Privacy in Blockchain

Murat Osmanoglu

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  'Blind Signatures for Untraceable Payments', 1982

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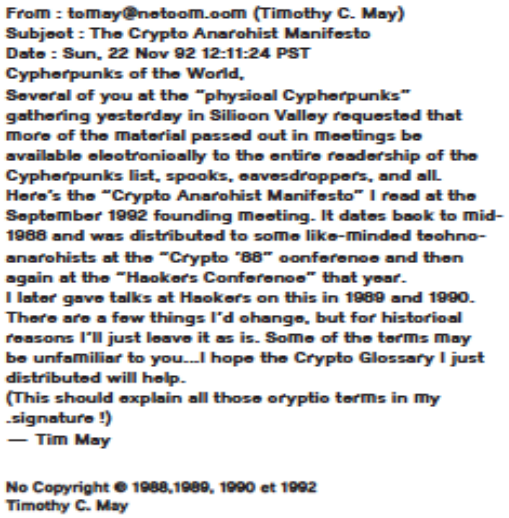
- in late 1992, three people: Eric Hughes (mathematicians from Berkeley), Tim May (businissman retired from Intel), and John Gilmore (computer scientist) were gathering to discuss some cryptographic and programing issues

Cypherpunk Manifesto

- they later initiated a mailing list (the number of subscribers reached 2000 in 1997) to reach out some other cypherpunks outside of Bay Area.

- Timothy May published 'the Crypto Anarchist Manifesto' in 1992



From : tcmay@netcom.com (Timothy C. May)
Subject : The Crypto Anarchist Manifesto
Date : Sun, 22 Nov 92 12:11:24 PST
Cypherpunks of the World,
Several of you at the "physical Cypherpunks" gathering yesterday in Silicon Valley requested that more of the material passed out in meetings be available electronically to the entire readership of the Cypherpunks list, spooks, eavesdroppers, and all. Here's the "Crypto Anarchist Manifesto" I read at the September 1992 founding meeting. It dates back to mid-1988 and was distributed to some like-minded techno-anarchists at the "Crypto '88" conference and then again at the "Hackers Conference" that year. I later gave talks at Hackers on this in 1989 and 1990. There are a few things I'd change, but for historical reasons I'll just leave it as is. Some of the terms may be unfamiliar to you....I hope the Crypto Glossary I just distributed will help.
(This should explain all those cryptic terms in my .signature !)
— Tim May

No Copyright © 1988,1989, 1990 et 1992
Timothy C. May

THE CRYPTO-ANARCHIST MANIFESTO

Thimothy C.May

MANIFESTE CRYPTO-ANARCHISTE

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> "Computer technology is on the verge of providing the ability for individuals and groups to communicate and interact with each other in a totally anonymous manner. Two persons may exchange messages, conduct business, and negotiate electronic contracts without ever knowing the True Name, or legal identity, of the other."

Cypherpunk Manifesto

- Eric Hughes published *'A Cypherpunk's Manifesto'* in 1993, which can be considered as holy text of this movement.

> "When I purchase a magazine at a store and hand cash to the clerk, there is no need to know who I am. When I ask my electronic mail provider to send and receive messages, my provider need not know to whom I am speaking or what I am saying or what others are saying to me; my provider only need know how to get the message there and how much I owe them in fees. Therefore, privacy in an open society requires anonymous transaction systems."

Cypherpunk Manifesto

- Adam Back, inventor of Hashcash
- Nick Szabo, inventor of smart contracts, designer of bit gold
- Wei Dai, inventor of B-Money
- Hal Finney, the receiver of the first transaction made in Bitcoin
- Satoshi Nakamoto, inventor of Bitcoin
- Julian Assange, founder of wikileaks, author of 'Cypherpunks : Freedom and the Future of the Internet'

Privacy Issues

- each user can get all the transactions shared in the network
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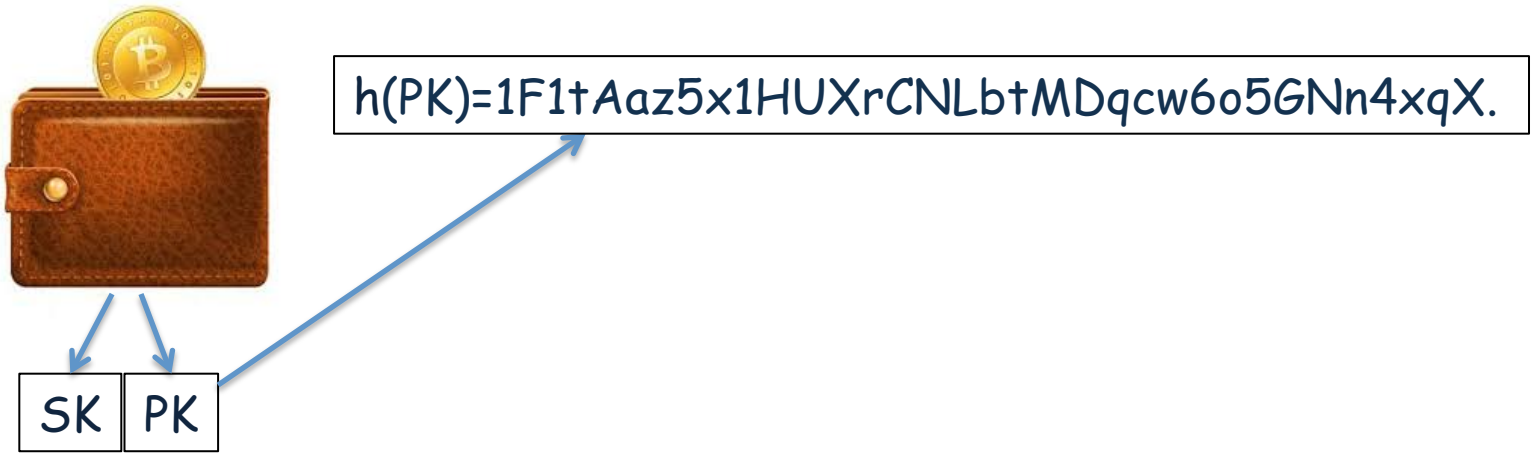

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- Bitcoin even allows users to have more than one address and to use a new one for each transaction to improve privacy

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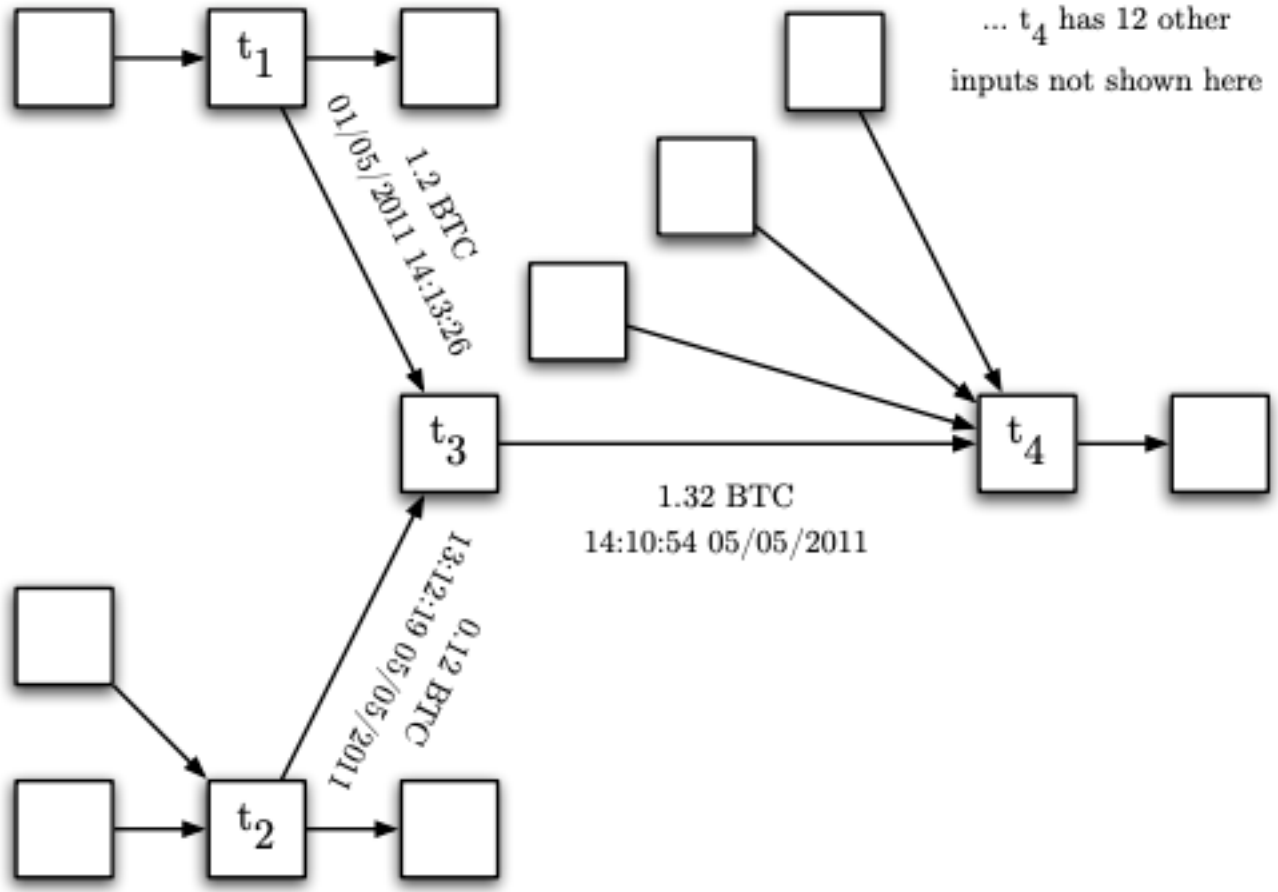
- analyze the study proposed Reid and Harrigan [1]
  - they obtained all the transactions recorded in bitcoin from January 2009 to July 2011 (1019486 txs between 1253054 addresses)
  - they built two networks (transaction and user) based on the input-output relationship between transactions and re-use and co-use of the addresses

Privacy Issues

- analyze the study proposed Reid and Harrigan [1]
- a sub-network of transaction network



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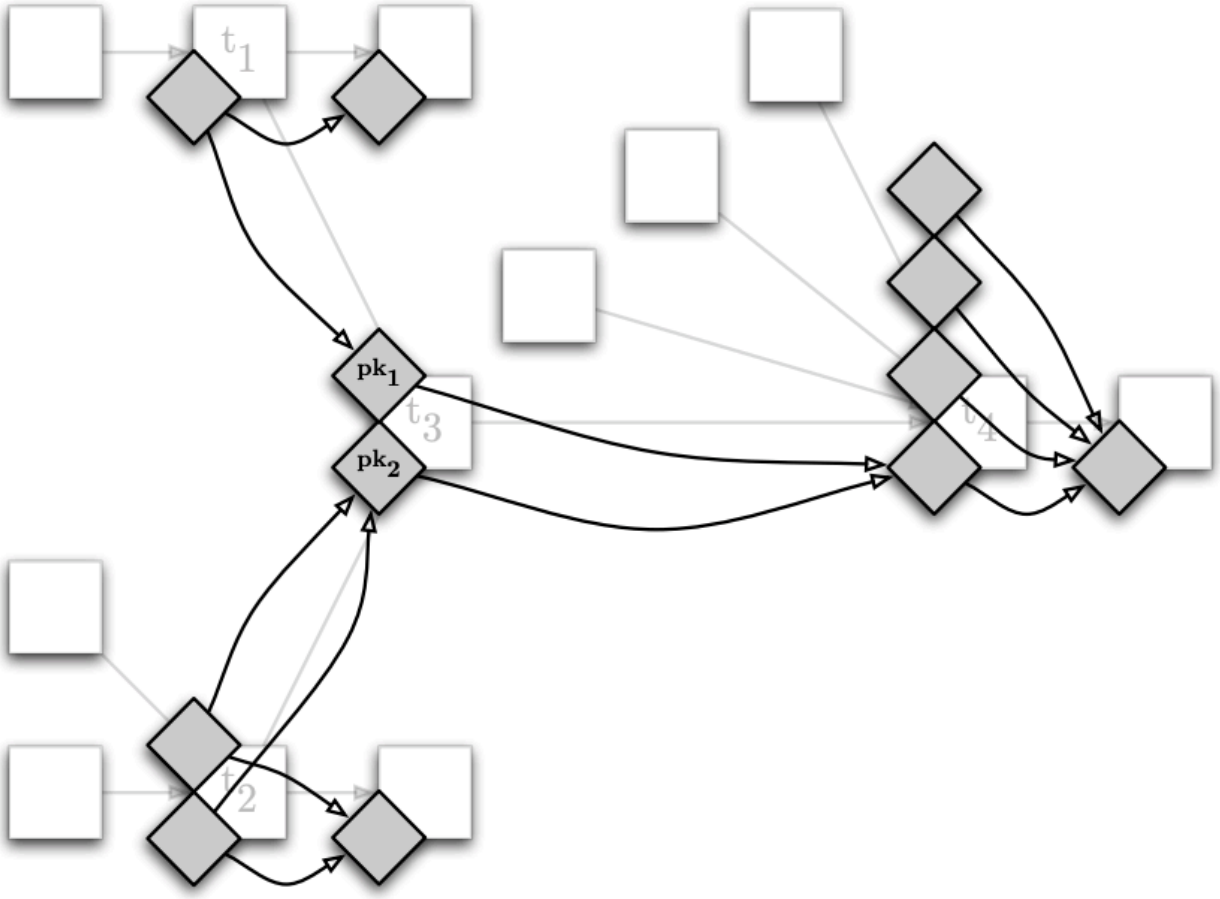

