Bitter to Better: How to make Bitcoin a Better Currency

Authors: Simon Barber, Xavier Boyen, Elaine Shi, Ersin Uzun

Presentation by Aroon Sharma
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What is Bitcoin?

- P2P online payment system introduced in 2009
- Developed by Satoshi Nakamoto
- Uses many cryptographic techniques to support the protocol

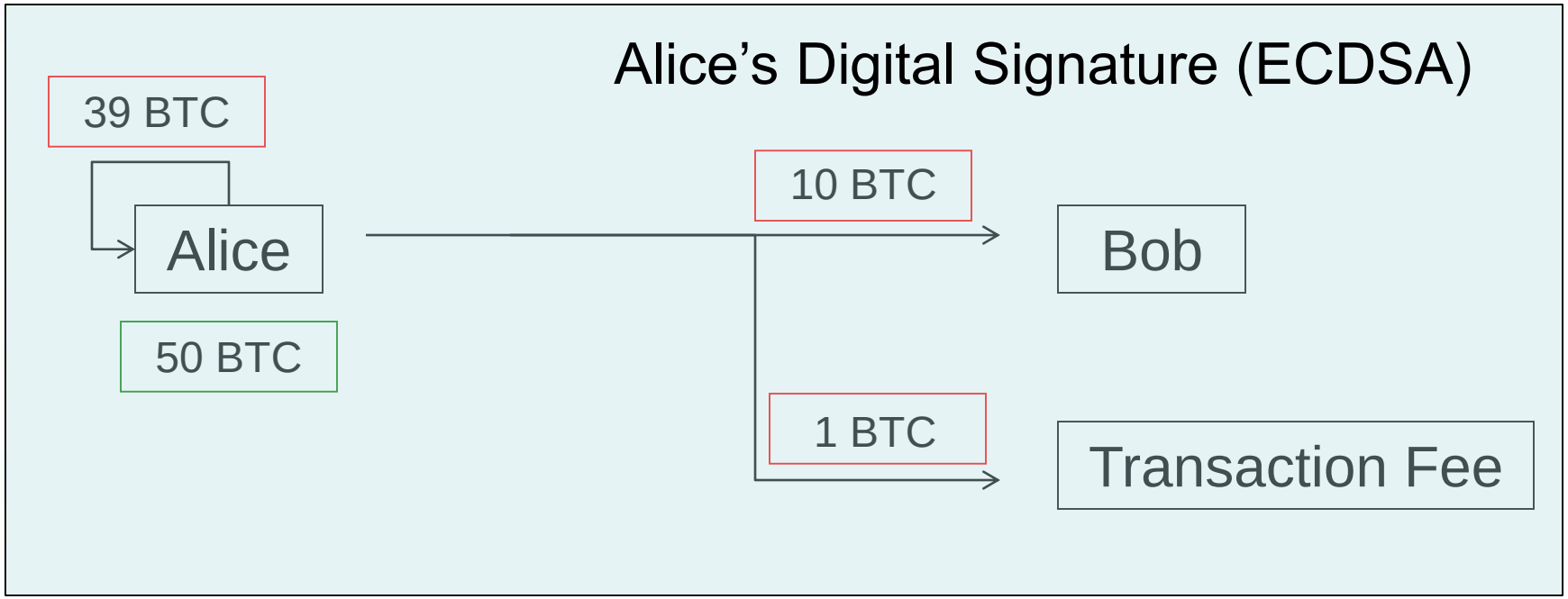
Bitcoin's Appealing Characteristics

- Decentralized
  - No central bank or entity controlling the currency
- Privacy and Anonymity
  - Transactions are difficult to tie to a particular individual
- Currency divisibility
  - 1 satoshi = 0.00000001 BTC
- Transaction irreversibility
  - By construction, transactions become final within 10 minutes

Bitcoin's Appealing Characteristics

- Low transaction fees
  - Fees included at discretion of payer
  - Fees for credit card processing usually total to 2-5%
- Incentives to participate
  - Coinbase transactions
  - Transaction fees
- Open source
  - Anyone with an Internet connection can open up a wallet and start transacting
  - Anyone can modify the client code and protocol

Transaction Example



- Inputs (green)
- Outputs (red)

Broadcast to network

Bitcoin Wallet

- A wallet is a file that contains a series of valid Bitcoin addresses
- Each address can contain its own balance of Bitcoins
- Loss of the Bitcoin wallet results in permanent loss of Bitcoins tied to those addresses!

