Incognito

The privacy layer of the decentralized web.

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Intro

Crypto networks have introduced an entirely new asset class: crypto assets. Bitcoin was the first crypto asset; today there are over 1,600. People have started buying bitcoin, instead of gold, as their long-term store of value. Stored under the mattresses of volatile economies, the world's most desirable fiat currencies are being replaced by stablecoins, that can be sent and received with borderless freedom. Waves of startups now sell crypto assets to investors, not equity.

For those who value privacy, crypto assets come with a big tradeoff. Transactions are recorded on a public ledger, displaying amounts involved, inscribing virtual identities of their senders and receivers. Given the choice, we strongly believe that very few people will willingly disclose their crypto financials to the entire world.

Incognito offers anyone the option to turn on privacy mode in this new world of crypto networks.

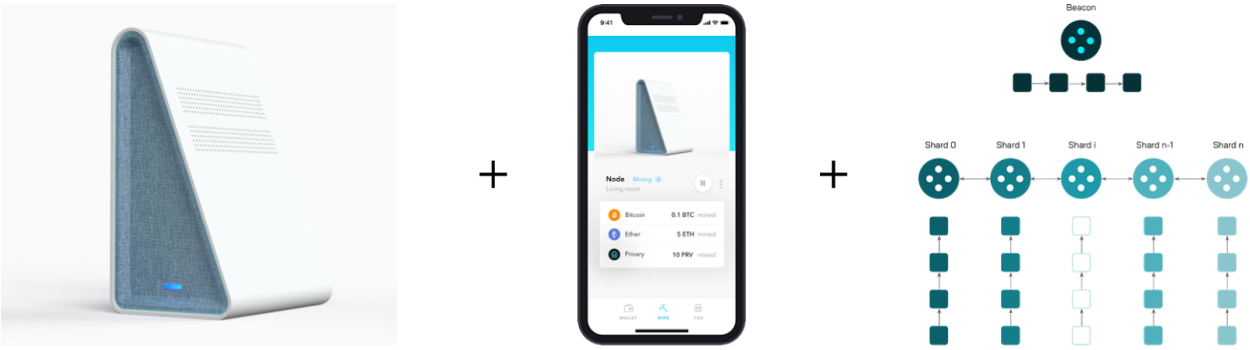
Incognito

Incognito is a decentralized privacy network composed of hardware, software, and a new blockchain protocol.

- **Blockchain.** Incognito's privacy-preserving sidechain can be attached to any commonly used blockchain, such as Bitcoin or Ethereum, enabling users to store, send and receive crypto assets, like BTC and ETH, with total privacy.

- **Hardware.** Incognito's low cost, efficient and streamlined mining hardware removes typical barriers to entry. It allows for anyone to become a validator and earn passive income, paid out in various crypto assets such as BTC and ETH.

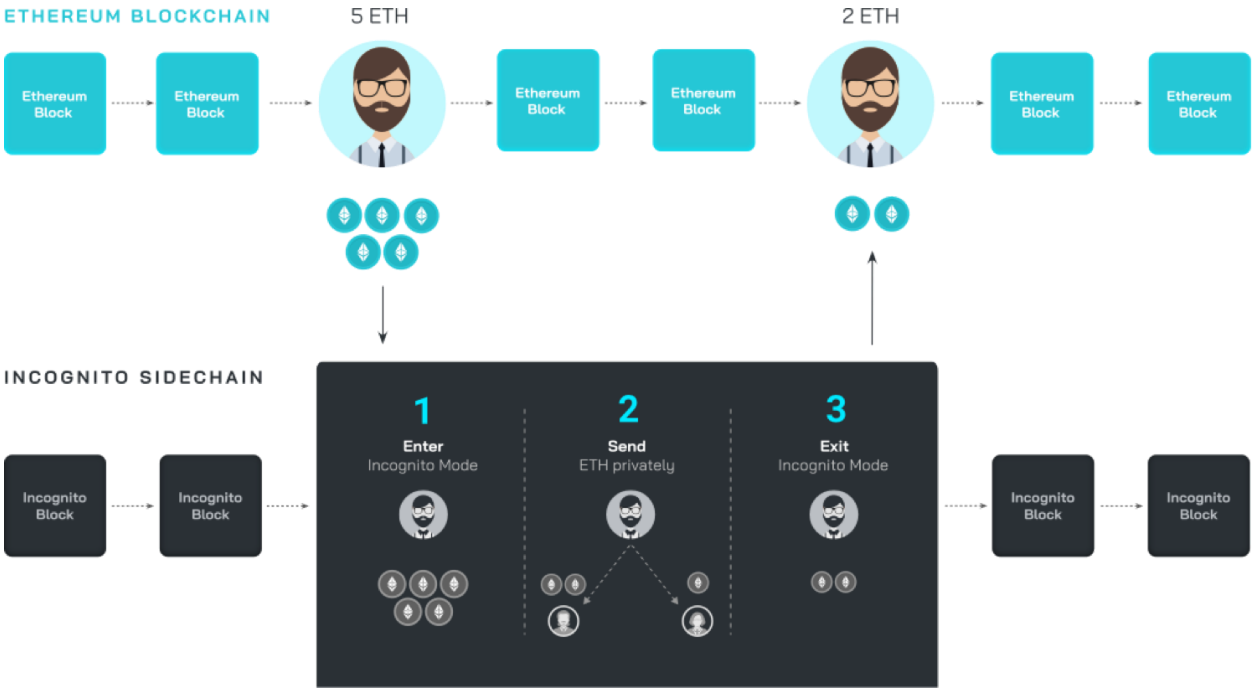
- **Software.** Incognito's wallet is a simple and secure tool for anyone to manage their crypto assets confidentially. It's available on Android, iOS, and Chrome Extensions.



Hardware Software Blockchain

Blockchain: A privacy-preserving sidechain

Incognito's privacy sidechain can be attached to any blockchain to conduct confidential asset transfer. The Incognito sidechain runs parallel to main blockchains, allowing for secure two-way transfers of crypto assets whenever privacy is needed.



Tokens

There are 3 types of tokens:

- **Privacy.** Privacy (PRV) is Incognito's native token — a work token[1]. Users stake Privacy to become miners. Miners earn block rewards in Privacy and transaction fees in various crypto assets (i.e. BTC, ETH, etc).

  This model avoids speculators and only attracts people interested in growing the network. If the demand for private transactions grows, miners will earn more revenue, which naturally triggers an increase in the price of Privacy.

- **Private tokens.** Anyone can convert tokens on other blockchains (i.e. BTC, ETH, DAI) to private tokens on Incognito (i.e. pBTC, pETH, pDAI). Private tokens maintain a 1:1 peg and are completely confidential. Because of this, anyone can store, send and receive any crypto assets with total privacy.

  Private tokens can be used to pay for transaction fees.

- **Custom tokens.** Anyone can issue their own privacy-preserving token on Incognito.

