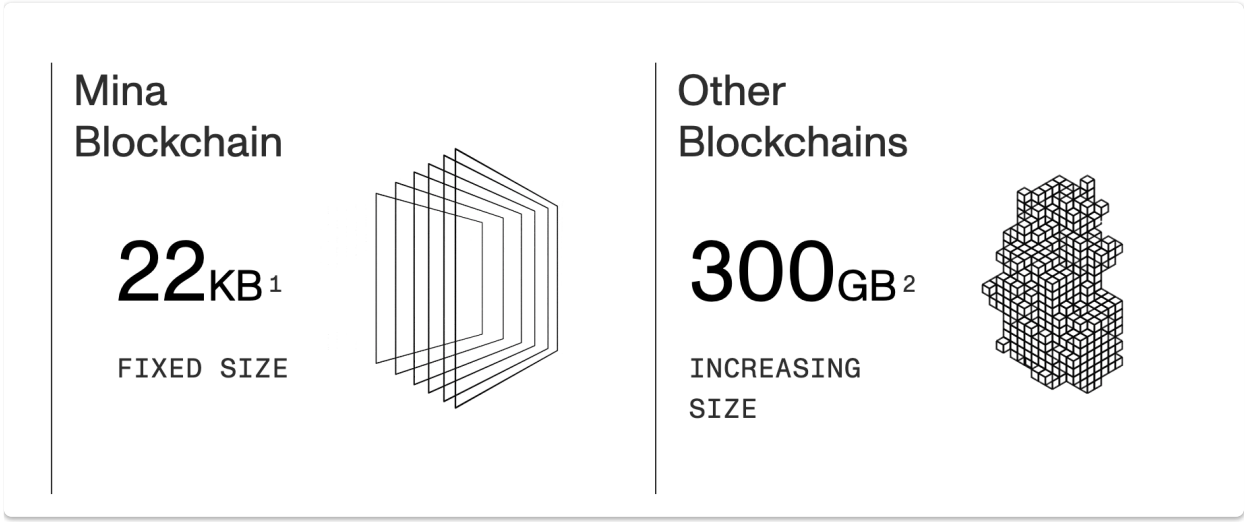
Lesson 10

Mina



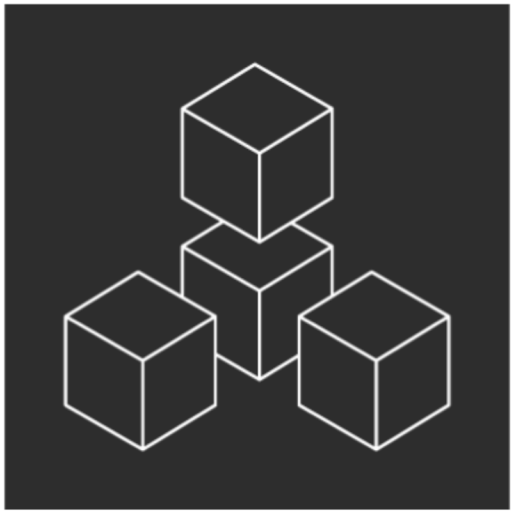
Mina is the first cryptocurrency protocol with a succinct blockchain. With Mina, no matter how much the usage of the network grows, the blockchain always stays the same size - about 22kb.

What data is needed for usable representation of the blockchain?

- A clear, usable representation of the basic data being queried of a state - accounts balances
- Data that a node needs in order to verify that this state is real in a trustless manner
- The ability to broadcast transactions on the network to make a transfer

Roles in Mina

Block producer



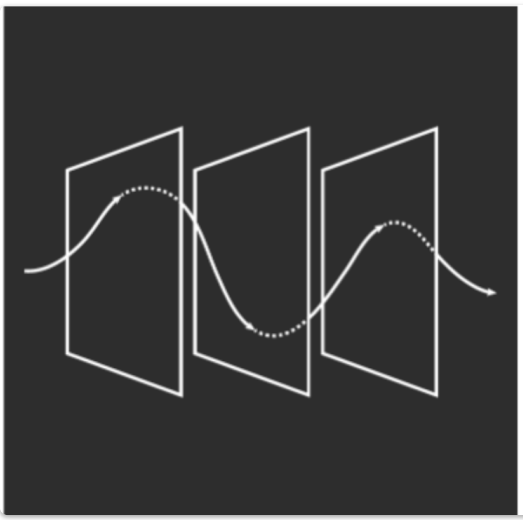
AS A BLOCK PRODUCER

Block producers are akin to miners or stakers in other protocols. By staking Mina, they can be selected to produce a block and earn block rewards in the form of coinbase, transaction fees and network fees. Block producers can decide to also be SNARK producers.

A block in Mina is constituted of:

- Protocol state
  - Genesis state hash
  - Blockchain state
  - Consensus state
  - Consensus constants
- Protocol state proof
- Staged ledger diff
- Delta transition chain proof
- Current protocol version
- Proposed protocol version

