Bitcoin's Moving Parts

- Coins
- Digital signatures
- Chain of blocks
- Proof of work
- Censorship resistance
- Anatomy of a Transaction

The Problem

Alice emails Bob: "I give you 2 BTC"

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1. Why is it worth anything?
2. What did Bob get that Alice gave up?

Coins

- Alice has two 1.5 BTC coins[1]
- Alice emails Bob:

  I spend my coins, and create:
  - 2 BTC coin for Bob; and
  - 1 BTC coin for Alice

[1] UTXO: Unspent Transaction (tx) Output

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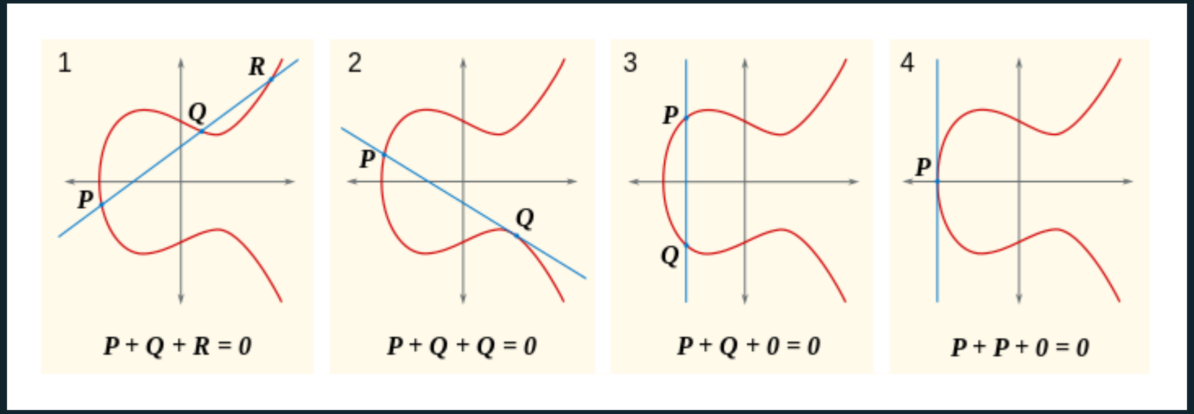
3. How does Alice prove she owned the coin?

Digital signatures

- Private key: big random number
- Public key: point on curve[2]



- private key can encrypt or sign message

[2] secp256k1

Digital signatures

- Coin is signed message: "Only Alice can spend me" [3]
- Who's Alice?
- Bitcoin address derived from public key [4]
- Alice is whoever can reveal public key and sign a message with private key

[3] The new coins say "Only Bob can spend me" and the change says "Only Alice can spend me".

[4] Q&A tip: why not just use the public key as a Bitcoin address?

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4. What if Alice sends Carol the same coins?

