Blockstream

Building the blockchain ecosystem

Blockchain Techlab

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Part 1: Blockchain

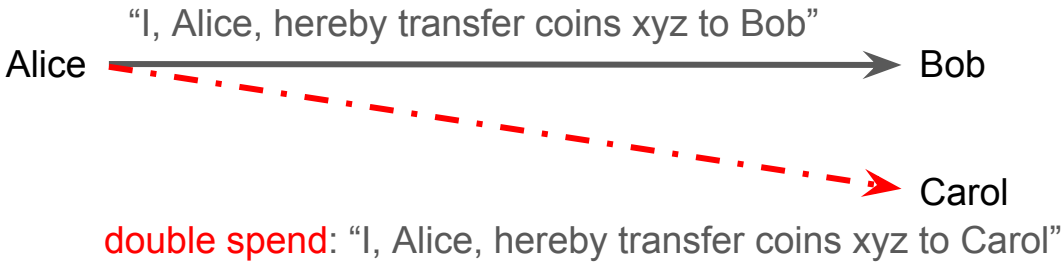
Peer-to-Peer Cash

- Ideal: Internet money without central control and anonymous

```
I've been working on a new electronic cash system that's fully
peer-to-peer, with no trusted third party.

[...]

Satoshi Nakamoto

--------------------------------------------------------------------------
The Cryptography Mailing List
```

A toy currency

- Start with arbitrary bits that you call coins from now on
- Use cryptographic signatures to make forging messages impossible



- A central bank could tell which transaction came first.

A toy currency

- Decentralize control: Shared ledger
  - Every participant keeps a record of the transaction history
  - This works as long you know all the participants and trust a majority.
- But in open peer-to-peer systems
  - It is impossible to know all the participants.
  - It is impossible to meaningfully count votes.
- Want: dynamic membership of the participant set

Bitcoin

- Proof of Work: small proof that some amount of computation was done

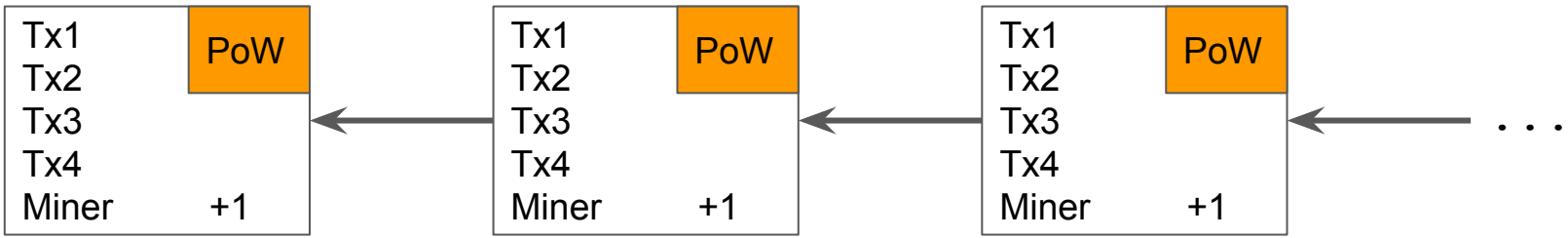
1. Define that the “official” transaction history
    a. is valid
    b. has the most proof of work
2. Providing PoW (mining) to the official history is rewarded with coins

Effect:

1. Consensus on official history.
2. Incentivizes mining on a history. Incentivizes mining on the official history.

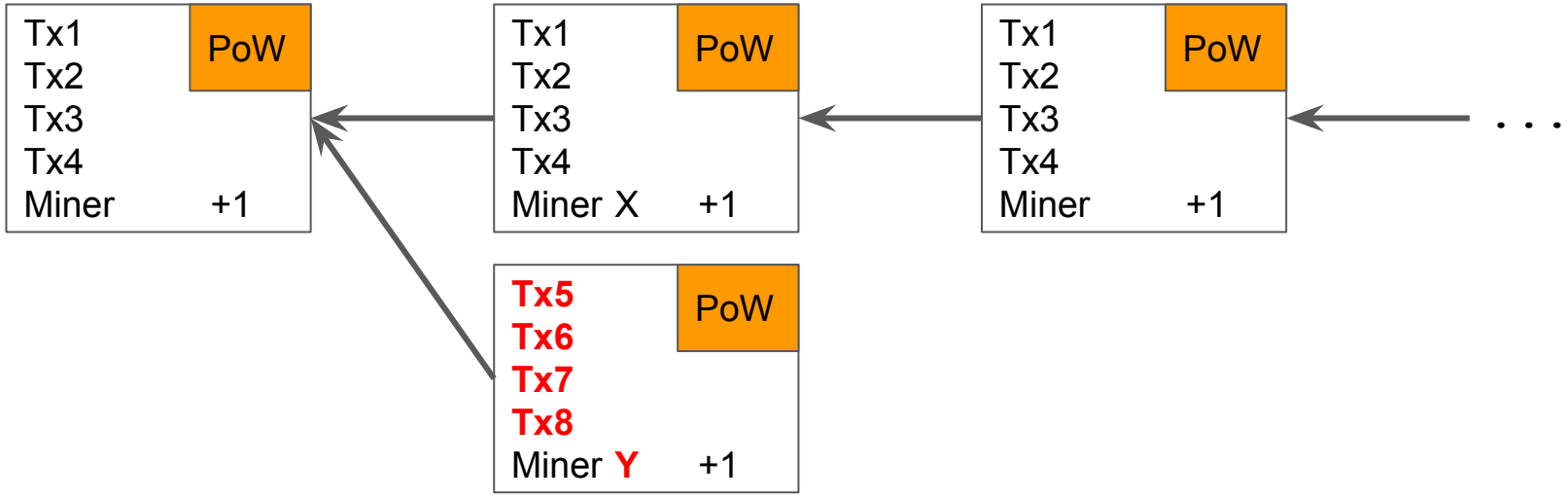
Mining

- History is represented as a chain of blocks.
  - Blocks contain transactions.
- Miners create blocks by collecting transactions.
- And attempt to solve the PoW function.
- Blocks are mined on expectancy every 10 minutes.
- The miner gets a mining reward.