Privacy Issues

- the transfer of an amount bitcoin ownership rights from one address to another one
- each tx consists of two main fields :
  - input : unspent transaction outputs claimed by the sender from previous transactions (previous transaction id, index, scriptsign)
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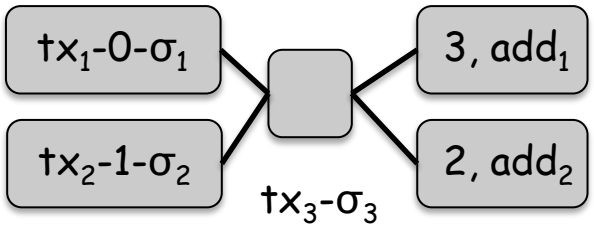

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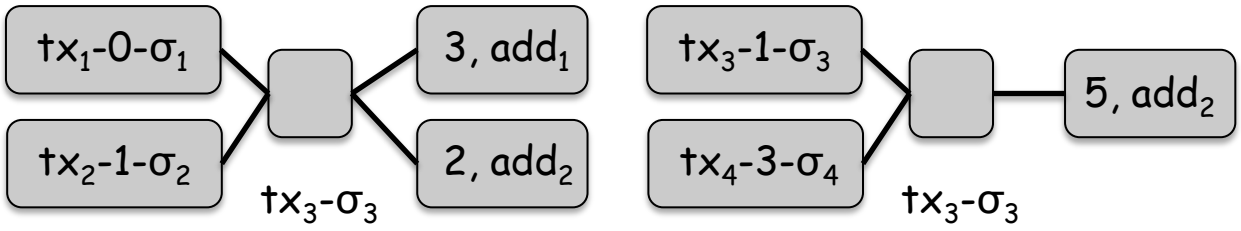

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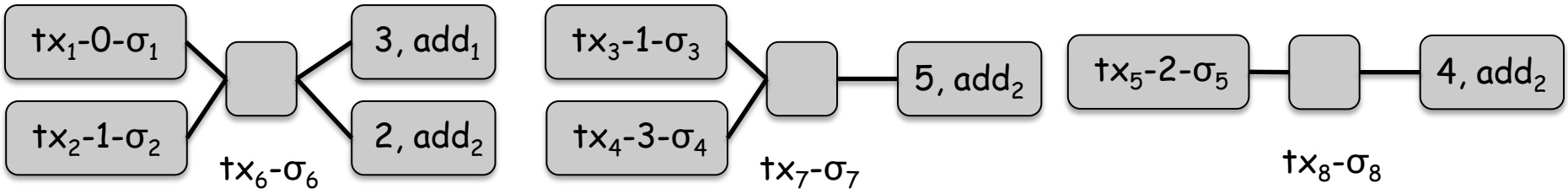

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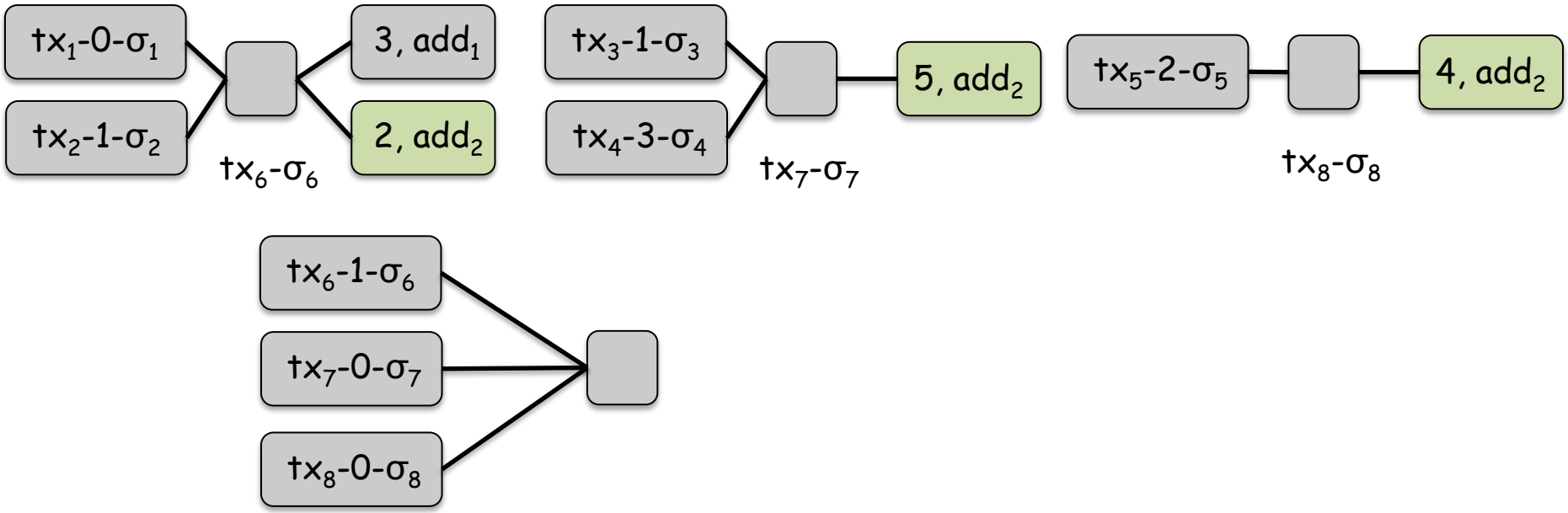

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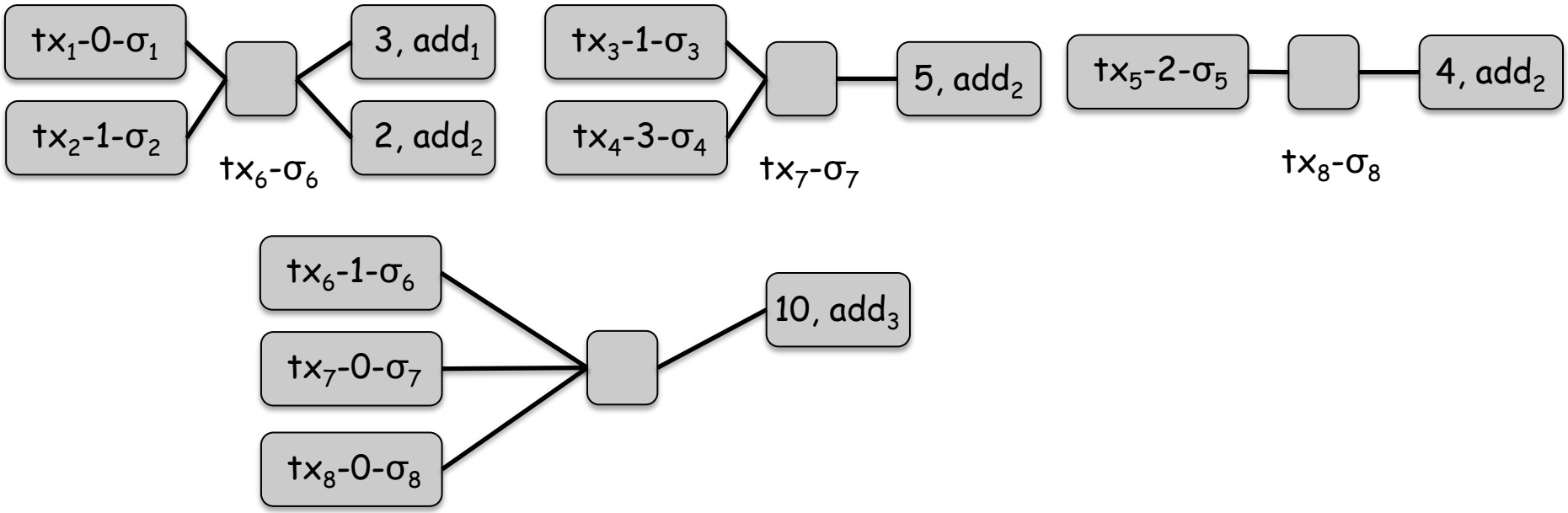

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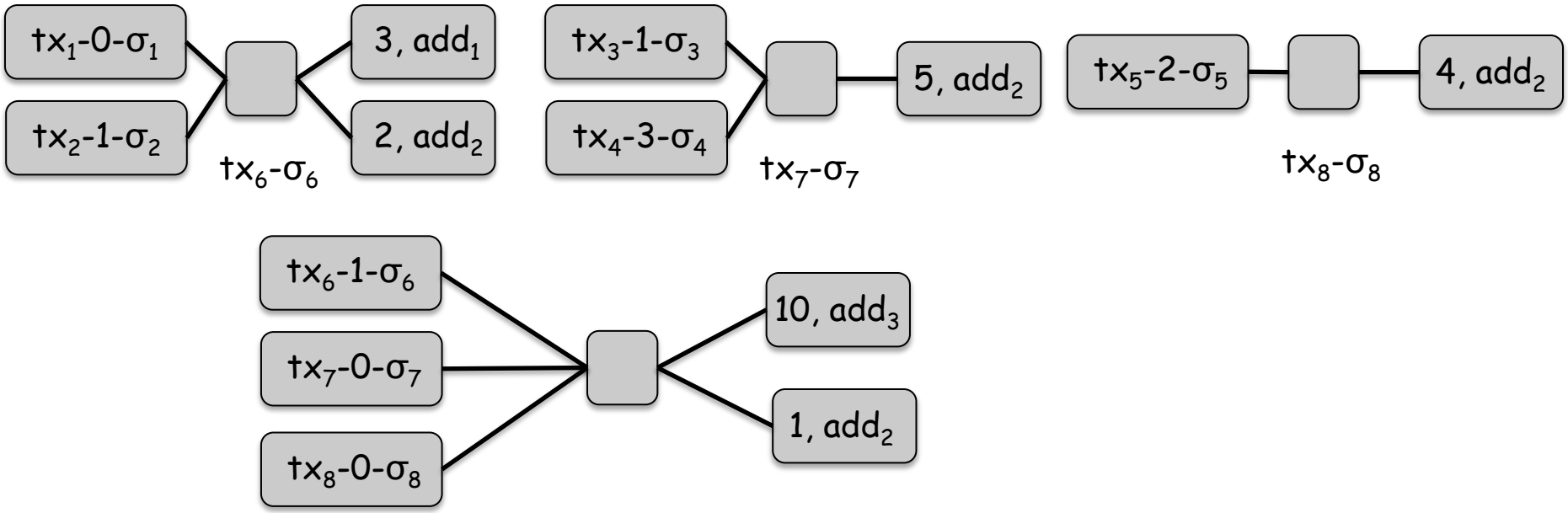

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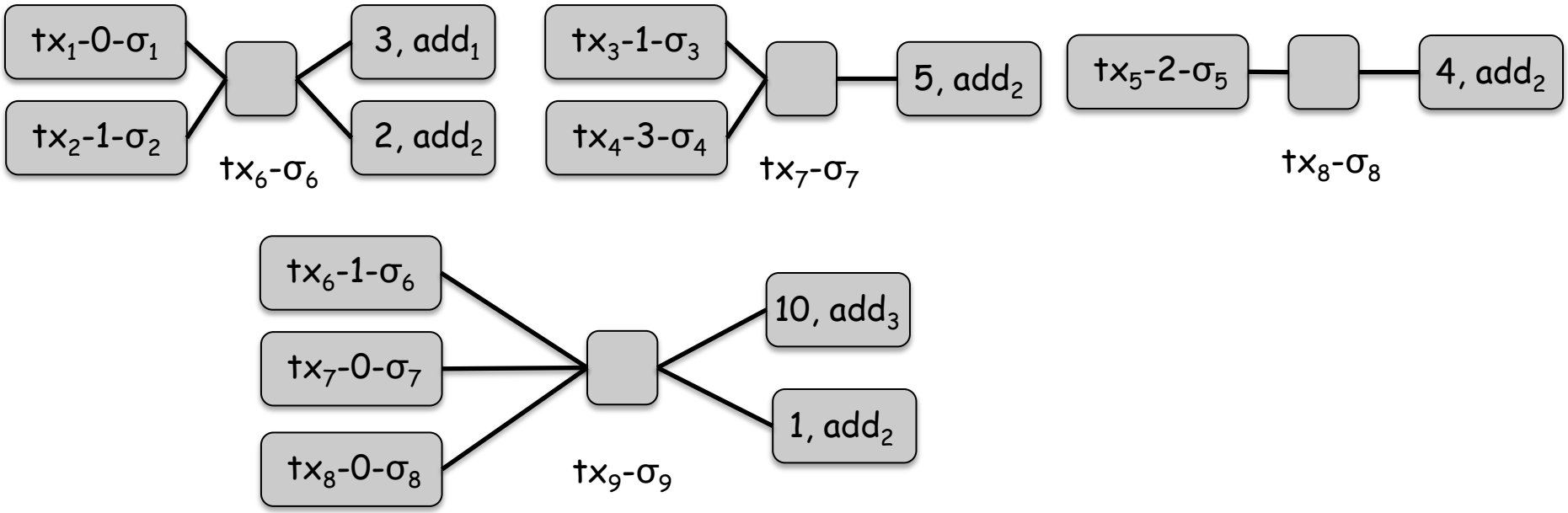