The Blockchain

A Blockchain is a chain of blocks

— Peter Todd

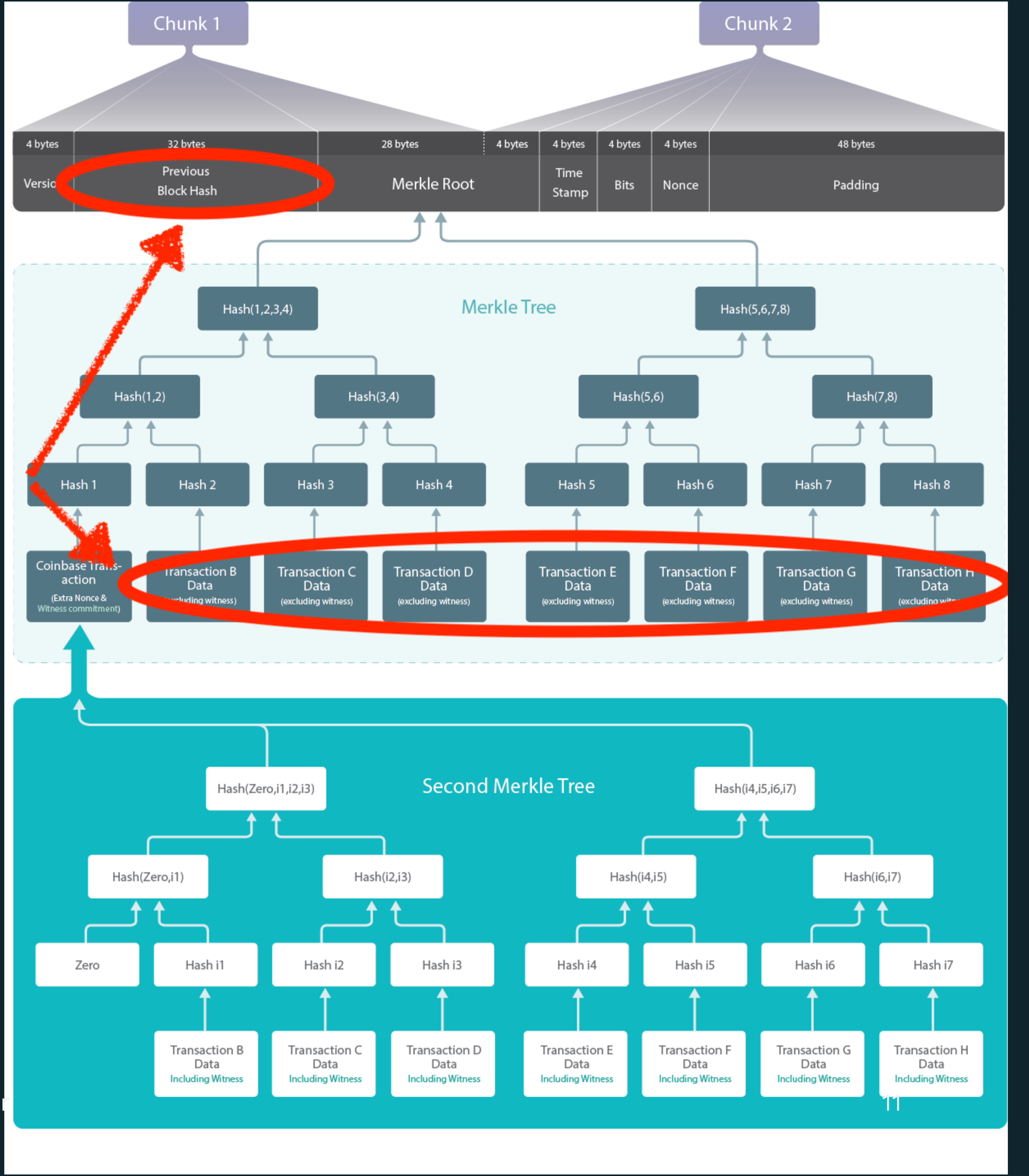
A Blockchain is a database with virtue

— Chris DeRose

The Blockchain

Things we care about to solve problem (4):

- Publish all transactions, and in which order
- Ensure everyone can see all transactions


Chunk 1
Chunk 2
4 bytes
32 bytes
28 bytes
4 bytes
4 bytes
4 bytes
4 bytes
48 bytes
Versio
Previous Block Hash
Merkle Root
Time Stamp
Bits
Nonce
Padding
Merkle Tree
Hash(1,2,3,4)
Hash(5,6,7,8)
Hash(1,2)
Hash(3,4)
Hash(5,6)
Hash(7,8)
Hash 1
Hash 2
Hash 3
Hash 4
Hash 5
Hash 6
Hash 7
Hash 8
Coinbase Transaction (Extra Nonce & Witness commitment)
Transaction B Data
Transaction C Data (excluding witness)
Transaction D Data (excluding witness)
Transaction E Data (excluding witness)
Transaction F Data (excluding witness)
Transaction G Data (excluding witness)
Transaction H Data
Second Merkle Tree
Hash(Zero,i1,i2,i3)
Hash(i4,i5,i6,i7)
Hash(Zero,i1)
Hash(i2,i3)
Hash(i4,i5)
Hash(i6,i7)
Zero
Hash i1
Hash i2
Hash i3
Hash i4
Hash i5
Hash i6
Hash i7
Transaction B Data Including Witness
Transaction C Data Including Witness
Transaction D Data Including Witness
Transaction E Data Including Witness
Transaction F Data Including Witness
Transaction G Data Including Witness
Transaction H Data Including Witness