Mining

- Miner attempting to rewrite the history always loses in the long run
  - As long as miner has less than 50% hash rate
- Miners can *not* spend your coins or include invalid transactions
  - f.e. A tx that send more coins than the attacker has available.



Blockchain technology

- 2 years ago: An application that uses Bitcoin in some way
- Now: **Consensus** on shared **state** with **immutable** rules in a **distributed** environment with potentially **dishonest** nodes.
- Goal: Reduce trust or expensive processes
- Can enable interactions that were previously impossible.

Workshop setup

- You start the alpha daemon
  - This is our Bitcoin fork that adds some features.
  - If not otherwise stated all functions we are going to look at apply to Bitcoin as well.
- You communicate to alphad with alpha-cli
- alphad connects you to a private altcoin network
- I mine blocks and I have all the coins.
- Further instructions: https://jonasnick.github.io/workshop/tutorial-part-1.html

Part 2: Transactions

Transactions

- Balance-based vs. UTXOs
- Balance-based (f.e. Ethereum)

Ledger state

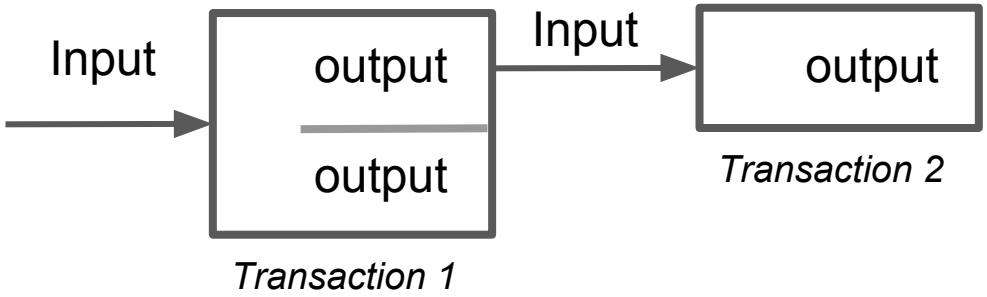
Alice	2
Bob	0

  - Transaction: Alice 1 coin ⟶ Bob

New ledger state

Alice	1
Bob	1

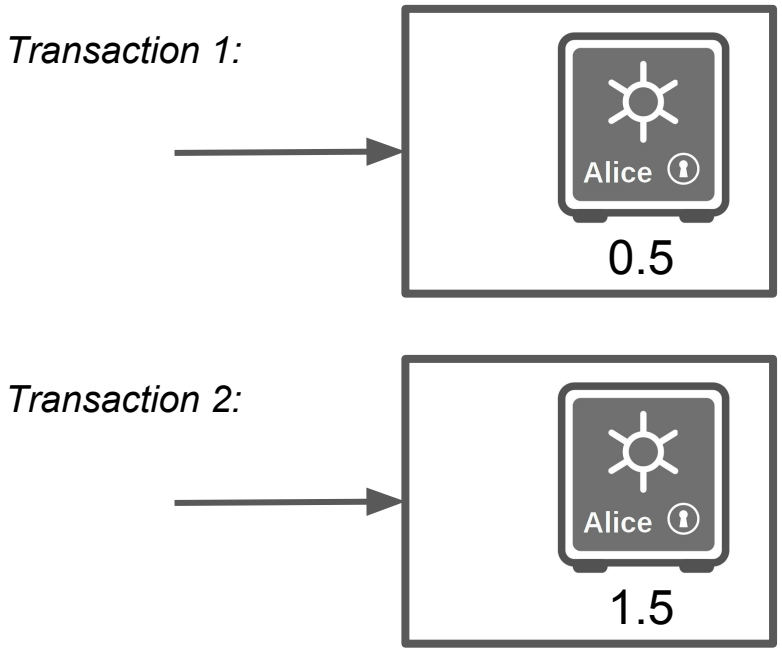
Transactions Inputs & Outputs



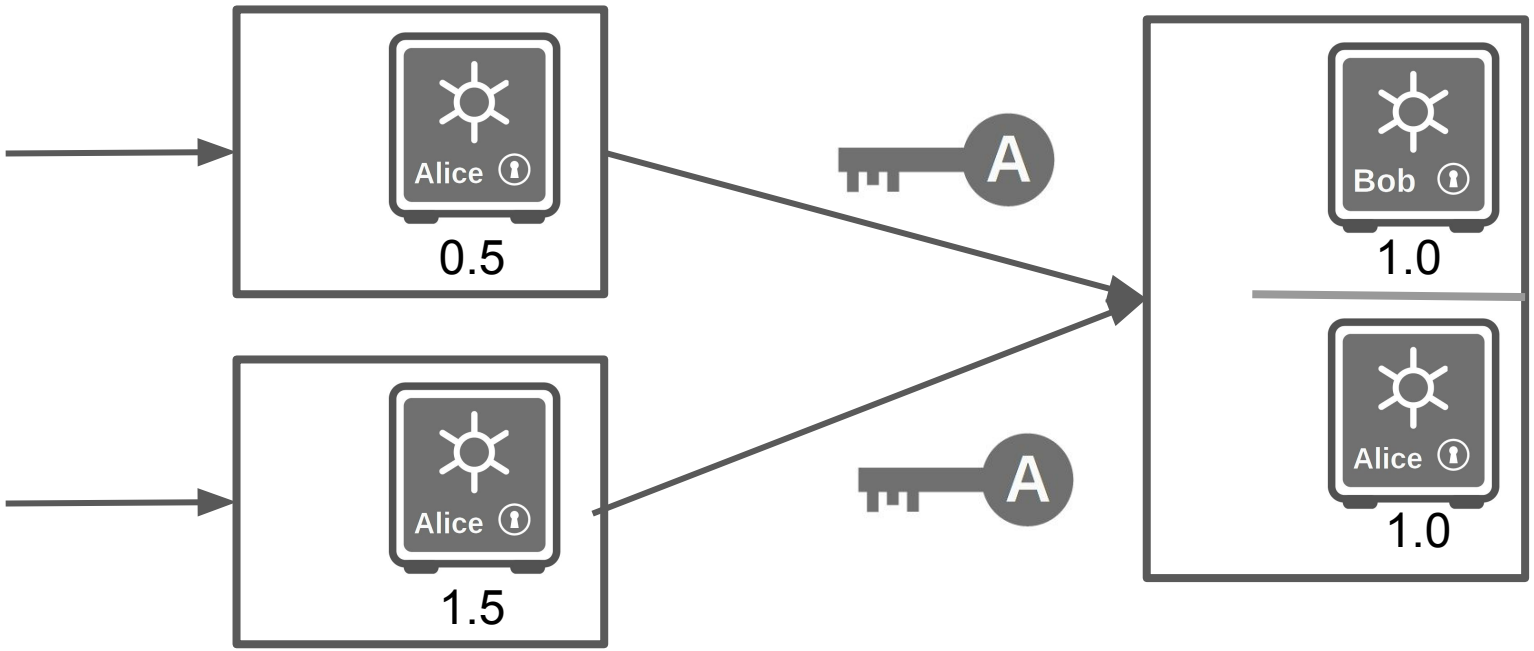
Transaction output: tuple of recipient and value
input: tuple of txid, vout and signature

