Competence Centers for
Excellent Technologies

User-Perceived Privacy in Blockchain

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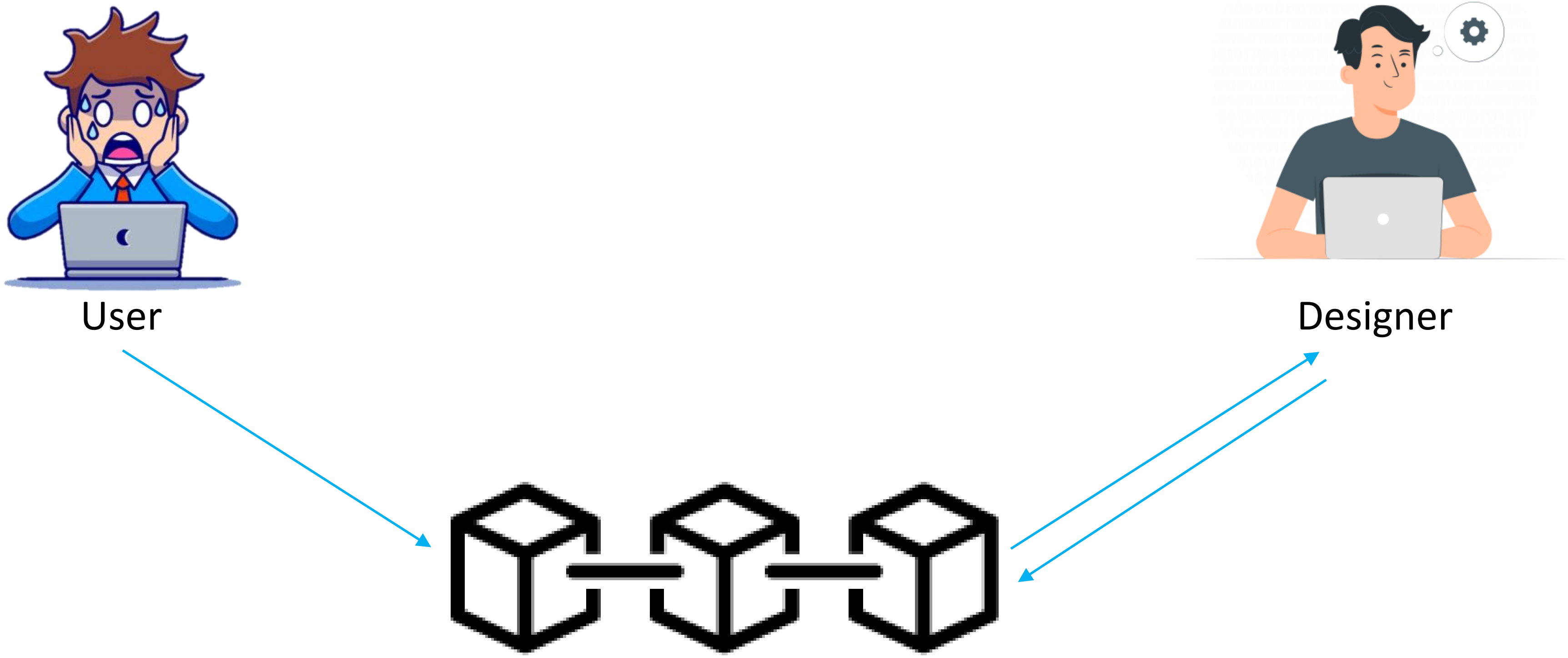
Monerokon 2022

Blockchain Privacy



User

Designer

To what extent are users **aware of privacy issues** and **privacy-enhancing technologies**?

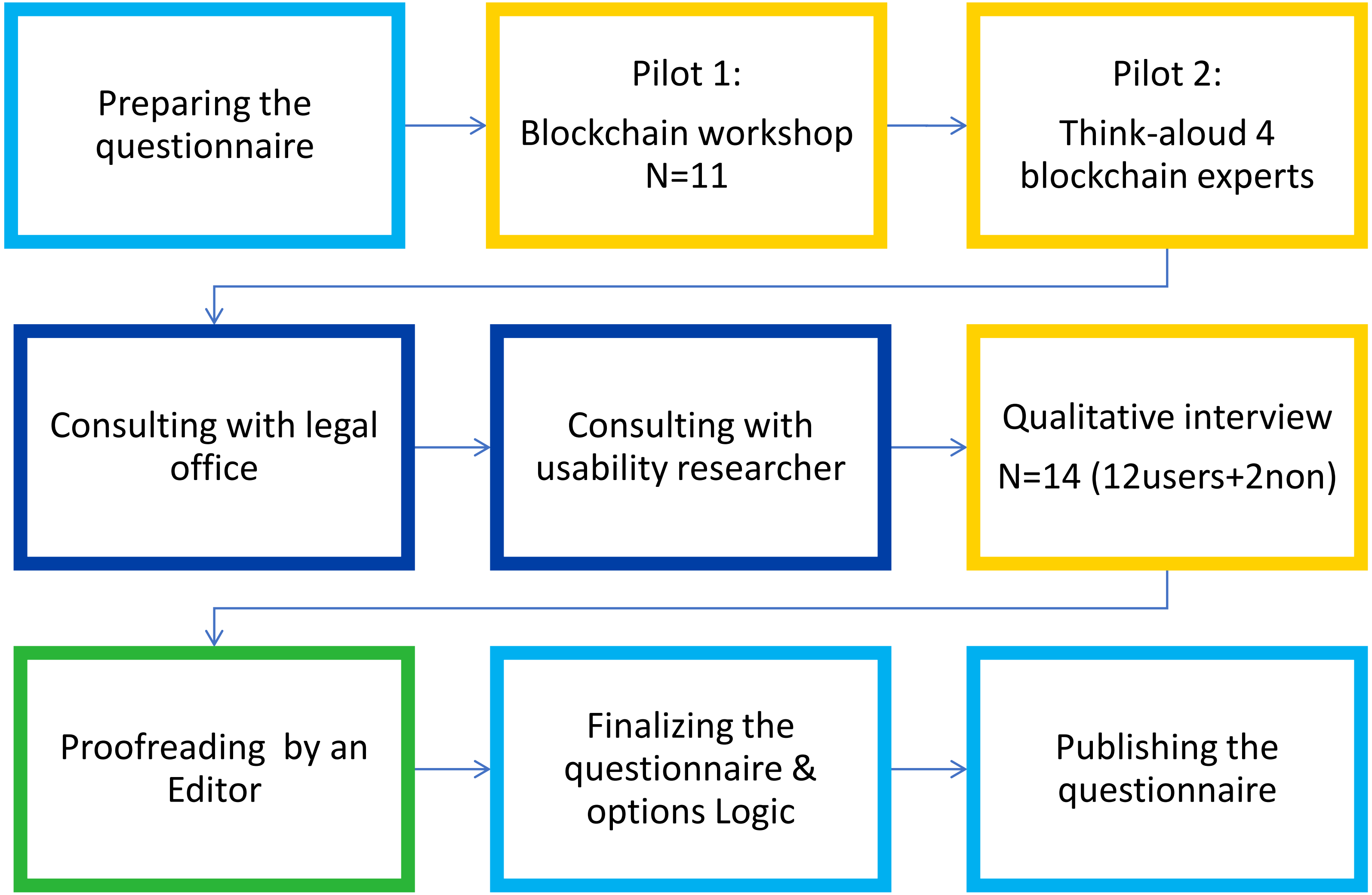
What preferences do the users have for privacy-enhancing technologies?

i. Do they prefer using add-on privacy techniques on top of Bitcoin or built-in features in privacy coins (e.g., Monero)?

ii. Are they willing to use privacy-preserving techniques despite the higher fees and longer transaction time?

iii. Do they trust third-party privacy-preserving services?