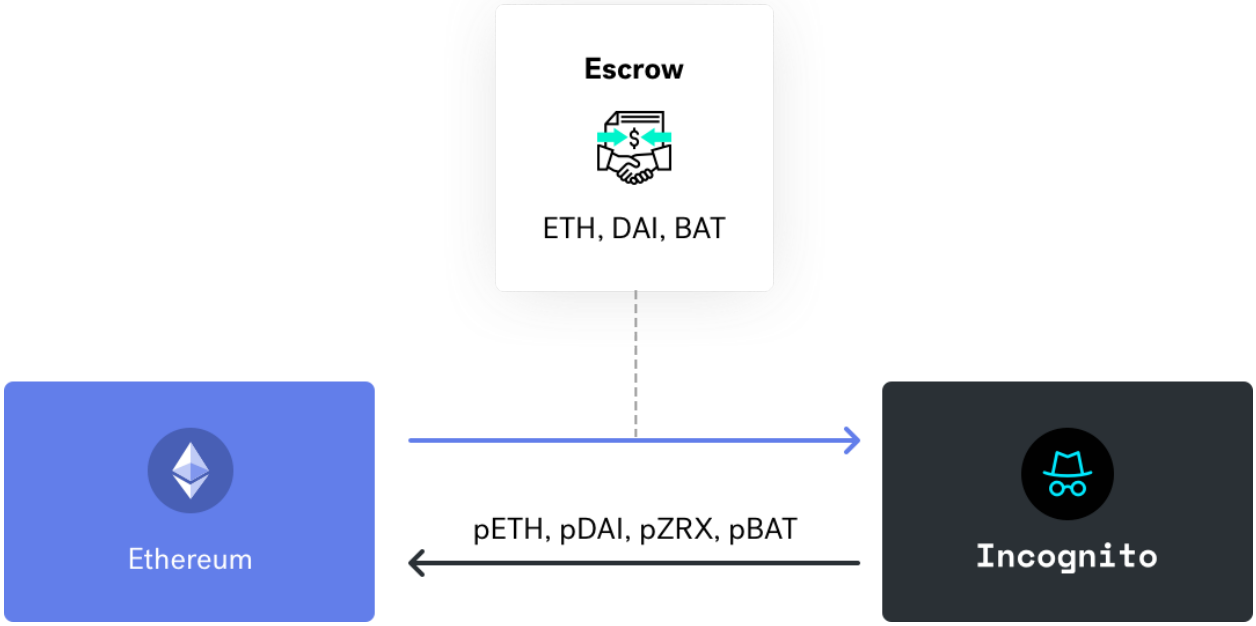
Fees

Users can pay transaction fees in their cryptocurrency of choice (PRV, pBTC, pETH, pDAI, etc).

Bridges

Bridges allow tokens to be securely moved from their native blockchains for use in Incognito, then moved back to the original chain if needed. There are two types of bridges implemented in Incognito: **custodial bridges** and **noncustodial bridges**.

[1] https://multicoin.capital/2018/02/13/new-models-utility-tokens/



The key difference between custodial bridges and noncustodial bridges is in the management of the escrow.

- **Custodial bridges.** Funds will be managed by independent third parties like Bitgo[2] or PrimeTrust[3].

- **Noncustodial bridges.** Funds are held in trustless smart contracts which run as programmed, without the need for human intervention. Our preference is to implement noncustodial bridges whenever possible.

Whether escrow management is custodial or non-custodial, the Incognito team never touches the funds. Funds are protected by independent trust companies or smart contracts.

Hardware: A mining device in every home

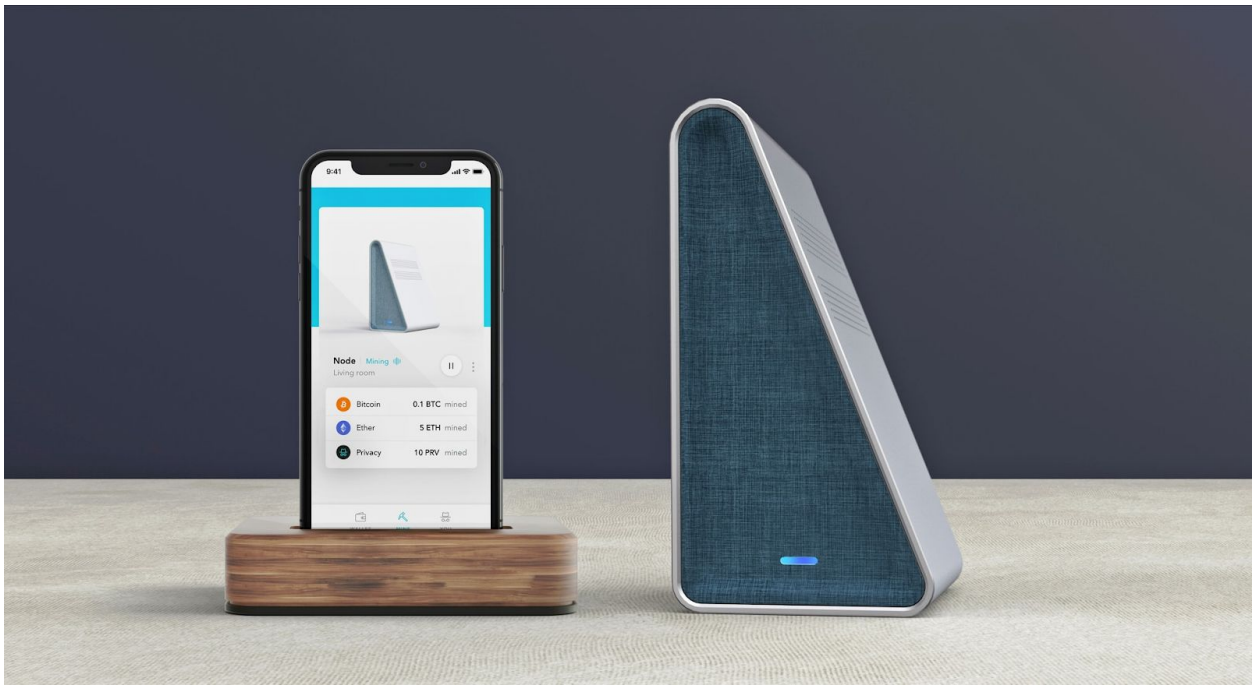
Technical users can host a virtual node by running software on their computers. Incognito will also ship its own mining hardware. This will:

- **Broaden the validator base.** For Incognito to be truly decentralized, we need as many users as possible to host nodes - including less technical users. With user-friendly hardware and software, any user can stake from their phone and become a validator.