Unspent Transaction Outputs (UTXOs)

- Alice owns 2 coins = Alice can spend transaction outputs whose values sum to 2

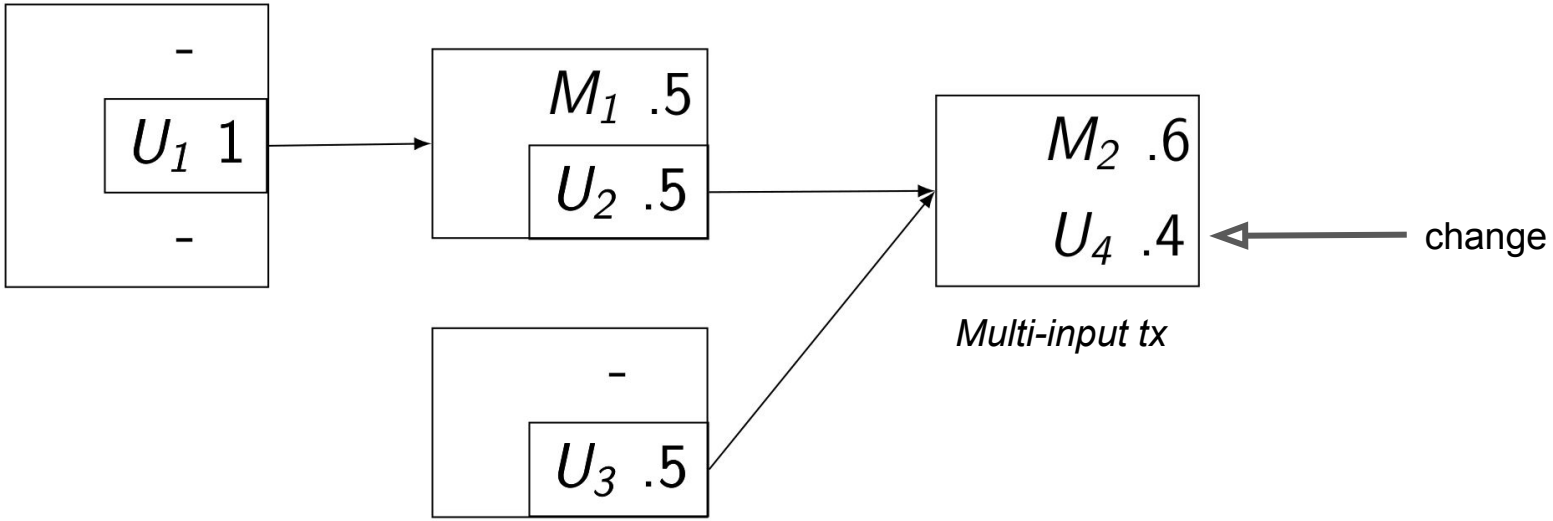


Spending Outputs



A Transaction Graph

User U with addresses `U_i`, Merchant M with addresses `M_i`



getrawtransaction <txid>

```
{
    "fee" : <fee>
    "vin" : [{
            "txid" : "<txid>",
            "vout" : <output_index>,
            "scriptSig" : {
                "asm" : "<scriptSig>",
             }
    }]
    "vout" : [{
            "value" <value>,
             "scriptPubKey" : {
                  "asm" : "<scriptPubKey>",
             }
    }]
}
```

Elements feature: Confidential Transactions (CT)

Tx verification: `input_value = output_value + fee`

Verification with CT: `Enc(input_value) = Enc(output_value) + fee`

`elements_address = bitcoin_address + blinding_pubKey`

Without corresponding blinding private key, values are hidden (blinded).

Auditors can import private blinding key

-> Exercise https://jonasnick.github.io/workshop/tutorial-part-2.html

Part 3: Script

Cryptography Basics

- Cryptographic hash functions
  - hash: `{0,1}* -> {0,1}^n`
  - Example: `sha1("foo") = f1d2d2f924e986ac86fdf7b36c94bcdf32beec15`
  - collision resistant
- Public key cryptography
  - key pair: secret key `sk` and public key `pk`
  - cryptographic signature over message m
    - `sign(message, sk) -> sig`
    - `verify(message, pk, sig) -> {0, 1}`
  - Nobody can create a `sig` for a `pk` without the `sk`.