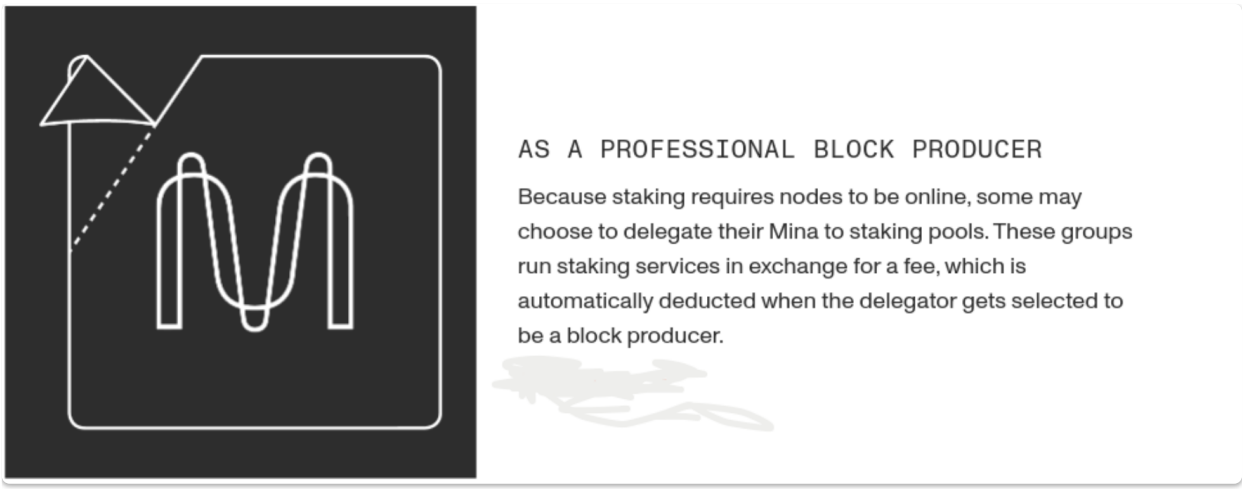
Snark worker



AS A SNARK PRODUCER

The second type of consensus node operator on Mina, snark producers help compress data in the network by generating SNARK proofs of transactions. They then sell those proofs to block producers in return for a portion of the block rewards.

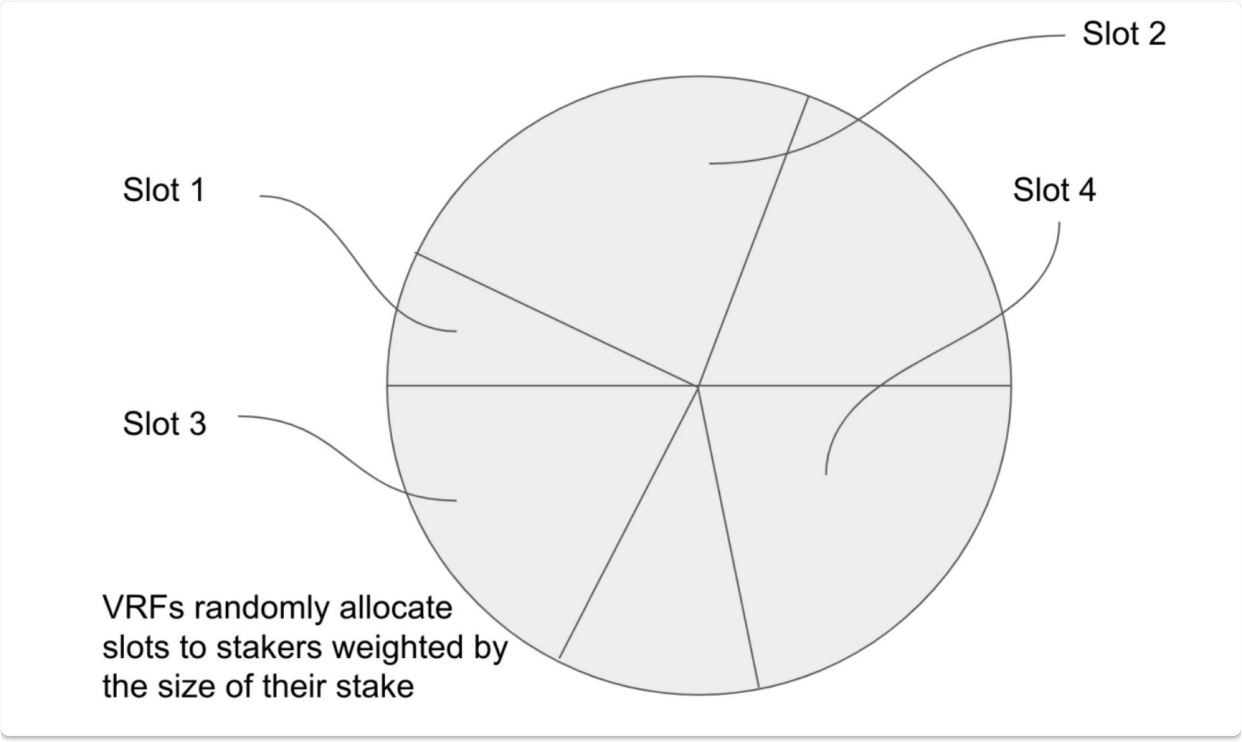
Professional block producer


AS A PROFESSIONAL BLOCK PRODUCER
Because staking requires nodes to be online, some may choose to delegate their Mina to staking pools. These groups run staking services in exchange for a fee, which is automatically deducted when the delegator gets selected to be a block producer.

See guide

Mina's consensus mechanism

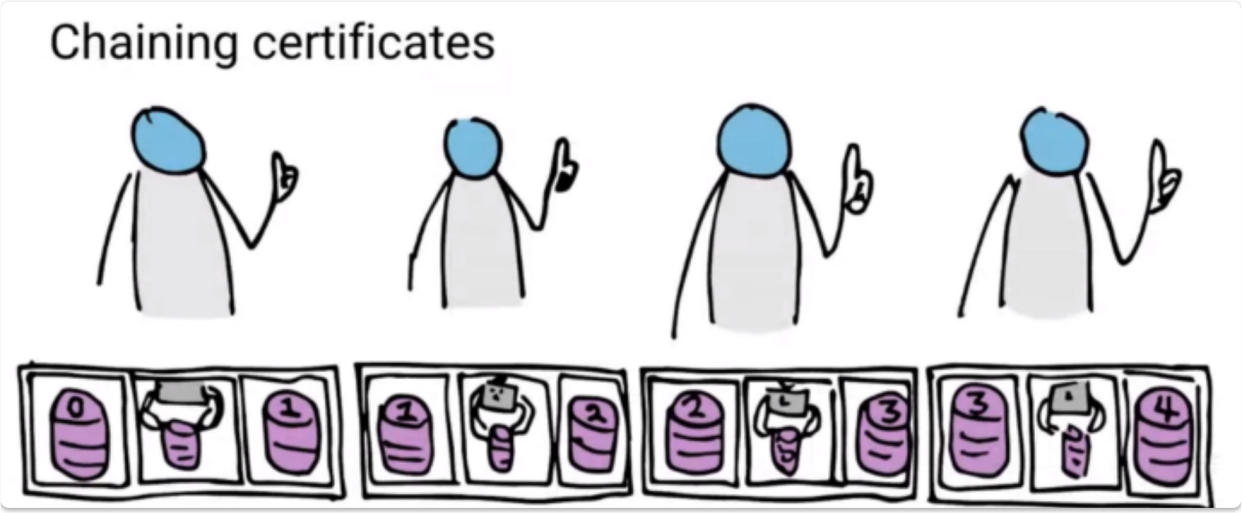
Mina's consensus mechanism is an implementation of Ouroboros Proof-of-Stake. Due to Mina's unique compressed blockchain, certain aspects of the algorithm have diverged from the Ouroboros papers, and the version Mina uses is called Ouroboros Samisika VRFs are used to decide whether to produce a block, the probability is proportional to the producer's stake.