Designing the Questionnaire



Preparing the questionnaire

Pilot 1:

Blockchain workshop N=11

Pilot 2:

Think-aloud 4 blockchain experts

Consulting with legal office

Consulting with usability researcher

Qualitative interview

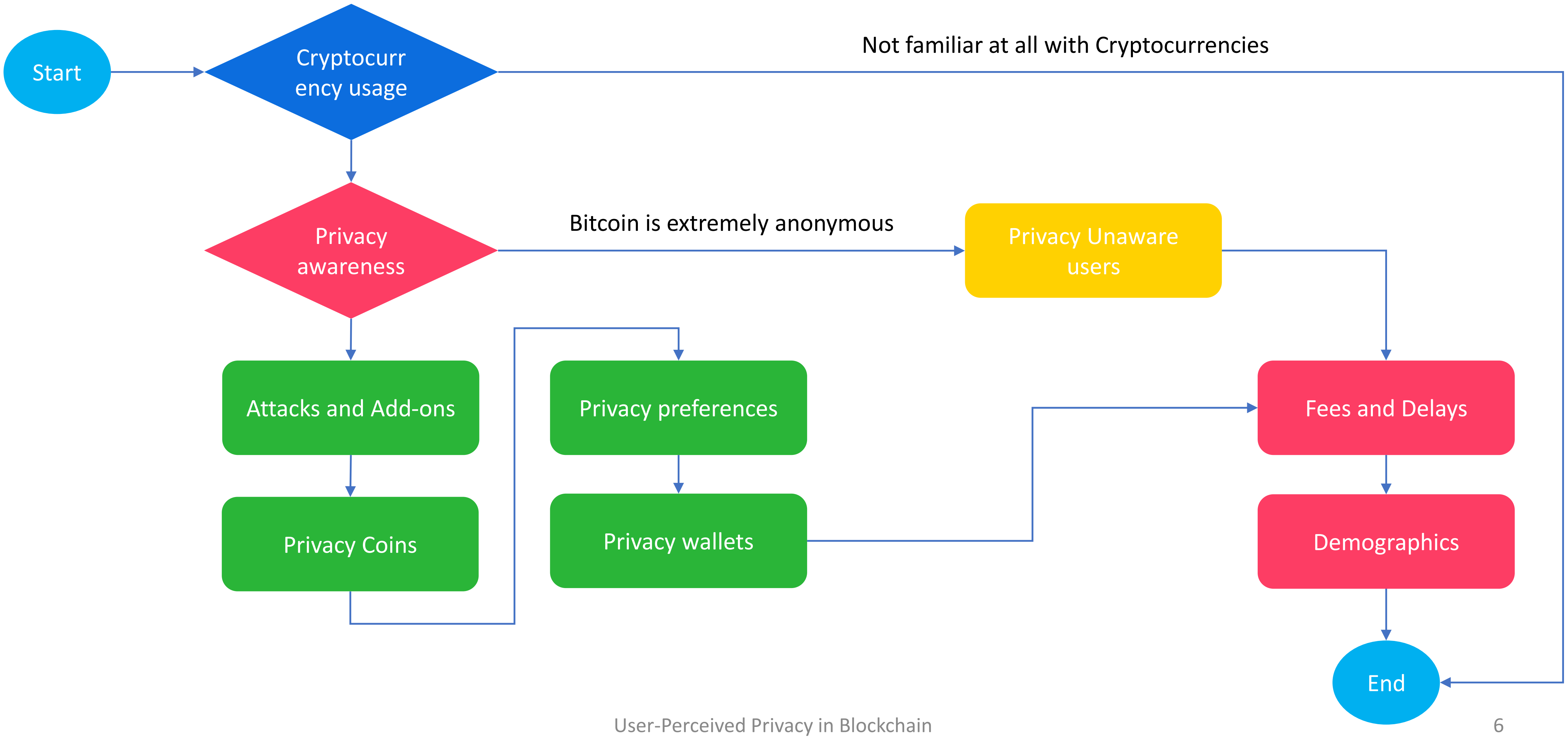
N=14 (12users+2non)

Proofreading by an Editor

Finalizing the questionnaire & options Logic

Publishing the questionnaire

Questionnaire Logic



Validity and Reliability

101 Respondents in Total

Elimination Criteria	Eliminated Respondents
No knowledge of cryptocurrencies.	8
Partially replied to the questionnaire.	27
Wrongly answered the quality control question with shuffled options.	7
Selected invalid answers (if they chose fake options in two questions).	1
Failed to successfully re-phrase the earlier question.	0

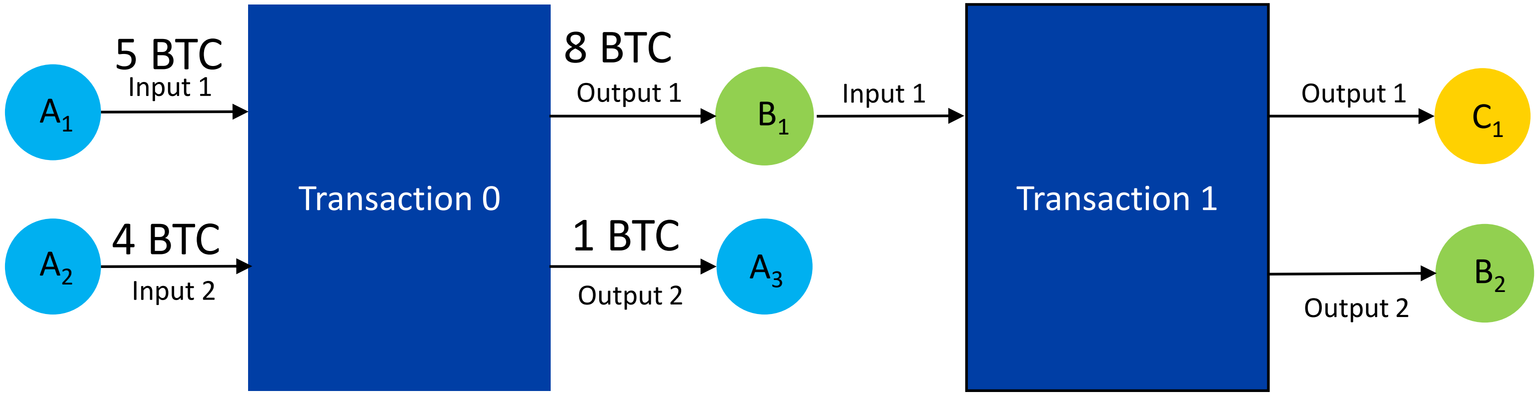
43 Respondents Eliminated

User Study
Final Data Set

Qualitative Research
N=12

Quantitative Research
N=58

Bitcoin Transactions



Is Bitcoin perfectly anonymo

or

Is it perfectly traceable?