Script Evaluation: Pay-to-pubkey (P2PK)

= Bitcoin script `<pubKey> OP_CHECKSIG`

= Bitcoin script `<sig>`

+

= `<sig> <pubKey> OP_CHECKSIG`

= `true`

Pay-to-pubkey-hash (P2PKH)

scriptPubKey: `OP_DUP OP_HASH160 <pubKeyHash> OP_EQUALVERIFY OP_CHECKSIG`

scriptSig: `<sig> <pubKey>`

Stack	Script
	`<sig> <pubKey> OP_DUP OP_HASH160 <pubKeyHash> OP_EQUALVERIFY OP_CHECKSIG`
`<sig> <pubKey>`	`OP_DUP OP_HASH160 <pubKeyHash> OP_EQUALVERIFY OP_CHECKSIG`
`<sig> <pubKey> <pubKeyHash>`	`<pubKeyHash> OP_EQUALVERIFY OP_CHECKSIG`
`<sig> <pubKey>`	`OP_CHECKSIG`

P2SH

https://github.com/bitcoin/bips/blob/master/bip-0016.mediawiki

Multisig

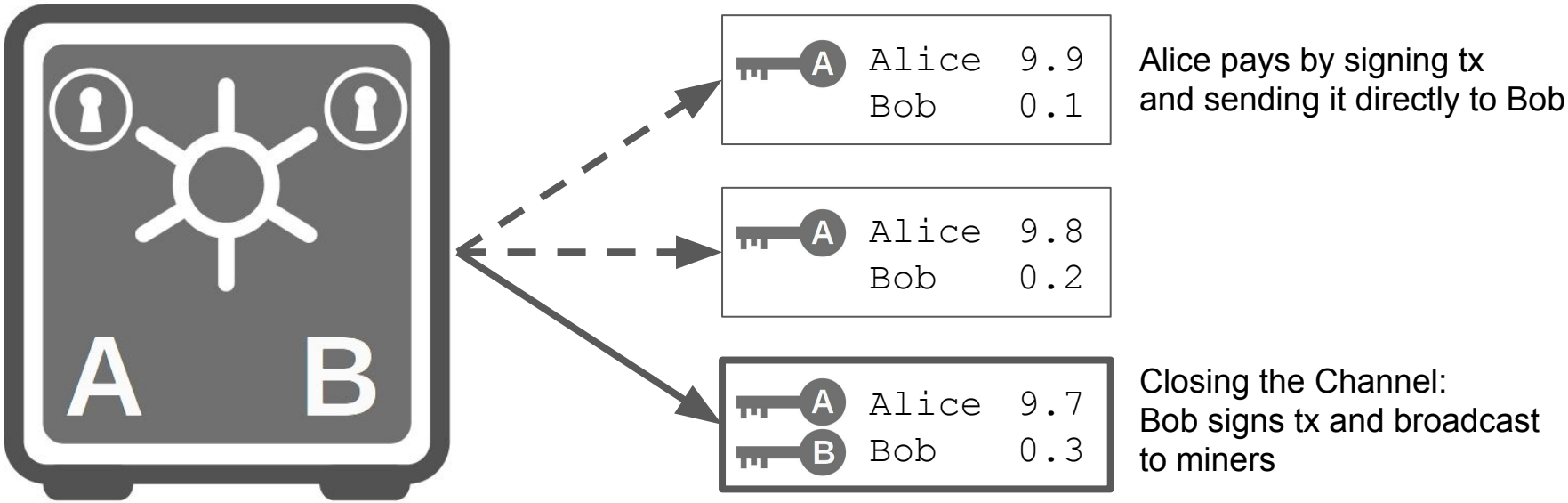
2 of 3 Multisig Output

Use cases: Wallet security, Escrow, Micropayment Channels

scriptPubKey: `<m> <pubKey_1> … <pubKey_n> <n> OP_CHECKMULTISIG`
scriptSig: `<sig_1> … <sig_m>`

Micropayment Channels

Setup: Alice creates transaction with 10 bitcoin to a 2-of-2 multisig with Bob



Micropayment Channel

- Problem: If Bob vanishes, Alice's coins are lost
- CheckLockTimeVerify
  - `12345 OP_CLTV`
  - script evaluation fails if blockchain < 12345 blocks
- Idea: After some time, Alice gets refund
- -> Exercise https://jonasnick.github.io/workshop/tutorial-part-3.html

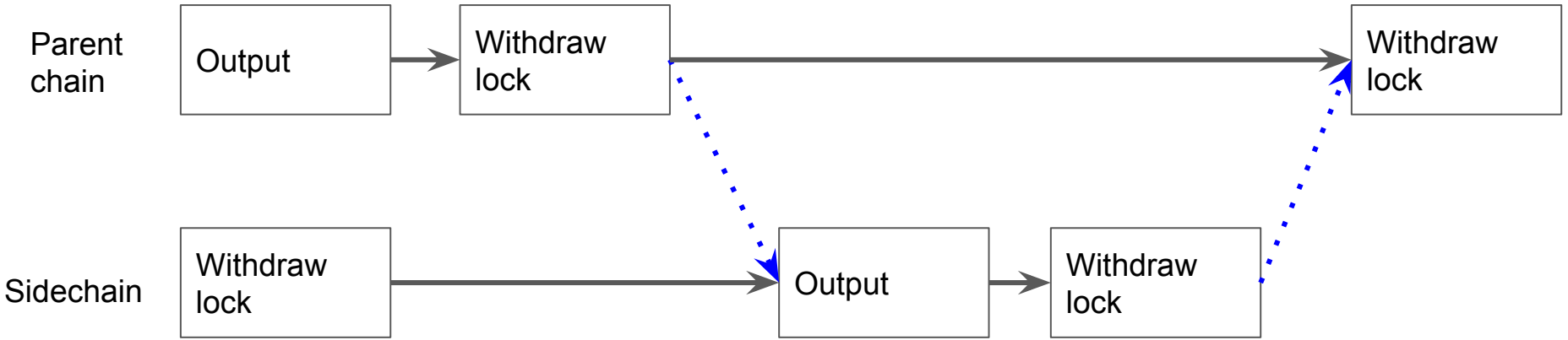
Part 4: Sidechains

Sidechains

- Observations
  a. There is no single blockchain that meets all requirements.
  b. Blockchains make different trade offs.
  c. New blockchain rules need consensus, slow process.
  d. Creating new blockchains from scratch is a huge challenge
     - Network effect, security
- Interoperability
  a. Pass information from chain to chain in a trustless and automated way.
  b. Leverage security from a different chain.
  c. Common API.