Bitcoin Wallet

Bitcoin Address

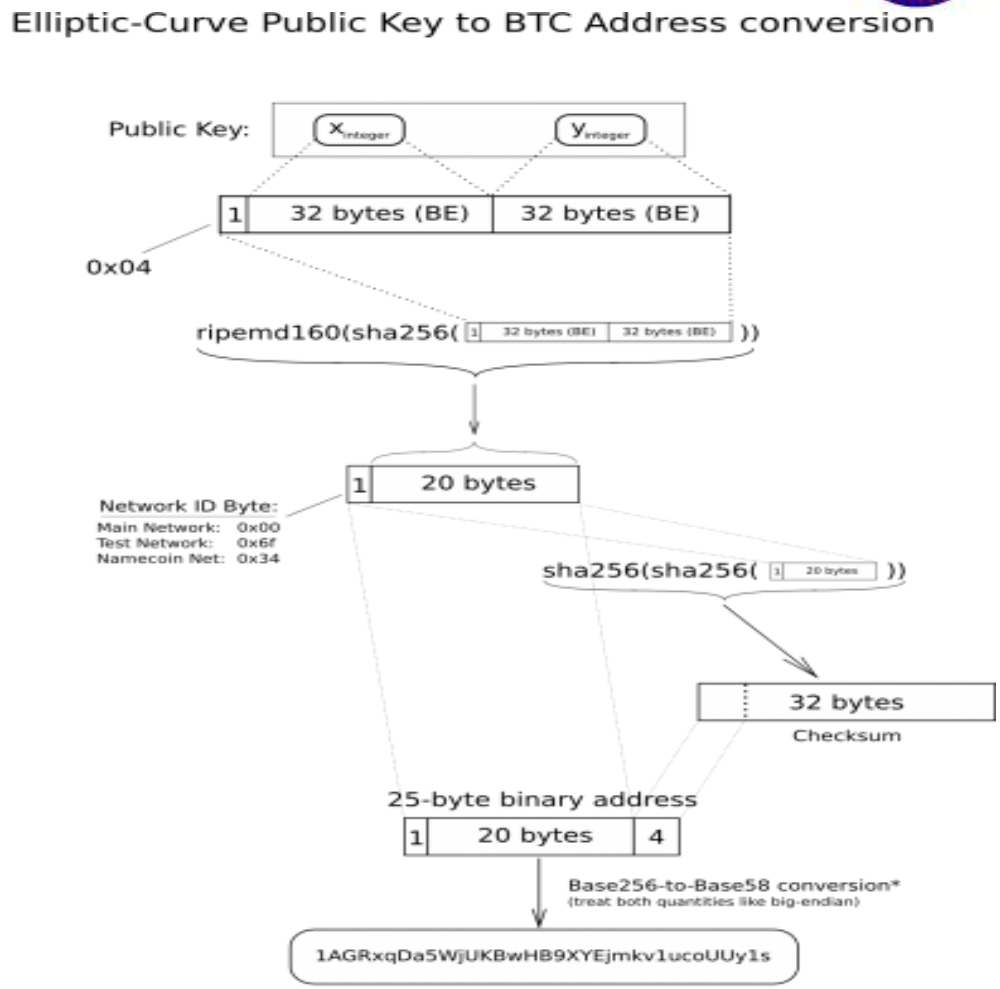
Bitcoin Address Generation

- Bitcoin transactions use Elliptic Curve Digital Signature Algorithm (ECDSA)

