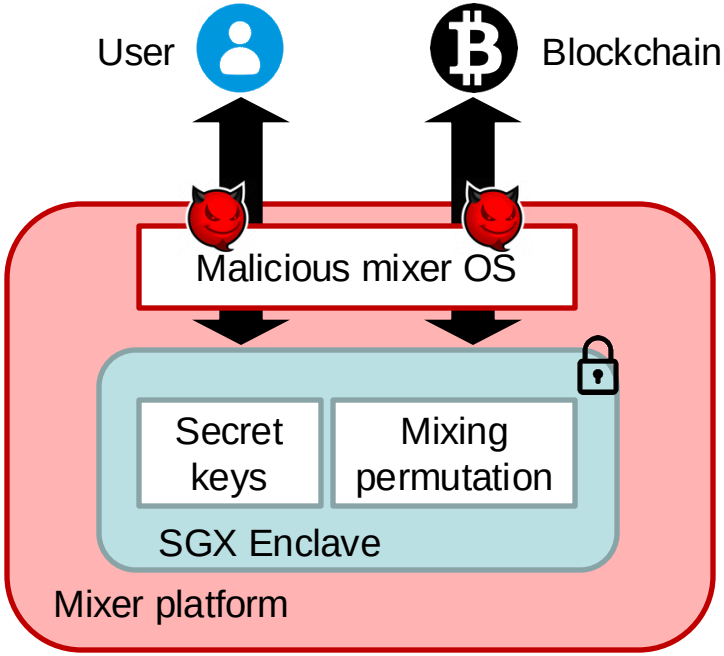

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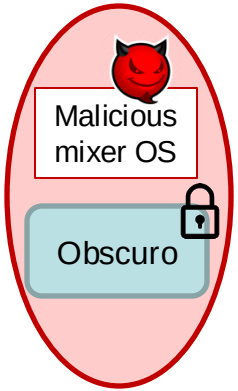
Two specific attacks:

(1) Participation rejection

(2) Blockchain forking

Attack 1: ***Participation Rejection***



Naïve Obscuro

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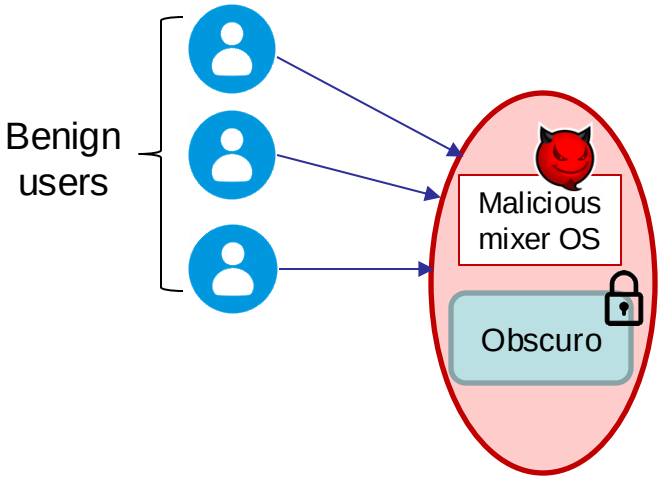

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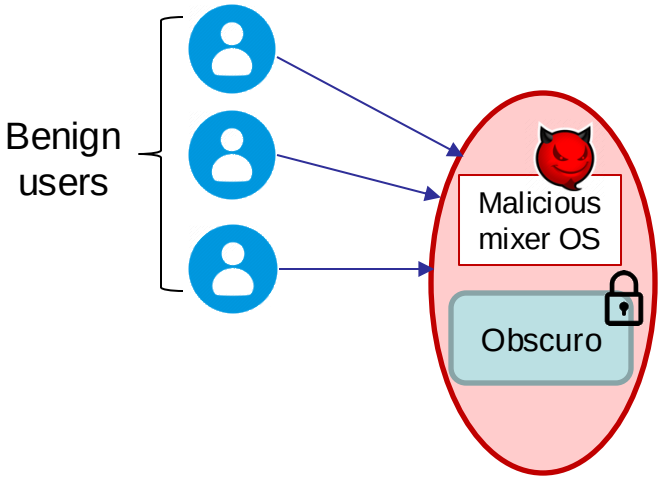

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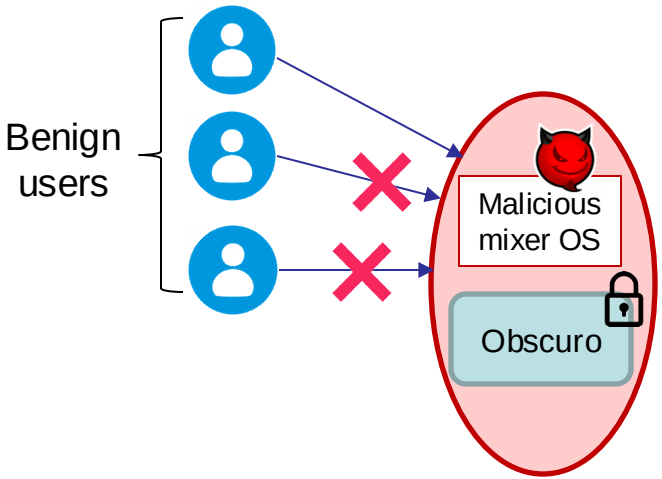

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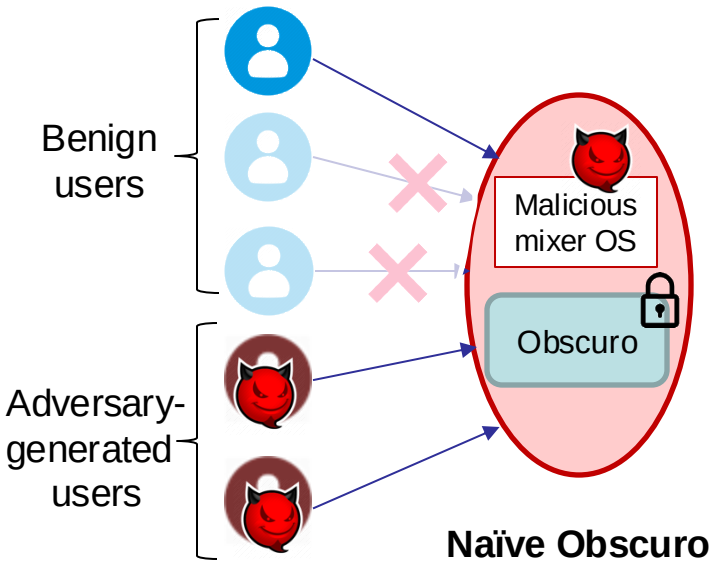

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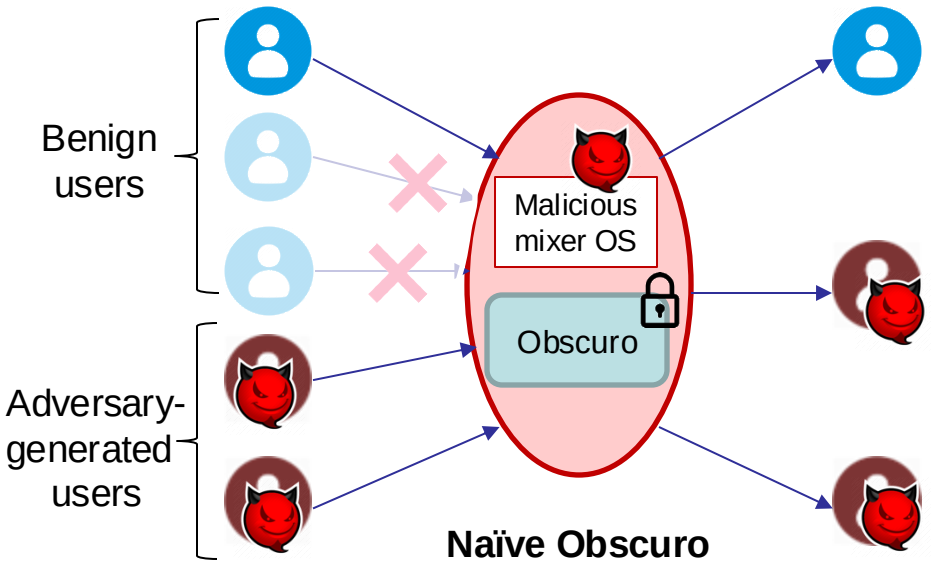

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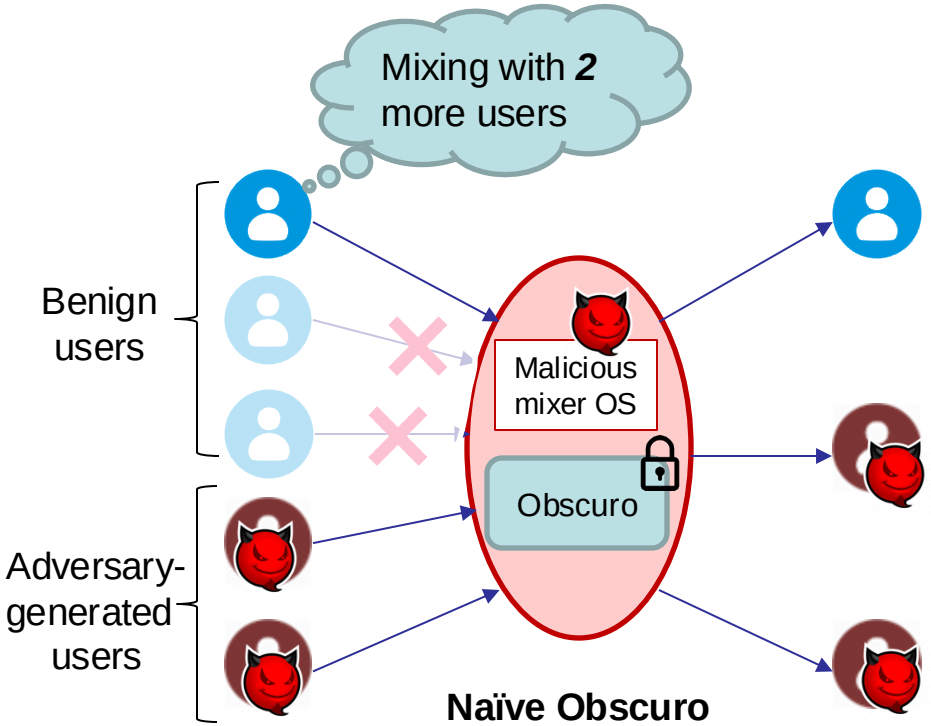