The Problem

Alice publishes: "I give Bob my 2 BTC"

1. Why is it worth anything?
2. What did Bob get that Alice gave up?
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4. What if Alice sends Carol the same coins?
   — it's on the blockchain so everyone can see it
   — what if there's many different blockchains?

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Solution 1: use a regulator

- declare existence of conflicting blockchains fraud
- give regulator(s) access to your database
- add additional crypto magic
- brand it "blockchain inspired technology"

Solution 2: Proof-of-Work

Convince someone to:

— do useless work
— which uniquely commits to transaction data
— in exchange for coins.

Throw dice on a piece of paper with the transaction list.

Extreme Luck?

Proof-of-Work

- `sha("000001 | Alice sends Bob 2 BTC, etc") = 0fed9a90`
- `sha("000002 | Alice sends Bob 2 BTC, etc") = e7c54529`
- `sha("000003 | Alice sends Bob 2 BTC, etc") = 6c48ab21`
- `sha("855453 | Alice sends Bob 2 BTC, etc") = 000005e6`
- N leading zeros -> X kWh * £0.10 -> £... per block [5]
- Miner creates coin out of thin air which Alice & Bob consider valid

[5] Any scarce resource will do, but the simplest known combination with the right properties is electricity + specialized chips + hashing.

The Problem

Alice publishes: "I give Bob my 2 BTC", miner burns electricity to attest this.

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5. What if someone doesn't like Bob?[6]

[6] i.e. wants to stop the transaction

Censorship resistance

- Miners compete, fees offer extra incentive
- P2P: transactions and blocks route around censorship
- Fungability: all transacions (should) look the same
- Lot's of problems left to solve

Anatomy of a Bitcoin Transaction

Alice publishes: "I give Bob my 2 BTC"

- Bob is whoever can reveal public key corresponding to Bob's address and sign a message with private key:

Alice publishes:
OP_DUP OP_HASH160 <Bob's address> OP_EQUALVERIFY OP_CHECKSIG

Bob spends:
<Bob's signature><Bob's pubkey>

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Script stack

- <Bob's signature>
- <Bob's pubkey>
- OP_DUP
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- <Bob's address>
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- OP_CHECKSIG