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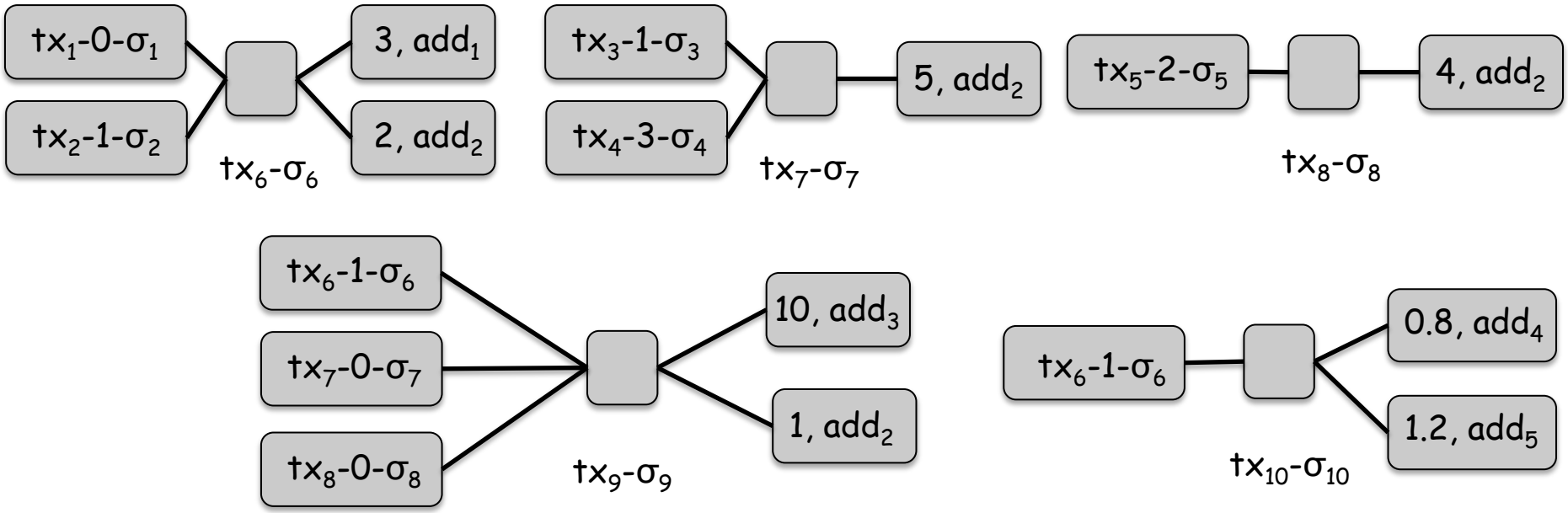

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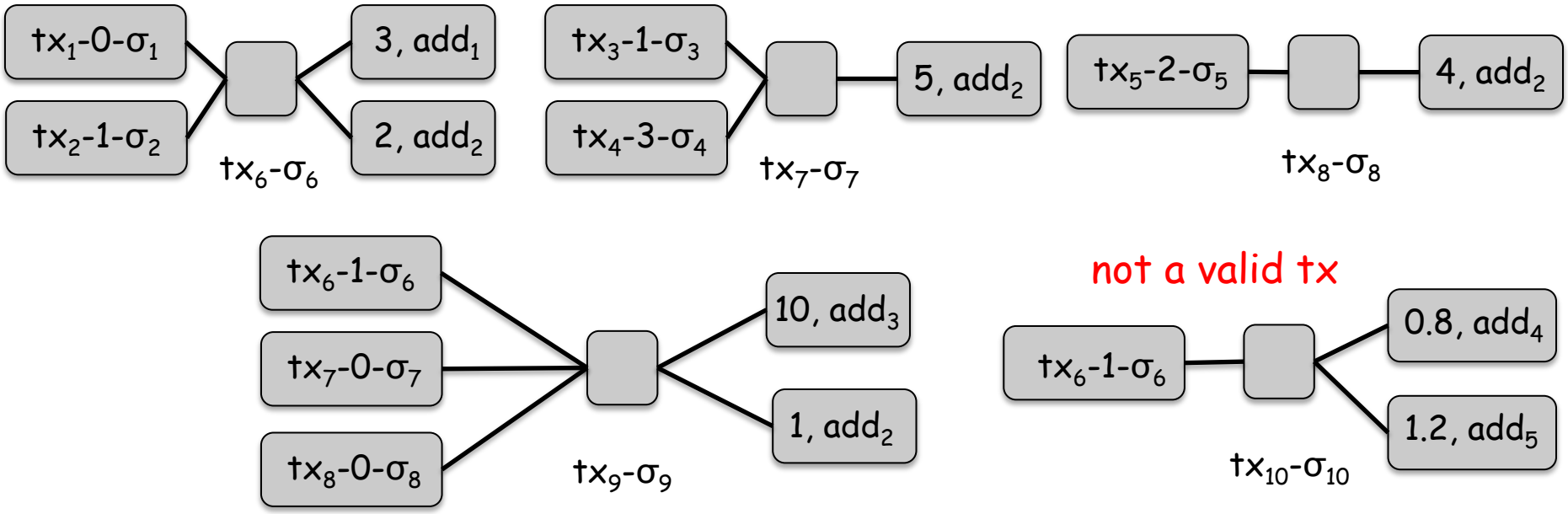

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- some findings:
  - user network has cyclic structure (it is expected to just contain Bitcoin flows between one-time addresses keys that were not connected to other addresses)
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  - a tx frequently has two outputs: one for payment, one directing to user's other address
- data obtained from different Internet sources such as twitter posts, bitcoin forums etc. (they usually post one of their addresses) used to link an address to a real identity
  - utilizing user network, they can even link public addresses to some other address belonging to same users

Privacy Issues

- analyze the study proposed Reid and Harrigan []

- they also examined the theft of 25k BTC reported in the bitcoin forums

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- attacker broke into allinvain's Slush pool account and changed the payout address as his address

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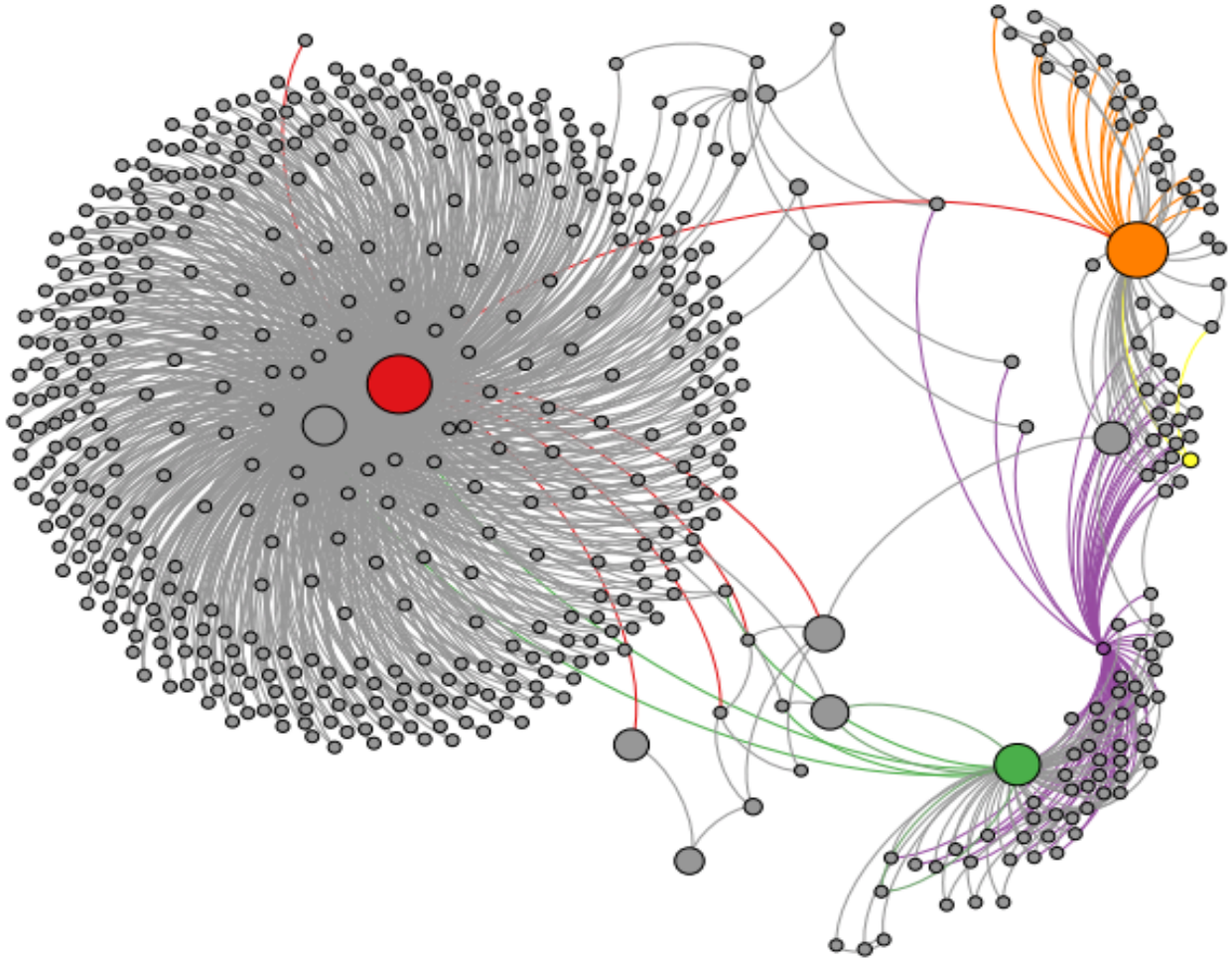

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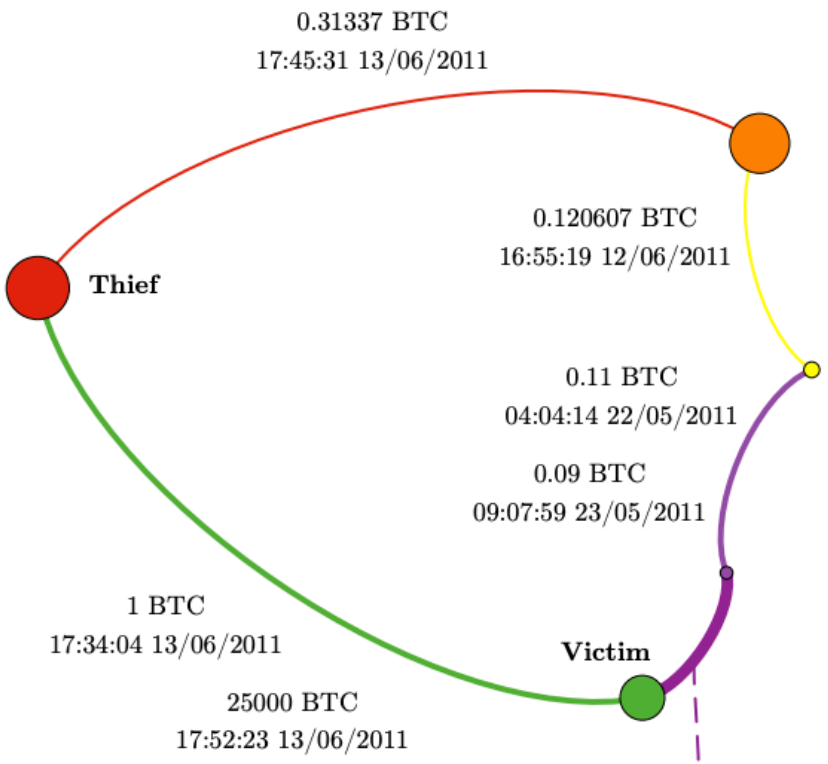

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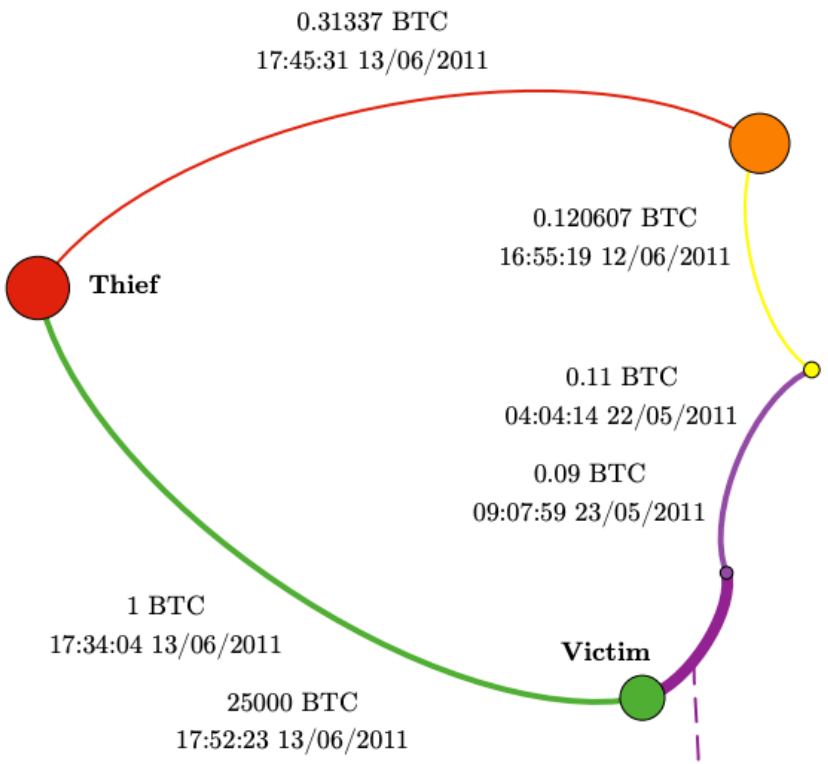

he even tried to associate the thief with the hacker group LulcSec by creating a transaction from hacker to that group