[2] https://www.bitgo.com/
[3] https://primetrust.com/

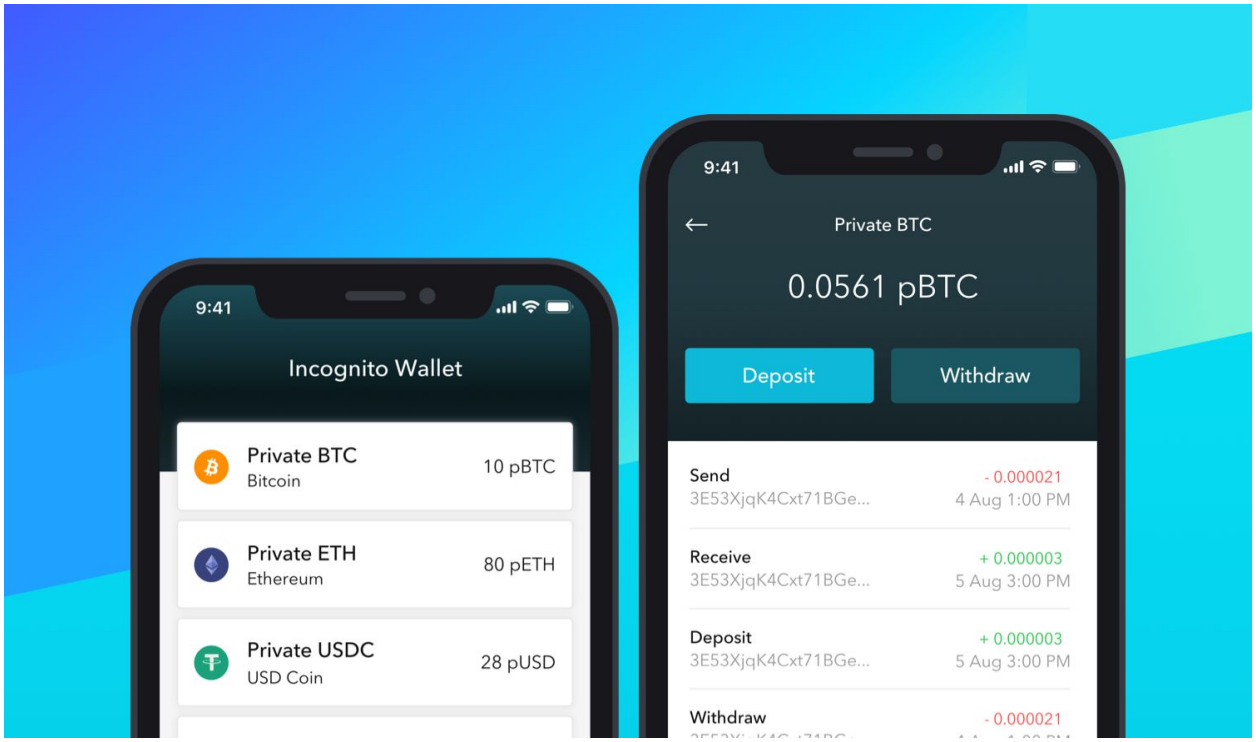
- **Make it more affordable to be a validator.** Designed for the individual then produced en masse, Node saves on manufacturing and software maintenance costs. Affordability opens up access and leads to a greater degree of decentralization.

- **Distribute tokens more effectively.** Our team wants to build a thriving, engaged community focused more on the health of the network than price speculation. Instead of participating in a public token sale, users will receive Privacy tokens preloaded into Incognito hardware, so they can reap rewards and add value to the network right away.



Software: A simple, secure, privacy-preserving wallet

The Incognito wallet is available on iOS, Android and Chrome Extension. Users hold their own keys and sign all transactions locally. High-performing zero-knowledge proof generation has been implemented on the client side, resulting in a fast, secure, privacy-first experience.



Privacy

Incognito privacy is implemented based on CryptoNote[4] and Bulletproof[5].

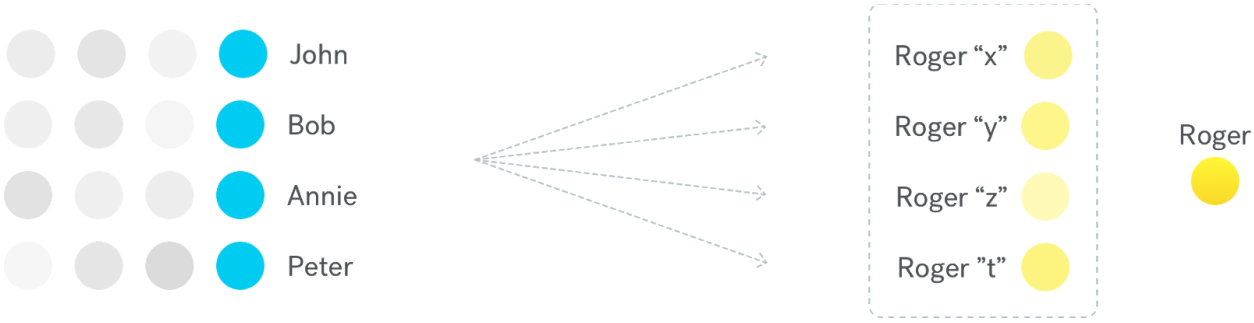
Ring signature: untraceable sender

In a ring signature[6], we have a group of users. A ring signature proves that a member of the group has signed the transaction, without revealing the identity of the signer. For example, if you encounter a ring signature with the public keys of Annie, Bob, John and Peter, you will be able to claim that one of these users is the signer but not be able to pinpoint him or her.

[4] https://cryptonote.org/whitepaper.pdf
[5] https://crypto.stanford.edu/bulletproofs/
[6] https://people.csail.mit.edu/rivest/pubs/RST01.pdf

Stealth address: unlinkable receiver

In a typical crypto network, only your public address is required for anyone to view your incoming transactions. Your transactions are public and can be easily linked together to infer your total balances and spending patterns. To avoid transaction linking, Incognito automatically creates multiple unique one-time keys; one for each incoming transaction, based on the Diffie-Hellman exchange protocol[7].



Confidential transaction: unknown transaction amount

A confidential transaction[8] is recorded on the Incognito public ledger but the amount is obscured. Miners can still verify the transaction without knowing the exact amount, as every confidential transaction includes a zero-knowledge proof of the transaction’s validity. Zero-knowledge proof is a powerful cryptographic proof that enables the prover to demonstrate a statement is true without revealing any of its contents. Incognito implements Bulletproof[9], short non-interactive zero-knowledge proofs that require no trusted setup and shrink the size of cryptographic proofs from over 10kB to less than 1kB.