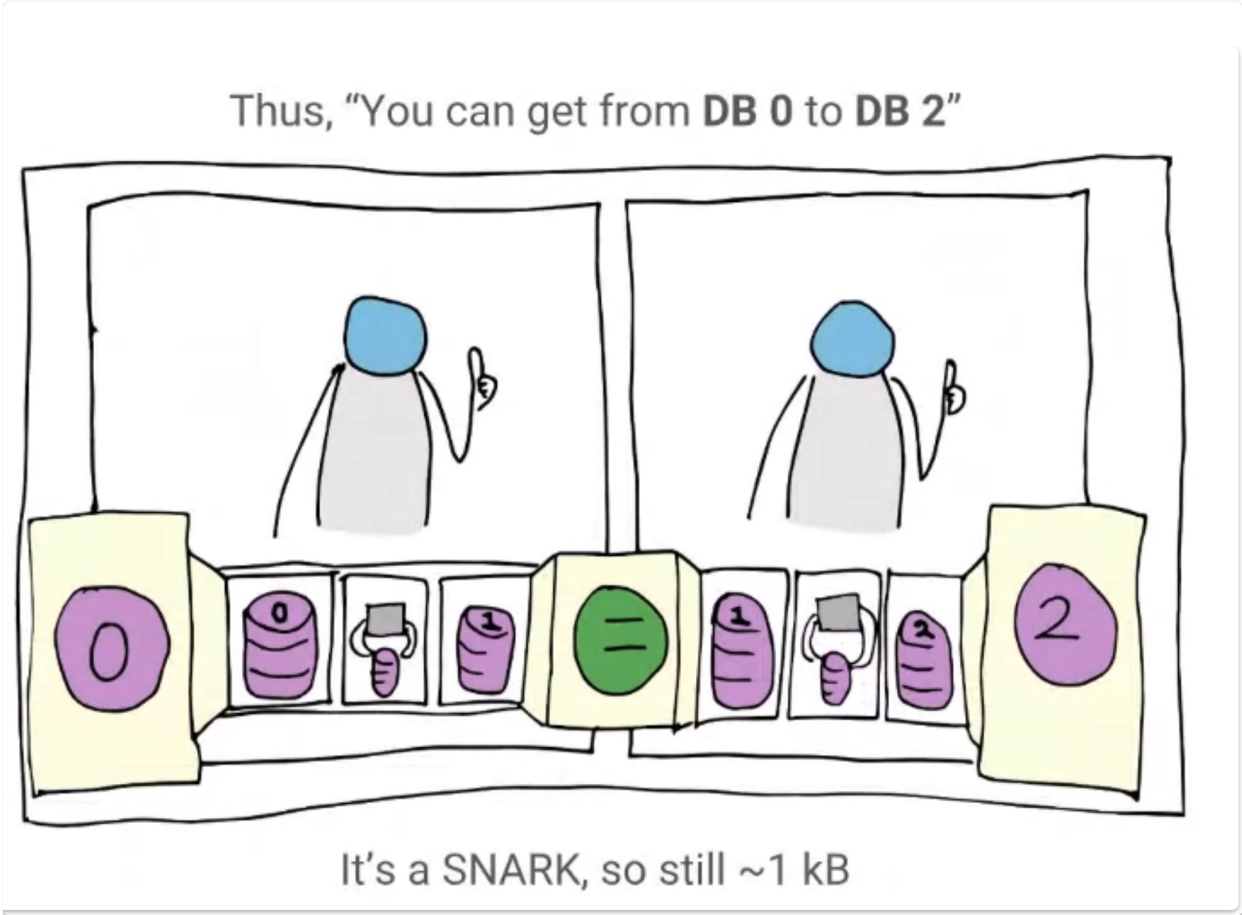
RECURSIVE COMPOSITION OF PROOF (SUCCINCTNESS)

