AnonStake: An Anonymous Proof-of-Stake Cryptocurrency via Zero-Knowledge Proofs and Algorand

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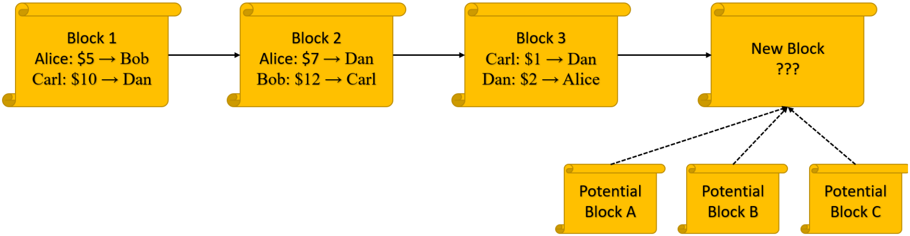
Cryptocurrencies



Cryptocurrencies are a form of digital currency

- Use consensus methods instead of central authorities
- Use encryption to guarantee that currency can only be spent by proper owner
- First cryptocurrency: Bitcoin

Problems with Bitcoin

Bitcoin's uses Proof-of-Work for "decentralized" consensus

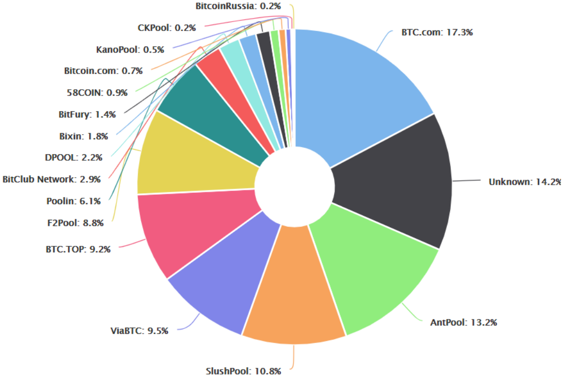


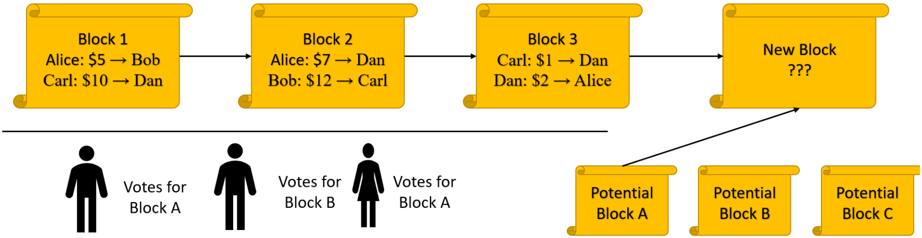
Figure 1: Four entities (mining pools) hold 51% of the hash power in the network. (Source: blockchain.com, 2018)

Problems with Bitcoin, continued

Bitcoin's uses Proof-of-Work for "decentralized" consensus

- Not decentralized
- Uses as much electricity as Switzerland
- Very slow: each block takes 10 minutes
- Possible solution: **Proof-of-Stake**

Proof-of-Stake



- Users reach consensus by voting (usually through committees)
- Voter's impact is proportional to amount of money they have
- Assumption is that most money is held by honest users
- Heavily invested users want currency to perform well

Algorand

Algorand is a fast Proof-of-Stake cryptocurrency, featuring

- Fast block times ($\sim$1 minute)
- Low confirmation times
- Generally more robust to user corruption than other Proof-of-Stake cryptocurrencies

Algorand Consensus

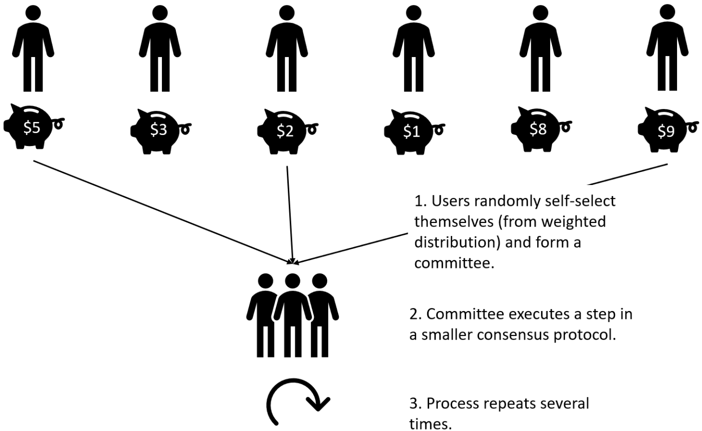


Figure 2: We will be focusing on modifying step one, sortition.