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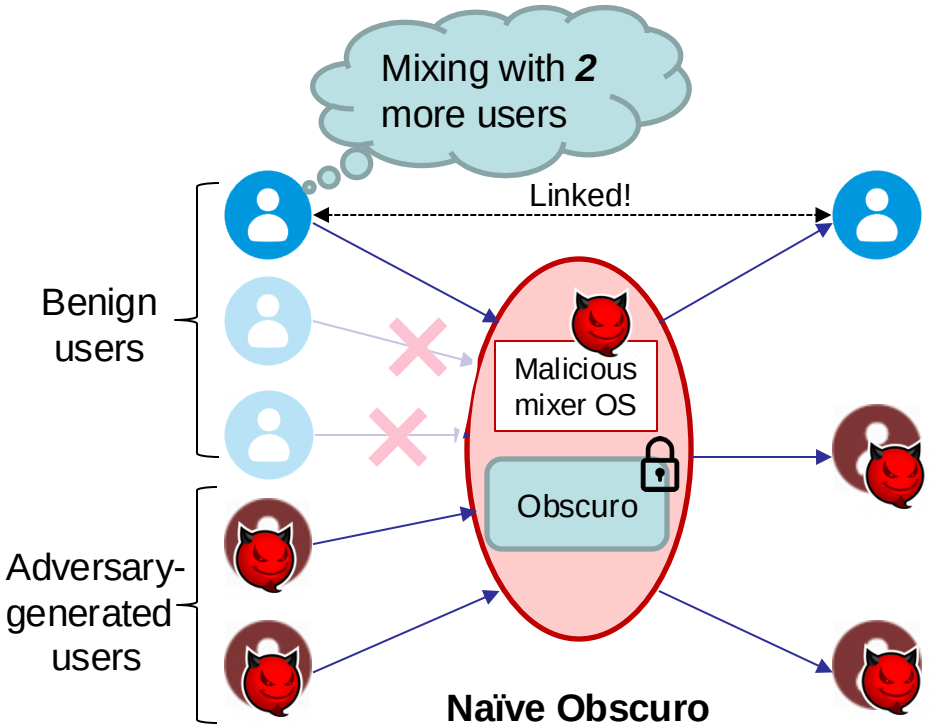

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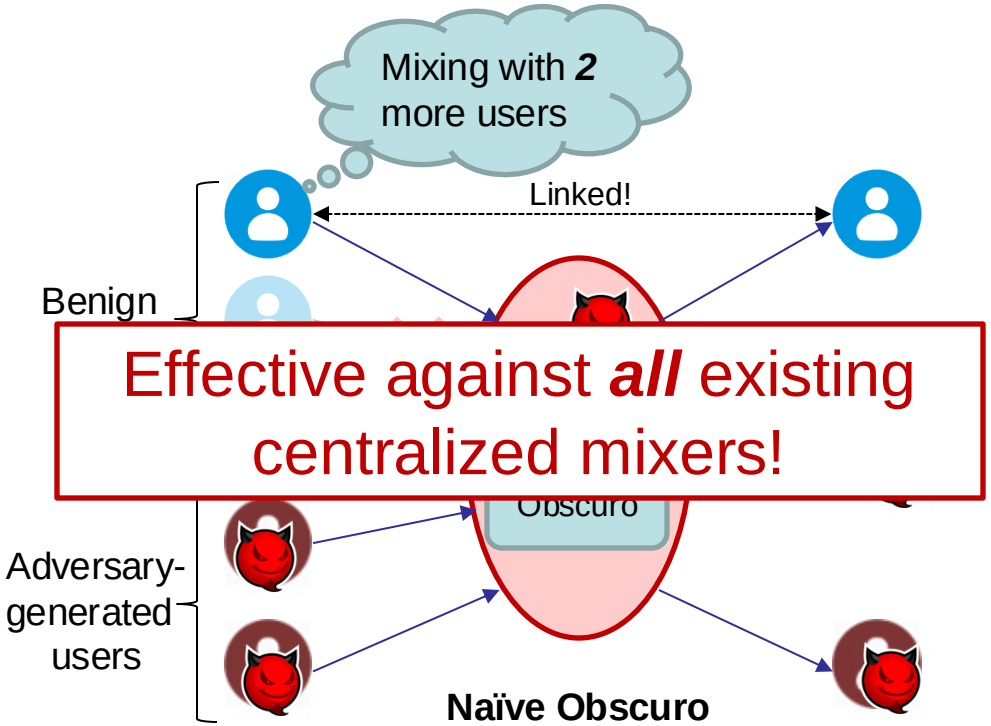

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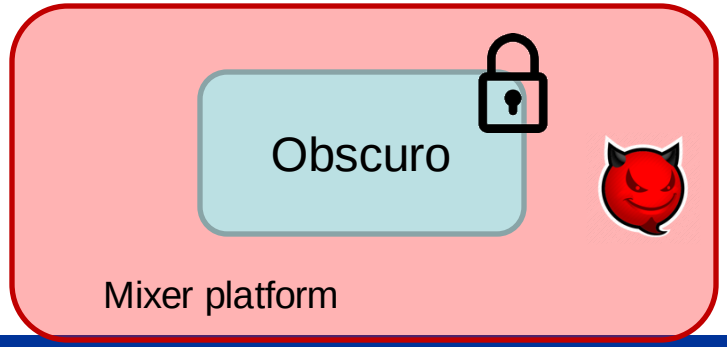
Indirect Participation against Attack 1

User

Blockchain

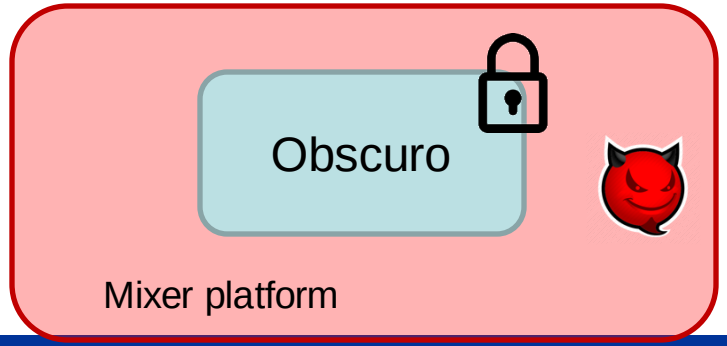


Indirect Participation against Attack 1

User

Blockchain

- Users ***never*** contact the mixer



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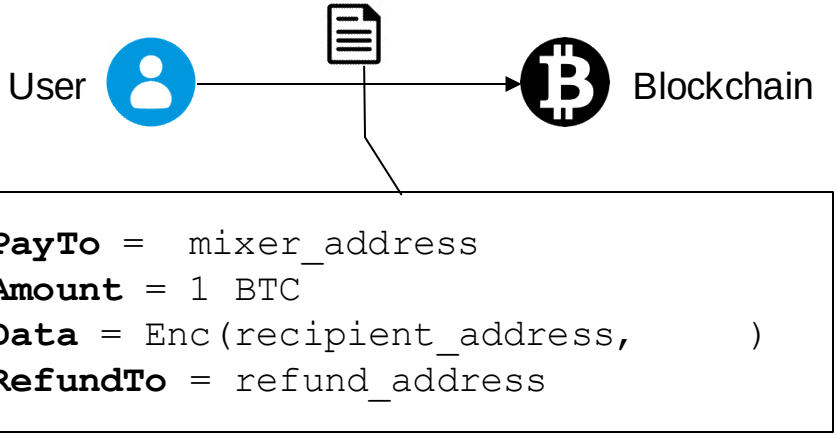
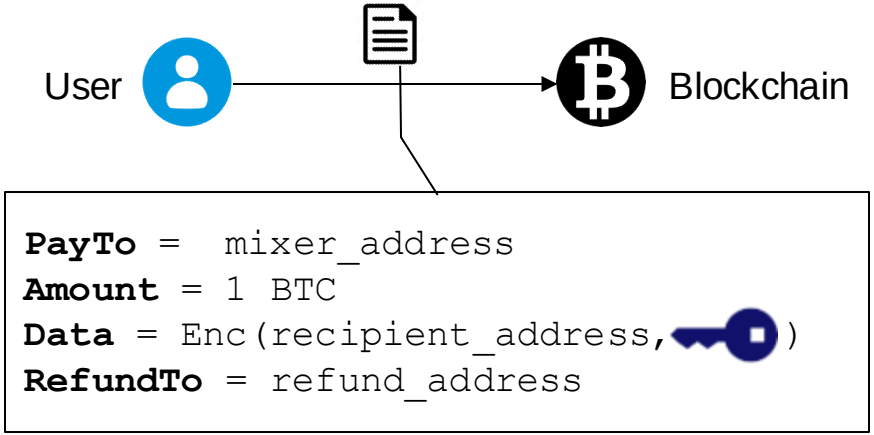


- Users ***never*** contact the mixer
- But submit transactions to the blockchain to participate mixing:

Indirect Participation against Attack 1



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*: Elliptic Curve Integrated Encryption Scheme

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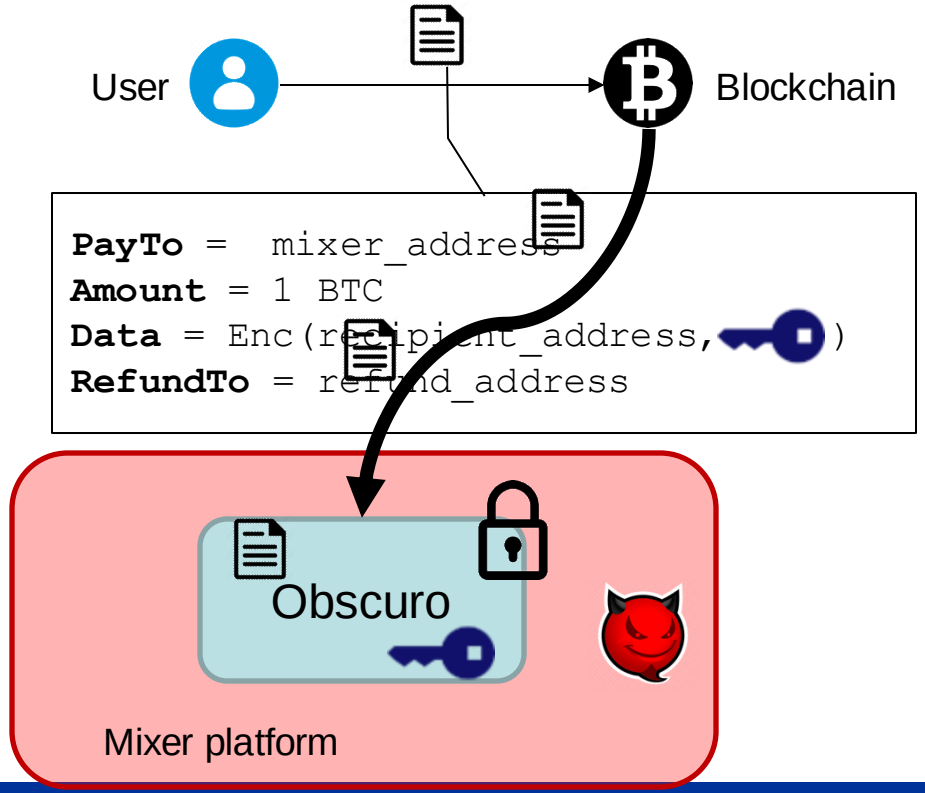

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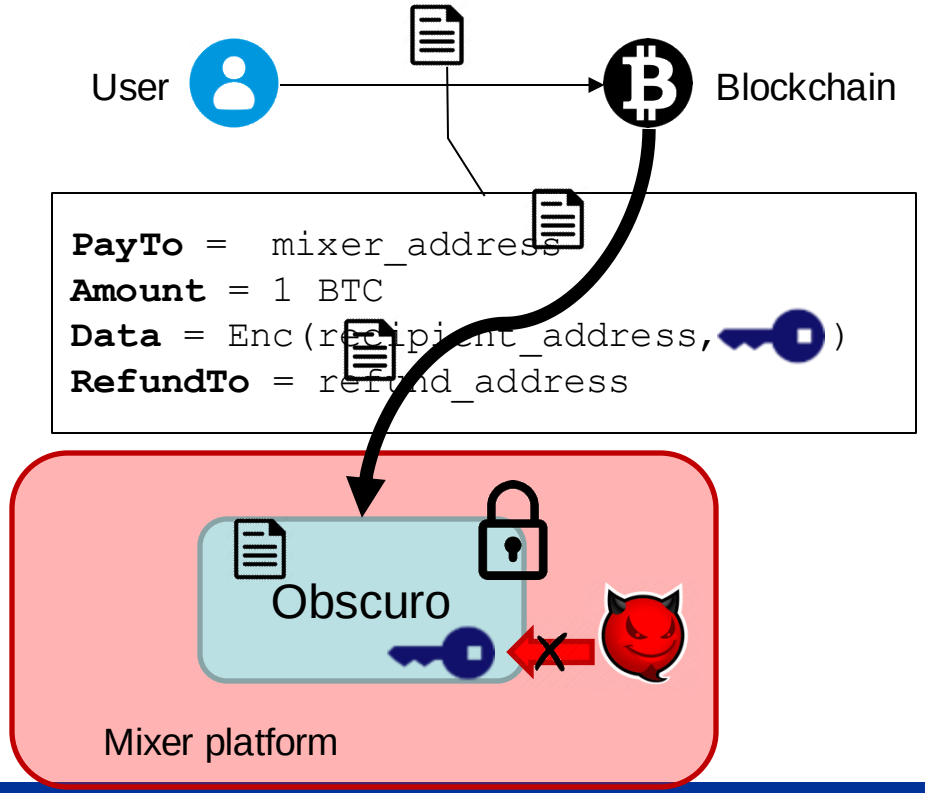