Sidechains

- Use case: Add features to Bitcoin



Two-way peg

- Minimizes additional trust over Bitcoin’s model
- Requires
  - Miner software upgrade
  - Softforking a new opcode into Bitcoin

Federated Peg

- Set of mutually distrusting functionaries
- Enforce the rules that Bitcoin is currently unable to.
- Uses m-of-n multisig instead of PoW.
- Auditable
- Allows creation of interoperable private chains.

Elements

https://elementsproject.org / https://github.com/elementsproject/elements

- Bitcoin Core code fork
- Uses federated peg
  - our public chain pegged to Bitcoin testnet
- Alpha released, Beta soon

Elements

https://elementsproject.org / https://github.com/elementsproject/elements

- Features
  - Confidential Transactions (CT)
  - More opcodes (`OP_CSV, OP_CAT, ...`)
  - Segregated witness
  - Federated peg
  - Block signing
  - Schnorr signatures
  - Soon:
    - Asset Issuance
  - In progress:
    - Full two-way peg
    - More powerful scripting system
    - More privacy
    - Better scalability

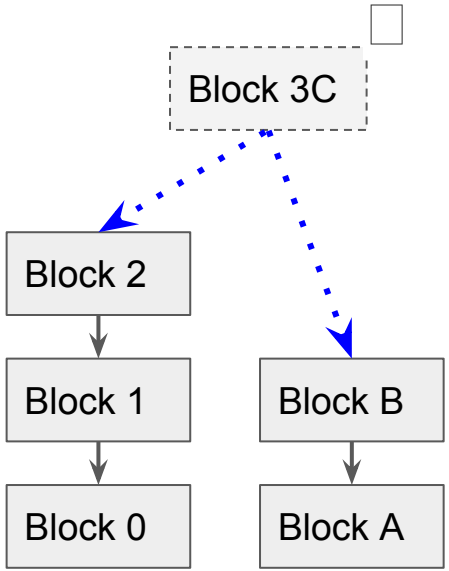
Liquid

https://elementsproject.org/sidechains/liquid/

- Production Bitcoin sidechain
- Based on elements
- Key feature: Improves interchange settlement lag (ISL)
  - Because Liquid uses federated Peg: improves latency, throughput
- + Elements features (CT)
- Primarily for Bitcoin exchanges, payment processors, traders
- Launch in summer 2016

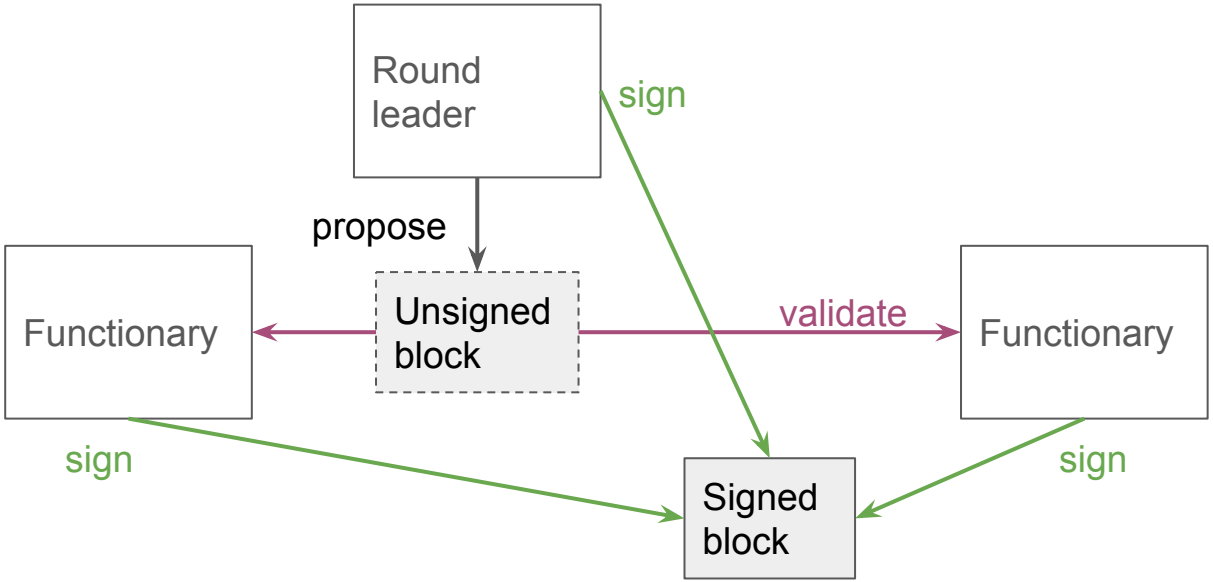
Block creation in sidechains

- Option: Leverage Bitcoin security with merged mining
  - Merged mined sidechain blocks are also valid bitcoin blocks.
  - When miner solves PoW for the block, work is sufficient for sidechain, parent chain or both.
  - Allows mining (securing) multiple chains at once instead of dividing work.
  - Miners collect transaction fee on the merge-mined chain
  - Requires miner software upgrade



Block creation in sidechains

- Option: Block signing
  - Valid blocks do not require PoW, but m-of-n multisignatures instead.
  - Separate software and network responsible for creating blocks.