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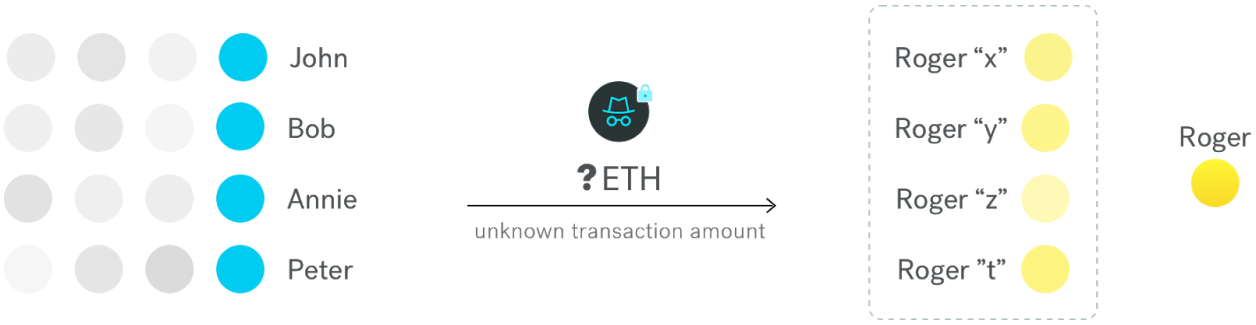
[7] https://ee.stanford.edu/~hellman/publications/24.pdf
[8] https://people.xiph.org/~greg/confidential_values.txt
[9] https://crypto.stanford.edu/bulletproofs/



Scalability

Incognito takes a practical approach in designing and implementing its consensus mechanism, based on previous research and existing engineering by OmniLedger[10], Bitcoin[11], Ethereum 2.0 [12], and Zilliqa[13].

Design

Incognito is designed with 1 beacon chain and N sharding chains. We'll start with 8 shards and slowly scale the number of shards. Each chain has its own committee.

Proof of Stake

Incognito implements the more energy efficient Proof-of-Stake (PoS) in lieu of Proof-of-Work[14]. Anyone can be a validator candidate by staking the native coin of Incognito, Privacy (the minimum stake is currently 1,750 PRV). The beacon chain randomly assigns validators for each shard. Each validator has one vote. A block is considered a valid block if it collects more than 2/3 valid signatures from the validator committee.

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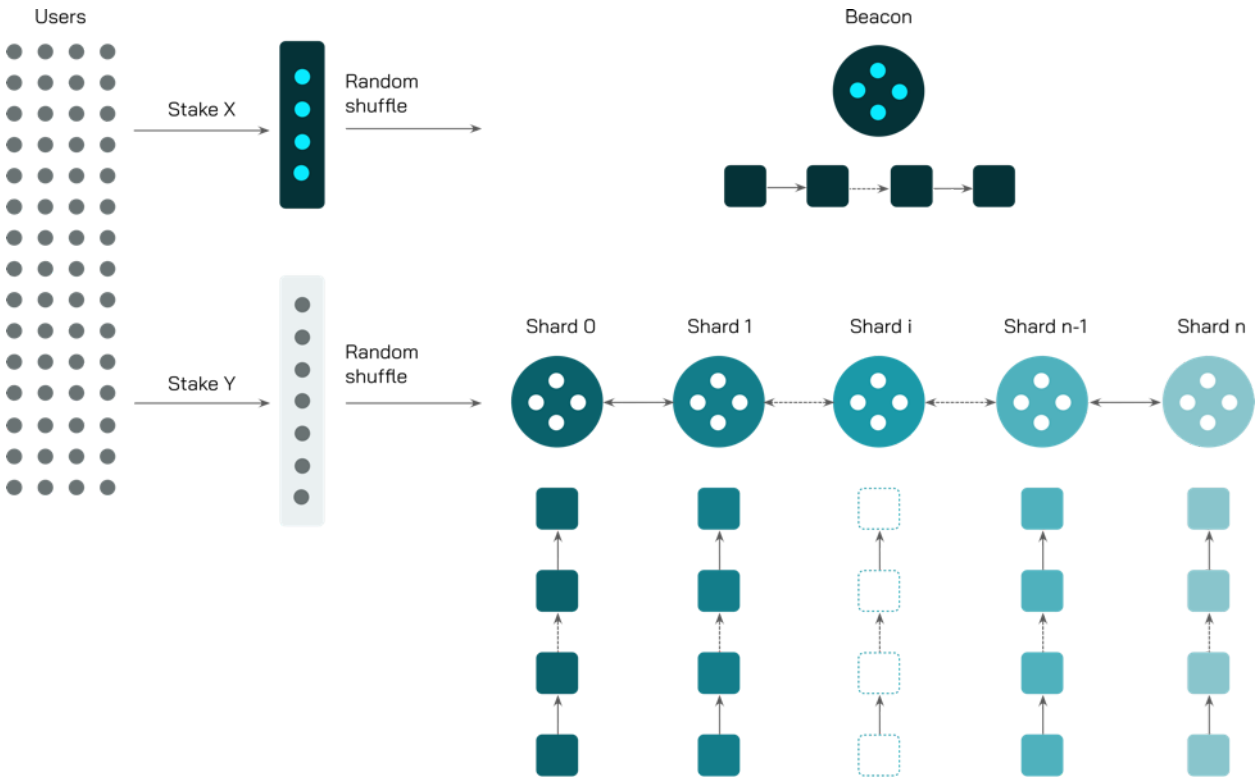
[10] https://eprint.iacr.org/2017/406.pdf
[11] https://bitcoin.org/bitcoin.pdf
[12] https://github.com/ethereum/eth2.0-specs
[13] https://docs.zilliqa.com/whitepaper.pdf
[14] https://digiconomist.net/bitcoin-energy-consumption



When selecting N validators from M candidates (M ≥ N) at random, the top 4N candidates by staked amount will be eligible for selection. This mechanism encourages validators to stake more tokens, increasing the safety of the chain while preserving randomness and inclusiveness.

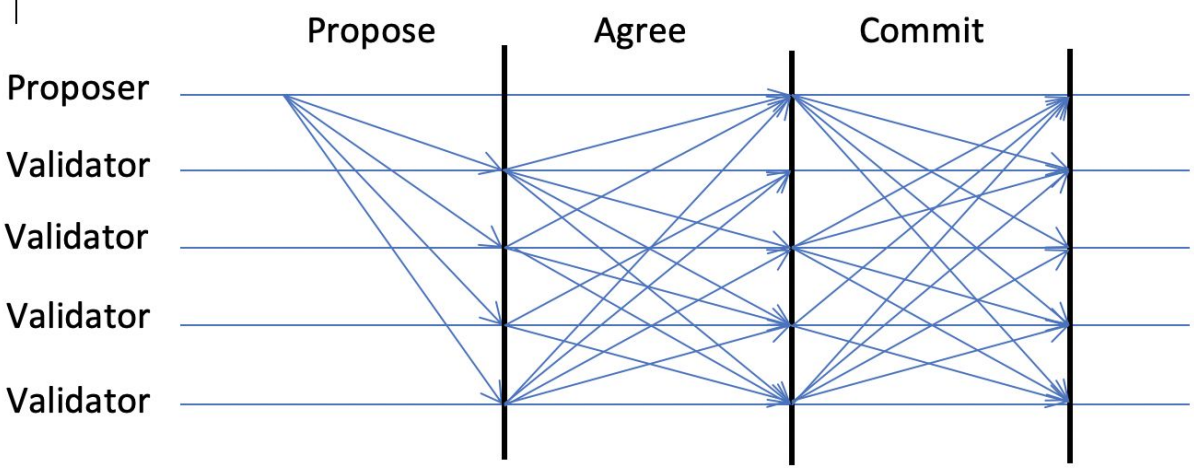
MuSig

Incognito implements MuSig[15], a new Schnorr-based multi-signature scheme, for aggregating validator signatures into a short joint signature.