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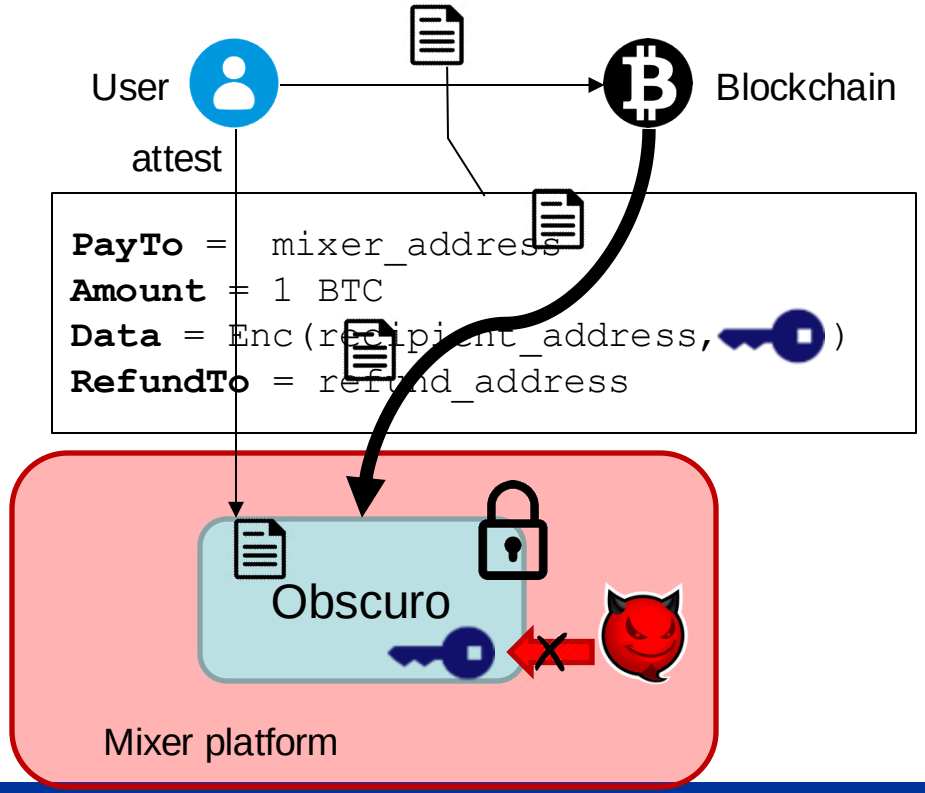

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Attack 2: ***Blockchain Forking***

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Reducing anonymity set even when Obscuro deploys ***indirect participation***

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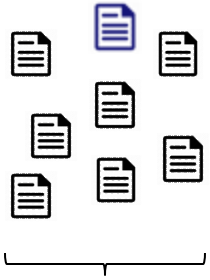

Users deposits

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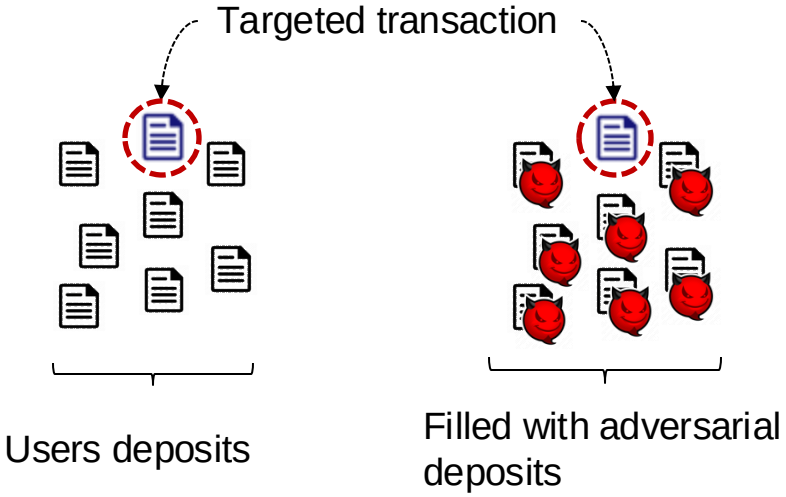

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  - ✓ including some targeted transactions and her transactions

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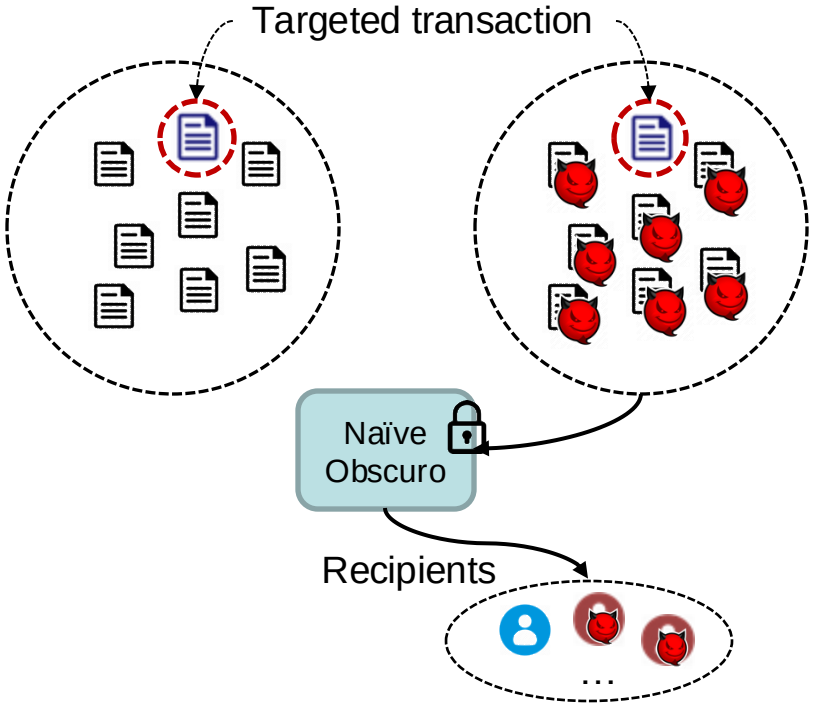

- Mixer OS creates ***another mixing set***
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- Adversarial set is fed to Obscuro

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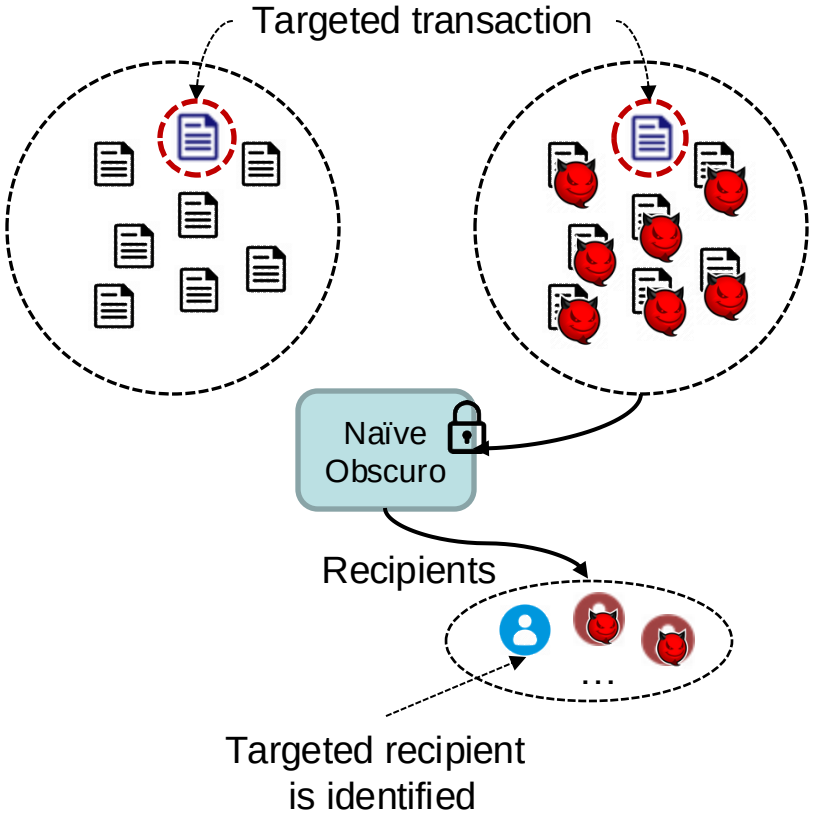

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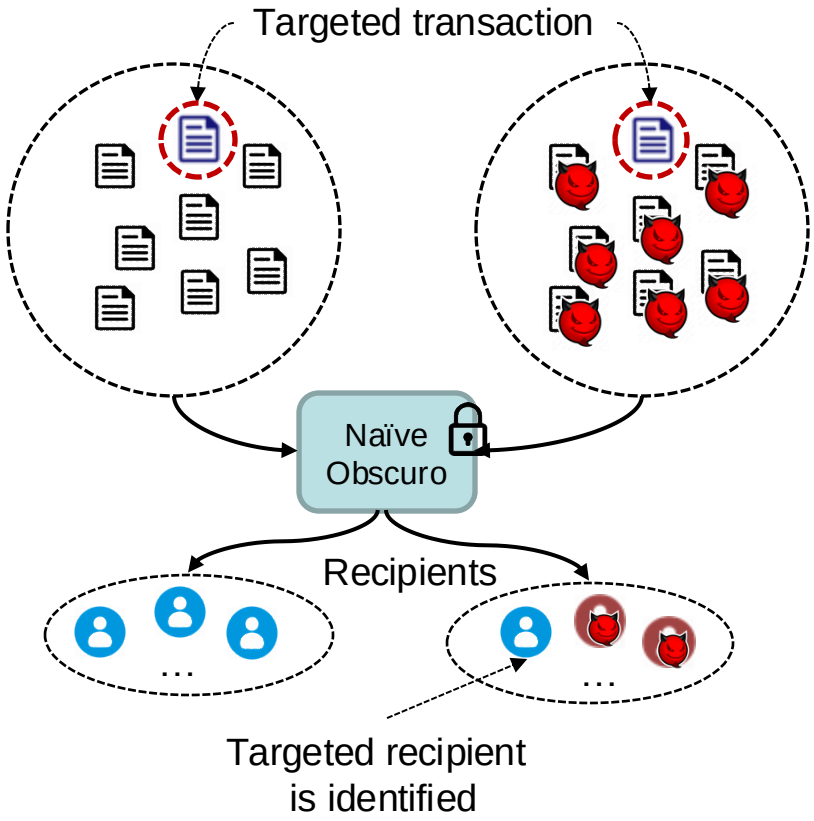