Bitcoin Traceability

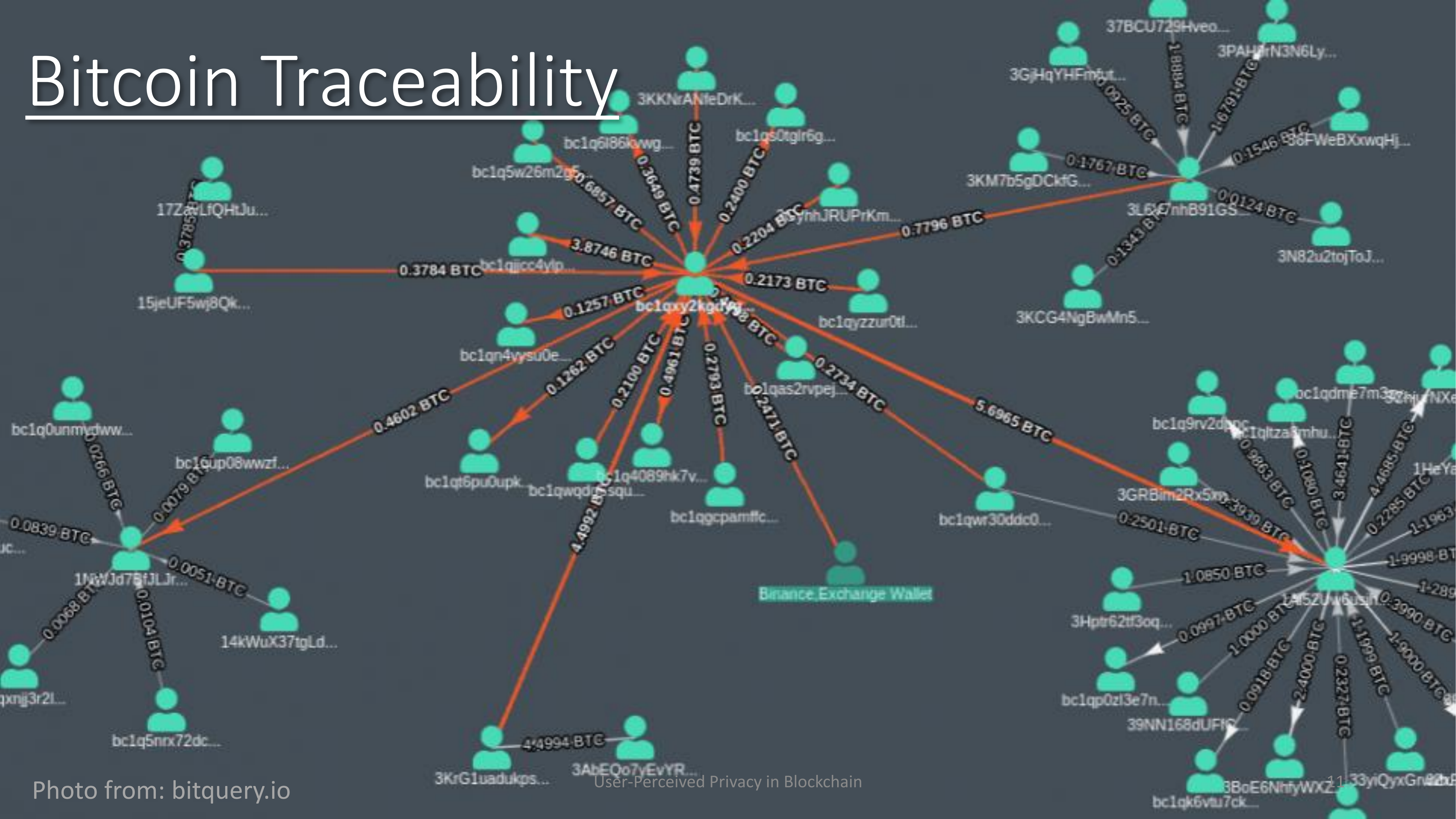


Photo from: bitquery.io

Which de-anonymization techniques in Bitcoin are you aware of?