Privacy Enhancing Techniques

- break the link between source and destination address

Privacy Enhancing Techniques - Mixing

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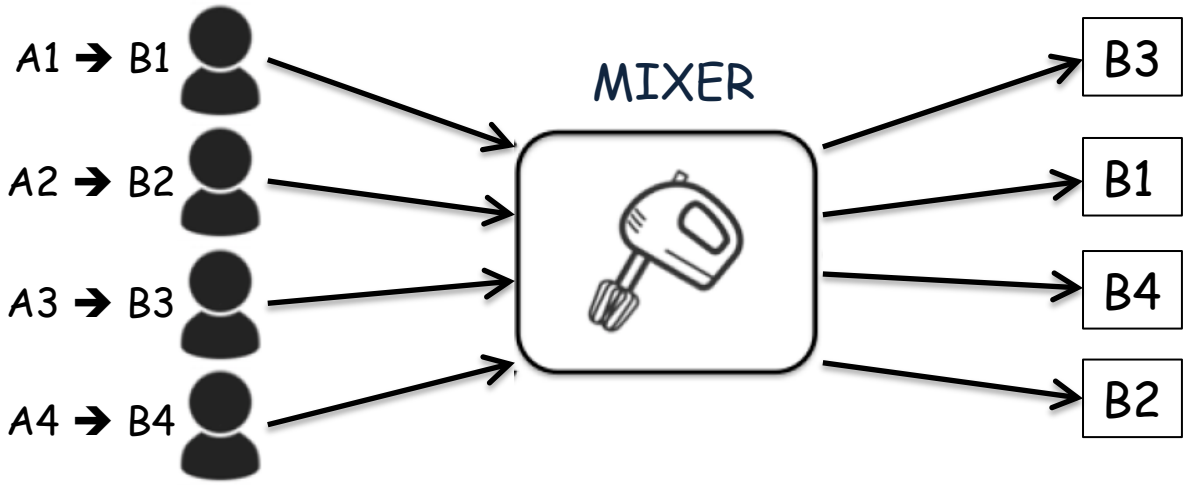

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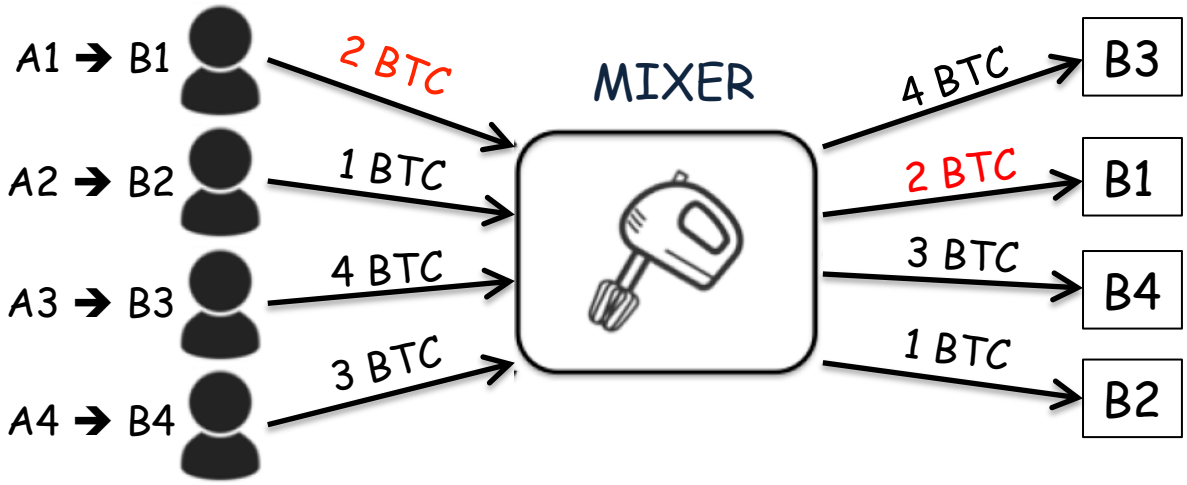

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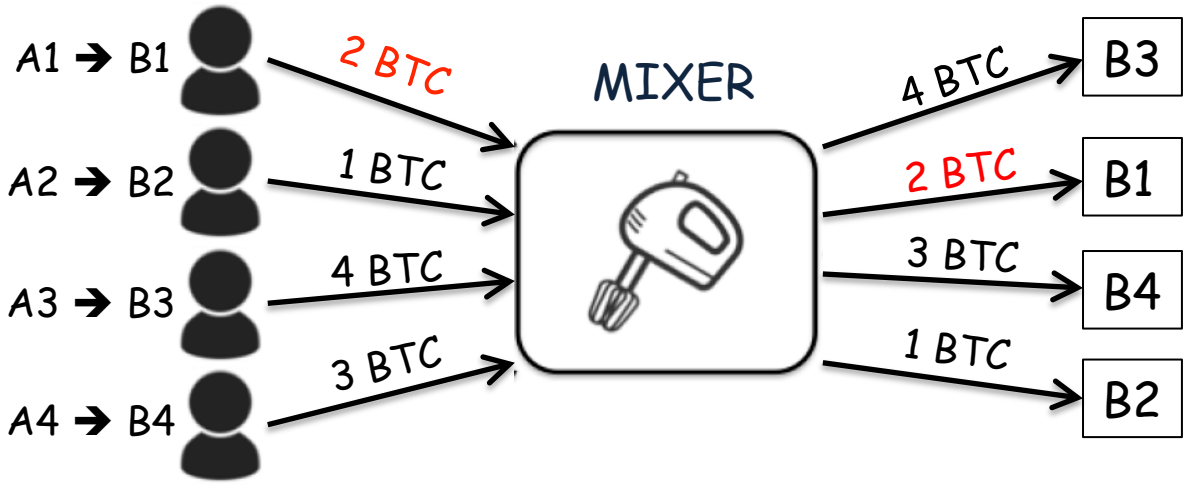

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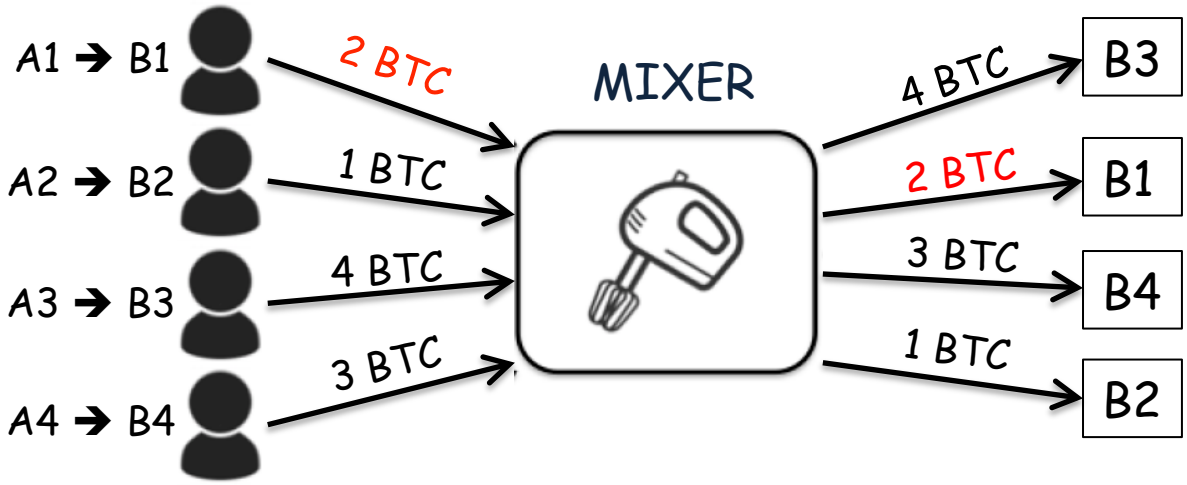

- transaction amount should be same to be indistinguishable
- mixer should be trusted
  - it can steal the money
  - it knows all the senders and receivers addresses, it can reveal that information

Privacy Enhancing Techniques - Mixing

Mixcoin

- introduced by Bonneau et al. [] in 2014

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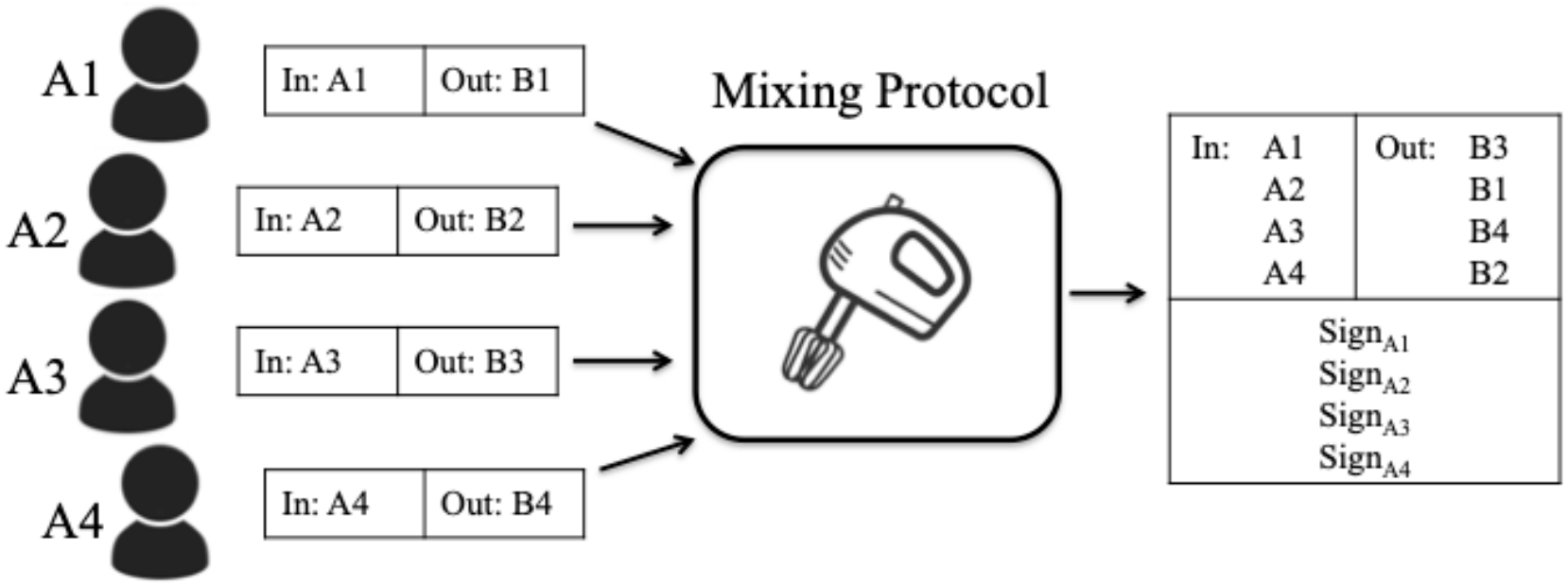
- mixer may reveal the sender's and receiver's address