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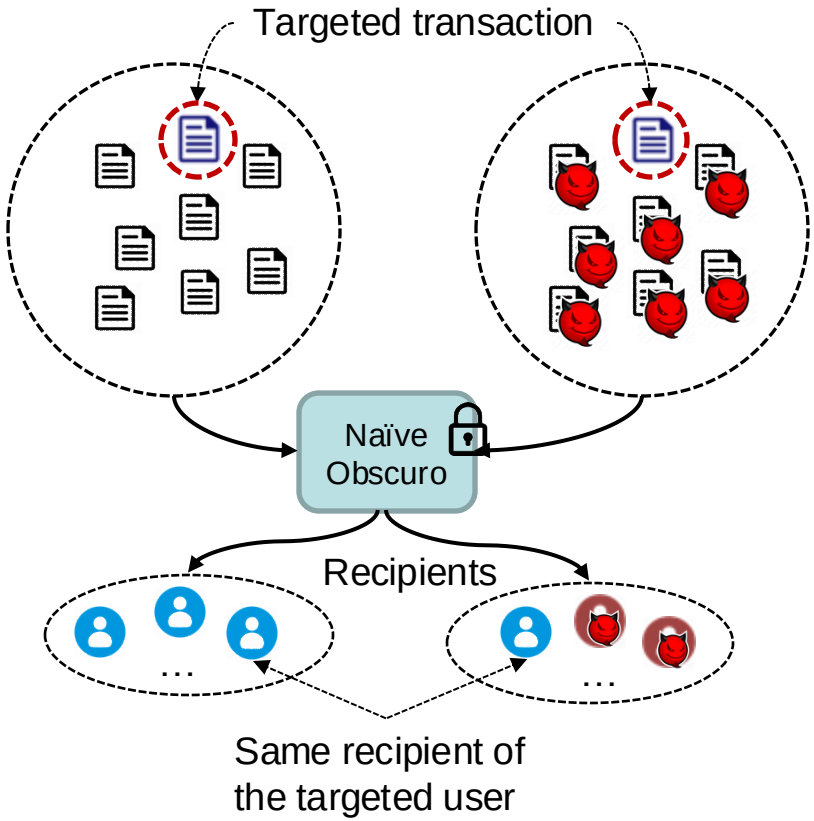

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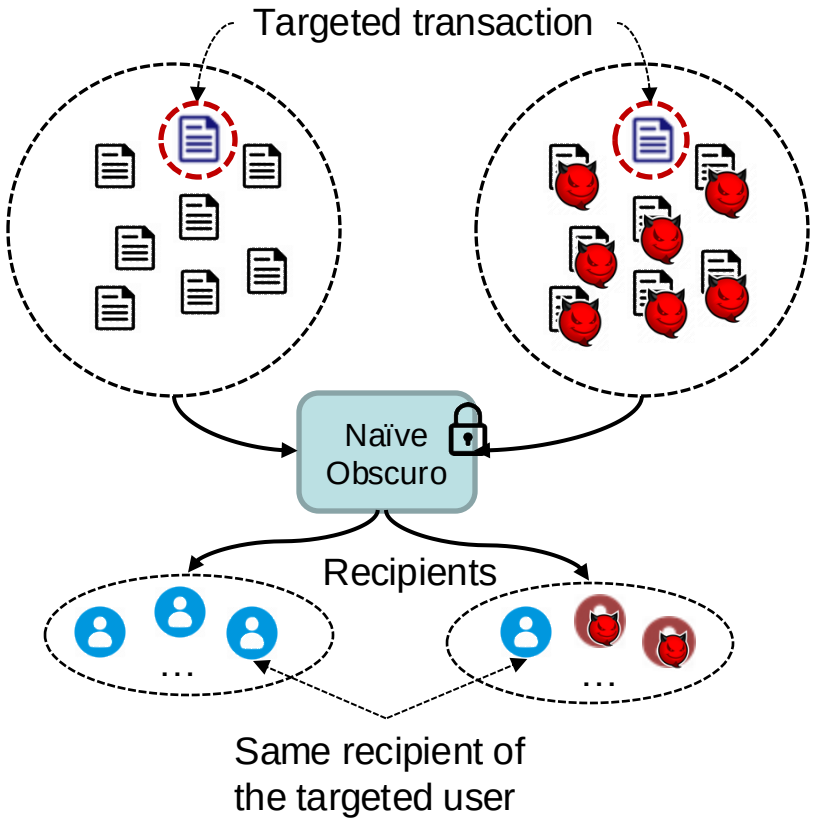
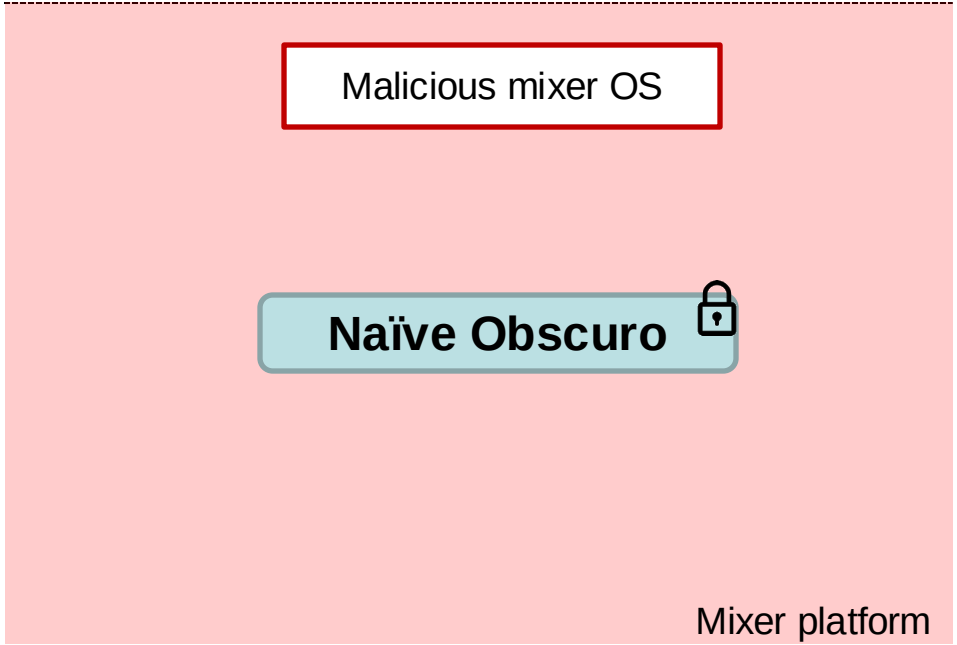
Reducing anonymity set even when Obscuro deploys ***indirect participation***



- Mixer OS creates ***another mixing set***
  - ✓ including some targeted transactions and her transactions
- How to enforce naïve Obscuro to mix a transaction twice?
- Valid users set is fed to Obscuro
  - ✓ the targeted recipient is ***already*** identified

How to ***fork*** blockchain



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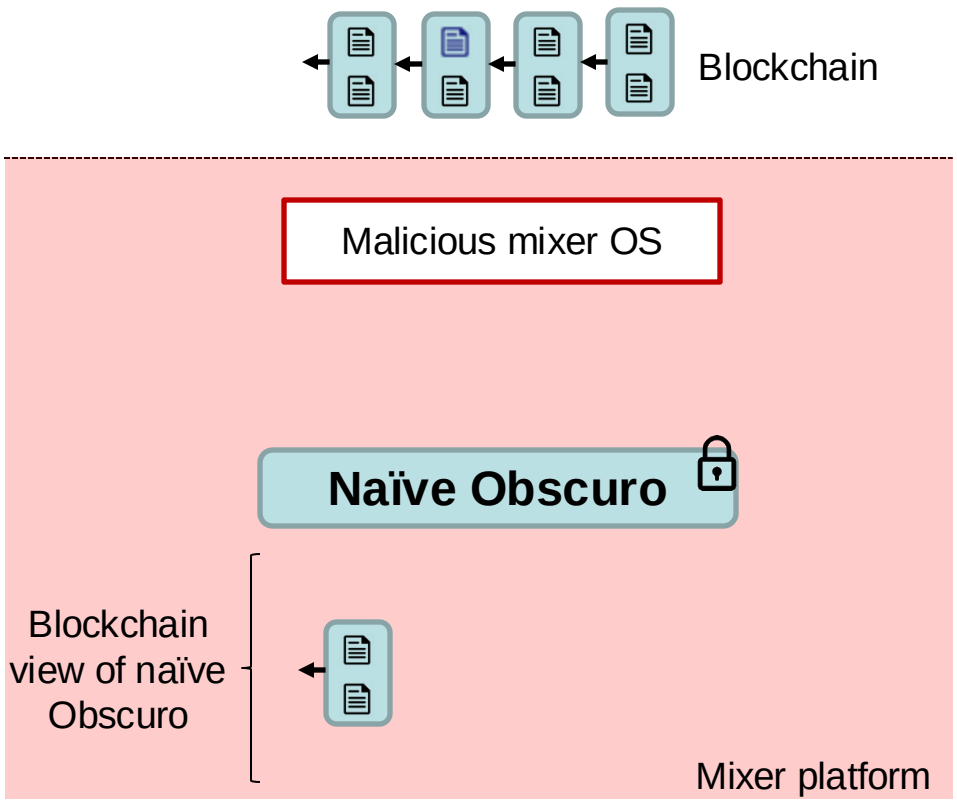

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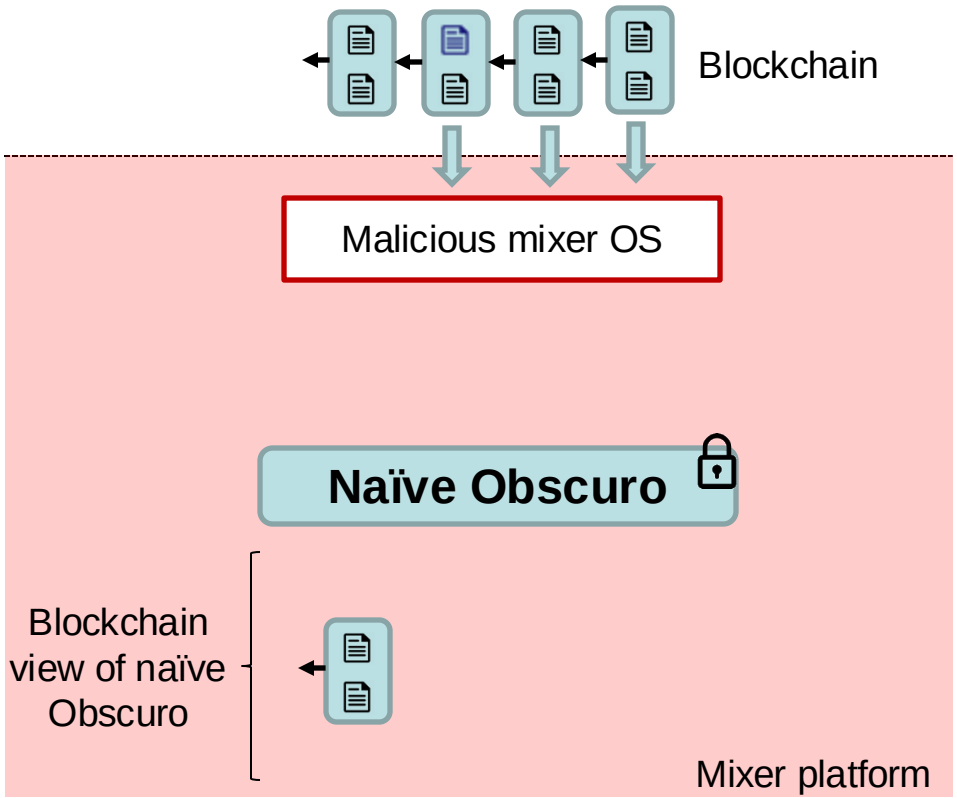