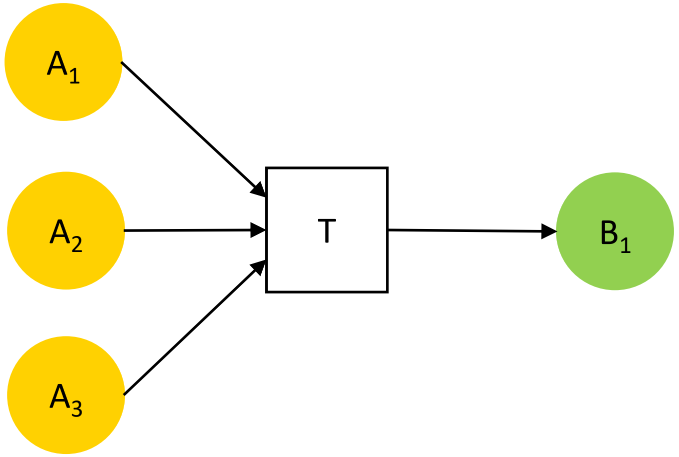
De-anonymization attacks

- Heuristics
- Flow analysis
- Side channel attacks
- Auxiliary information

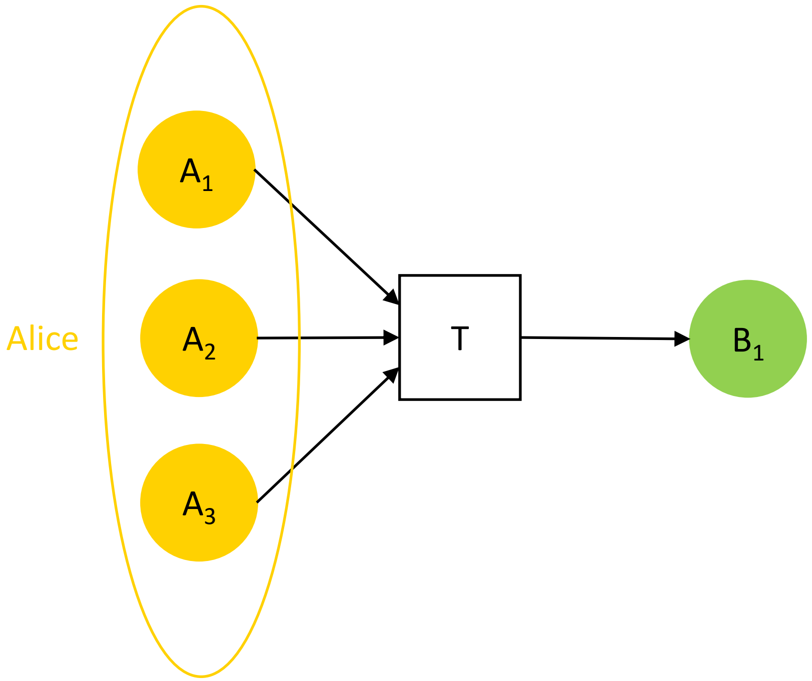
Important Heuristics

- ✓ Common input ownership
- ✓ Change address detection

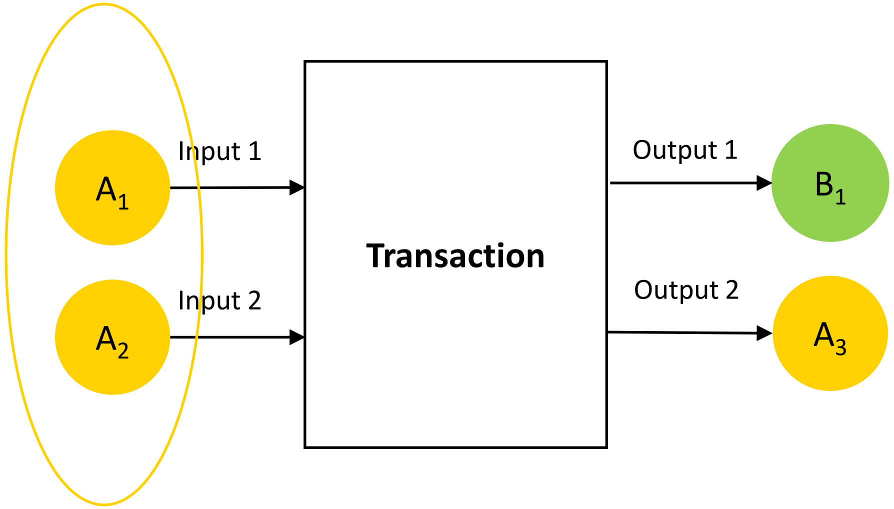
Common input ownership



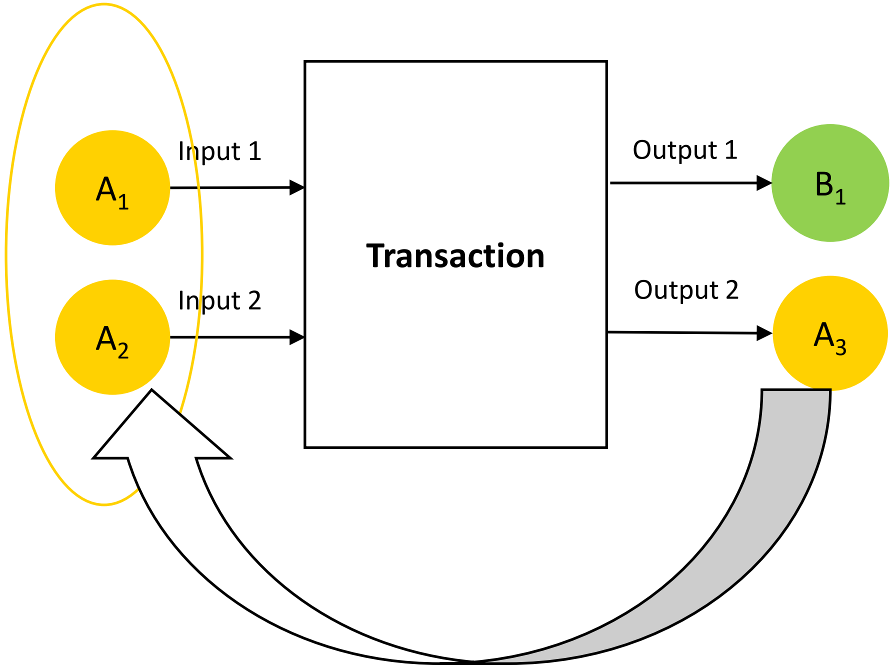
Common input ownership



Change address heuristic



Change address heuristic



Side channel attacks

Time correlation: Correlating the time that a transaction is confirmed with the time that a user interacted with other services.

Amount correlation: Correlating the amount that has been transferred in blockchain and the amount that has been paid in other services such as trading services.

Network layer information: Linking the IP addresses of the users to the transactions.

Flow analysis

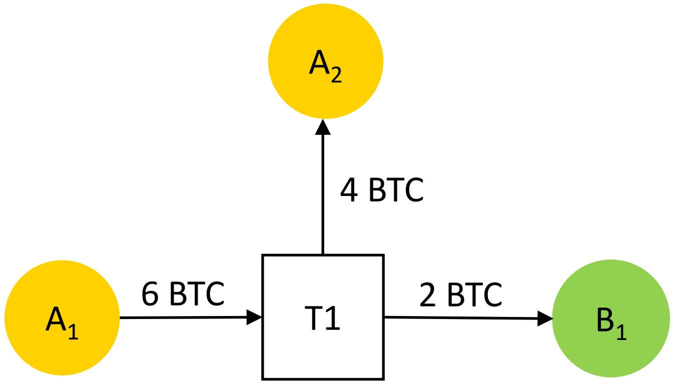
✓ Transaction graph

✓ Taint analysis

✓ User graph

Transaction graph

- The addresses are nodes, and the transactions are edges
- The attacker can find predecessors and successors by this graph