Practical Byzantine Fault Tolerance

Incognito implements pBFT at the consensus layer.

[15] https://eprint.iacr.org/2018/068.pdf



Below are the details of our pBFT approach:

LISTEN PHASE
Block Validators broadcast READY_MESSAGE then listen for PROPOSE_MESSAGE from the Block Proposer.

- Within a bounded time T, if Block Validators receive a valid PROPOSE_MESSAGE, they will continue to the next phase.
- Otherwise, return a timeout error.

PROPOSE PHASE
Block Proposer collects valid READY_MESSAGE(s) from Block Validators.

- Within a bounded time T, if |READY_MESSAGE(s)| > ⅔ COMMITTEE_SIZE then Block Proposer broadcasts the new block.
- Otherwise, return a timeout error.

AGREE PHASE
Everyone broadcasts AGREE_MESSAGE and collects valid AGREE_MESSAGE(s).

- After bounded time T, if |AGREE_MESSAGE(s)| > ⅔ COMMITTEE_SIZE then calculate the aggregated value R from individual random R_i and sign new block with R and continue to the next phase.
- Otherwise, return an error.

COMMIT PHASE

Everyone broadcasts COMMIT_MESSAGE (sig, R) and collects valid COMMIT_MESSAGE(s).

- Within bounded time T, if |signatures_list[R]| > ⅔ COMMITTEE_SIZE then combine these signatures and return new block to consensus engine.
- Otherwise, return an error.

UTXO-based

Incognito is UTXO-based. We chose a UTXO-based model over an account-based model because of the following reasons:

- In a UTXO model, transactions can be easily processed in parallel. This makes it easier to scale through sharding.

- The UTXO model is stateless. Users can easily use a new address for every transaction. This improves privacy.

- Transaction inputs are always linked to existing UTXOs. Because of this linkage, a sequential transaction order is easily authenticated. It is also easy to verify if a UTXO is double spent.

Full sharding

Overview

Incognito has a single beacon chain (the “coordinator”) and 256 shard chains (the “workers”) which produce blocks in parallel. The idea was first proposed by OmniLedger. All shards work in parallel and are synchronized by beacon block time, which is divided into equal epochs.

Shards are organized by sender addresses. Each shard has its own committee, randomly assigned by the beacon chain at the beginning of every epoch. A shard committee validates and detects double-spending locally within the shard.

Both shard chains and beacon chain use the previously described PBFT-like protocol to reach consensus on new blocks.

Round robin

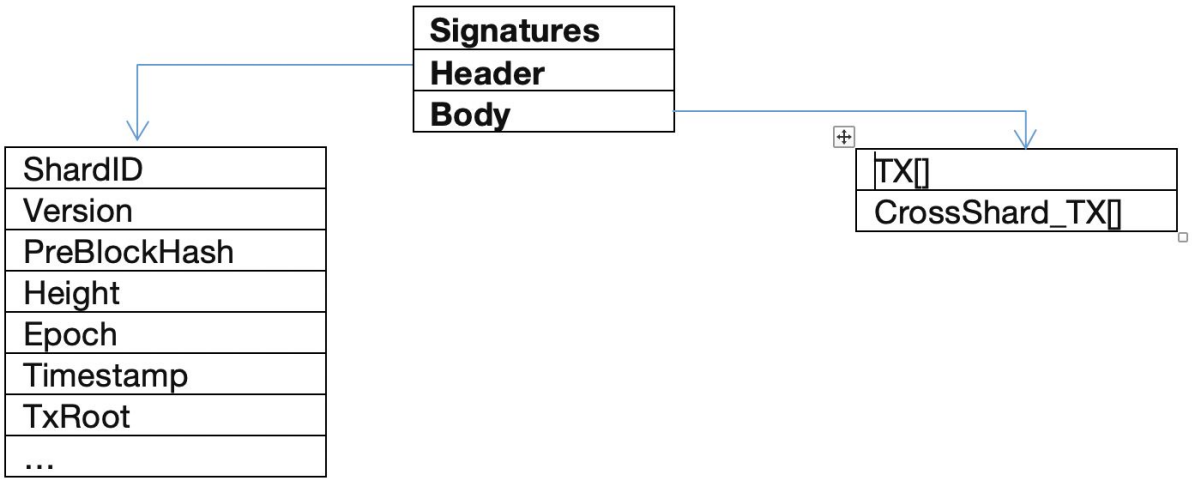
At the beginning of each round, the smallest id validator is the first proposer. The proposer proposes the block and broadcasts to the shard committee. Proposers take turns in a round robin fashion, based on their id in the current committee setup.

If a proposer fails to propose its block in less time than the time taken to build the last three blocks, the next validator will be elected as a new proposer.

If a proposer fails to propose its block on time, it will lose its reward in the epoch. If a proposer fails to propose its block three times in an epoch, it cannot be a committee member for the next three epochs.

Shard block

A shard block contains three main parts: signature, header, and body. The header stores information related to the current block, including previous hash, epoch number, and timestamp. The body stores transactions.



Shard-to-Beacon communications

Every time a shard block is created, it includes a Shard-to-Beacon block which contains block header and control messages (if any), and sends it to the beacon committee.

Beacon-to-shard data structure:

Signature
Validator_List
Shard_Header
Instruction

Shard-to-Shard communications

For cross-shard transactions, the sender shard creates a receipt containing all transactions to the receiver shard, then sends this receipt to the receiver shard. A brief of cross-shard transactions is also sent to the beacon chain. The UTXOs in the sender shard are locked to make sure they cannot be double spent. The receiver shard checks the validity of the receipt and waits for confirmation of cross-shard info from the beacon chain, before approving the corresponding UTXOs as spendable.

Cross-shard data structure

Signature
Validator_List
Shard_Header
Destination_Shard
Merkle_ShardPath
CrossShard_UTXO

Beacon chain

The responsibility of the beacon chain is to coordinate shard chains. It is the global state of the entire network. Beacon chain has its own committee and uses the same pBFT consensus mechanism as the shard chain.

- Beacon chain confirms the height of each shard chain based on the Shard-to-Beacon block data. The validators of the beacon chain reach consensus on the heights of each shard chain, which is then confirmed on the beacon chain.

- Beacon chain confirms cross-shard information. Each shard-to-beacon block header includes cross-shard information, indicating which shard this block has cross-shard to. In addition to the height of shard chain, this information also is included in the block body.

- Beacon chain manages the candidate and validator list: whenever a user stakes coin to become a validator, this action will be recorded in the block header.

- Beacon chain shuffles committees. When a new random number is generated, it is recorded in the beacon block header.

The beacon block stores the Merkle root of the candidate list and validator list of both the beacon chain and shard chains.