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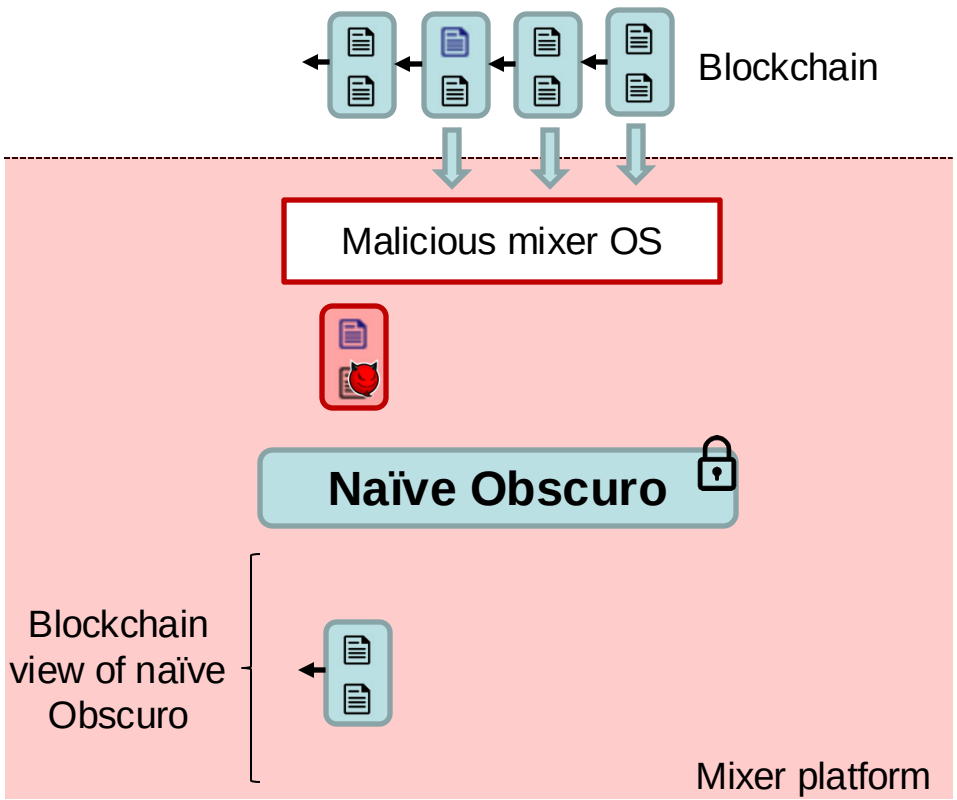

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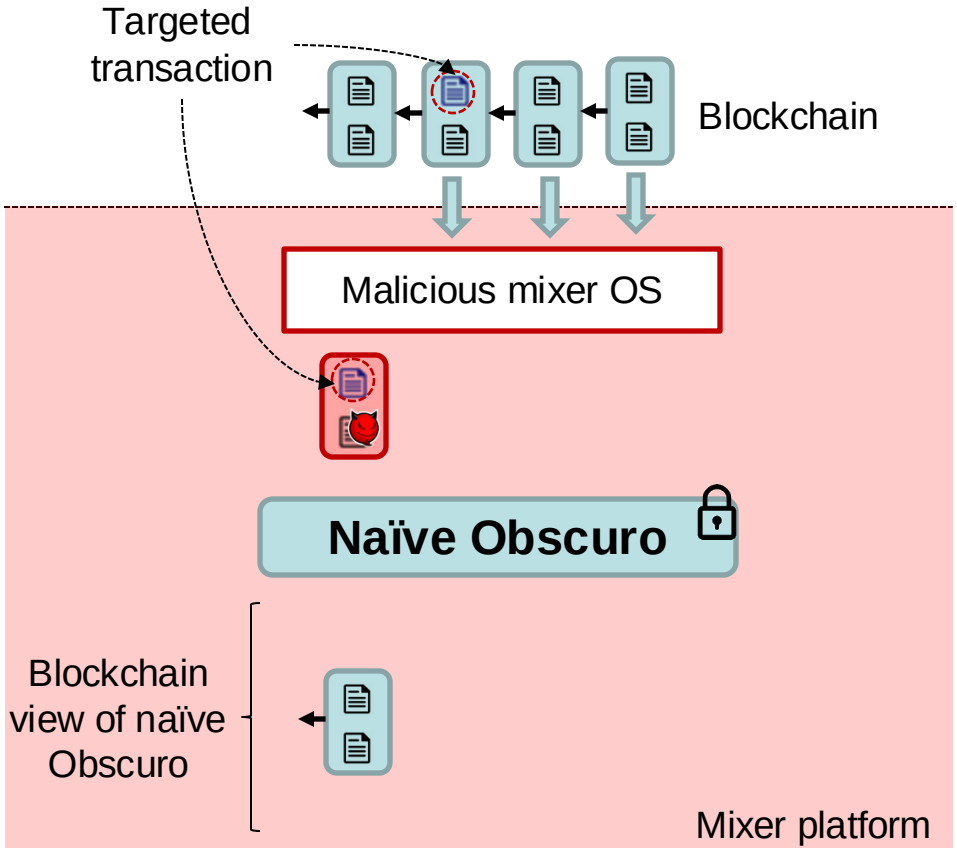

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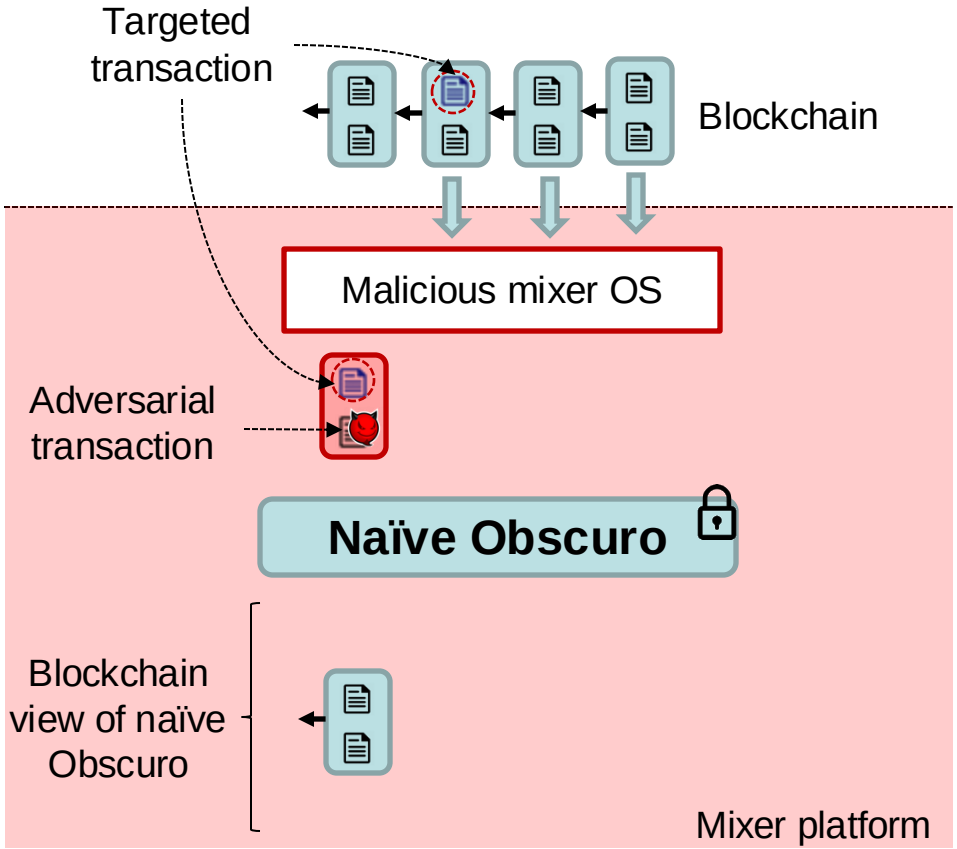

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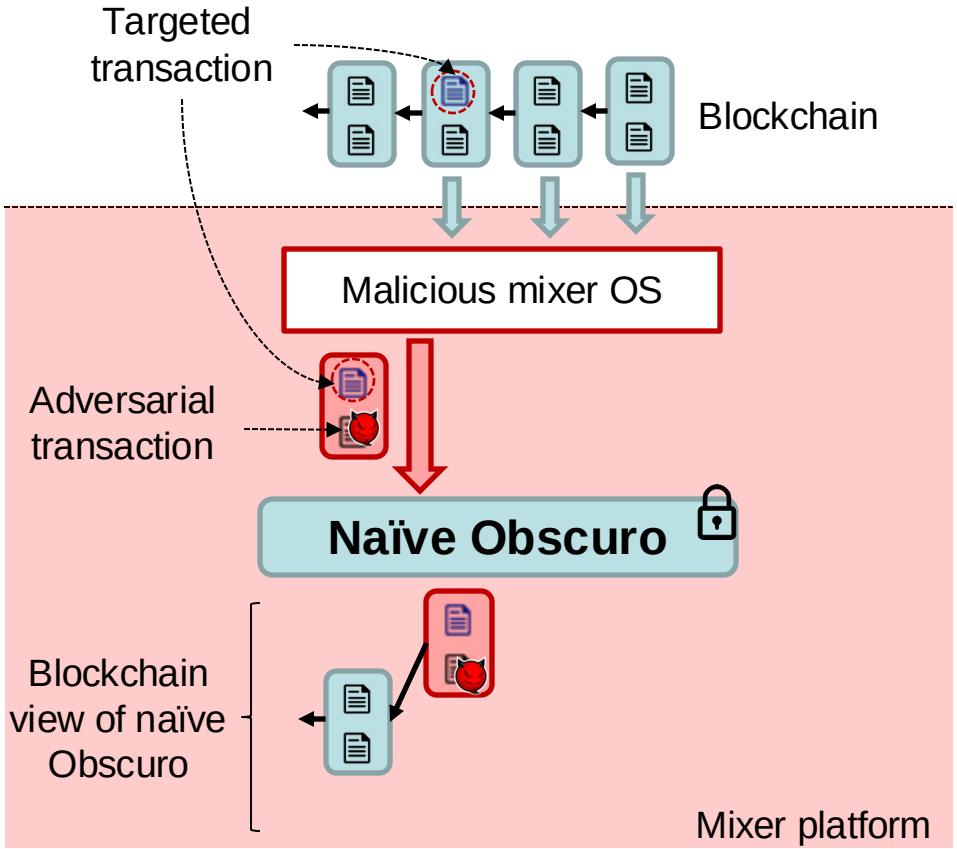