- Public and private keys generated per address
  - Private key is signing key
  - Public key is verifying key

- Actual Bitcoin address is a series of hashes of the ECDSA public key

Bitcoin Address Generation



*In a standard base conversion, the 0x00 byte on the left would be irrelevant (like writing '052' instead of just '52'), but in the BTC network the left-most zero chars are carried through the conversion. So for every 0x00 byte on the left end of the binary address, we will attach one '1' character to the Base58 address. This is why main-network addresses all start with '1'

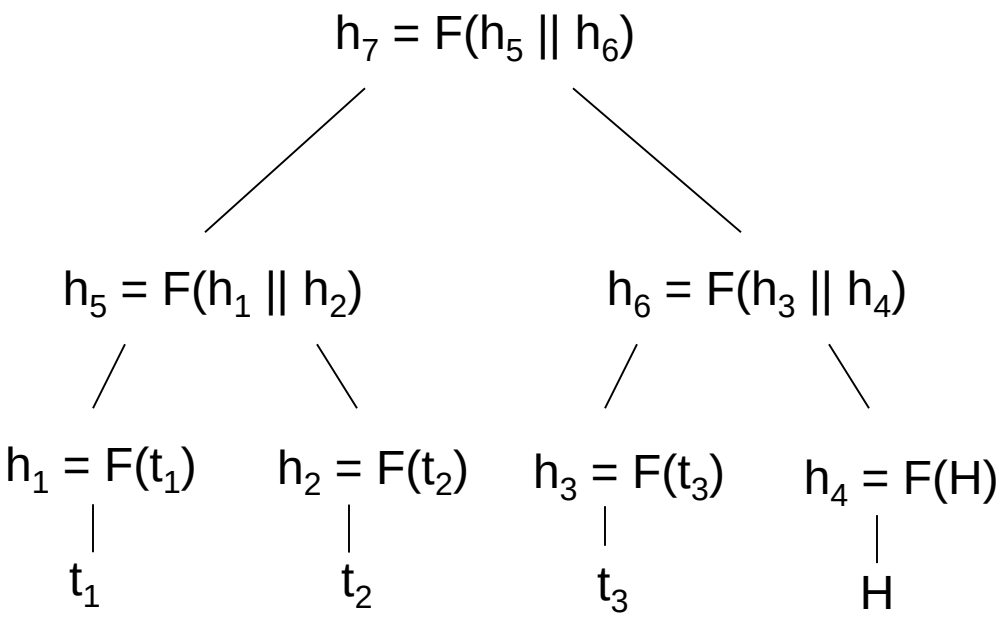
etotheipi@gmail.com / 1Gffm7LKXcNFPrtxy6yF4jBoe5rVka4sn1

Bitcoin Block Chain

- Transactions are grouped together in bundles called *blocks*.
  - Also contains the hash of the previous block
- The collective history of transactions and blocks is known as the *block chain*
- Parameters of the protocol make it so a new block is created every 10 minutes
- Bitcoin miners race to compute a cryptographic hash of the current block
  - Coinbase transactions
  - Transaction fees

Block Details

- Transactions within a block are organized as a Merkle hash tree structure
  - Transactions t1, t2, t3
  - Previous block hash H
  - F(.) = SHA256(SHA256(.)) – double hash



Money Supply

- 21 million Bitcoins to ever be in circulation
  - Deflationary currency
  - Currently about 12.5 million BTC in circulation
  - Expected to reach 21 million BTC by 2140

- How are new Bitcoins created?
  - Coinbase transactions – rewards for miners that correctly create a new block
  - Reward is currently 25 coins per block
  - Reward halves every four years