Proposer
Version
PreBlockHash
Height
Epoch
Timestamp
ValidatorsRoot
BeaconCandidateRoot
ShardCandidateRoot
ShardValidatorsRoot

Privacy (PRV) mining & distribution

Total Supply

A strict limit of 100M Privacy (PRV) will be minted. This number will never increase.

Self-funded

No ICO, private sale or VC funding. The team pooled together a collective $1M to kickstart the project.

As such, the core team bears all risks until the mainnet goes live. Potential users and investors should not be asked to pay for coins prior to any code being written; we felt this was not the right thing to do. We also want to avoid token price speculation around the project and keep the core team focused on building and shipping Incognito.

After the mainnet launch, Incognito may conduct a small public or private sale only if it is necessary for fuelling network growth and adding significant value to the project.

100% mined

PRV is 100% mined. The total block reward for the first year is 11,360,736 PRV. Block rewards are reduced by 12.5% for every subsequent year. PRV will be fully mined after 35 years.

Block reward split

The block reward is split between the miners and the Incognito Foundation (IF). The IF funds are initially managed by the core team. Management responsibilities will be gradually distributed to the community.

Period	**Miners**	**Incognito Foundation**
2020 - 2024	75%	25%
2025 - 2029	80%	20%
2030 - 2034	85%	15%
From 2035	90%	10%

Incognito Foundation (IF) Loan

As PRV is 100% mined, there seems to be a chicken-and-egg problem. How can miners start mining (or staking) when they don't have coins to stake?

This is our approach. The network advances IF a loan of 10,000,000 PRV. The loan is secured by IF's income from the block reward split. The 10,000,000 PRV loan is technically premined but will be paid back in full plus interest over time. This is similar to how the U.S. government borrows from the Federal Reserve; loans are secured by its income from taxes, through the issuance of long-term bonds.

IF repays every block with 70% of its block reward income. It makes the full repayment of 11,368,703 PRV after 12 years, all of which goes to the miners.kk

With an initial 10,000,000 PRV, IF could reward core developers, fund community projects, and sponsor community growth initiatives.

Core Team Rewards

The core team bought 5M PRV with their $1M ($0.20 per token) from the IF in May 2018, prior to the first line of code being written. This effectively funds the project until the mainnet launch.

The core team will not receive the 5M PRV in full immediately, so as not to curtail network growth. The 5M PRV will be paid over 5 years (1M PRV per year). This is designed to ensure that IF has sufficient funds to fuel network growth over the first 5 years.

Date	**Amount (PRV)**
December 31, 2020	1,000,000
December 31, 2021	1,000,000
December 31, 2022	1,000,000
December 31, 2023	1,000,000
December 31, 2024	1,000,000

Denominations

Privacy is the native coin of Incognito. The smallest sub-denomination of Privacy is Nano. 1 Privacy is defined as 10^9 Nano. There exist other sub-denominations of Privacy.

In the future, we expect Privacy to be used for regular transactions, Milli for micro transactions, Micro for transaction fees, and Nano for technical discussion and implementation.

Multiplier	**Name**
10^9	Privacy
10^6	Milli
10^3	Micro
10^0	Nano

Governance

The initial governance model is simple – the core team will adjust the network parameters. Over time, Privacy owners will collectively run and govern the network.

Applications

Privacy Token Systems

At the time of writing, 1,600 tokens have been created in the blockchain ecosystem. We believe that there will be many more tokens created to represent everyday assets, including stocks, fiats, gold, real estate and any form of ownership. We also strongly believe that very few people will willingly disclose their token holdings to the entire world. Incognito offers developers a simple way to create privacy-preserving tokens.

Privacy Stablecoin (aka. Cash)

The stablecoin is one of the most promising iterations of blockchain utility. Stablecoins are typically pegged to world currencies like the USD or Euro, and not subject to the volatility of other cryptocurrencies. As a digital currency, stablecoins are borderless, making them the perfect vessel for cross-border business payments or simply personal savings. Stablecoins are digital cash, and it is unlikely that holders will be happy showcasing how much money they have to the entire world. On the Incognito platform, a privacy-preserving stablecoin (such as private DAI or private USDT) can easily be created.

Privacy DAO

In a Decentralized Autonomous Organization[16], governance and decision making are automated. The most common design is that everyone holds a number of voting tokens, used to cast votes on proposals. The problem is that the voters are exposed on a public ledger, and could be compromised. A privacy-preserving voting token would make the system more secure.

Anonymous Prediction Market

Prediction markets[17], or decentralized betting, were first proposed by Robin Hansen. This concept was later materialized by crypto projects like Augur[18] and Gnosis[19]. While these betting platforms remove the middlemen (the bookies), they still suffer from the identity problem. A privacy-preserving token could be used on these platforms to keep users completely anonymous.

Network Analysis

Our team continuously optimizes the code. This analysis is based on the current code base as of June 20, 2019. The code is open-source on Github. We expect performance to significantly improve over the next few months.

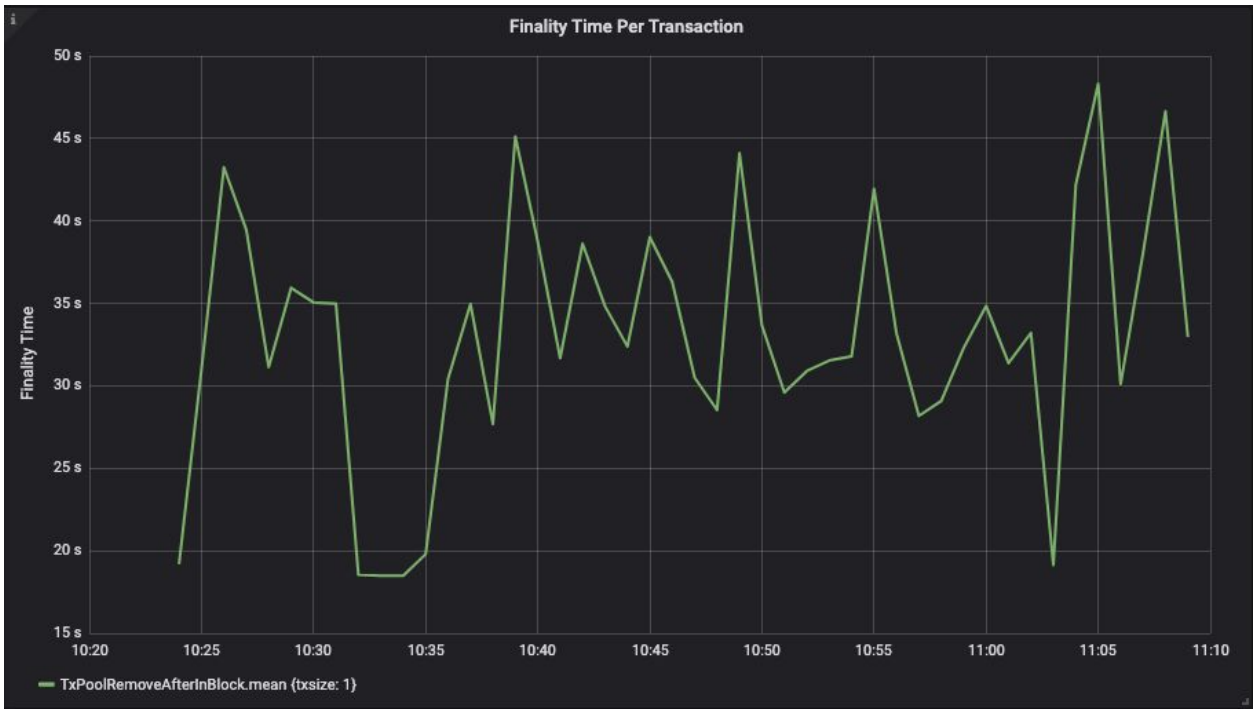
The current network performance is:

FINALITY TIME OF IN SHARD TRANSACTION	25s

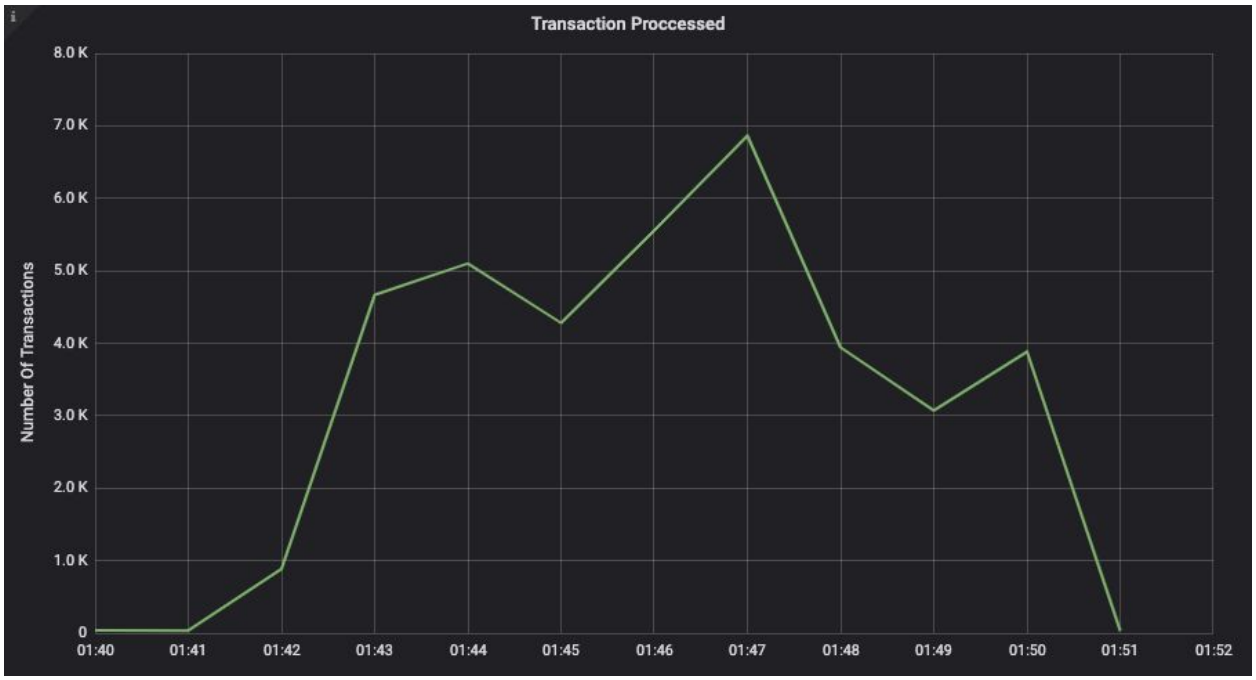
[16] https://download.slock.it/public/DAO/WhitePaper.pdf
[17] http://mason.gmu.edu/~rhanson/ideafutures.html
[18] https://www.augur.net
[19] https://gnosis.io/

FINALITY TIME OF CROSS SHARD TRANSACTION	75s
TRANSACTION PER SECOND	60 tps/shard

For the testnet, the system is set up with two shard chains and one beacon chain. Beacon chain has 4 validators, and each shard chain has 8 validators. The validator node is equipped with CPU 4 core, RAM 8GB, SSD 512GB. The connection bandwidth is 1 Gbps. In shards, transactions are continuously feeding to the mempool, starting at a rate of 200 tx/s before descending gradually to 5 tx/s over 3 hours. The finality times, transactions per block, and mempool size are shown in the following figures.

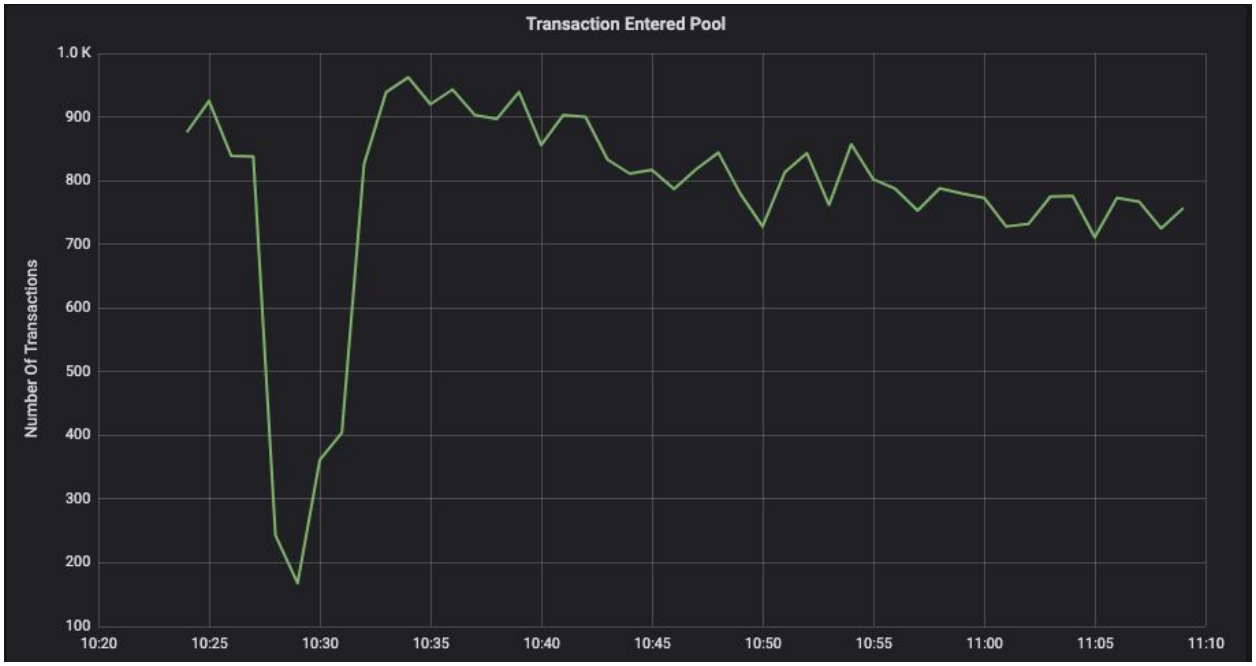


Finality time



Transaction per block

Mempool Size (Current Number of Transactions in Pool)



Number Of Transaction Entered Pool

Team

We’re a diverse team of 15 cryptographers, distributed system researchers, programmers and hardware makers - on a mission to build the privacy layer of the decentralized web.