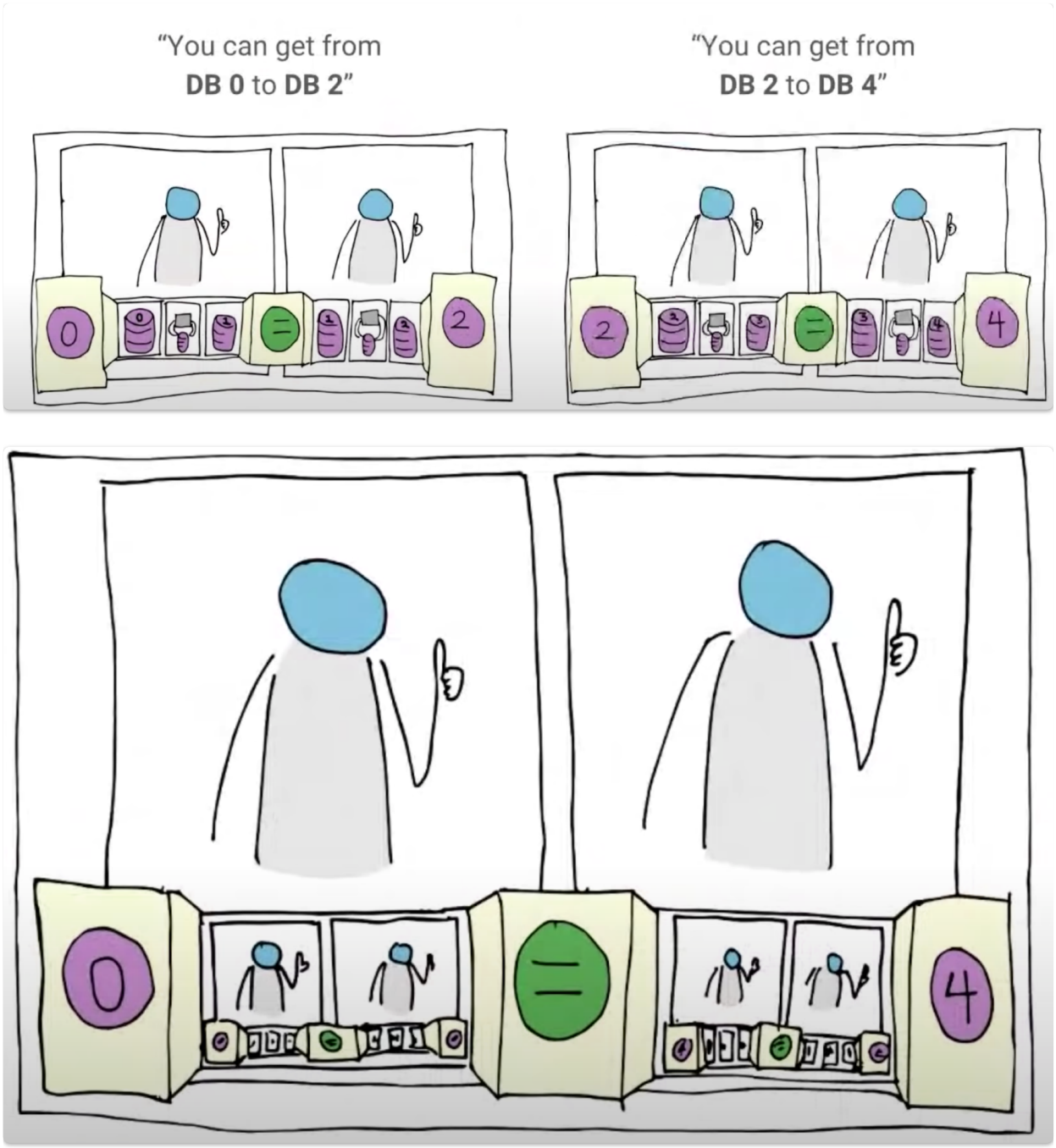
The blockchain is dynamic and new blocks keep getting added to it. However, we would like to ensure succinctness at any given point in time. Therefore, as the blockchain “grows”, we compute a new SNARK proof that not only validates the new blocks, but also the existing SNARK proof itself. The notion of a SNARK proof that attests to the verifiability of another SNARK proof is the notion of “incrementally-computable SNARK”

from Mina: Decentralized Cryptocurrency at Scale (whitepaper)



Better to use recursive proofs :