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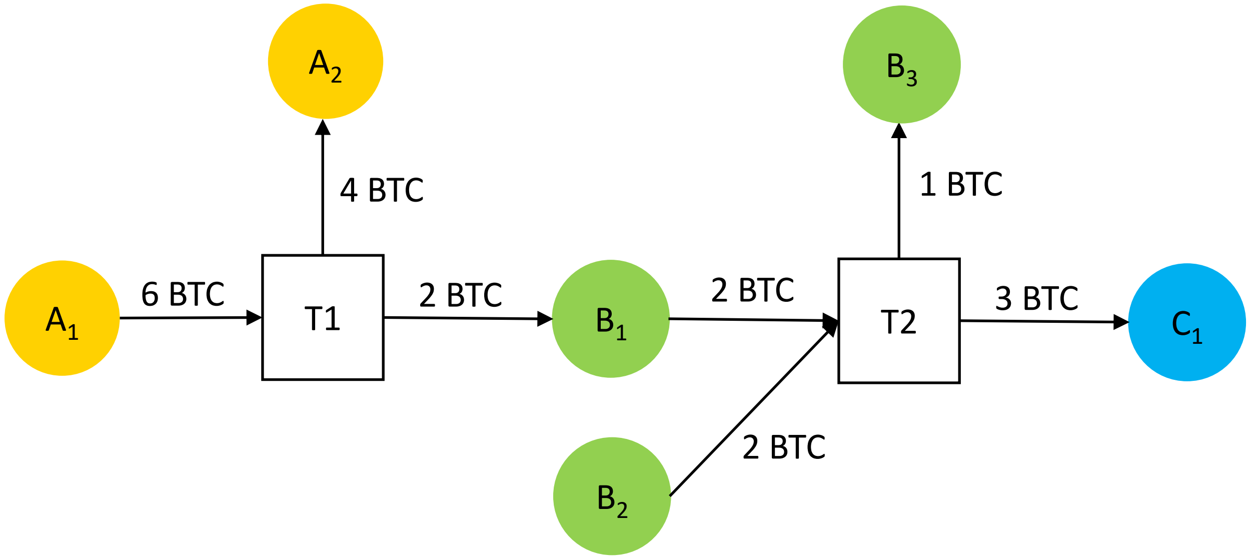
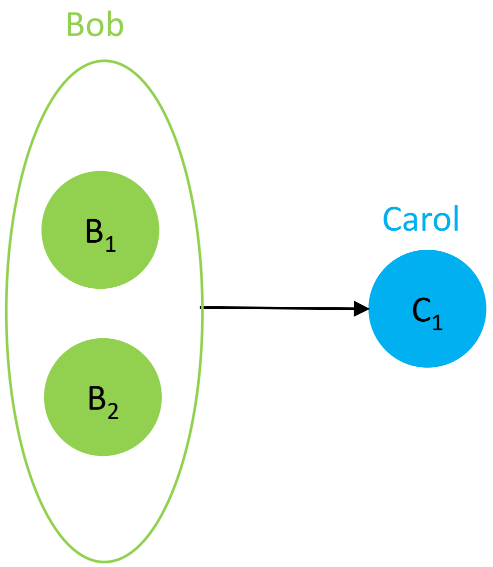


User graph

- Users are nodes and the transactions are edges which creates the clusters.



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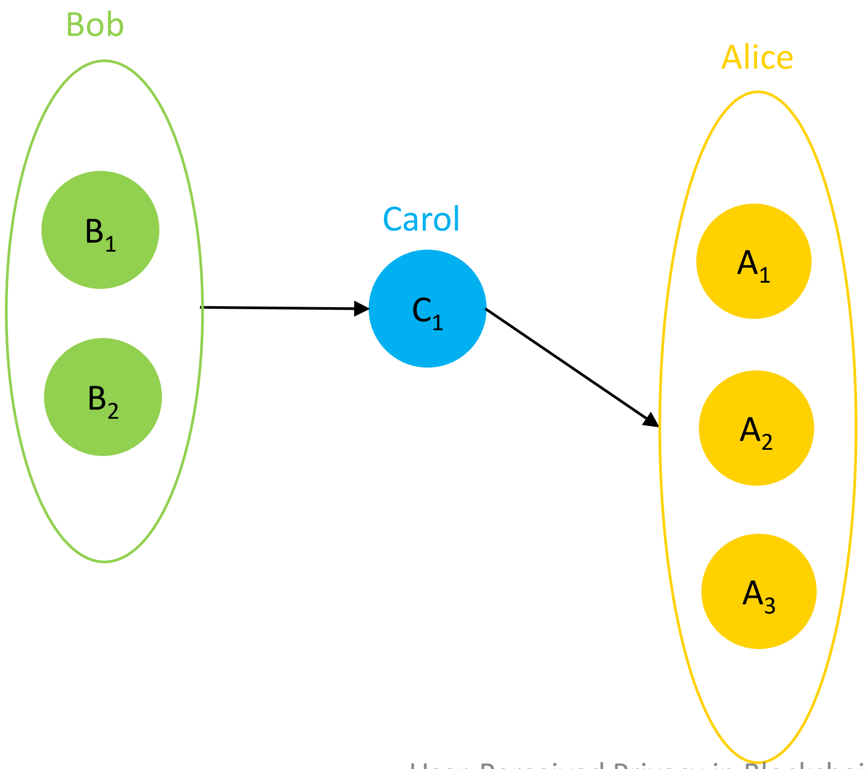