Transaction verification and mining

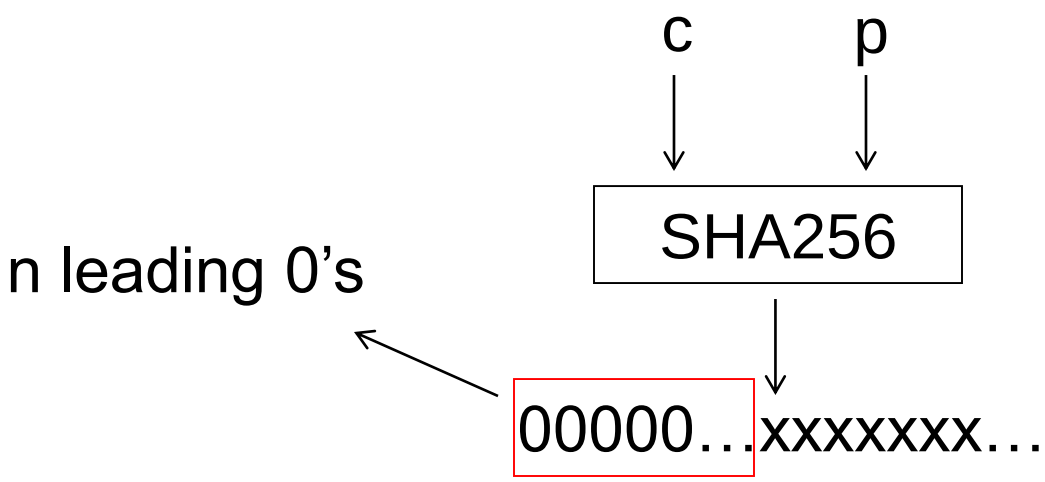
- If there is no central authority, how can the network agree on a single history of transactions?
  - Once a block is confirmed, it is sent out across the network and all transactions within the block are considered final.
  - Other nodes on the network now use this block to extend the chain and produce the next block
  - Protocol works under the assumption that the majority of the nodes and computational power are honest

Transaction verification and mining

- Bitcoin Miner
  - A node on the network that races to compute a new transaction block
  - Solves a cryptographic puzzle based on a proof of work protocol
  - Proof of work protocol's difficulty is adjusted based on the total computational power on the network in order to maintain a new block every 10 minutes

Proof of Work Protocol

- A cryptographic puzzle that takes substantial computational power to solve
- A correct solution to the puzzle can be easily verified
- In Bitcoin
  - Given a challenge string c
  - Produce a proof string p such that the hash of c concatenated with p has n leading 0's.



Proof of Work Protocol

- Why is the protocol set up this way?
  - Answer: The hash function is one-way pseudorandom. The only way to produce the required output is to try many inputs
- The difficulty in solving the puzzle is tuned by n, the number of leading 0's
  - Remember, a block must be solved every 10 minutes
  - Change in difficulty accounts for changes in total computational power on the network

Proof of Work Protocol

- Complicated hardware configurations dedicated solely to mining
- ASICs – Application Specific Integrated Circuits
  - Hardware designs specifically designed to computed hashes at higher throughput and lower power
- Mining Pools
  - Nodes pool their computational power together and share the block reward payouts

Potential Problems with Bitcoin – Loss of Bitcoins

- If a wallet file is lost, all bitcoins associated with that wallet are lost forever
  - Possible solution – generate bitcoin addresses for a wallet using a deterministic pseudo-random generator
  - Only need to store the seed of the generator to retrieve wallet addresses

Potential Problems with Bitcoin – History Revision Attack

- Bitcoin transactions are generally valid once they are added to the block chain
- What happens if two nodes solve the same block simultaneously?
  - The node with the higher computational effort in solving the block wins
- A group of malicious nodes having the majority of the computational power could produce a valid but incorrect transaction history
- It would be accepted if the computational effort to produce the incorrect history exceeded the true branch's effort

Potential Problems with Bitcoin – Quantum Attack

- Bitcoin transactions use ECDSA for signing and verifying
- This signature scheme is vulnerable to Shor's algorithm, a quantum algorithm that can efficiently determine the signing key from the verifying key
- Possible solution: Replace ECDSA with a quantum resistant signature scheme such as NTRU (Nth Degree Truncated Polynomials)