Privacy Enhancing Techniques - Mixing

CoinJoin

- introduced by Maxwell [] in 2013
- utilized in practice by different systems



- insiders can reveal the link of each transaction

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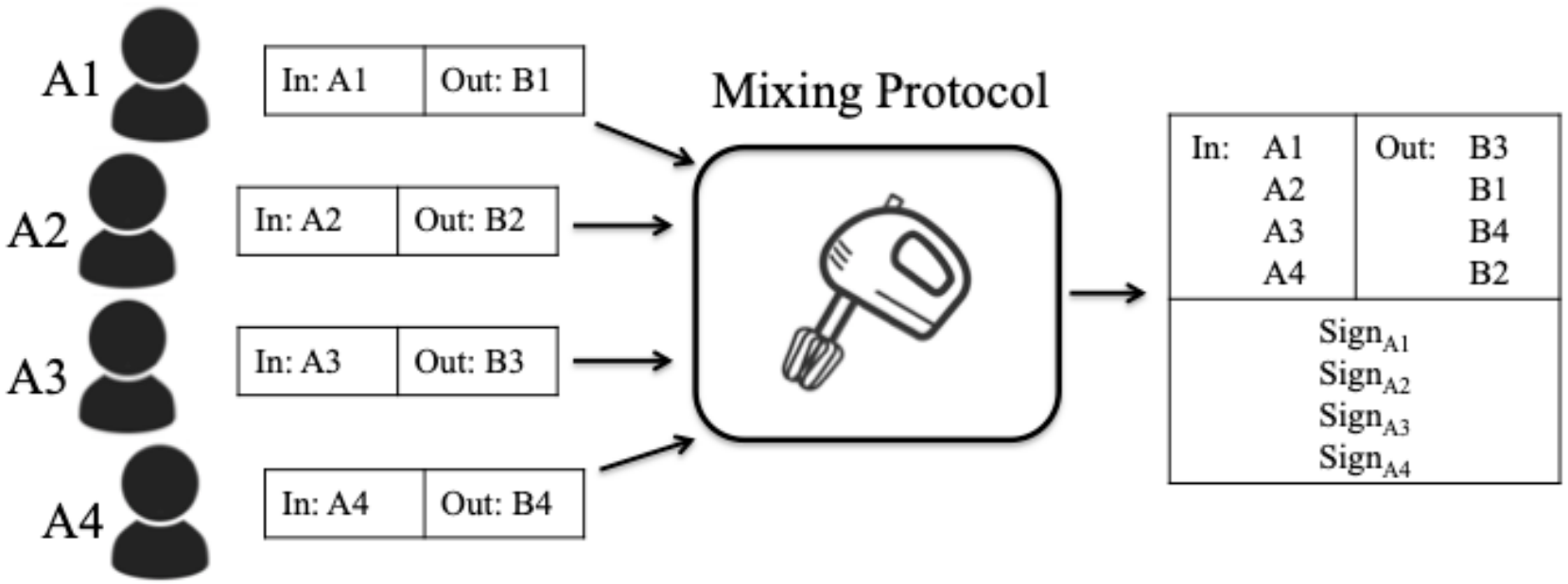
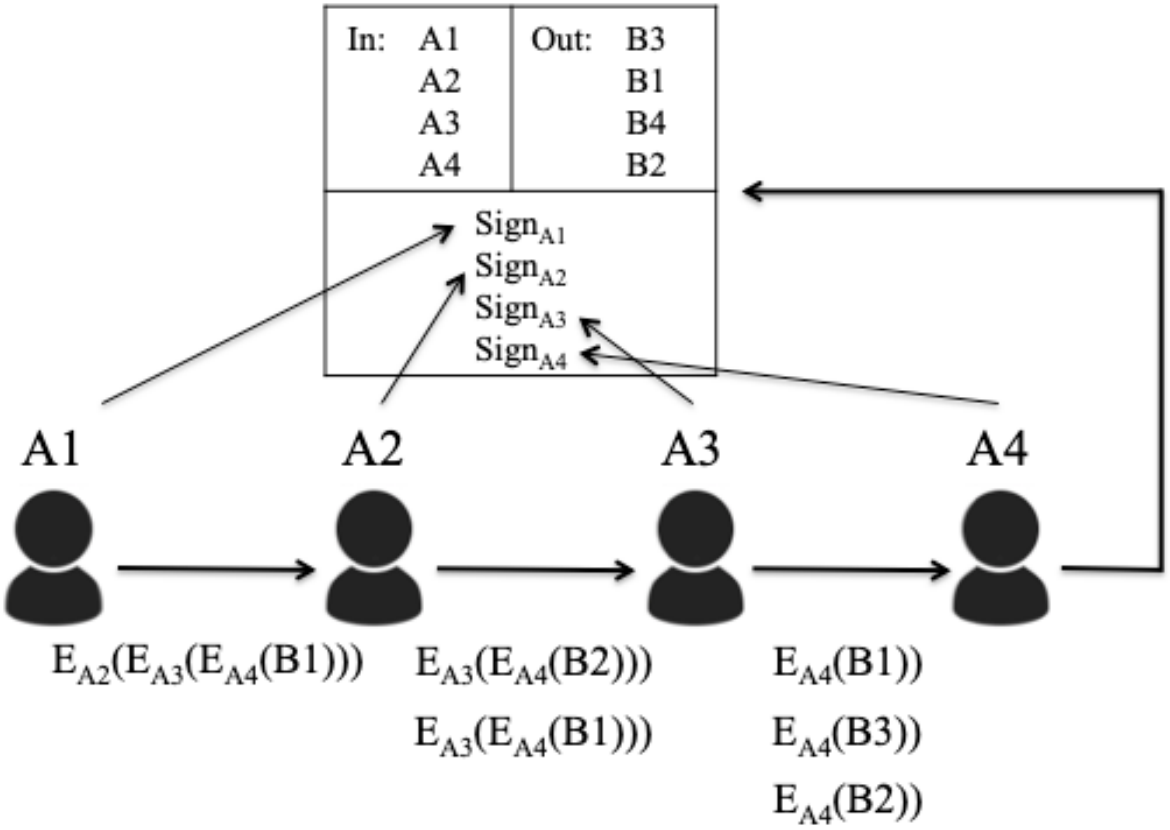


CoinShuffle

- introduced by Ruffing et al. [] in 2014



Privacy Enhancing Techniques - Ring Signatures

Digital Signatures

PK, SK

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Digital Signatures

PK, SK

SK

Signature

SIGNING ALGORITHM

Privacy Enhancing Techniques - Ring Signatures

Digital Signatures

PK, SK

Privacy Enhancing Techniques - Ring Signatures

Digital Signatures

PK, SK

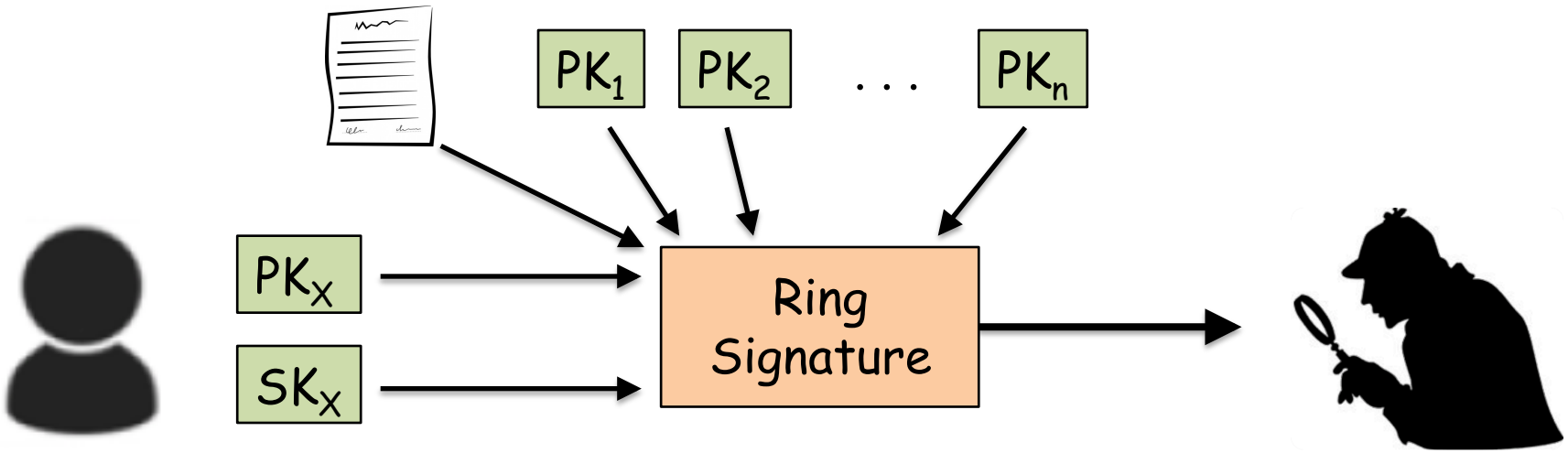
1 or 0

PK

VERIFICATION ALGORITHM

Privacy Enhancing Techniques - Ring Signatures

- introduced by Rivest et al. [] in 2001



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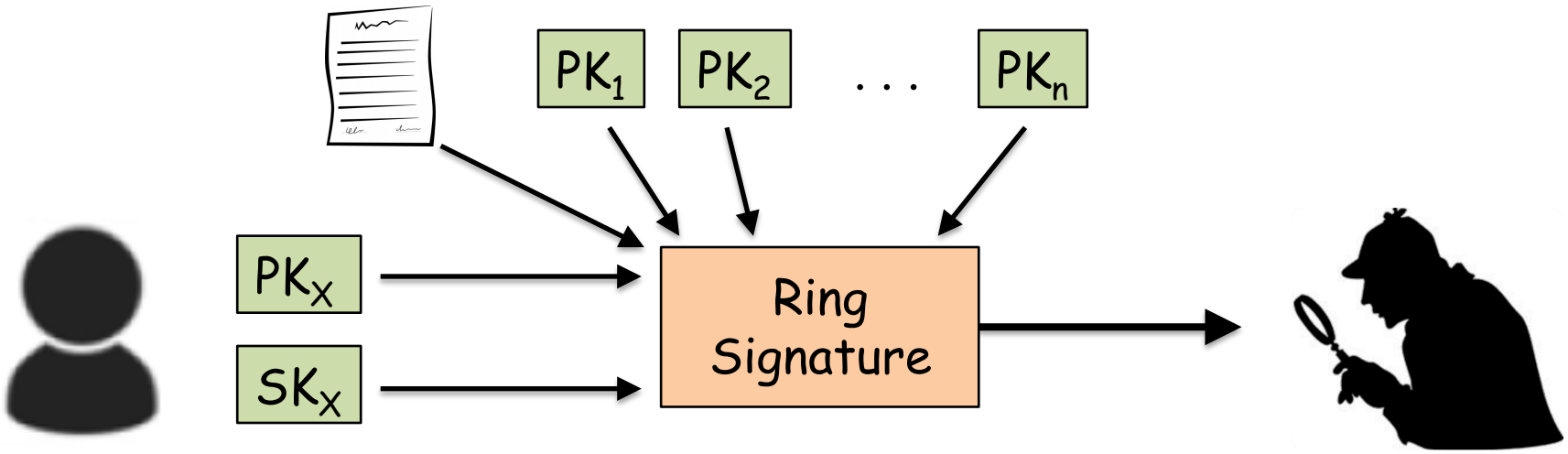

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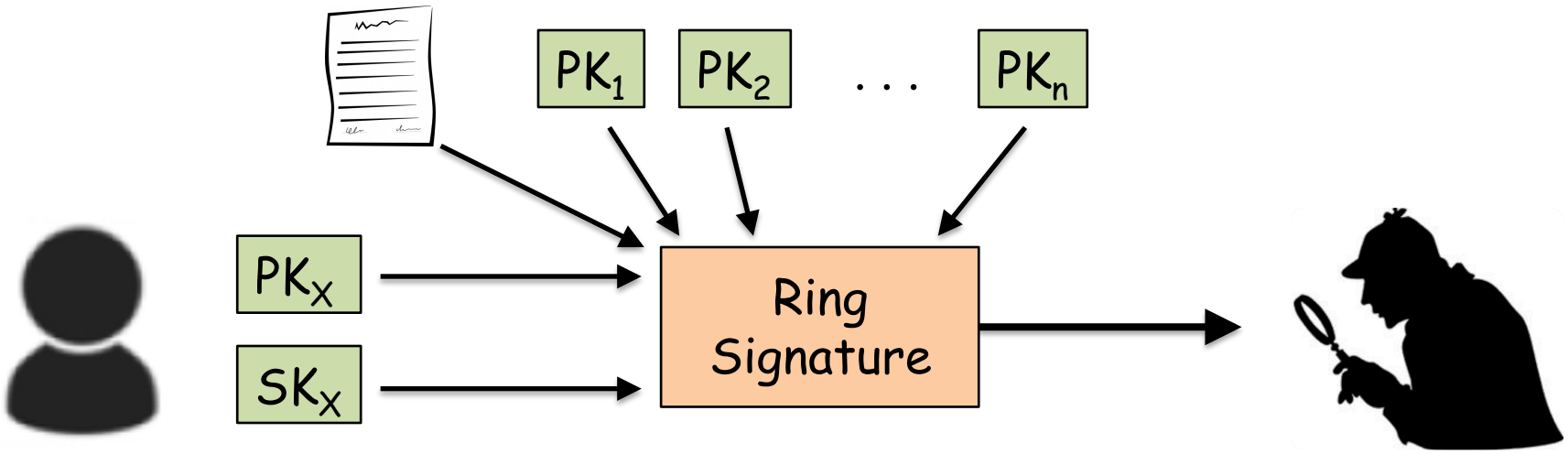

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- assume you designing a voting scheme using ring signatures
  - one can vote for two different candidate without being detected