New Hands-on Setup

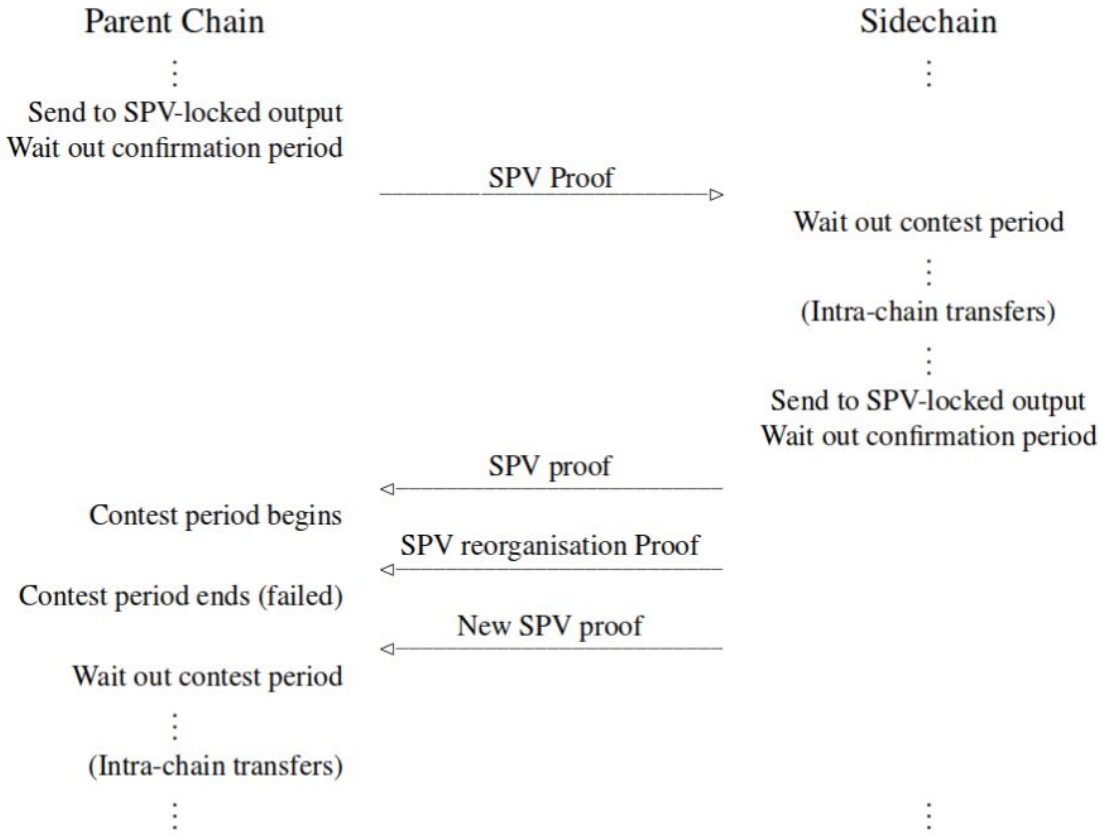
- Create own sidechain that uses block signing and federated peg.
  - Feature: 2MB blocks
- You are only user of your chain (initially).
- No coins without peg-in.

Part 5: Peg mechanisms

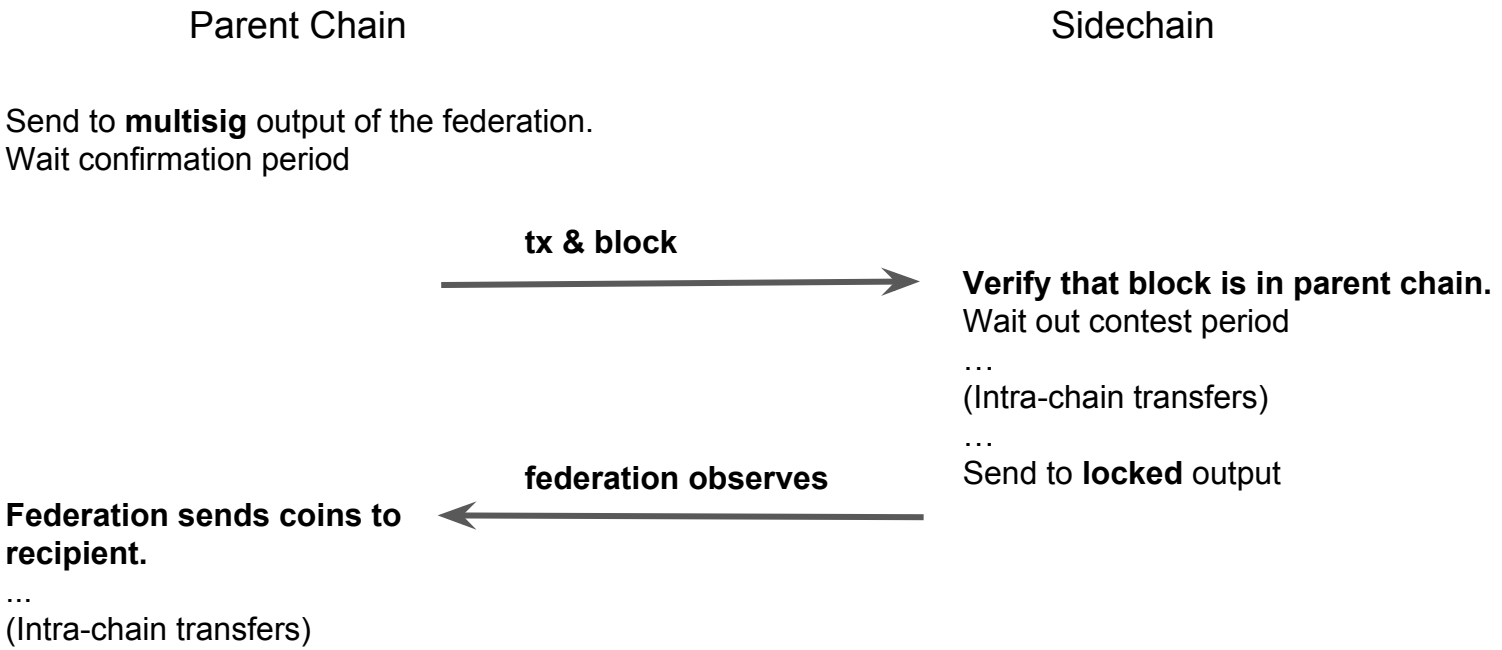
SPV Proof

- Small Proof “There is x work on top of block y in chain z”.
- Verifier can’t check validity of the block
  - But in the long run can always distinguish between majority chain and attacker chain.
- Usually accompanied by Merkle proof that tx is in block.
- Is used in lightweight wallets.
- Is used in two-way peg.
  - Proof that a lock transaction took place.
  - Pegged chains should not be required to validate each other’s rules.