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Script stack

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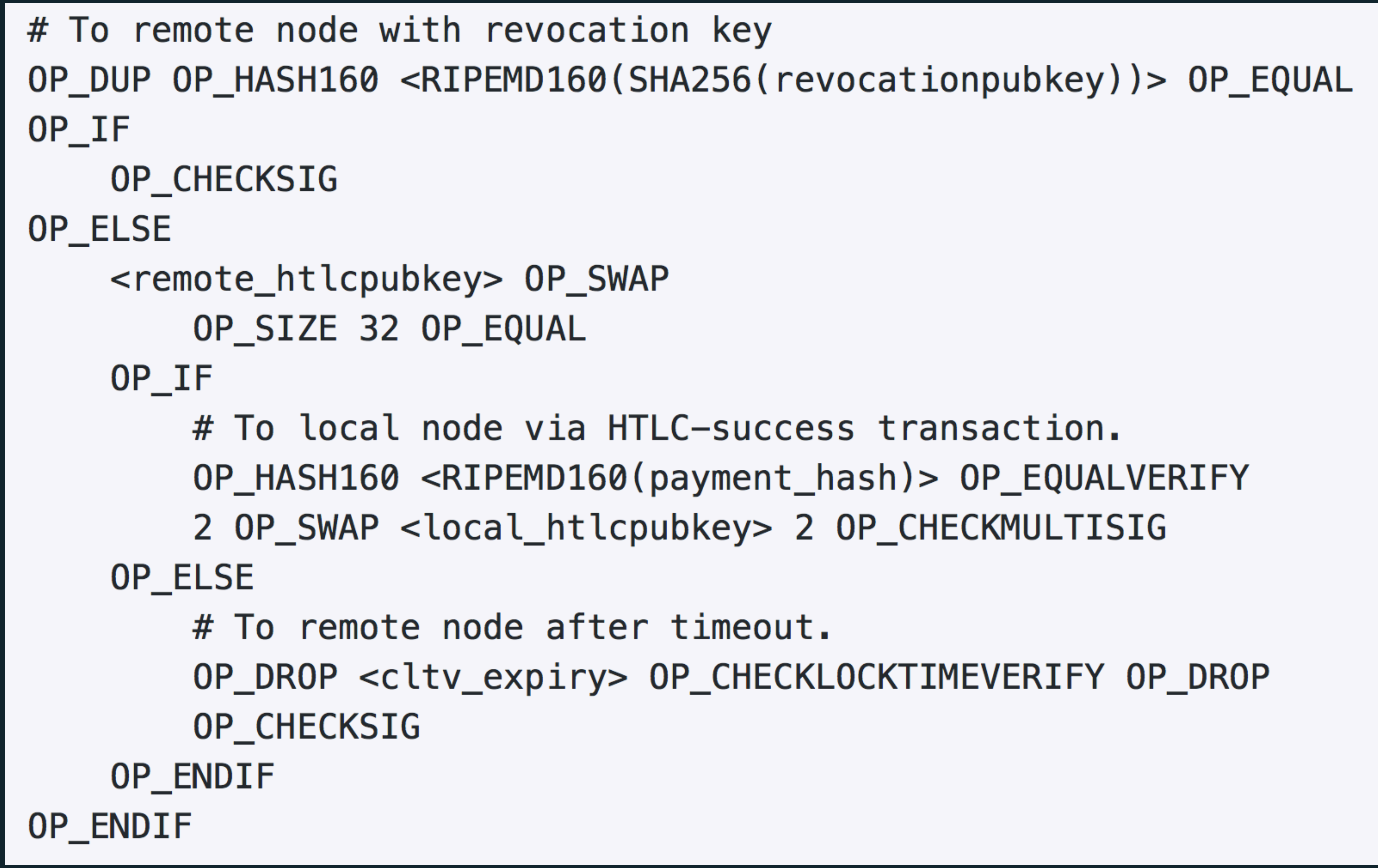
- OP_CHECKSIG

Script stack

— `true`

Other opcodes

- OP_CHECKMULTISIG : N of M sigs
- OP_CHECKLOCKTIMEVERIFY: HODL
- OP_IF / OP_ELSE
- OP_RETURN: 80 bytes spam [8]
- OP_NOP: does nothing (yet!)



```
# To remote node with revocation key
OP_DUP OP_HASH160 <RIPEMD160(SHA256(revocationpubkey))> OP_EQUAL
OP_IF
    OP_CHECKSIG
OP_ELSE
    <remote_htlcpubkey> OP_SWAP
        OP_SIZE 32 OP_EQUAL
    OP_IF
        # To local node via HTLC-success transaction.
        OP_HASH160 <RIPEMD160(payment_hash)> OP_EQUALVERIFY
        2 OP_SWAP <local_htlcpubkey> 2 OP_CHECKMULTISIG
    OP_ELSE
        # To remote node after timeout.
        OP_DROP <cltv_expiry> OP_CHECKLOCKTIMEVERIFY OP_DROP
        OP_CHECKSIG
    OP_ENDIF
OP_ENDIF
```

[8] e.g. Rare Pepe trades: CryptoKitties, but with frogs

Thanks

Slides: slideshare.net/provoost

Blog: medium.com/provoost-on-crypto

PGP:

```
ED9B DF7A D6A5 5E23 2E84  5242 57FF 9BDB CC30 1009
```