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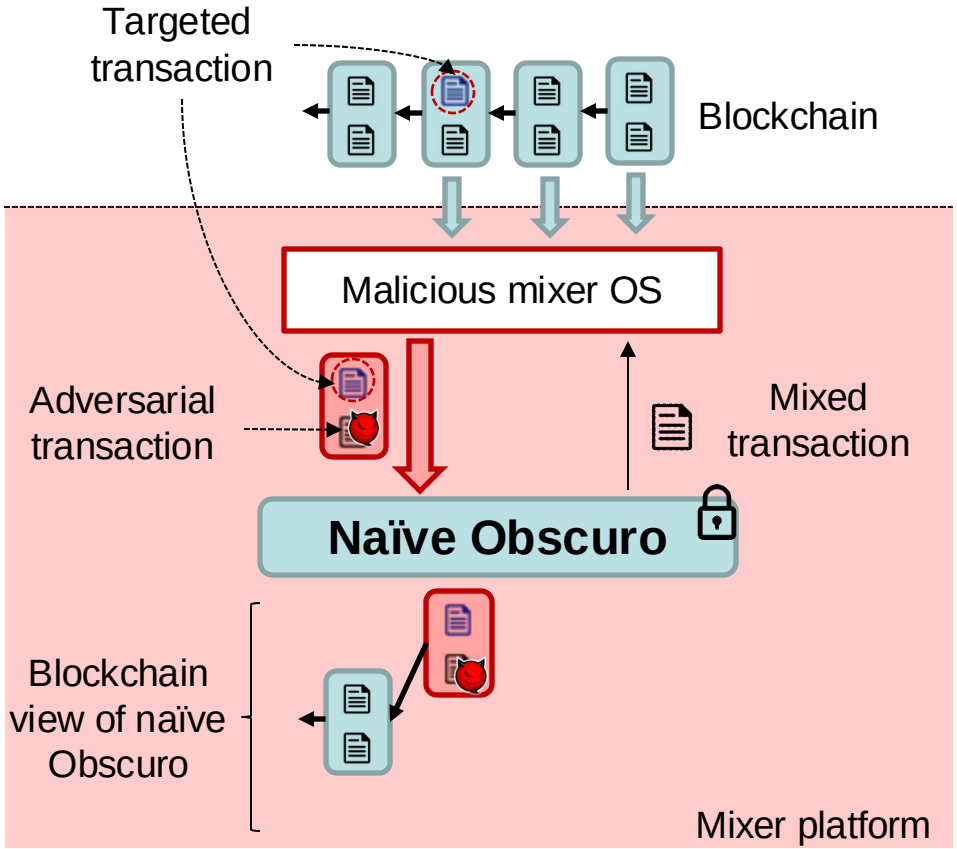

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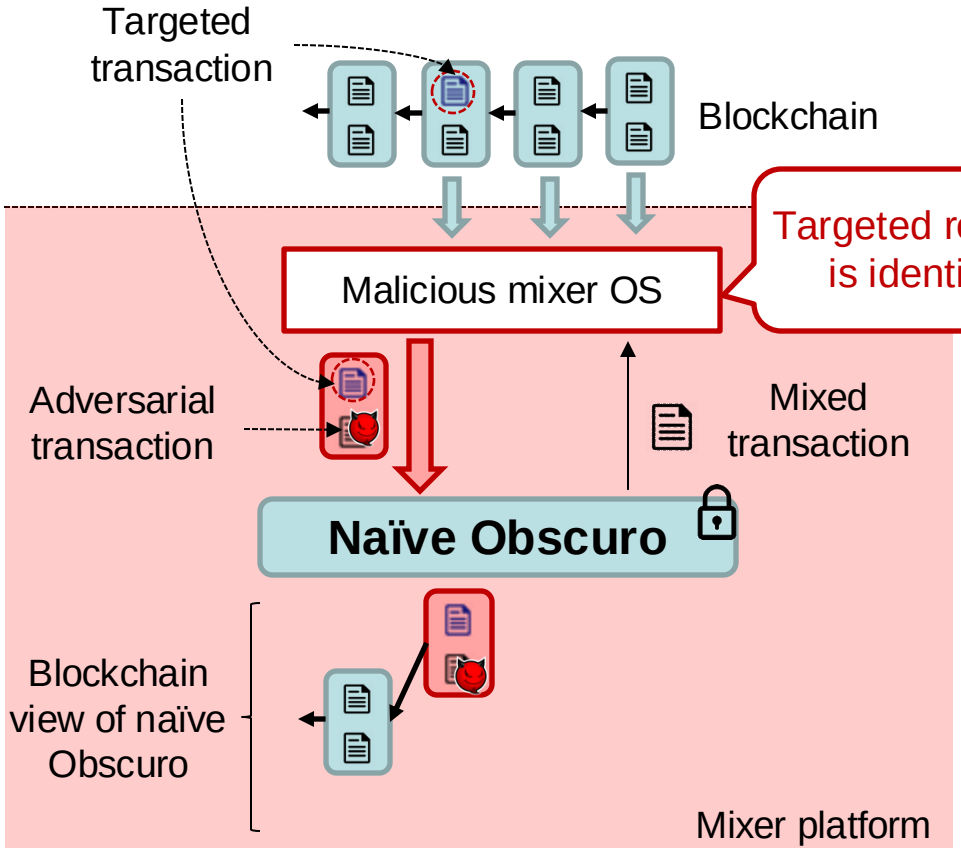

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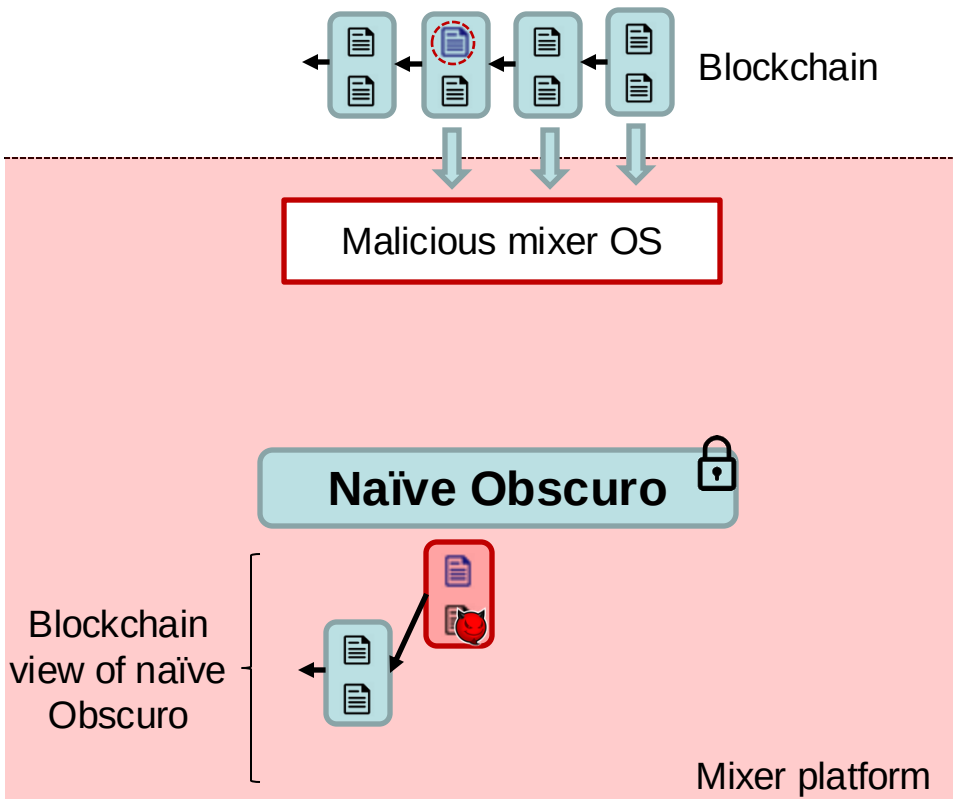

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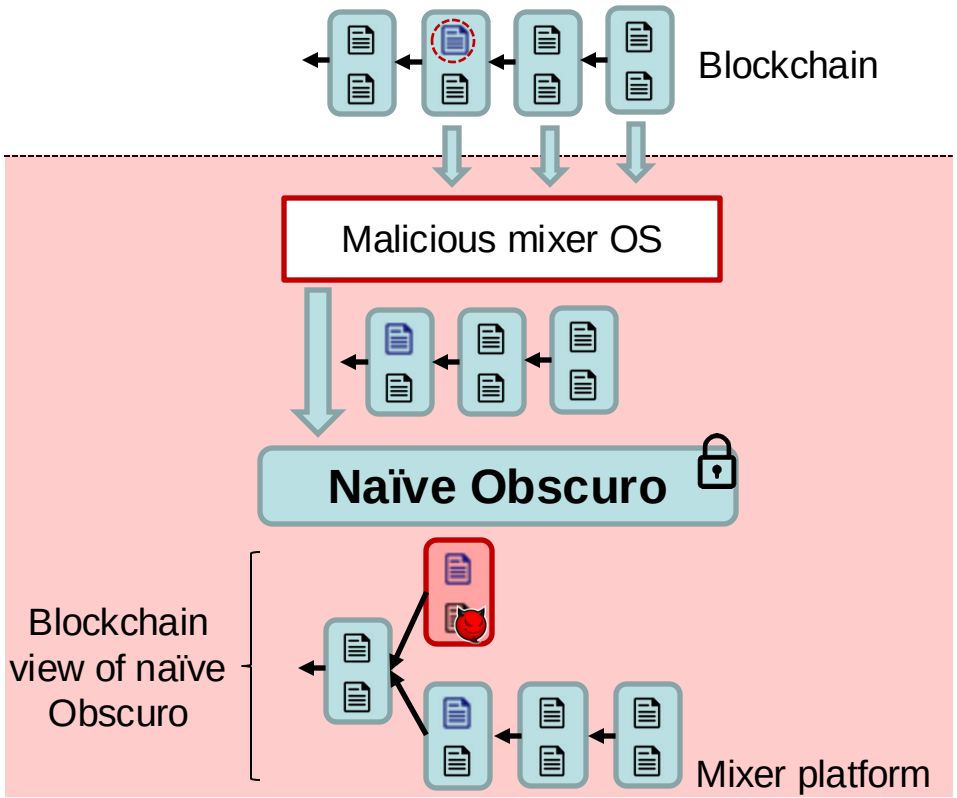

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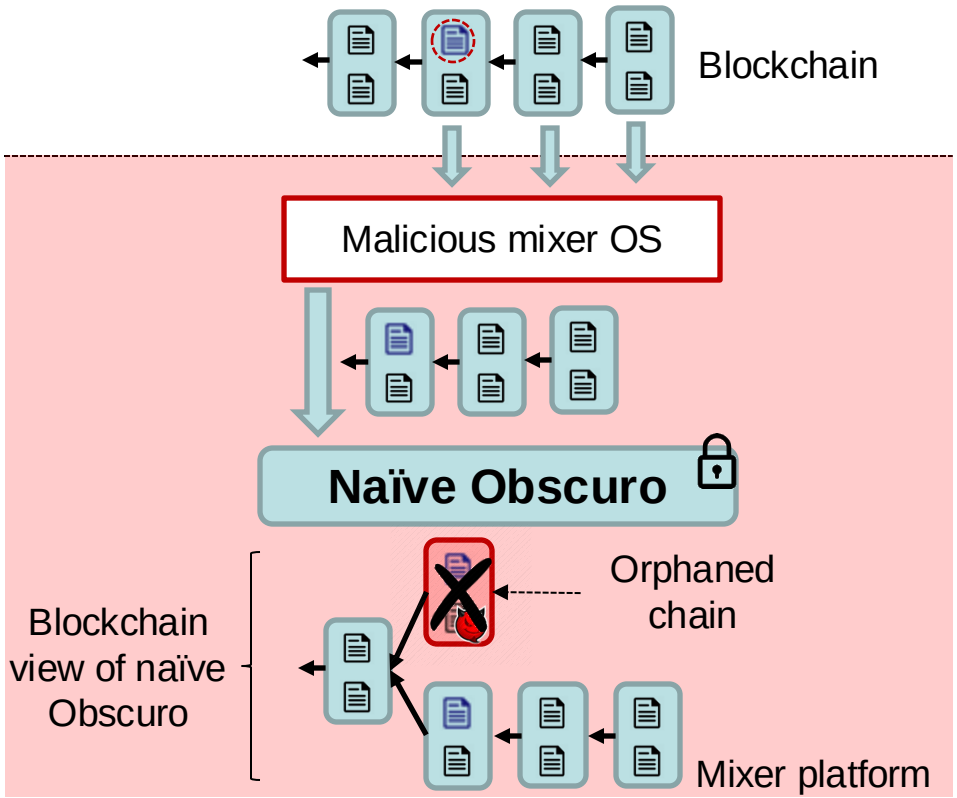