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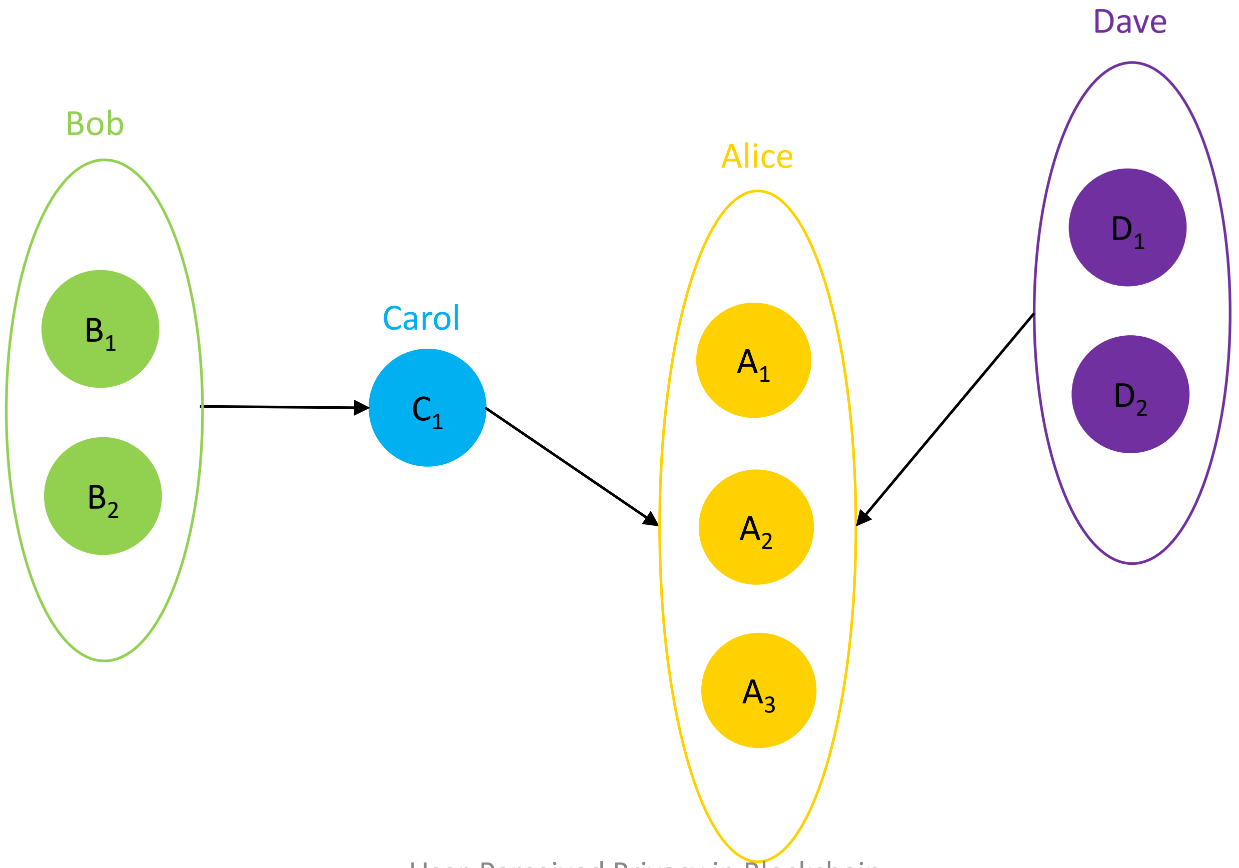
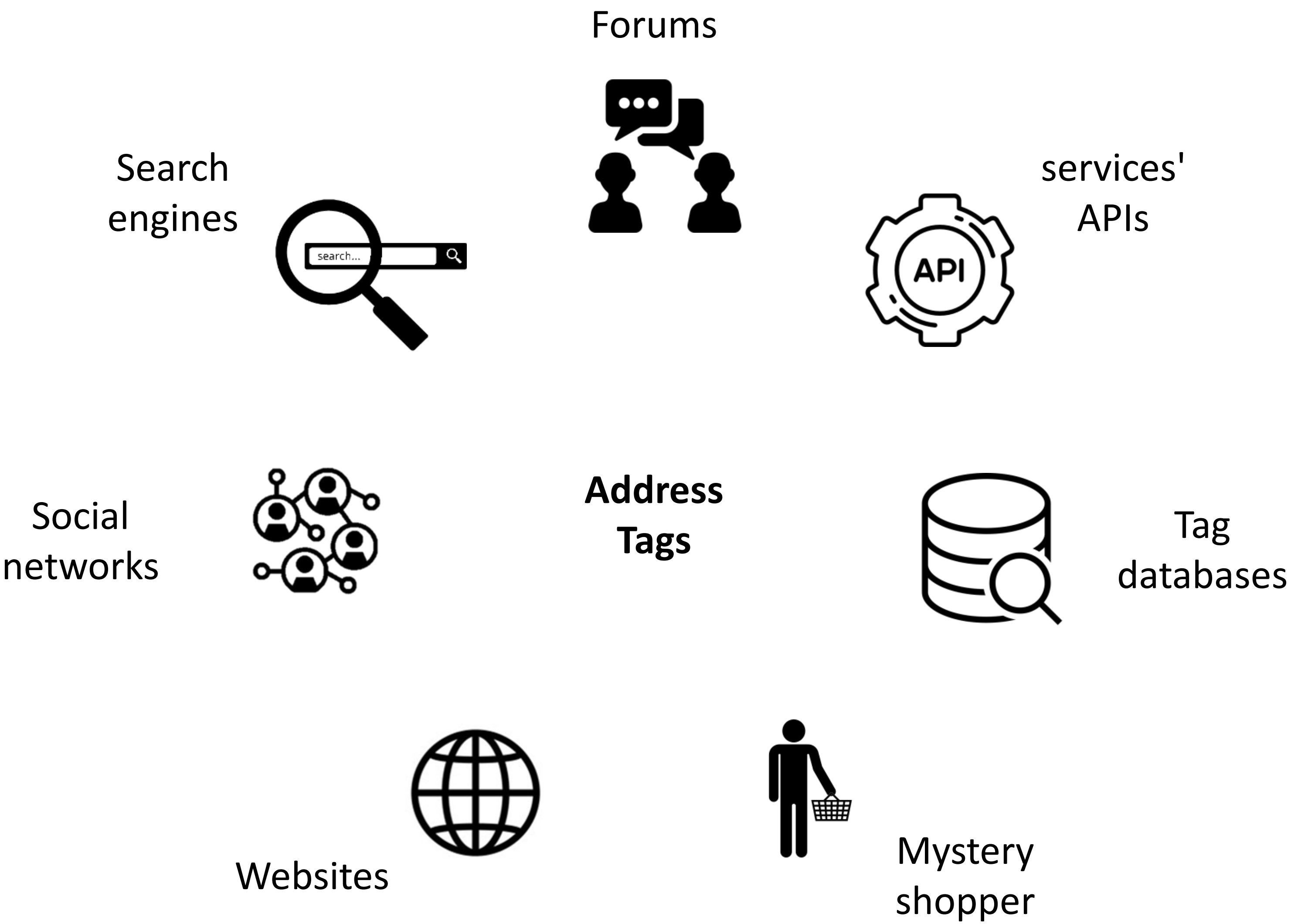


Auxiliary information



Forums

Search engines

services' APIs

Social networks

Address Tags

Tag databases

Websites

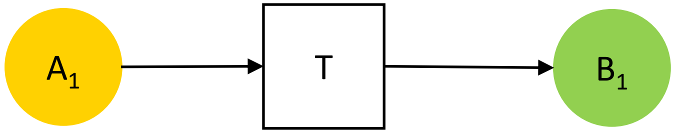
Mystery shopper

Mystery shopper payment

- The attacker pays to the target's Bitcoin address.
- Tracks the transaction in the blockchain to obtain information.
- The attacker can tag the payment address which belongs to the target.

Address reuse

- Why we should use a fresh address for every transaction?

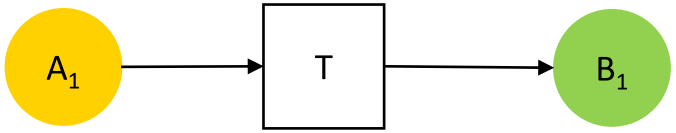


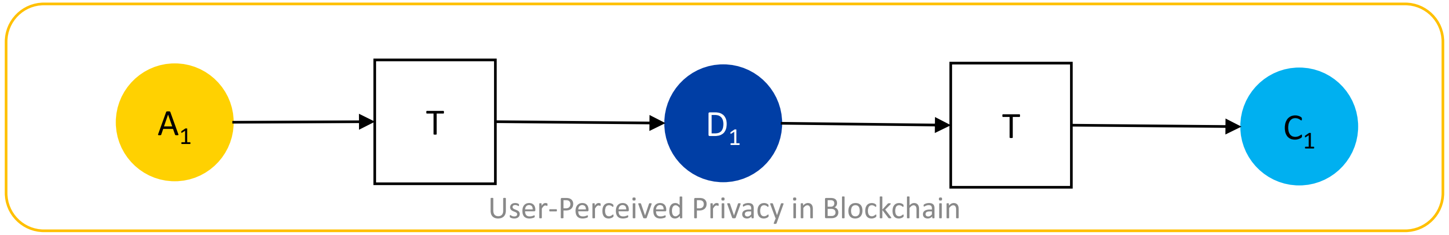
Barclay, 2017

Address reuse

- Use a fresh address for every transaction!