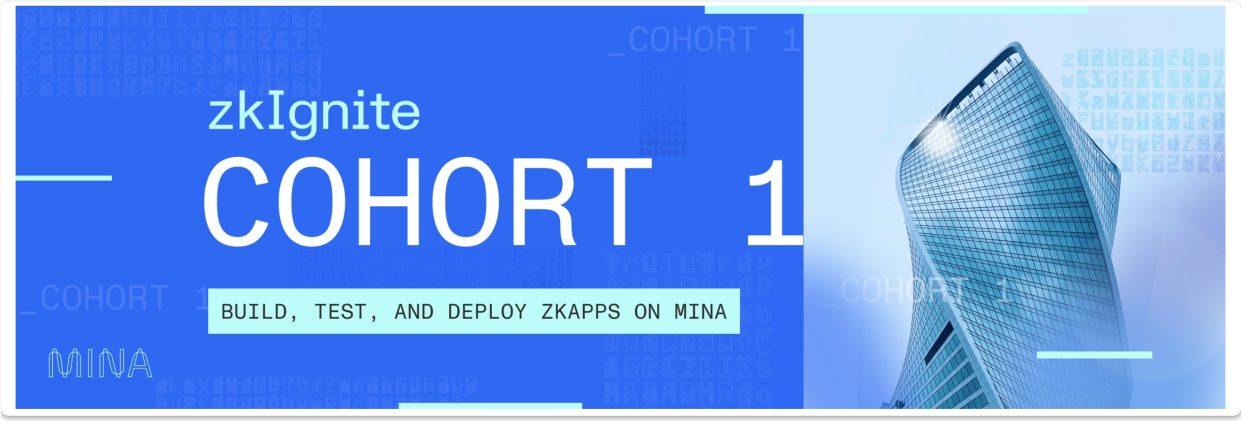


See video

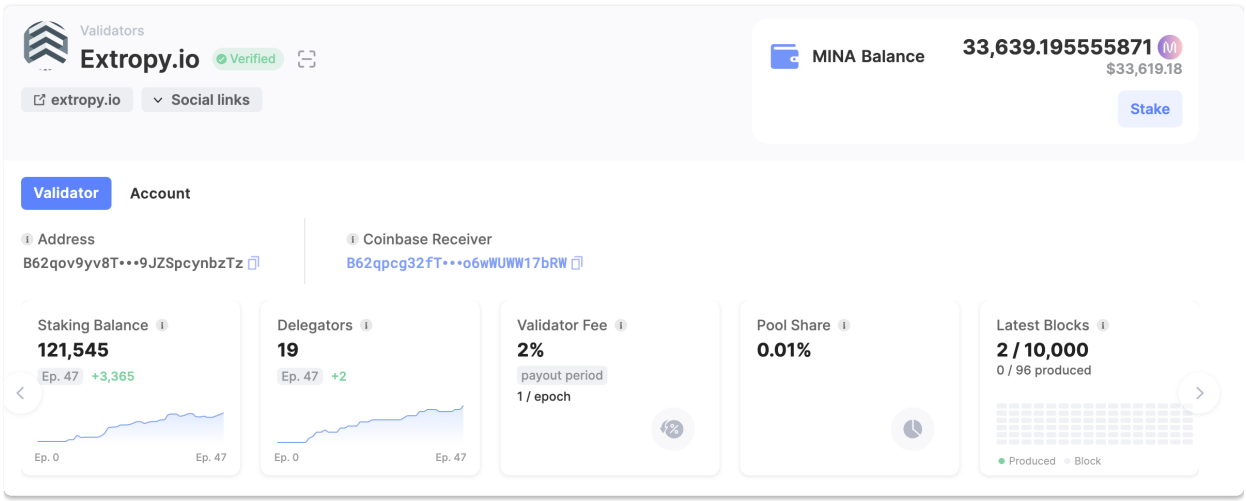
Community

https://awesome.mina.tools/

https://minacrypto.com/



Staking with Extropy

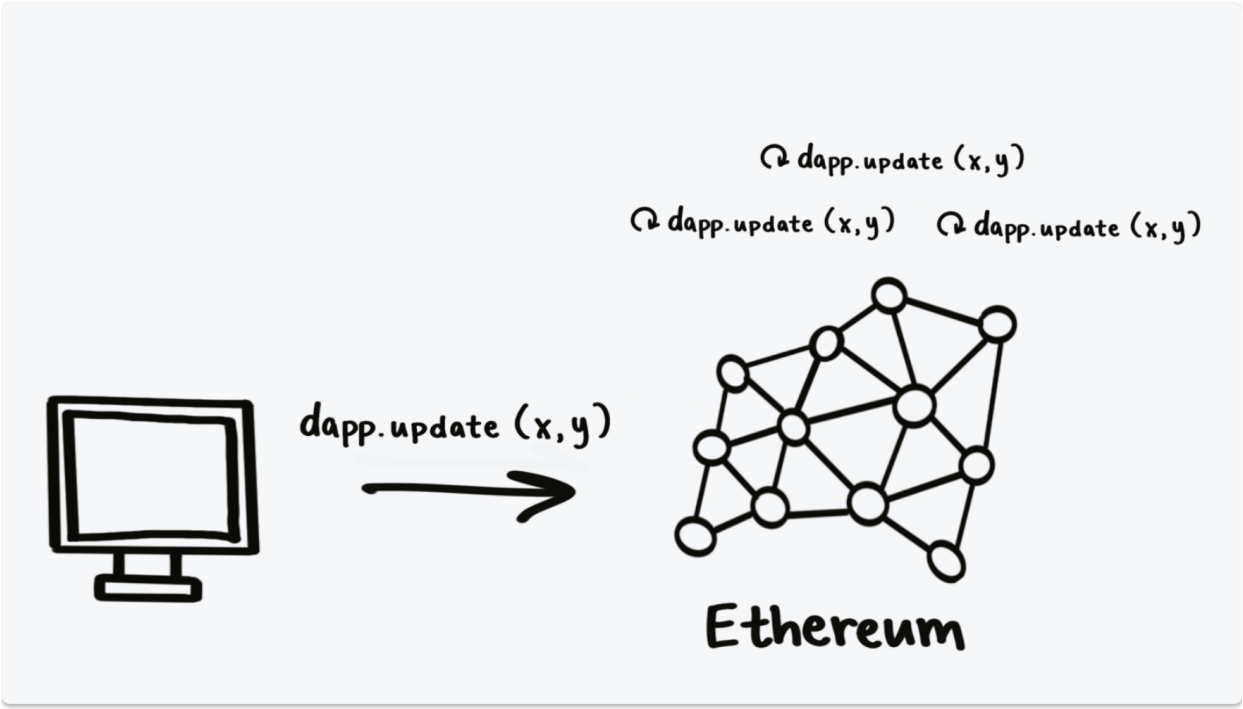


See guide

zkApps

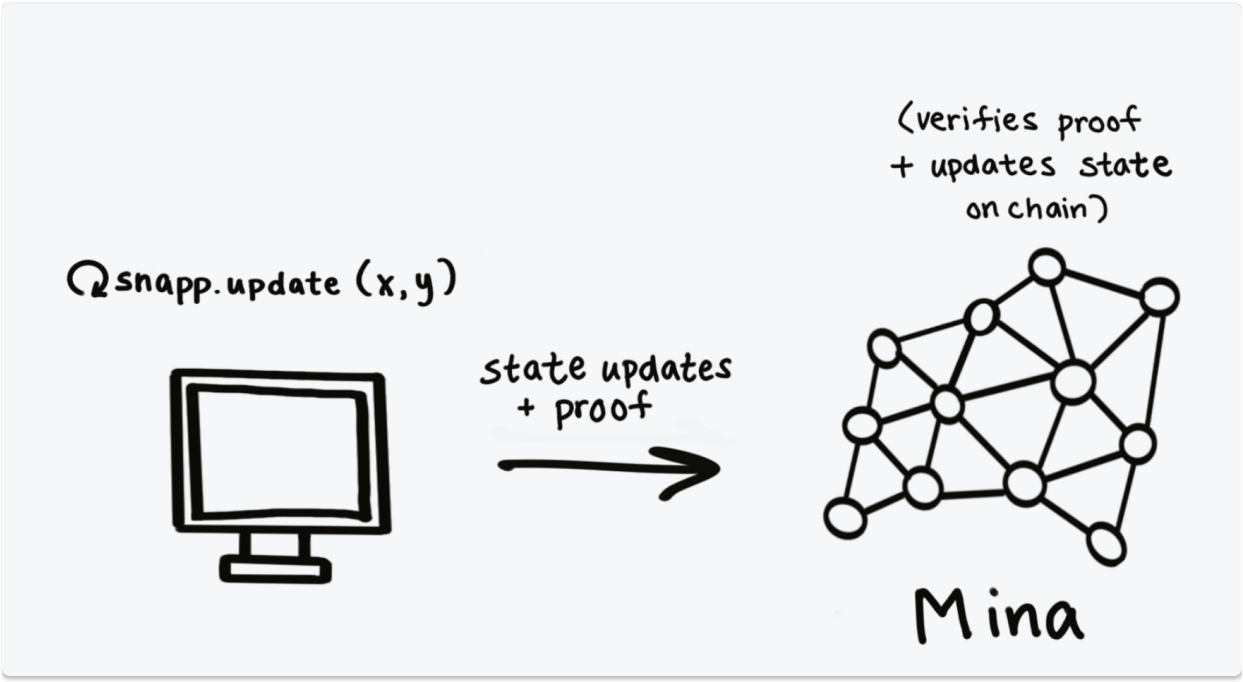
zkApps ("zero-knowledge apps") are Mina Protocol's smart contracts that use an off-chain execution and mostly off-chain state model.
This allows for private computation and state that can be either private or public.