Privacy Enhancing Techniques - Ring Signatures

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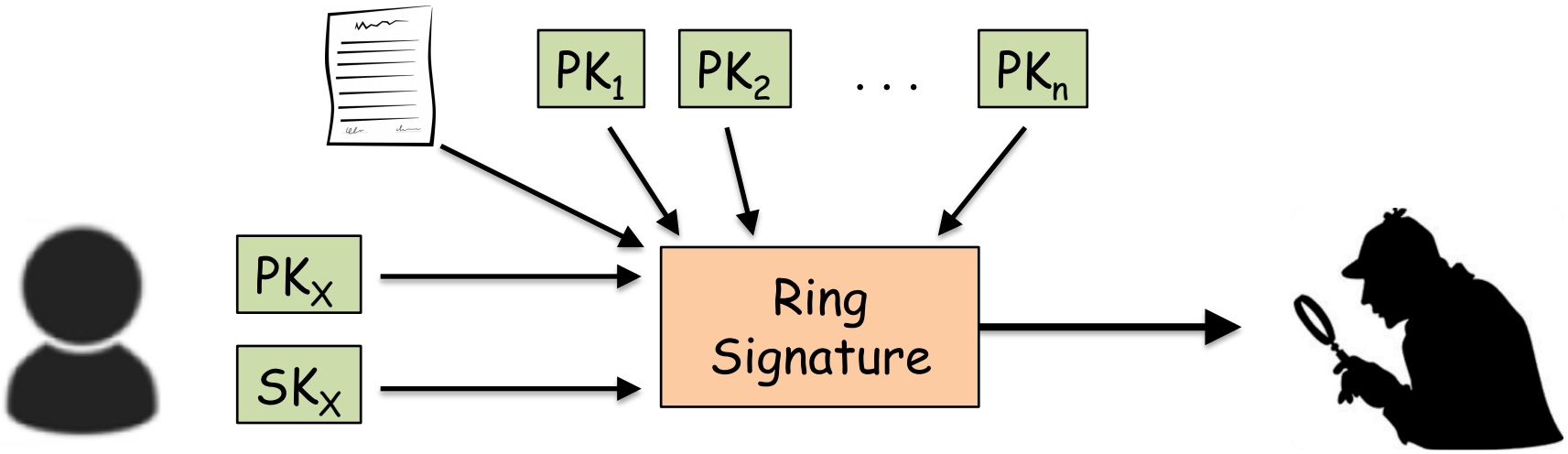
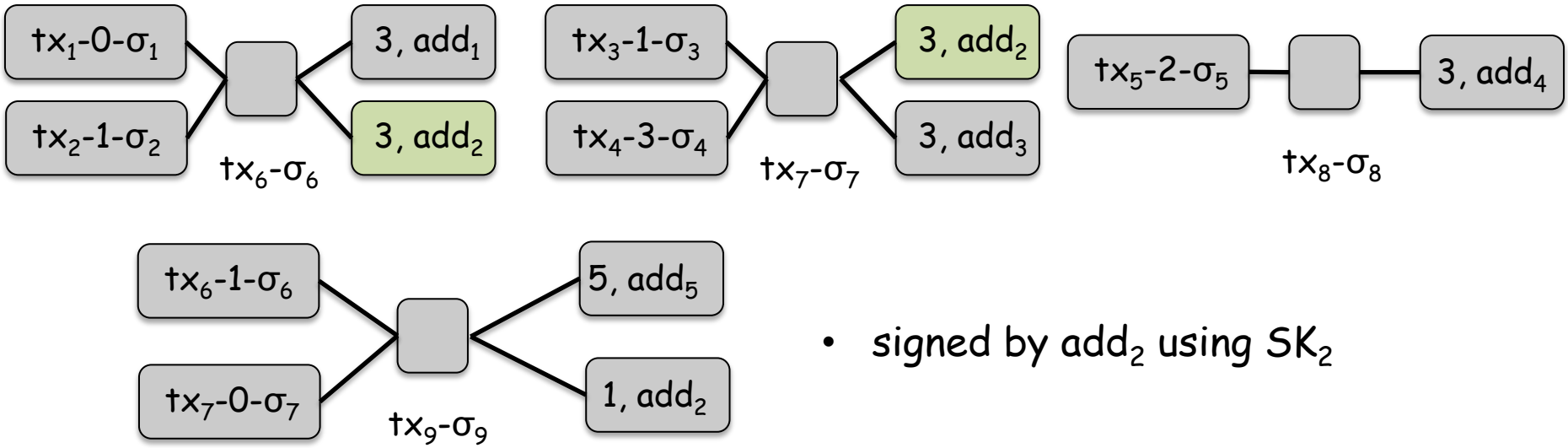


- verifier can tell that one member from the set $\{PK_1, PK_2, \ldots, PK_n, PK_X\}$ signed the message, but cannot tell which one the actual signer

- assume you designing a voting scheme using ring signatures
  - one can vote for two different candidate without being detected
  - traceable ring signatures, introduced by Fujisaka and Suzuki [] in 2007, enabling us to detect if two signatures produced by same user

Privacy Enhancing Techniques - Ring Signatures

- the transfer of an amount bitcoin ownership rights from one address to another one
- each tx consists of two main fields :
  - input : unspent transaction outputs claimed by the sender from previous transactions (previous transaction id, index, scriptsign)
  - output : instructions for claiming the sent bitcoins (value, scriptpublickey)
- if the transaction output not spent before, and the signature is valid, the transaction considered as valid



- signed by add_2 using SK_2

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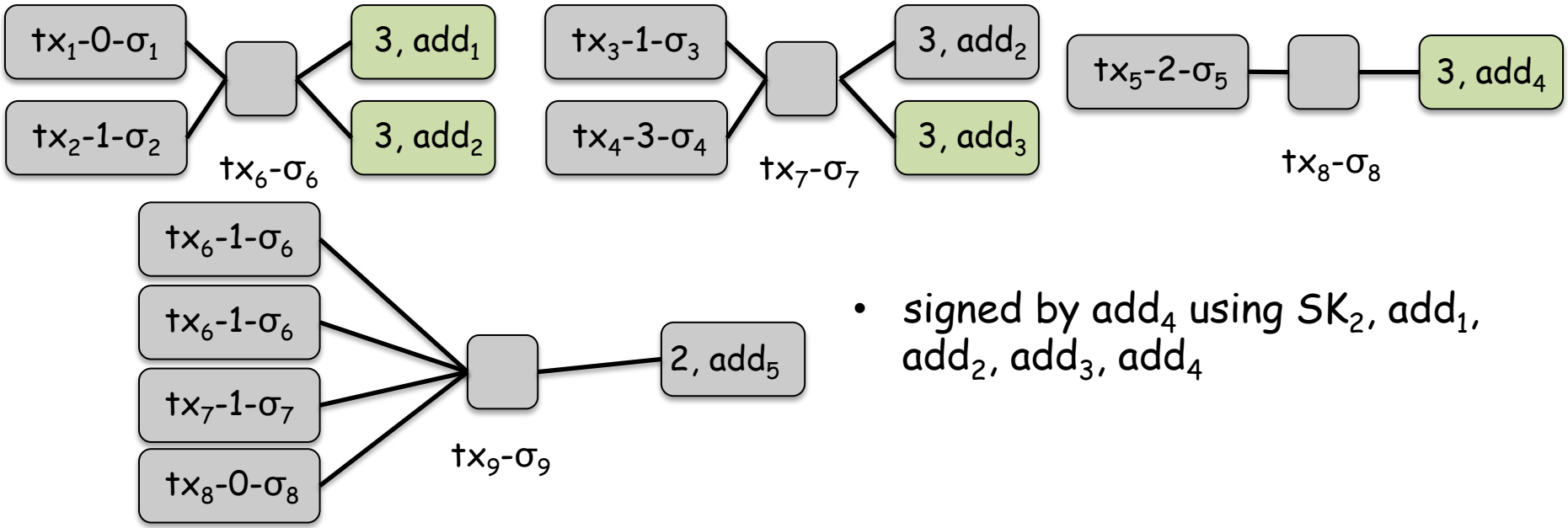

- signed by add_4 using SK_2, add_1, add_2, add_3, add_4

Privacy Enhancing Techniques - Ring Signatures

CryptoNote

- introduced by van Saberhagen [] in 2013

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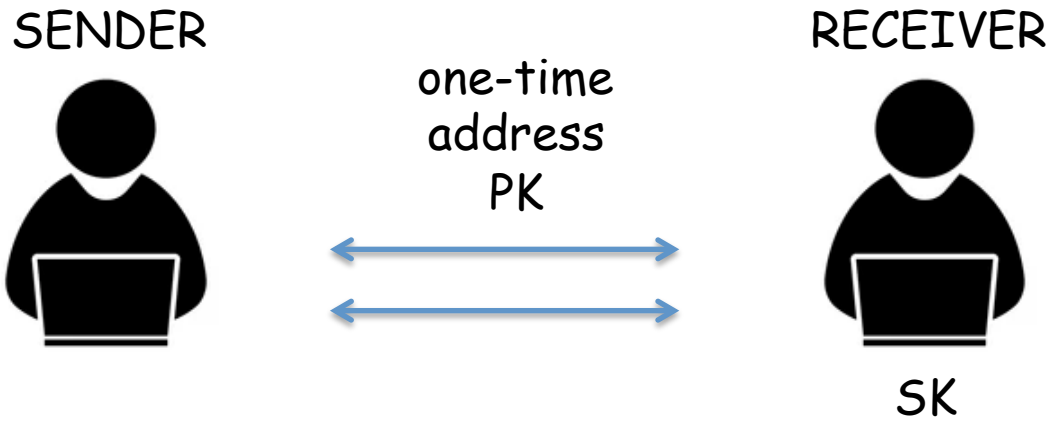

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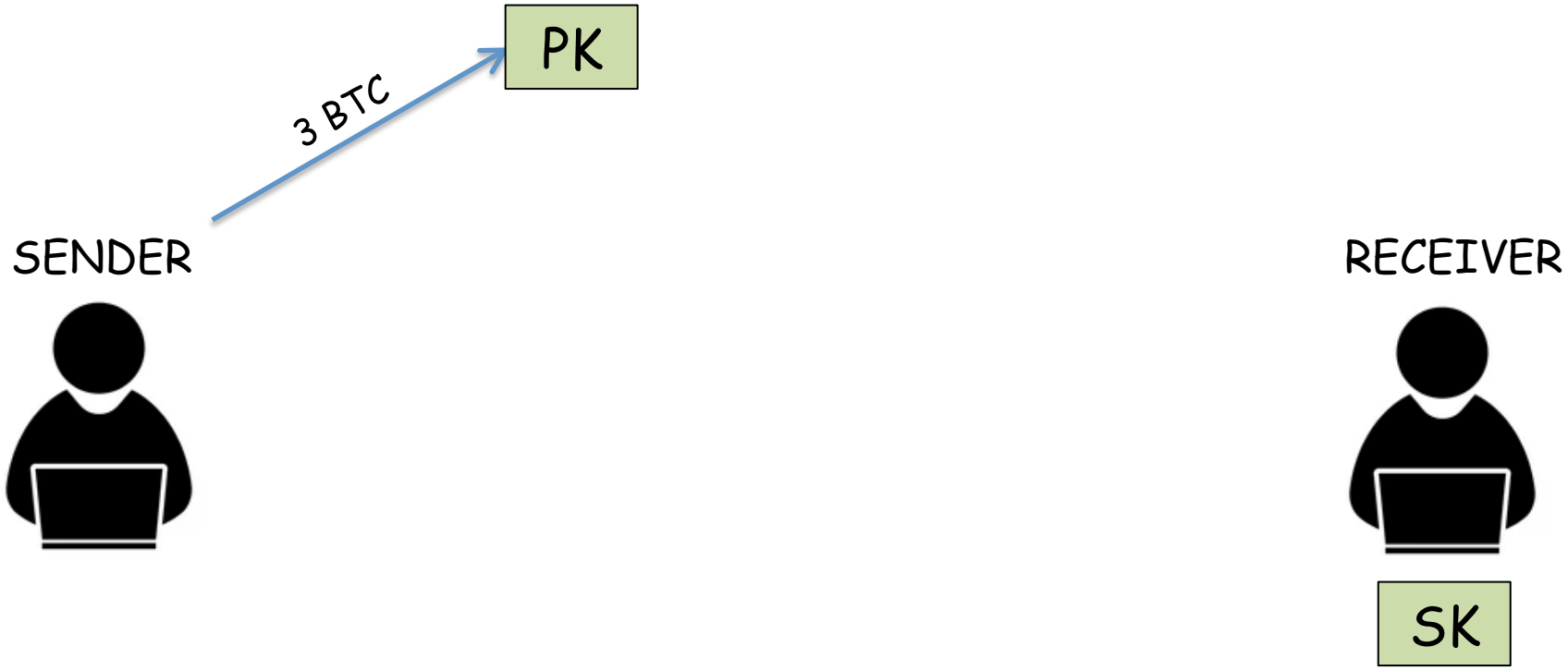