- Whenever the same address is reused, it relates the current transaction to all the transactions that the address previously appeared in.



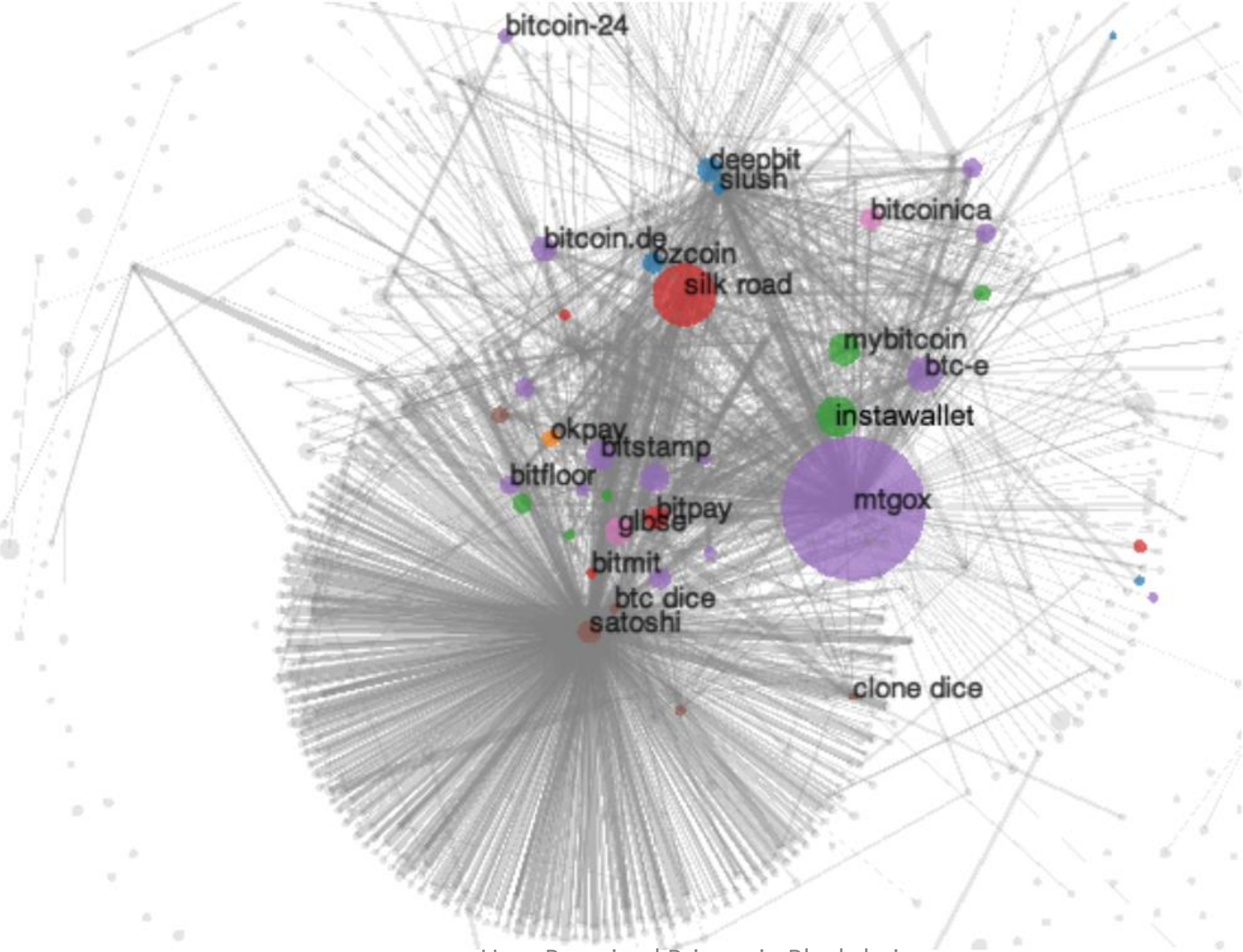


Barclay, 2017

Forced address reuse

- The attacker pays often a small amount to the target’s Bitcoin address that **has already been used**.
- If it is lately used as one the inputs in another transaction, it **reveals the other addresses** using common input ownership heuristic.

Address Classification



Meiklejohn et al., 2013

Which add-on privacy techniques in Bitcoin are you aware of?

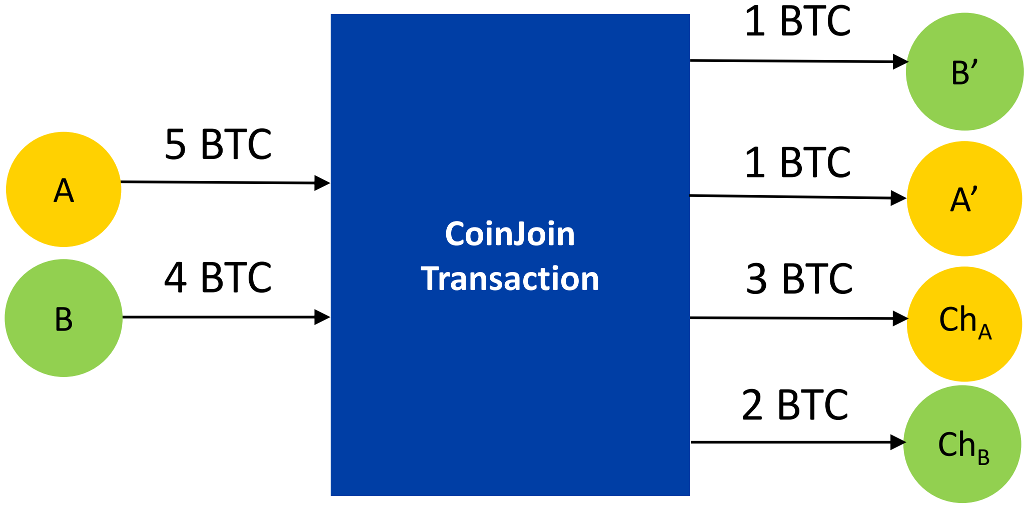
Which built-in privacy coins are you aware of?