Ethereum dapps

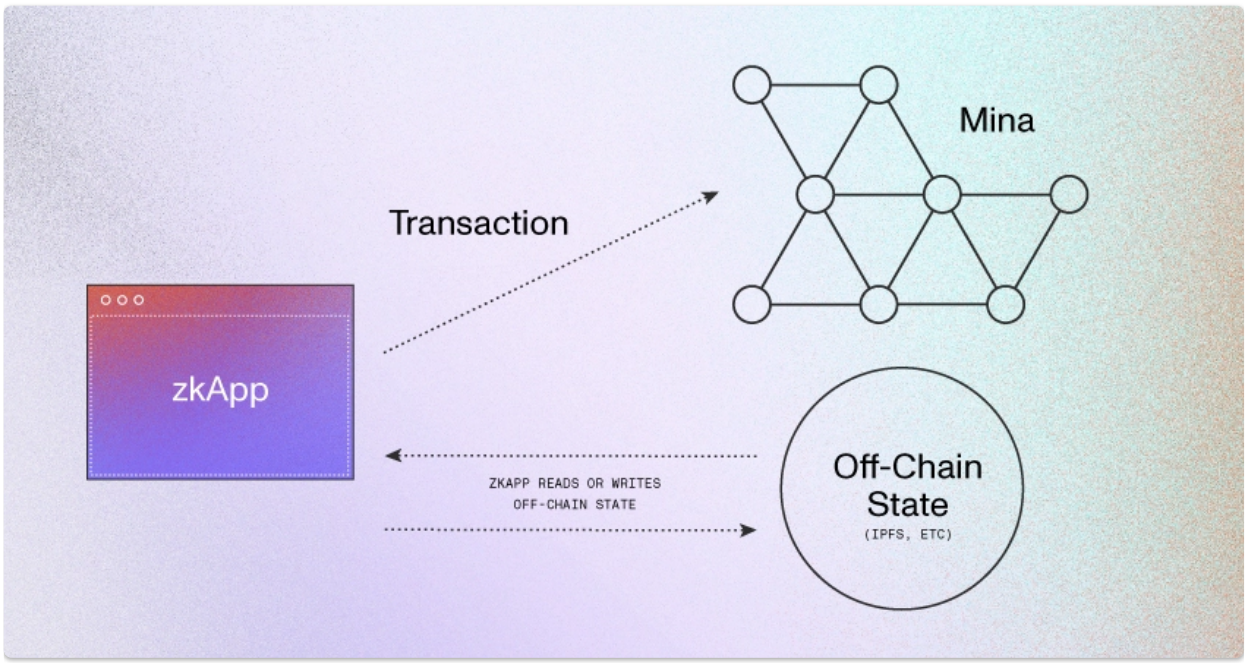


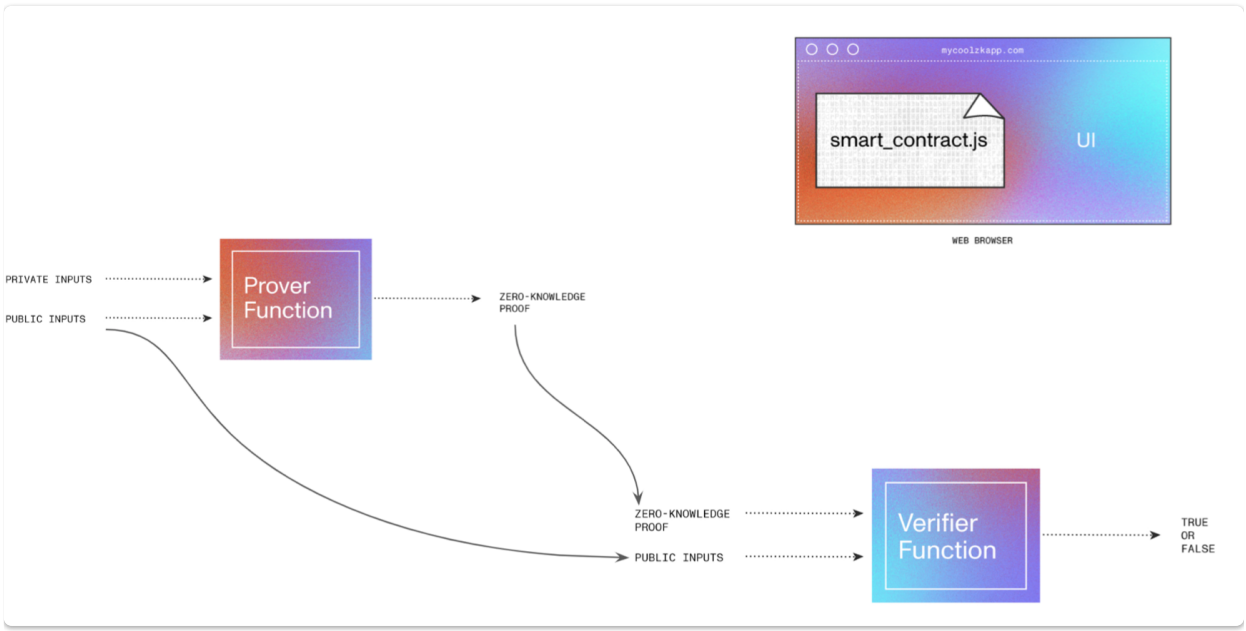
Ethereum uses on-chain computation.