Two-way peg

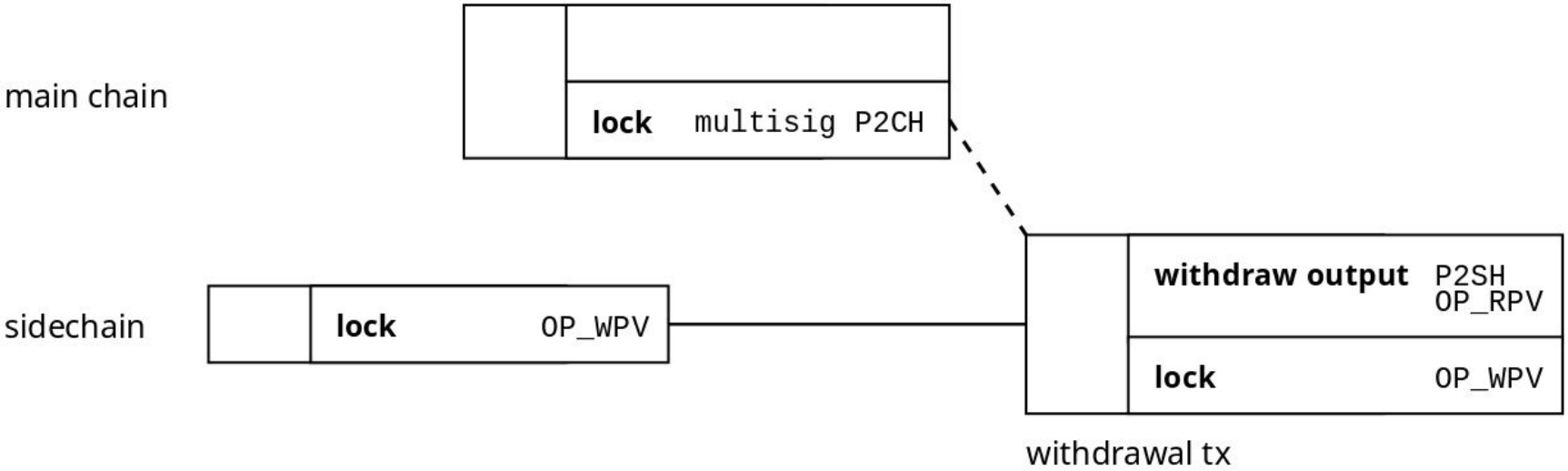

Parent Chain
Sidechain
Send to SPV-locked output
Wait out confirmation period
SPV Proof
Wait out contest period
(Intra-chain transfers)
Send to SPV-locked output
Wait out confirmation period
SPV proof
Contest period begins
SPV reorganisation Proof
Contest period ends (failed)
New SPV proof
Wait out contest period
(Intra-chain transfers)