Privacy solutions

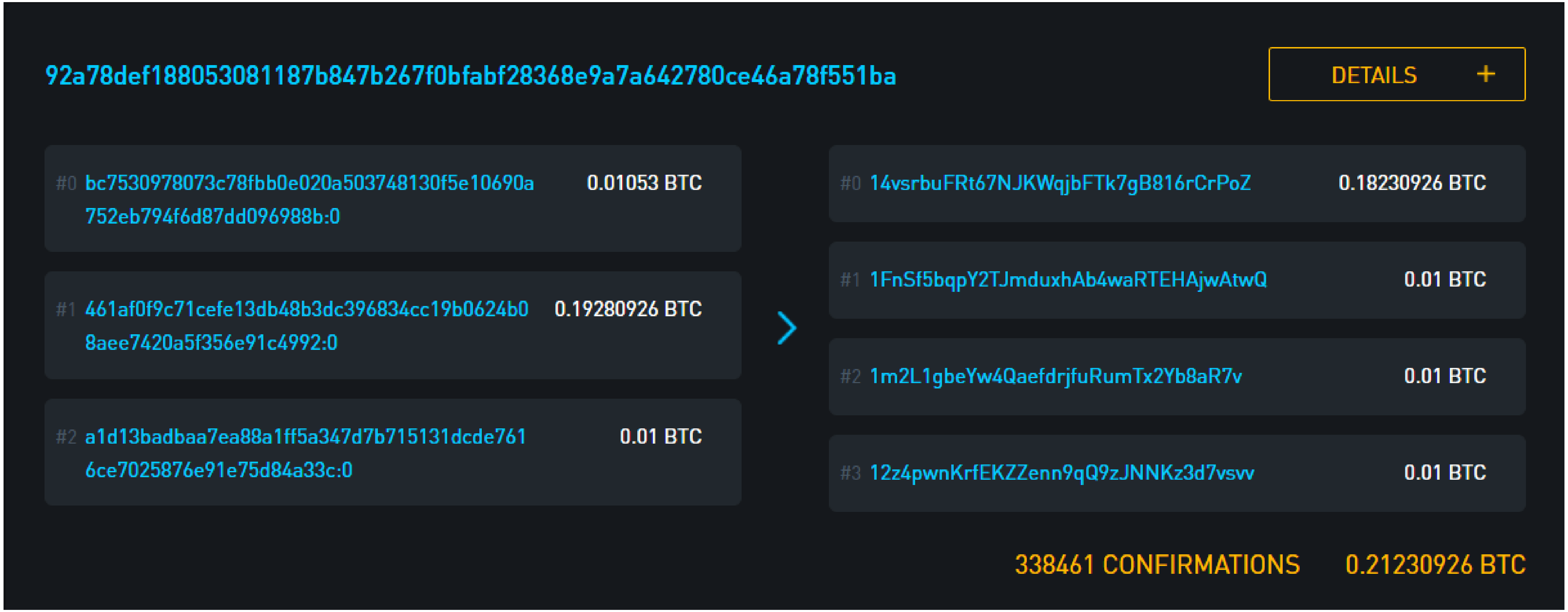
Add on solutions:
Mixing techniques

Built in solutions:
Privacy coins

CoinJoin Transactions



CoinJoin example



92a78def188053081187b847b267f0bfabf28368e9a7a642780ce46a78f551ba

#0 bc7530978073c78fbb0e020a503748130f5e10690a752eb794f6d87dd096988b:0 0.01053 BTC

#1 461af0f9c71cefe13db48b3dc396834cc19b0624b08aee7420a5f356e91c4992:0 0.19280926 BTC

#2 a1d13badbaa7ea88a1ff5a347d7b715131dcde7616ce7025876e91e75d84a33c:0 0.01 BTC

#0 14vsrbuFRt67NJKWqjbFTk7gB816rCrPoZ 0.18230926 BTC

#1 1FnSf5bqpY2TJmduxhAb4waRTEHAjwAtwQ 0.01 BTC

#2 1m2L1gbeYw4QaefdrjfuRumTx2Yb8aR7v 0.01 BTC

#3 12z4pwnKrfEKZZenn9qQ9zJNNKz3d7vsvv 0.01 BTC

338461 CONFIRMATIONS 0.21230926 BTC

https://www.localbitcoinschain.com/tx/92a78def188053081187b847b267f0bfabf28368e9a7a642780ce46a78f551ba

CoinJoin wallets

- Joinmarket
- Wasabi
- Samourai

Plausible deniability

In compute science:

“a situation in which people can deny transmitting a file, even when it is proven to come from their computer”.

- Equal-sized CoinJoin transactions are distinguishable in the blockchain!
- Therefore, you can not deny to participate in a mixing transaction!

Privacy Awareness

Lack of knowledge of custodial and non-custodial wallets

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Privacy misconception

Privacy Awareness

Lack of knowledge of custodial and non-custodial wallets

Privacy misconception

PU11: *Bitcoin is based on encryption algorithms which makes it anonymous!*

Privacy Awareness

Lack of knowledge of
custodial and non-custodial wallets

Privacy misconception

PU6: *The users don't know to whom the public key belongs, it's an alphanumeric phrase and all the identities are hidden in the network!*

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Privacy misconception

Mitigation in case of awareness

Privacy Awareness

Lack of knowledge of
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Privacy misconception

Mitigation in case of awareness

PU11: *I have never heard about these privacy issues, but if I knew about them, I would have researched possible solutions to mitigate them!*

Privacy Awareness

Lack of knowledge of
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Privacy misconception

Mitigation in case of awareness

Popularity of address reuse
& information from exchanges

Unpopularity of common input ownership
Unpopularity of privacy tools

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Unpopularity of common input ownership
Unpopularity of privacy tools

Distrust of privacy tools

Privacy Awareness

PU12: *I am not a big businessperson who wants to run away from taxes. I have no reason to be anonymous!*

cus

ess

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& information from exchanges

Unpopularity of common input ownership
Unpopularity of privacy tools

Distrust of privacy tools

Privacy Preferences

More than half preferred to **use privacy coins**.

Those chose to use add-on techniques, expected future built-in privacy **improvements to Bitcoin**.

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Users are willing to **accept** longer transaction **times** to achieve better privacy.

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Half of users **dismissed** the idea of paying **extra fees**.

Users who were aware of the distinguishability of CoinJoin were not willing to use it.

Privacy Wallets

Unpopularity

- Wallets struggle to attract more users.

Complexity

- Complex and require a minimum understanding of privacy concepts & techniques.

Privacy Wallets

Unpopularity	• Wallets struggle to attract more users.
Complexity	• Complex and require a minimum understanding of privacy concepts & techniques.
Distinguishability	• Wallets implemented CoinJoin suffer from distinguishability.
Government Bans	• Indistinguishable techniques (e.g., Wabisabi & PayJoin) may be banned by governments.

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Multi-Coin Wallets

- Users prefer wallets support different coins;
- Installing additional wallets for privacy & spend time to learn wallet functions would be a burden.

Problem

- ? Little knowledge of privacy issues and privacy-enhancing techniques
- ? Privacy techniques are too technical
- ? Negative understandings of privacy tools (criminal or tax evasion)

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Solution

- Education
  - ✓ Integration with wallets
  - ✓ Documentation & social media
- Proposing privacy techniques for public privacy while possible to find criminals

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https://eprint.iacr.org/2022/287.pdf

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