Mina zkApps

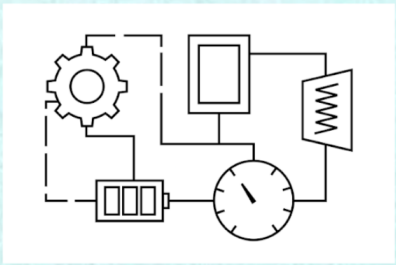


Mina uses off-chain computation & on-chain verification.



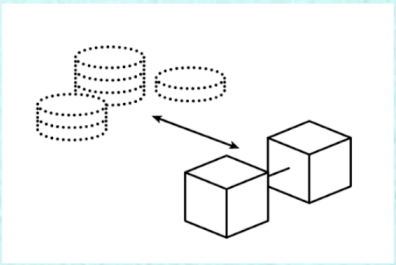


zkApps use cases



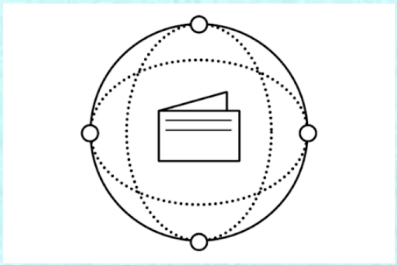
BUILD ZKAPPS[3] PRIVACY-ENABLED APPS

Develop dapps that use zero knowledge to ensure data-level privacy, verifying requirements without exposing the underlying user information.



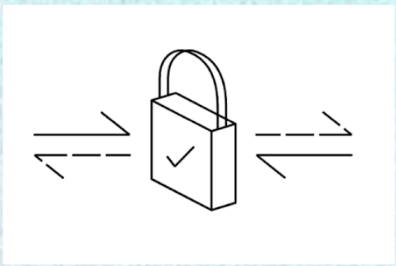
POWER ENTERPRISE INTEROPERABILITY

Use Mina to combine the cost-efficiency and privacy of a private chain with the interoperability of a public chain.



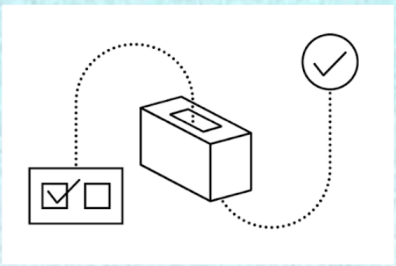
MINIMIZE TRANSACTION FEES

Power trustless e-commerce and global peer-to-peer transactions without using centralized intermediaries, or paying costly transaction fees.



POWER SECURE & FAIR FINANCIAL SERVICES

Ensure lenders only use fair criteria to make decisions and securely verify relevant information without accessing private user data.



ENABLE PRIVATE & AUDITABLE ELECTIONS

Guarantee fully verifiable and auditable elections, while keeping the process private and protecting individuals' voting information.

ACCESS MONEY FROM ANYWHERE IN THE WORLD

With a 22kb[1] Mina chain, access peer-to-peer stablecoins and tokens via smartphone and bring hard-earned money anywhere you go.

zkBridge ETH & WMina example

The bridge is currently only one way- i.e MINA state can be read on Ethereum , but not the other way around.

How does the bridge works ?

- Retrieve MINA state proof and the verification key.
- Generate an Auxiliary proof for the state received.
- Post the Auxiliary proof to Ethereum blockchain , where a smart contract will update only if valid.

[ETH] A Wrapped MINA contract on ETH will be created which will be the minter. This contract has a MINA address where a user will deposit funds into.

[MINA] User deposits funds into address above on MINA blockchain.

[MINA] Deposit transaction gets committed.

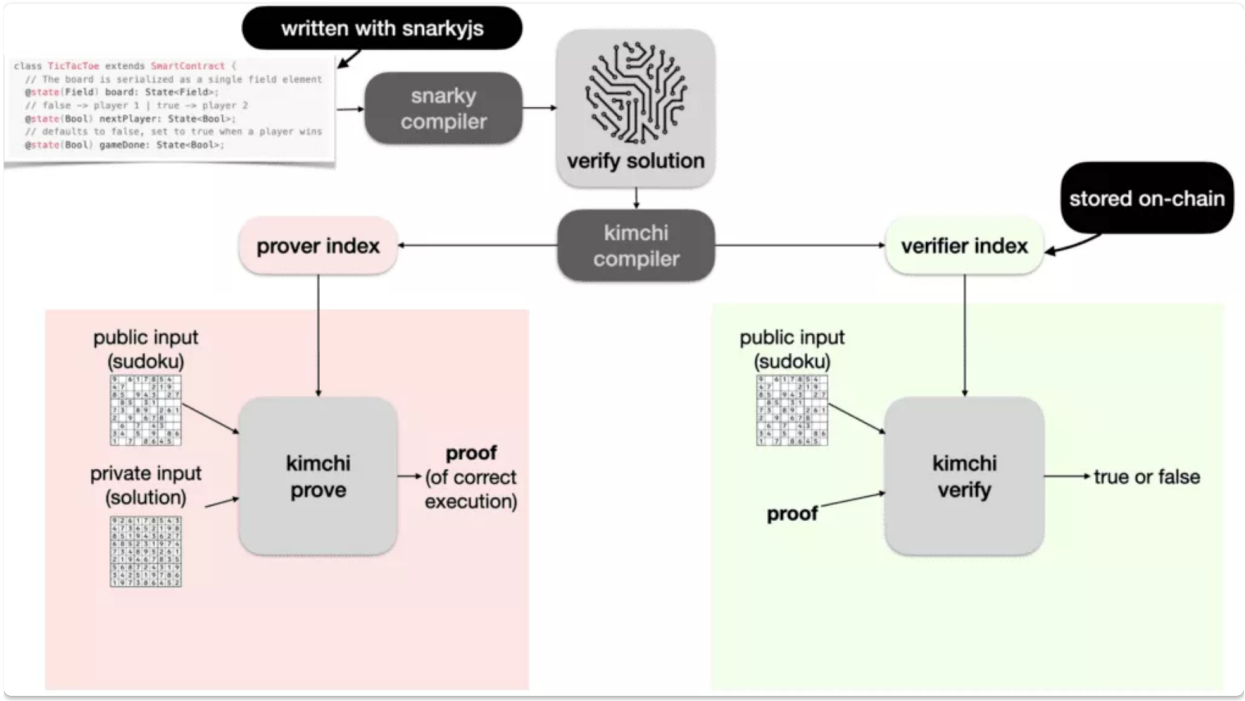
[ETH] Auxiliary Proof of MINA state is submitted to ETH.