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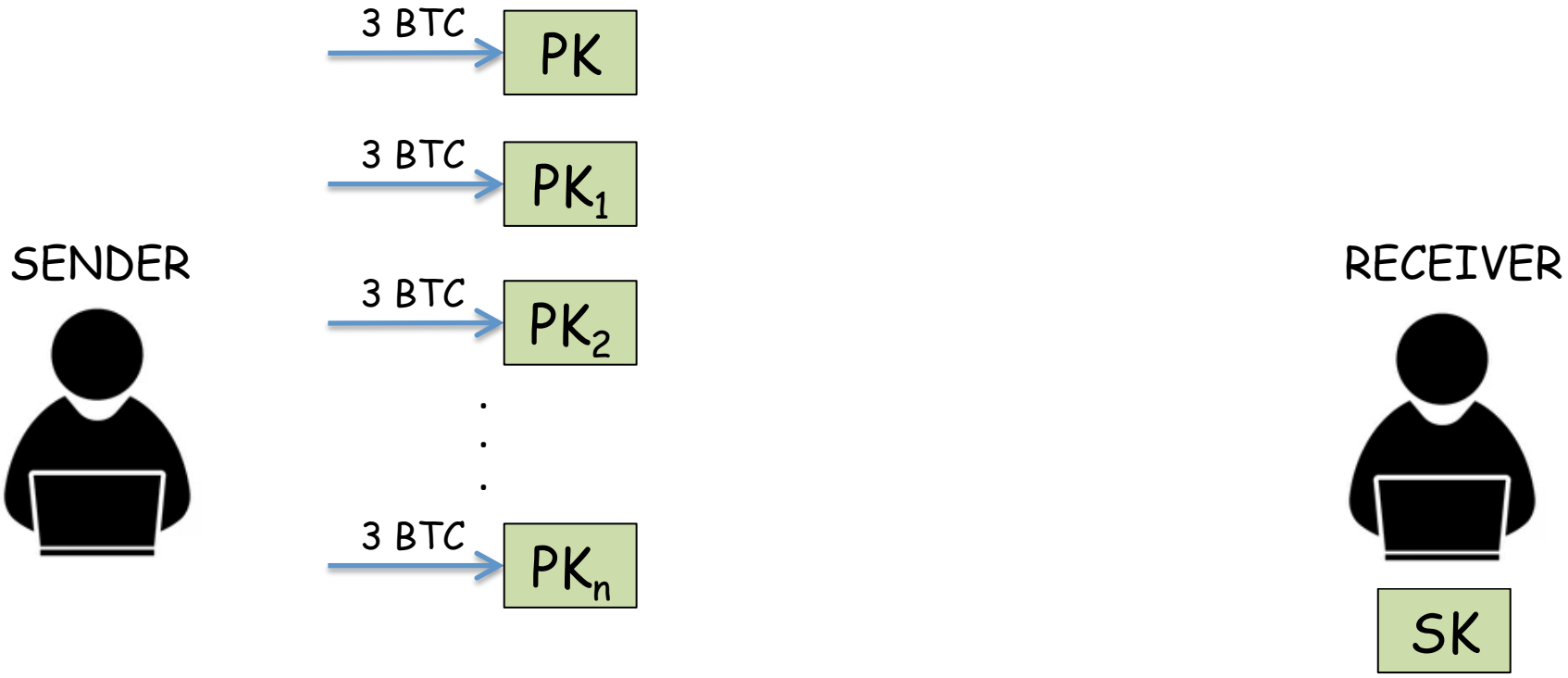

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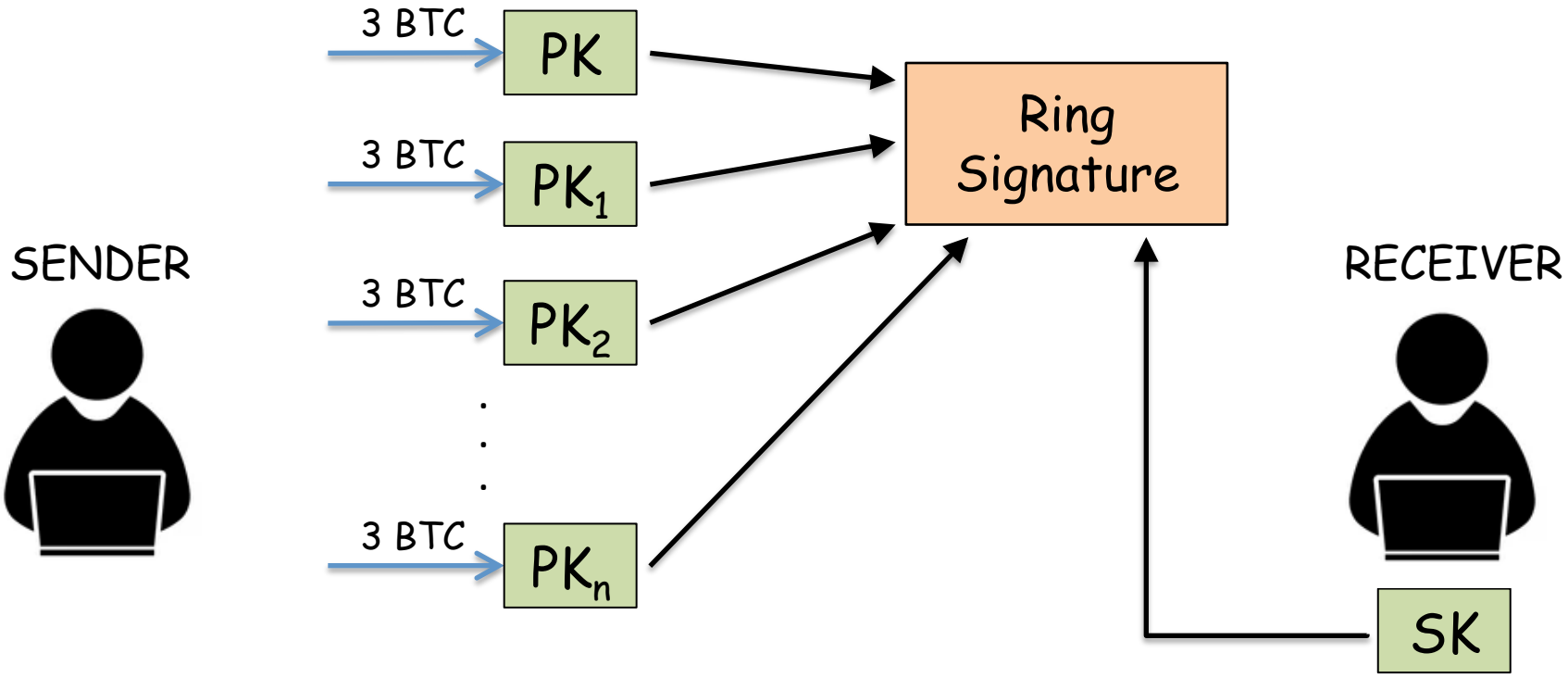


Privacy Enhancing Techniques - Ring Signatures

CryptoNote

- introduced by van Saberhagen [] in 2013

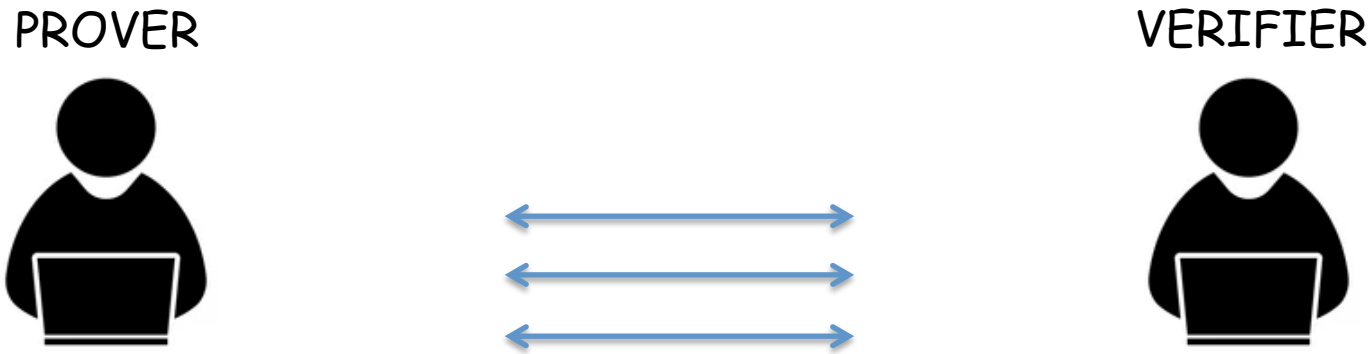
- Kumar et al. [] analized Monero network to examine the untreacibility characteristics of CryptoNote

  - 93% of all transaction output amounts appear only once in the network
    (cannot be combined with others to form ring signatures)

  - users mostly use small number of transaction outputs to avoid high fees

Privacy Enhancing Techniques - Zero Knowledge

- introduced by Goldwasser et al. [] in 1985



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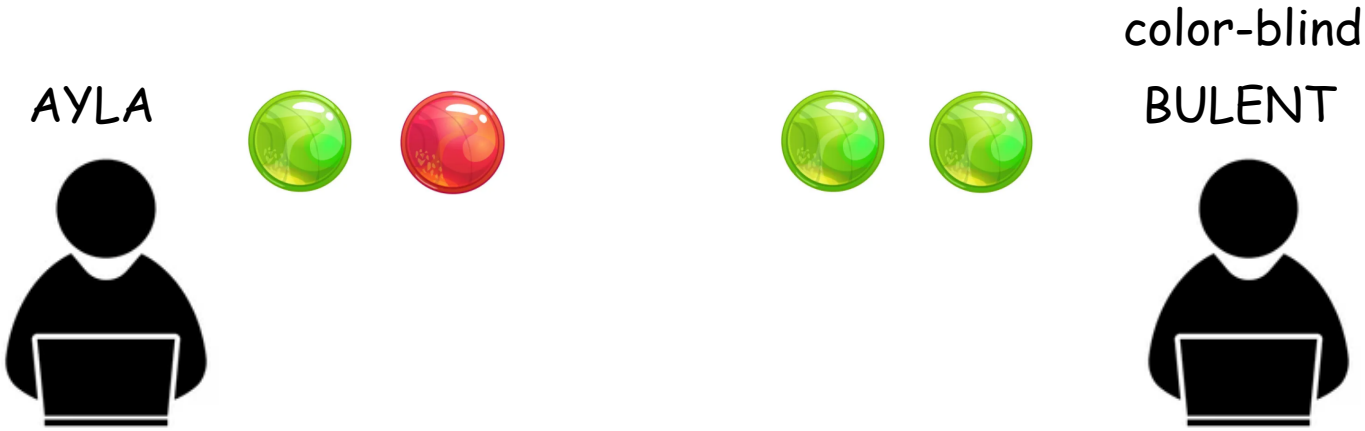

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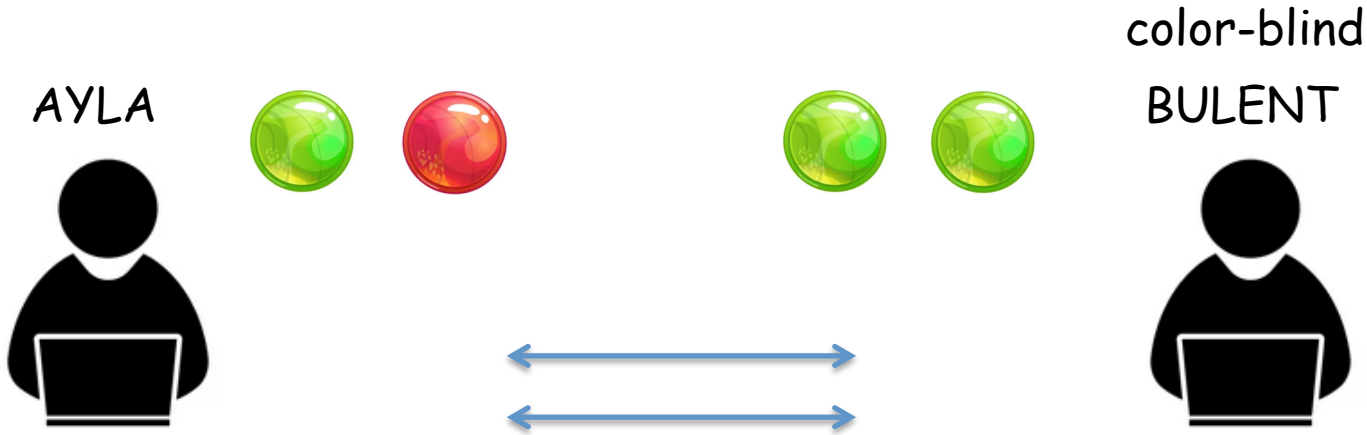

Ayla wants to convince Bulent they are in diffferent colors without revealing which one is red and which one is green

they seem completely identical to Bulent

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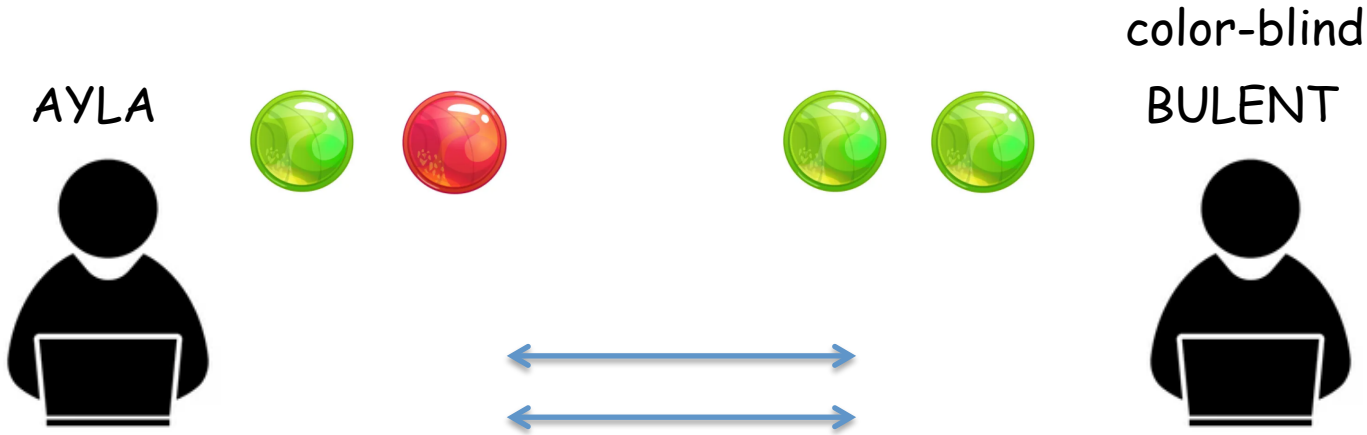