Risks & Mitigations

Risk 1: Nothing at stake problem

A validator may sign multiple competing chains at once.

Potential solution:

- Finality conditions - the longest chain is considered final. In the event that there are multiple such chains of equal length, the one that obtains the most signatures is considered final.
- Slashing conditions - if a validator is voting for multiple conflicting blocks at the same time, its entire deposit will be deleted.

Risk 2: Single shard attack

Attackers may take over validators in a shard in order to submit false collations.

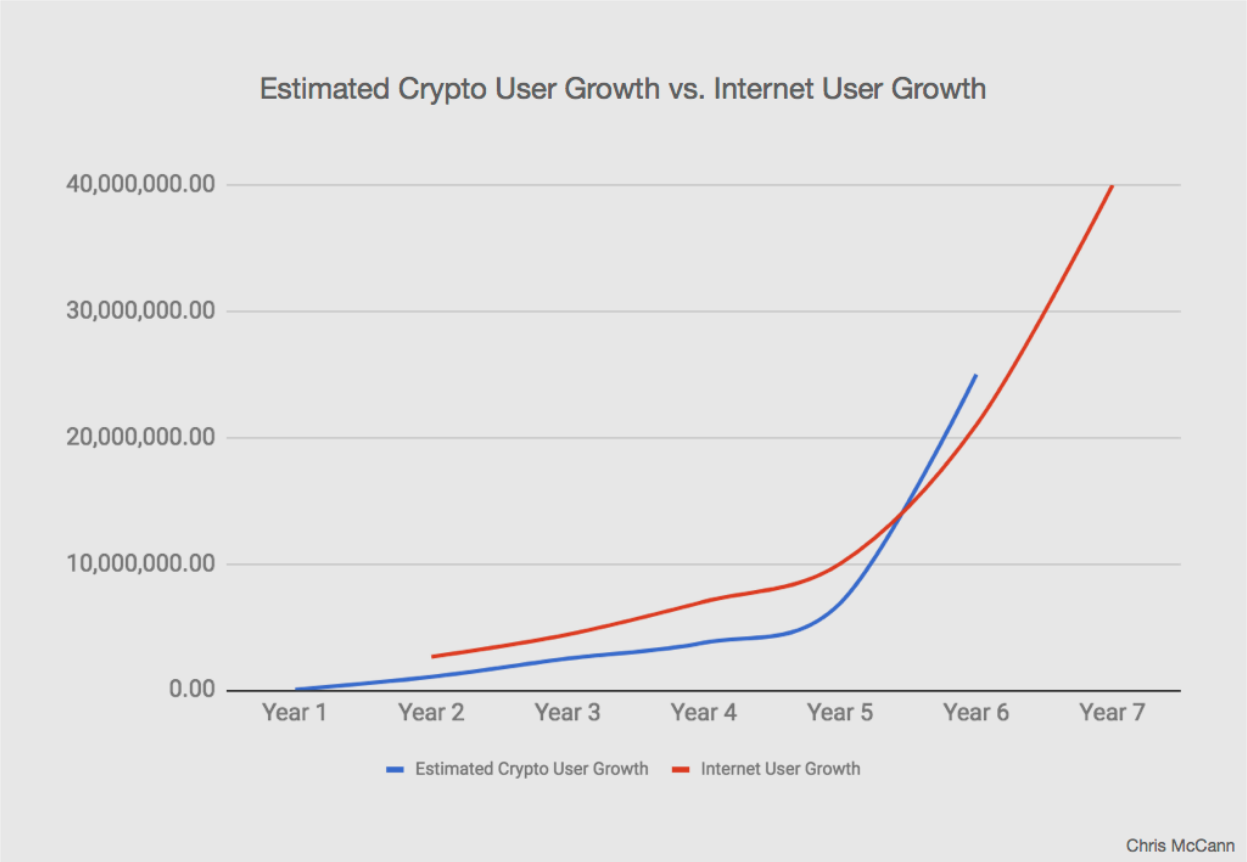
Potential solution: We'll randomly sample all validators. This way, the chances of a shard committee of size N being more than 50% corrupted by an attacker with p% of the global stake pool, are fairly low:

	N = 50	N = 100	N = 150	N = 250
p = 0.4	0.0978	0.0271	0.0082	0.0009
p = 0.33	0.0108	0.0004	1.83 * 10-5	3.98 * 10-8
p = 0.25	0.0001	$6.63 * 10^{-8}$	$4.11 * 10^{-11}$	1.81 * 10-17
p = 0.2	$2.09 * 10^{-6}$	$2.14 * 10^{-11}$	$2.50 * 10^{-16}$	$3.96 * 10^{-26}$

The data shows that, for N >= 150, the chance that any random seed will lead to a sample favoring the attacker is very small indeed.

Summary

The internet in 1994 looked nothing like what we have today. Blockchain's 1994 is happening right now.



Crypto assets are increasing in number every day. Some of them wrap around existing assets like fiats (TUSD) and gold (DGX) and make them more efficient. Some of them introduce entirely new asset classes, like programmable governance tokens (MKR). Crypto assets are on the right path to play a very important role in the near future. Crypto assets will increasingly compose an individual's net worth, or a company's balance sheet.

Incognito hopes to give these assets and their owners - both now and in the future - the option to claim their right to privacy.

Parameters

NUMBER OF SHARDS	256
MINIMUM STAKING - SHARD	1,750 PRV
NUMBER OF SHARD NODES	Dynamic
SHARD REWARD WEIGHT	1
NUMBER OF BEACON	1
MINIMUM STAKING - BEACON	5,250 PRV
NUMBER OF BEACON NODES	Dynamic
BEACON REWARD WEIGHT	2
BLOCK TIME	~10 seconds
BLOCK REWARD	0.4 PRV (reduced by 12.5% annually)
TOTAL REWARD	BLOCK REWARD + TRANSACTION FEES
DEVELOPMENT FUND	5% OF TOTAL REWARD
GROWTH FUND	5% OF TOTAL REWARD
MINER REWARD	90% OF TOTAL REWARD
REWARD	MINER REWARD / (NUMBER OF SHARDS * SHARD REWARD WEIGHT + NUMBER OF BEACON * BEACON REWARD WEIGHT)
SHARD NODE REWARD	SHARD REWARD WEIGHT * REWARD / NUMBER OF SHARD NODES
BEACON NODE REWARD	REWARD * BEACON REWARD WEIGHT / NUMBER OF BEACON NODES
EPOCH LENGTH	~34,560 blocks (~4 days)