Federated peg

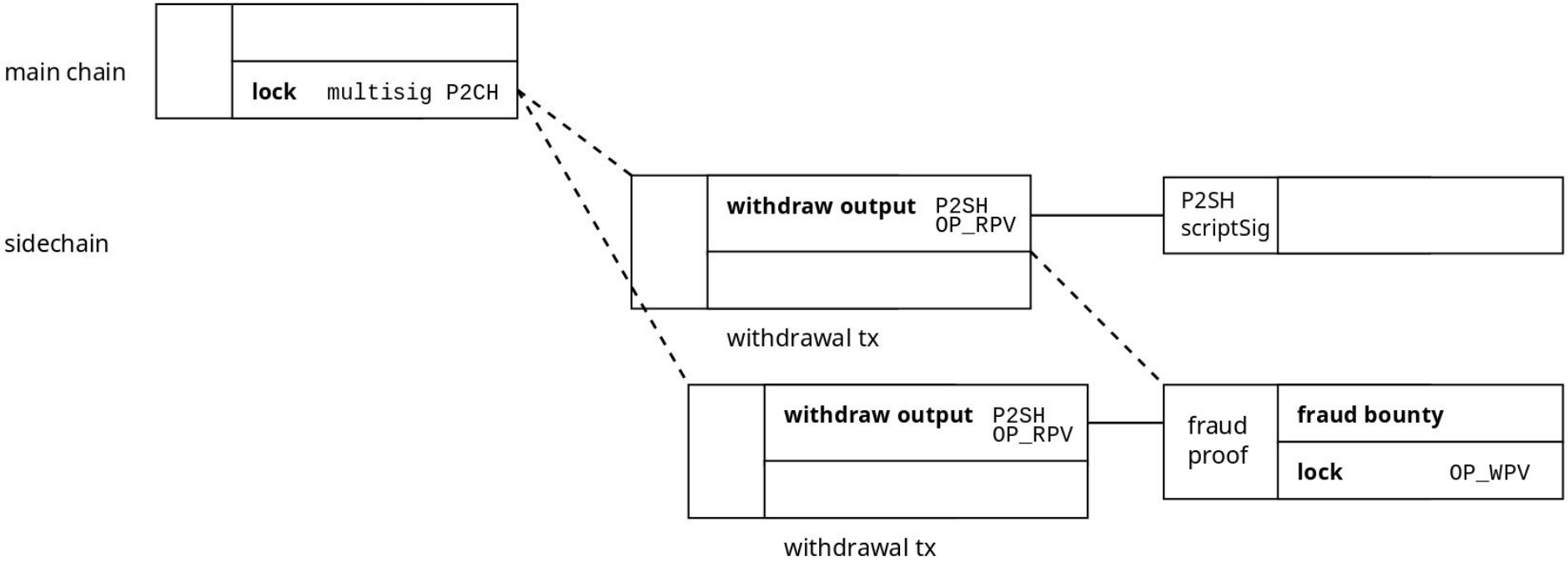


Peg in Elements Alpha

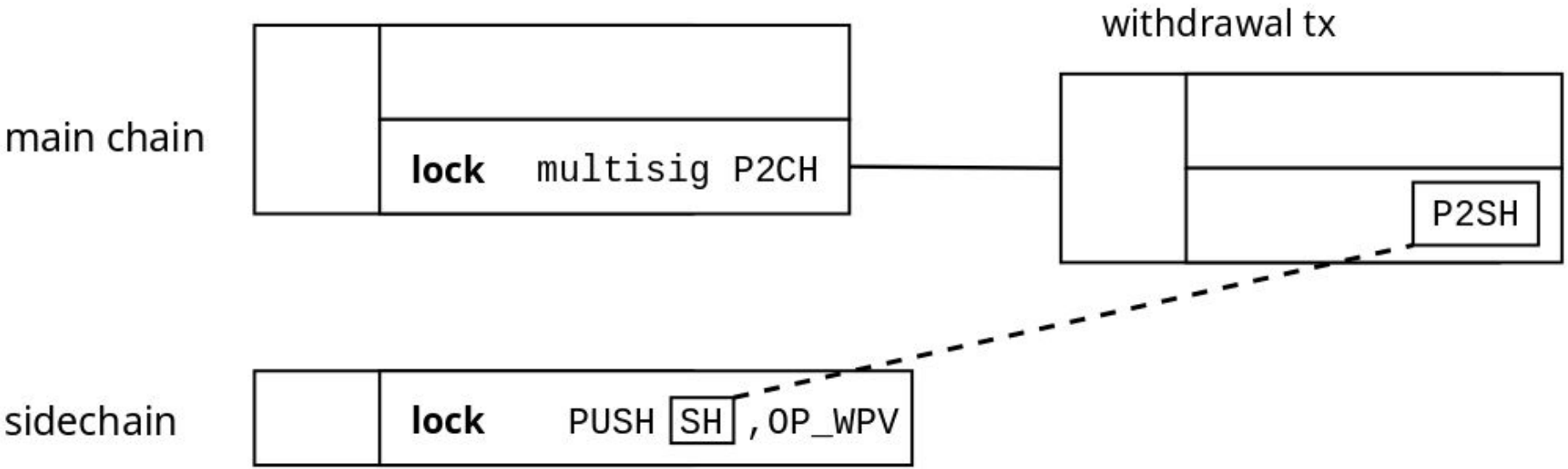
- Genesis block:
  - 21 million coins, OP_WITHDRAWPROOFVERIFY (OP_WPV) locked
  - OP_WPV is special, must be spent by tx with withdraw output and relock
  - Withdraw output: `OP_IF … OP_RPV OP_ELSE 144 OP_CSV P2SH OP_ENDIF`



Fraud Proofs



Peg-out in Elements Alpha

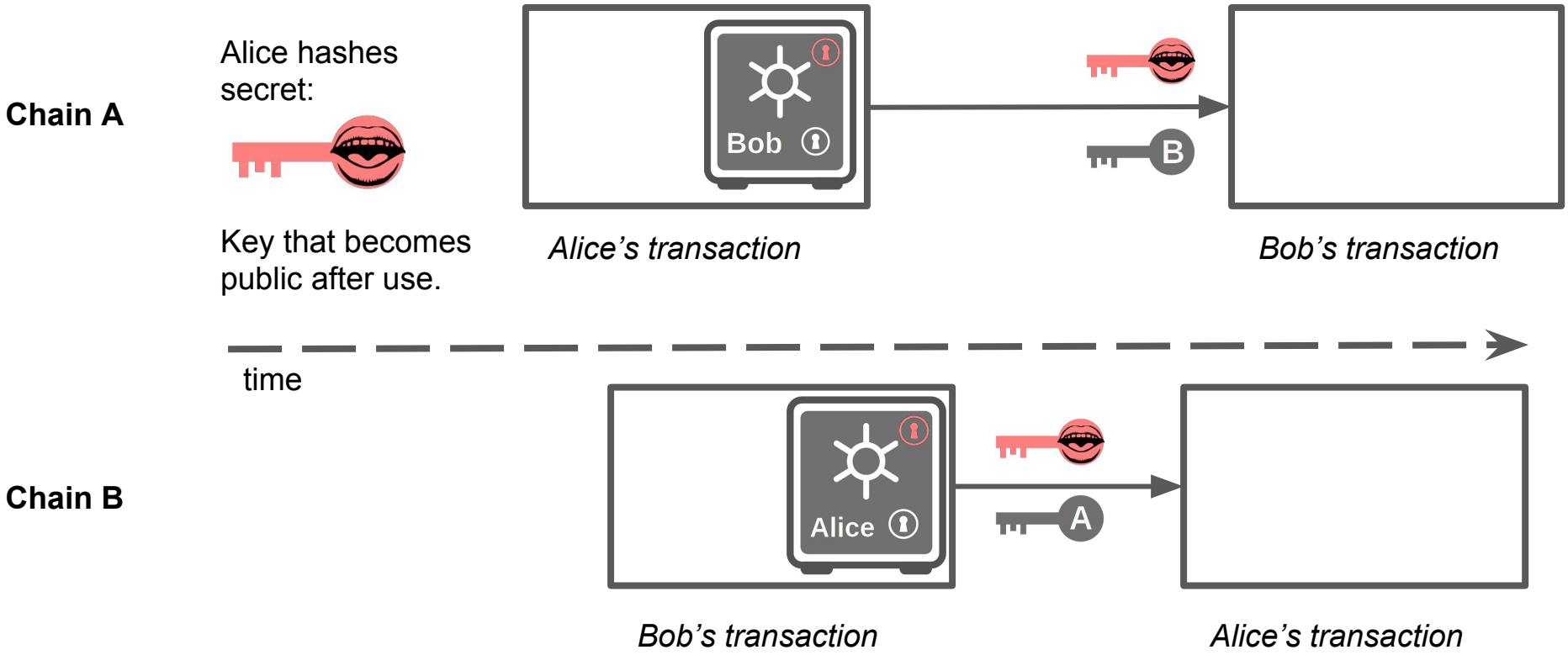


Withdrawwatcher

- Members of the federation run withdrawwatcher program
  - Separate network
- Identifies outputs on the parent chain
- Watches sidechain for withdraw transactions.
- Round leader proposes parent chain transaction.
- Functionaries validate tx, sign and collect signatures.
- Broadcast to the network if enough signatures.

Atomic Cross Chain Swap (ACCS)

Alice (Chain A) swaps coins with Bob (Chain B) relatively quickly and without requiring trust. Simplified.



Conclusion

- Bitcoin is a versatile platform for blockchain apps.
- Elements Project adds state of the art features and can be starting point for custom blockchains.
- Sidechains will power production applications by summer.
- A lot of research and innovation is happening in this space.