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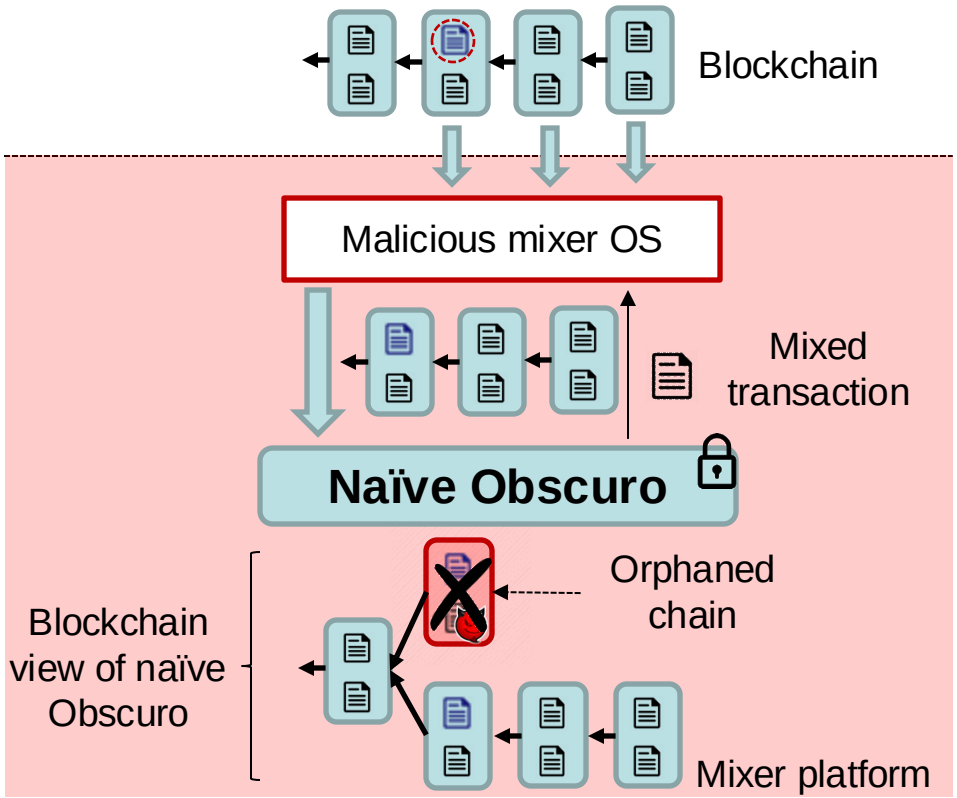
How to ***fork*** blockchain



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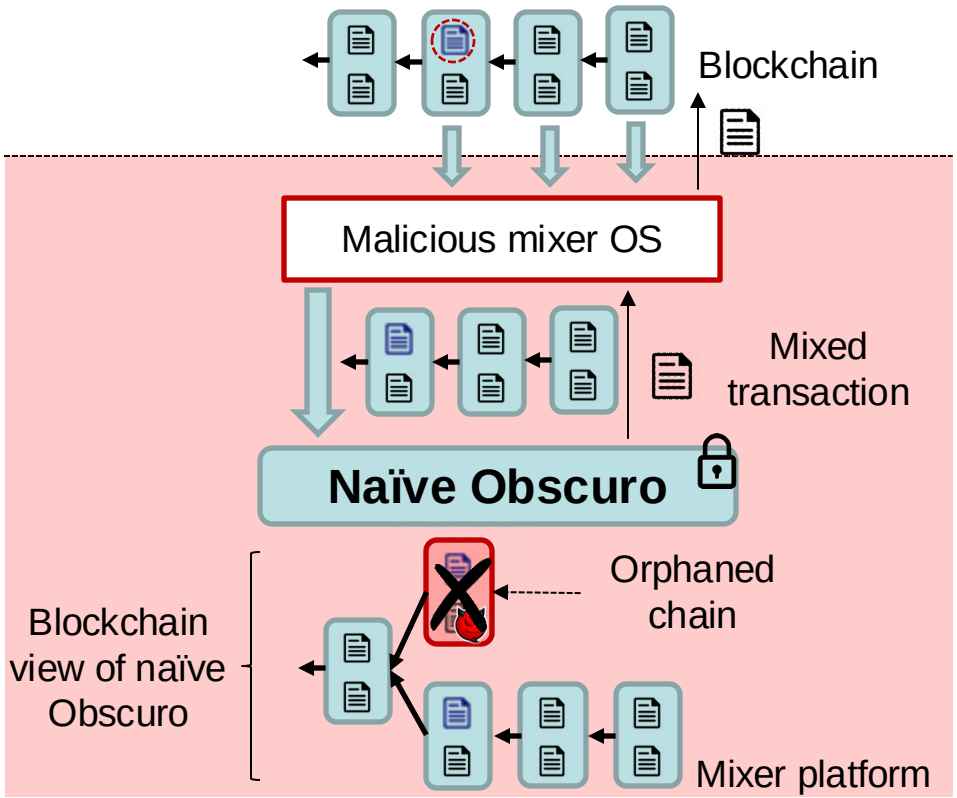

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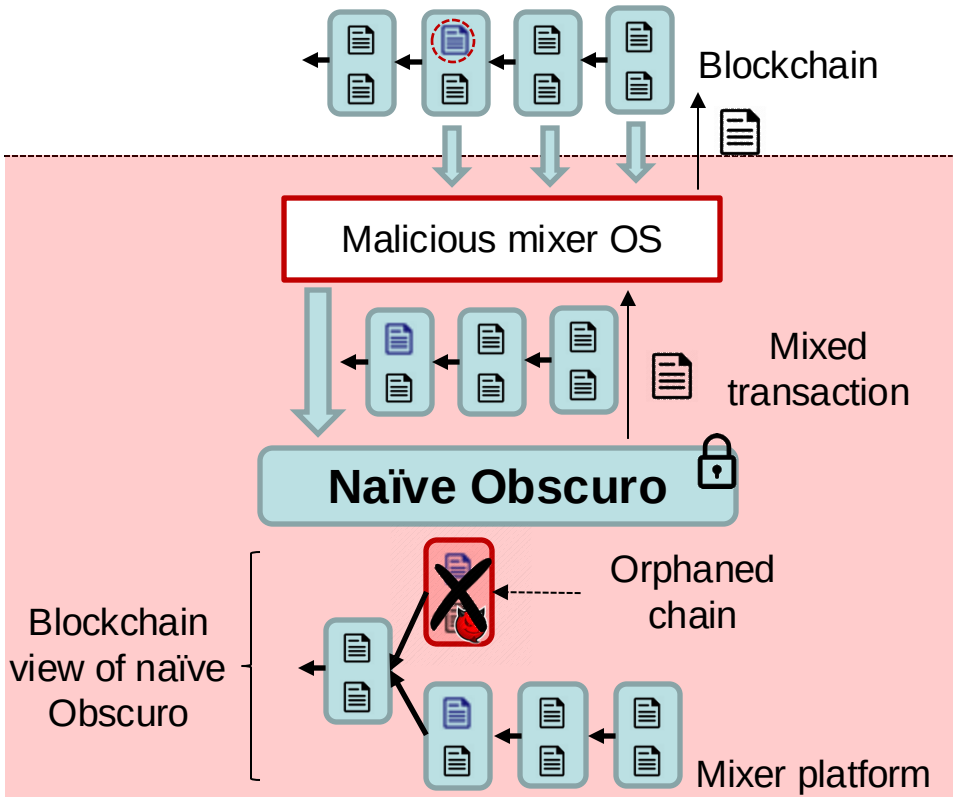

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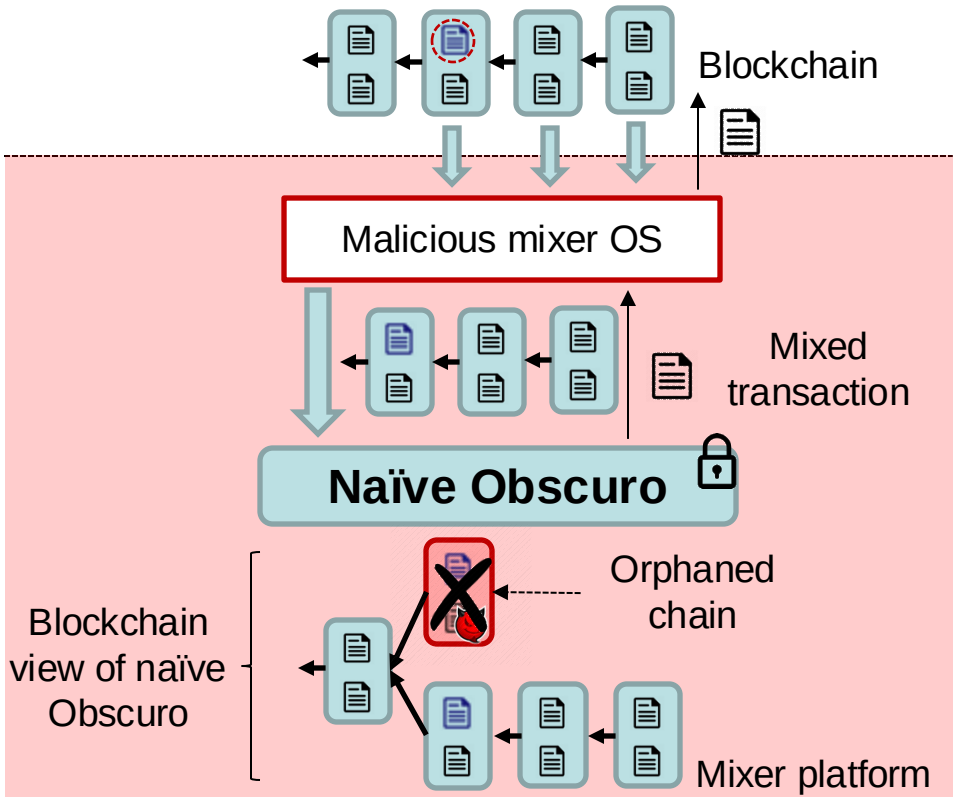

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Effective against ***all*** existing centralized mixers!