Anonymous Cryptocurrencies

Algorand is fully public; we want to make it anonymous. Some cryptocurrencies have a strong focus on anonymity (ZCash, Monero). Able to hide:

- The senders and receivers of the transaction
- The amount sent in the transaction

Goals

We want to create an anonymous cryptocurrency with Proof-of-Stake consensus.

- Algorand consensus needs users to *know* each other's account balances
- Anonymity implies that user's *don't know* each other's account balances

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- **Solution:** Use zero-knowledge proofs

Zero-Knowledge Proofs

- Introduced as "Proofs that yield nothing but their validity"
- zkSNARKs can be used to prove validity of *any* NP statement

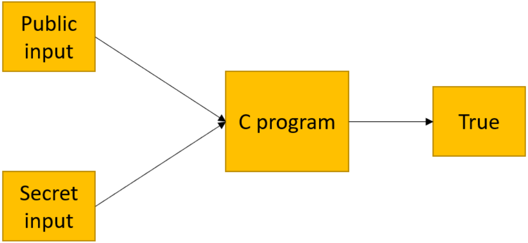
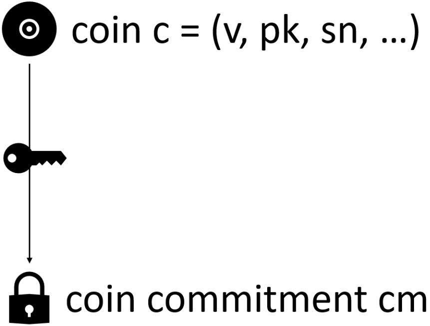


Figure 3: zkSNARKs can be used to prove that a (publicly-known) C-program will return *True*.

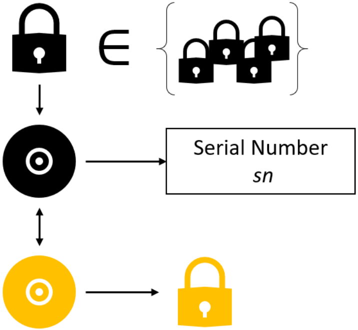
Coins and Coin Commitments



Transaction Structure

- Use the same transaction structure as ZCash
- An anonymous transaction consists of a serial number sn, a new coin commitment cm^{new}, and a zkSNARK proof

Transaction Structure, continued

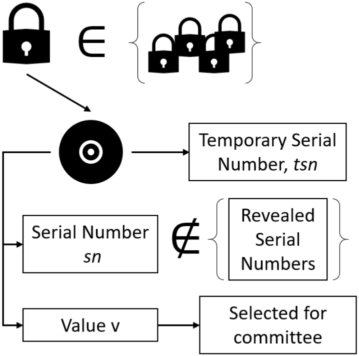


zkSNARK proof proves that:

- You own a valid coin:
  - You know a (secret) coin c^{old} with (secret) commitment cm^{old}
  - cm^{old} in {all coin commitments}
- The coin has not been spent yet:
  - You reveal the coin's serial number sn
- You aren't creating money:
  - You know (secret) coin c^{new} that has commitment cm^{new}
  - The values of c^{new} and c^{old} are the same

Ultimately, proves that the transaction was valid.

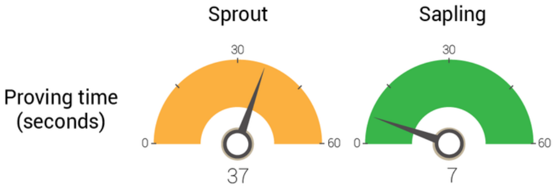
Anonymous Sortition



General idea:

- Prove ownership of a secret coin
  - Same as before
- Prove coin has not been spent yet:
  - Prove the (secret) *sn* of the coin is not in {spent serial numbers}
- Prove you aren't trying to vote twice
  - Reveal the temporary serial number *tsn* of the coin
- Prove that the user was selected from (secret) coin value *v*

Need For Speed



- Want to retain Algorand's speed
- Even 7 second proof generation is too slow
- Our proof is much larger than a ZCash transaction

Need For Speed, continued

- Pursued many different methods
- Replace SHA256 hash with MiMC hash

Future Work

- Faster computations
- Compositional analysis of security
- Code implementation

Acknowledgements

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Questions?