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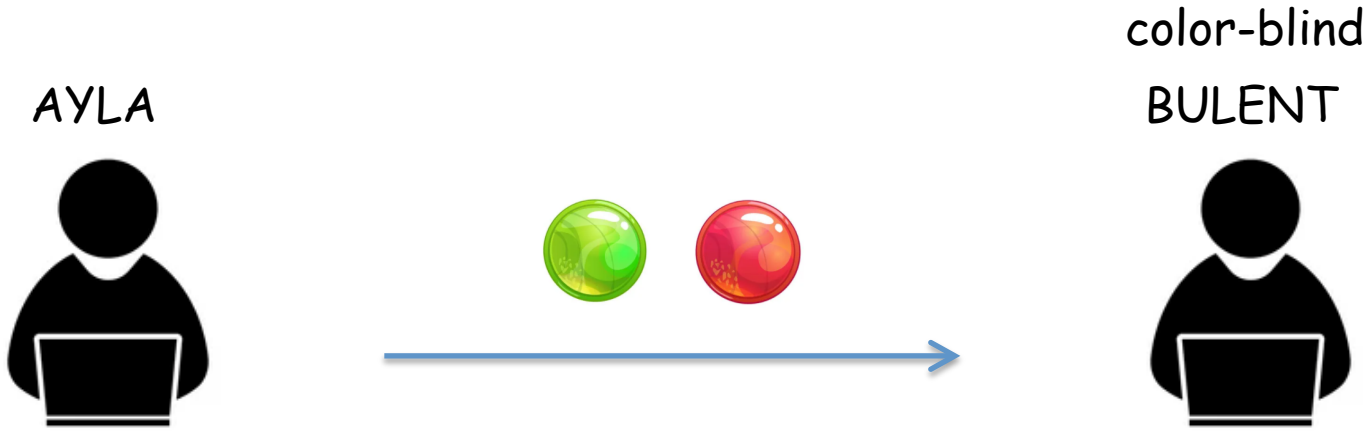

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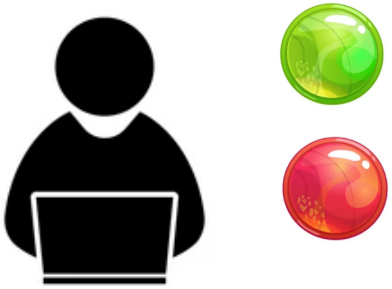
AYLA

color-blind

BULENT



he either switching the balls, or keeping them in same hands

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$1 / 2^2 = 0.25$

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$1 / 2 = 0.5$

$1 / 2^{10} = 0.00097$

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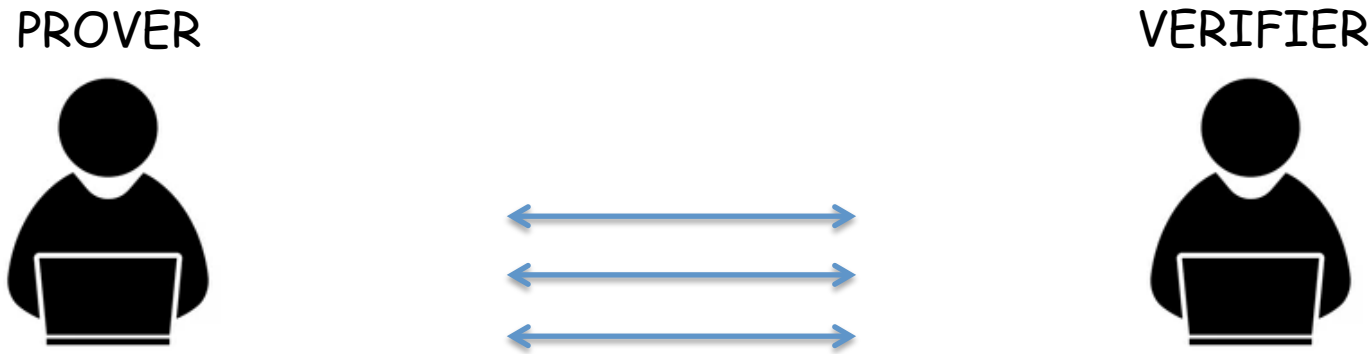

- allows one party (prover) to convince another party (verifier) that a statement is true without revealing any information other than this fact
- Completeness : if the statement is true, the honest verifier will be convinced by the honest prover
- Soundness : if the statement is false, no cheating prover can convince the honest verifier that it is true
- Zero-Knowledge : the verifier learns anything other than the statement is true

Privacy Enhancing Techniques - Zero-Knowledge

ZeroCoin

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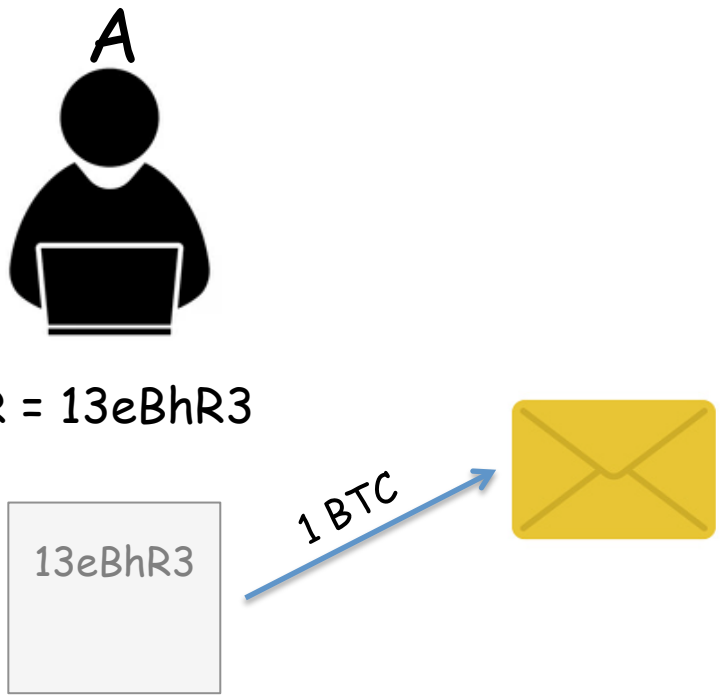

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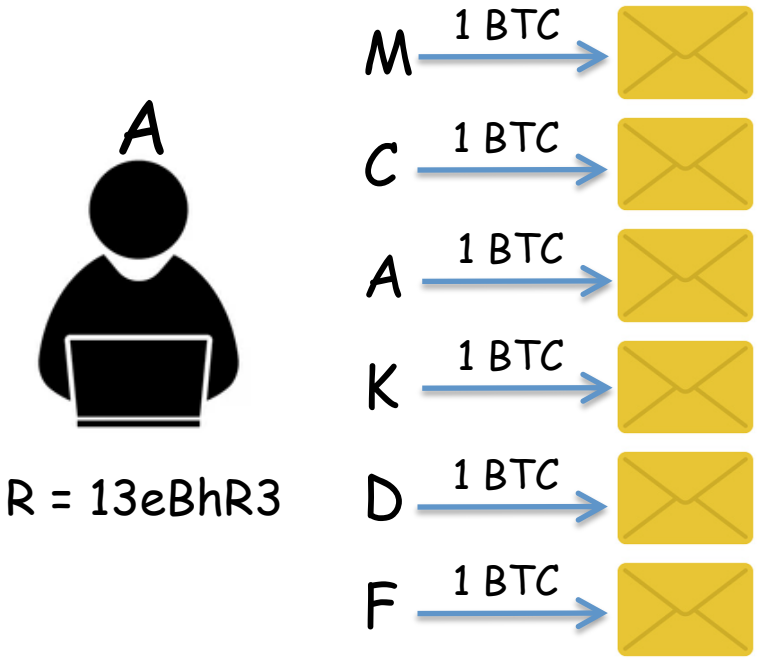

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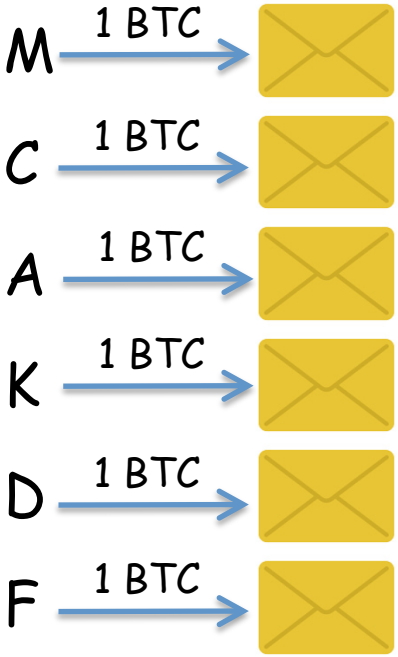

- R, proof

proof shows that on of the unclaimed zerocoins contains the serial number R

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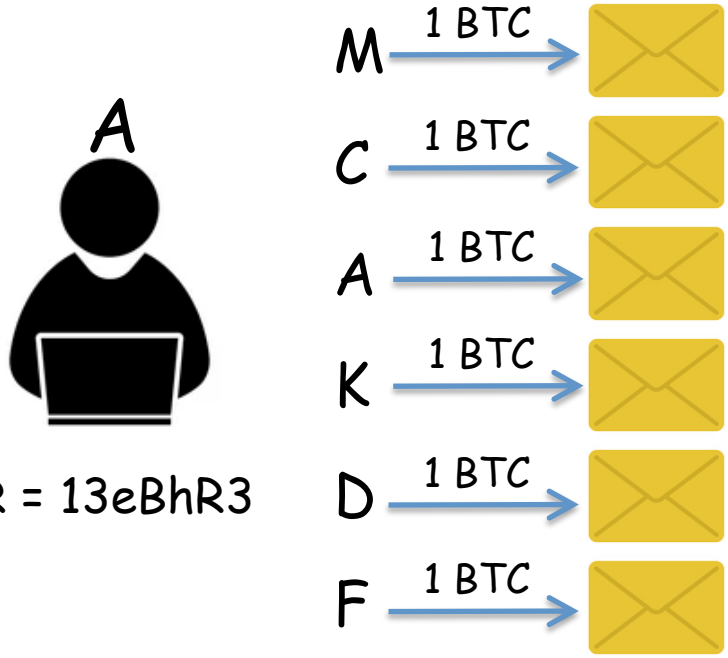

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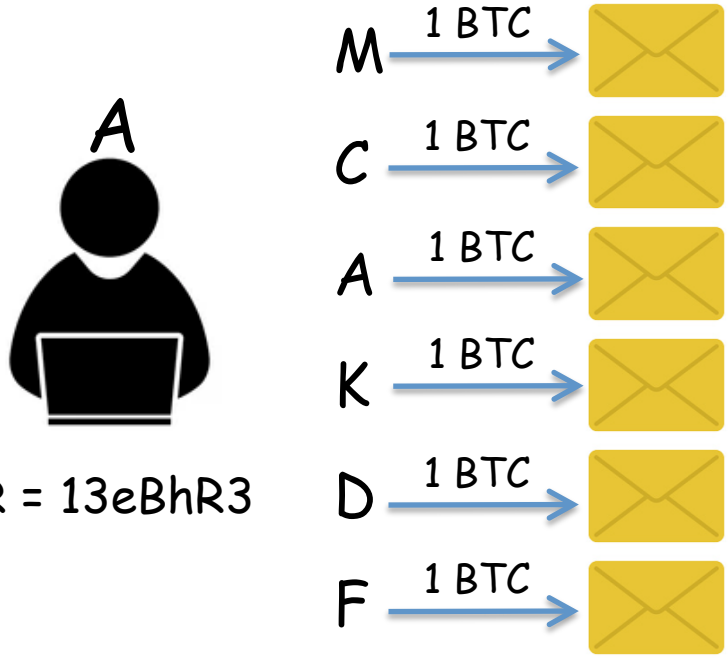

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  - 'zero knowledge' prevents one to link this transaction to a specific address

Privacy Enhancing Techniques

Privacy vs Accountability

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Privacy vs Accountability

- attractive tools for criminals to perform illegal activities
- introducing serious concerns for regulatory authorities
- Singapore exchange Bittrue hacked in June 2019, over $4 million stolen

"Bittrue working with Houbi, Bittrex to freeze stolen cryptocurrencies and accounts associated with the hack"

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- Japan exchange Liquid hacked in August 2021, over $97 million stolen

" stolen funds converted to Ether using Uniswap and Sushiswap, then Ether laundered through Tornado Cash"