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  ✓ Excluded transactions are refunded

(Informal) Security Analysis

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Anonymity set size reduction attacks (Attack 1 & 2)

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More (informal) security analysis can be found in our paper

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Obscuro's functions	**1,150** SLoC
Bitcoin core modification	**1,292** SLoC

Additional TCB

Performance Evaluation

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Experiment setup

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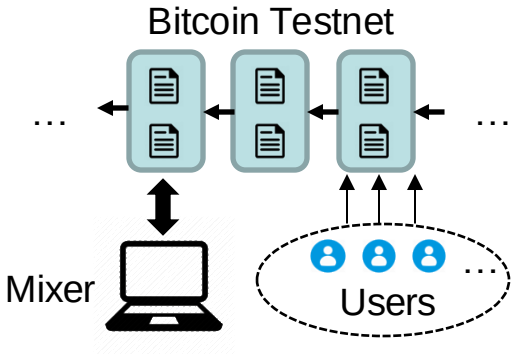

CPU: Intel Core i7-6820HQ

RAM: 8GB

Ubuntu 16.04 LTS

Intel SGX SDK for Linux

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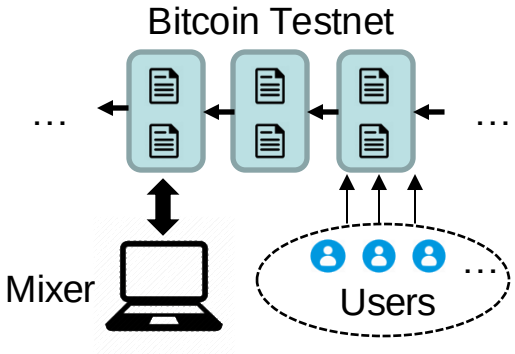

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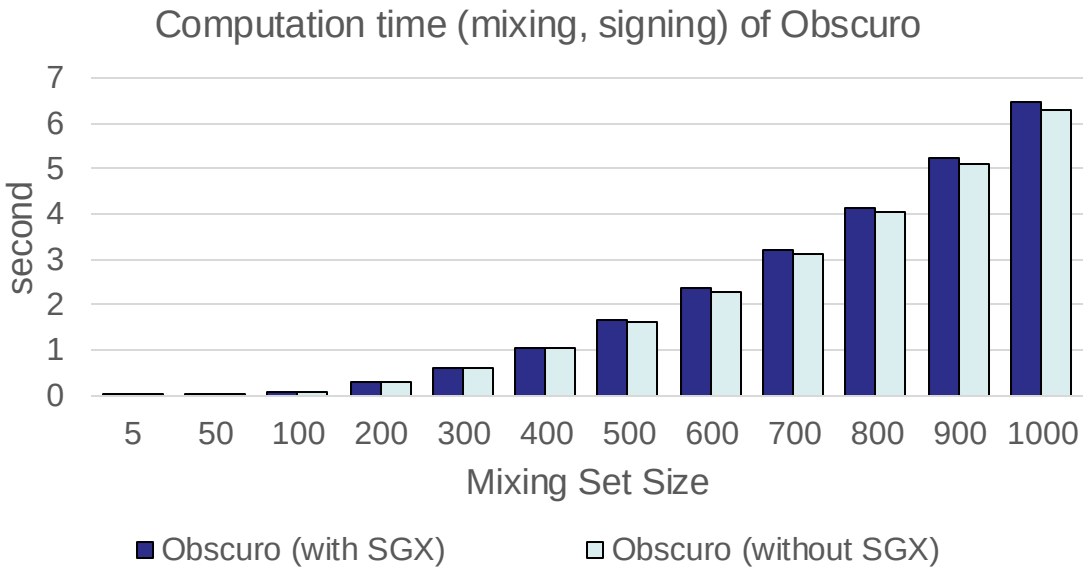

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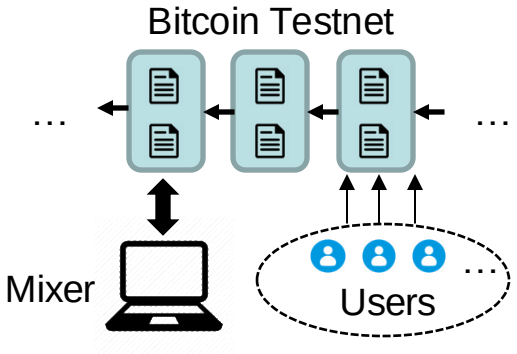

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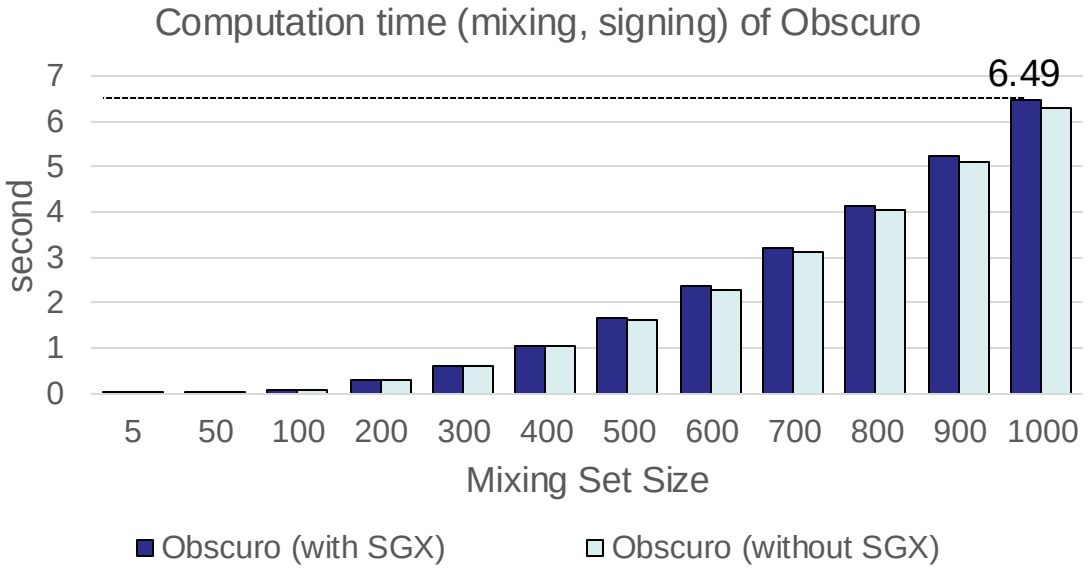

Obscuro mixed ***1,000 users*** on Bitcoin Testnet in ***6s***

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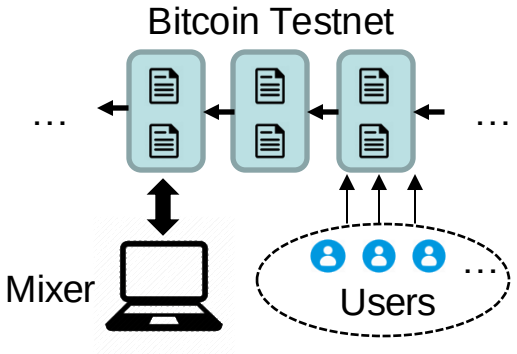

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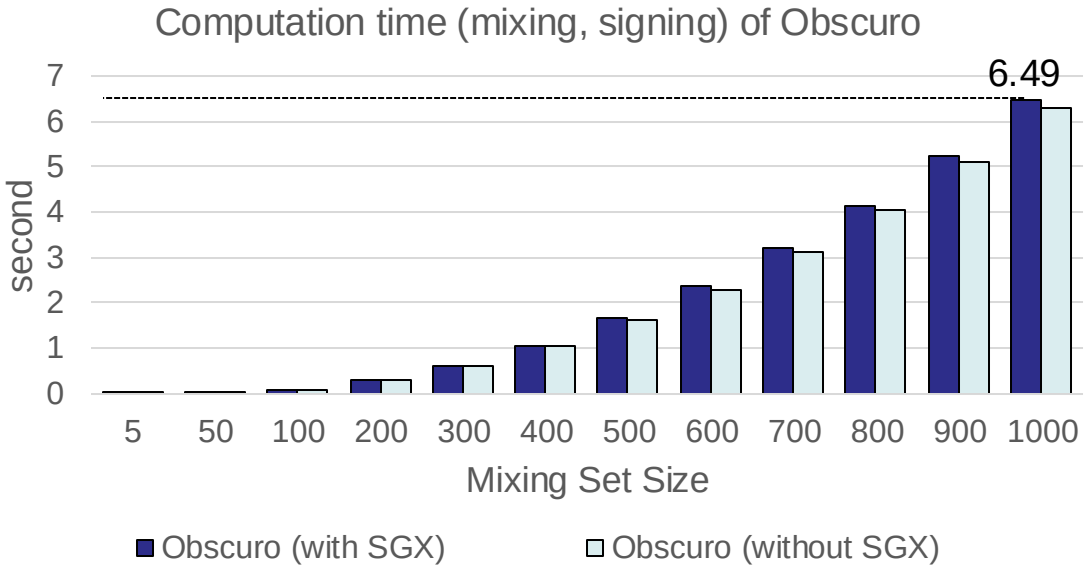

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E.g., TumbleBit [NDSS' 17] computation time for ***one*** pair of sender-recipient is ***0.6s***

Performance Evaluation

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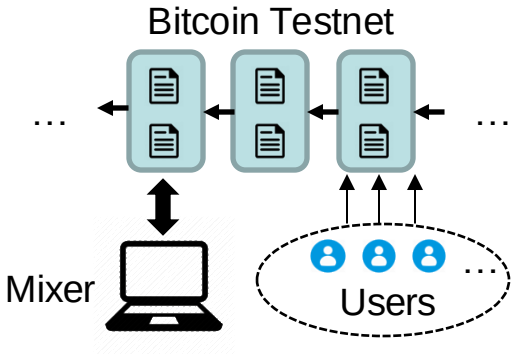

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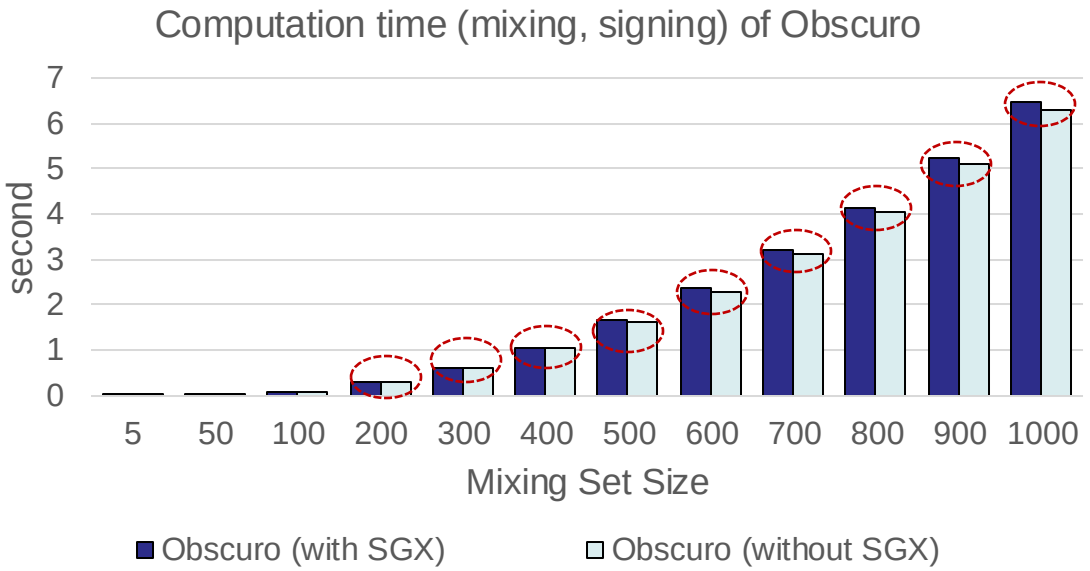

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SGX overhead is ***negligible***!

Comparison with Existing Mixers

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- Vulnerable to side-channel attacks → defenses are orthogonal with Obscuro

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  - ✓ guarantees any user can join the mix, and get refunded if the mix is unsuccessful.
- Obscuro is ***available today***
  - ✓ Obscuro is implemented with Intel SGX and available at:

https://github.com/BitObscuro/Obscuro

Question?

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