[ETH] MINA state proof is validated and confirmed.

[ETH] Wrapped MINA Contract is called which uses the proof and validates the balance and mints Wrapped MINA on Ethereum.

How Mina creates proofs.

Pickles and Kimchi



Pickles

Pickles has two components:

- core zk-SNARK,
- developer toolkit (containing a wide array of library functionality and the Pickles Inductive Proof System)

Kimchi

The heart of the Mina proving system is Kimchi, this is the protocol that creates the proofs.
Kimchi is based on the Plonk family of zkSNARK proof systems.

One notable improvement over Plonk is that Kimchi doesn't require a trusted setup. This is achieved by adding a polynomial commitment to the setup (similar to Bulletproofs)

Other Improvements in Kimchi

- The gates used in the circuit have changed from being generic gates (which could represent any functionality) to specific gates to target known functionality such as Posiedon Hashes.
- More than 2 inputs are allowed for gates.

- The use of lookup tables for public data or simple boolean operations.

How does Pickles compare to other proof systems ?

System	Setup	Programmability	Proof Size	Prover Speed	Recursion Ready	Open Source
Pickles	Trustless	Full	8kB	Fast	Arbitrary	Yes
AIR STARKs	Trustless	Partial, complex constraint system model limiting to succinct circuits	100kB	Very fast	No	No
Halo	Trustless	Full	3.5kB	Fast	Linear	Yes
BN128 PLONK	Trusted, universal	Full	0.5kB	Fast	No	Yes
MNT Groth16	Trusted, per-circuit	Full	1.5kB	Medium	Arbitrary	Yes

Curves used

Mina uses the curves Pallas and Vesta (collectively Pasta).

PALLAS

- curve equation: y2=x3+5
- base
  field: 28948022309329048855892746252171976963363056481941560715954676764349967630337
- scalar
  field: 28948022309329048855892746252171976963363056481941647379679742748393362948097
- mina
  generator: (1,12418654782883325593414442427049395787963493412651469444558597405572177144507)
- arkworks generator: (−1,2)

VESTA

- curve equation: y2=x3+5
- base
  field: 28948022309329048855892746252171976963363056481941647379679742748393362948097
- scalar
  field: 28948022309329048855892746252171976963363056481941560715954676764349967630337
- mina
  generator: (1,11426906929455361843568202299992114520848200991084027513389447476559454104162)
- arkworks generator: (−1,2)

Resources

Extropy Medium Article

A great introduction to ZKPs and Mina is the Mina Book
Zero Knowledge Podcast ZKP Intro
Zero Knowledge Podcast Mina Episode

SnarkyJS

zkApps are written in TypeScript using SnarkyJS.

SnarkyJS is a TypeScript library for writing smart contracts based on zero-knowledge proofs for the Mina Protocol. It is included automatically when creating a new project using the Mina zkApp CLI.

Primitive data types

Field elements are the basic unit of data in zero-knowledge proof programming. Each field element can store a number up to almost 256 bits in size.

```
new Bool(x); // accepts true or false

new Field(x); // accepts an integer,or a numeric string

new UInt64(x); // accepts a Field - useful for constraining numbers
to 64 bits

new UInt32(x); // accepts a Field - useful for constraining numbers
to 32 bits

PrivateKey, PublicKey, Signature; // useful for accounts and signing

new Group(x, y); // a point on our elliptic curve, accepts two
Fields/numbers/strings

Scalar; // the corresponding scalar field (different than Field)
```

In typical programming, you might use:

`const sum = 1 + 3;`

In SnarkyJS, you would write this as:

`const sum = new Field(1).add(new Field(3));`

This can be simplified as:

`const sum = new Field(1).add(3);`

Conditionals (Important !)

Traditional conditional statements are not supported by

SnarkyJS:

```
// this will NOT work
if (foo) {
x.assertEquals(y);
}
```

Instead, use SnarkyJS' built-in Circuit.if() method, which is a ternary operator:

```
const x = Circuit.if(y.equals(Field.zero)), a, b); // behaves like
`foo ? a : b`
```

Common methods

```
let x = new Field(4); // x = 4

x = x.add(3); // x = 7

let hash = Poseidon.hash([x]); // takes array of Fields, returns
Field

x = x.sub(1); // x = 6

let privKey = PrivateKey.random(); // create a private key

x = x.mul(3); // x = 18

let pubKey = PublicKey.fromPrivateKey(privKey); // derive public key

x = x.div(2); // x = 9

let msg = [hash];

x = x.square(); // x = 81

let sig = Signature.create(privKey, msg); // sign a message

x = x.sqrt(); // x = 9

let b = x.equals(8); // b = Bool(false)

b = x.greaterThan(8); // b = Bool(true)

b = b.not().or(b).and(b); // b = Bool(true)

b.toBoolean(); // true

sig.verify(pubKey, msg); // Bool(true)
```

Setup

DEPENDENCIES:

NodeJS 16+ (or 14 using node --experimental-wasm-threads)
NPM 6+
Git 2+
IDE (VS Code recommended)

zkapp-cli

```
npm install -g zkapp-cli

zk project my-proj-name

npm run build && node ./build/src/index.js
```

Useful links for snarkyJS

Crowdcast

Resource Kit