

# BITCOIN AND BLOCKCHAIN

Robin Ye:

*"At this moment, just like in 2000, software development into the Internet age, programmers either continue learning or be weeded out. Now the Internet age is over, welcome to the age of AI and blockchain."*

# WHAT WE ARE GOING TO TALK ABOUT?

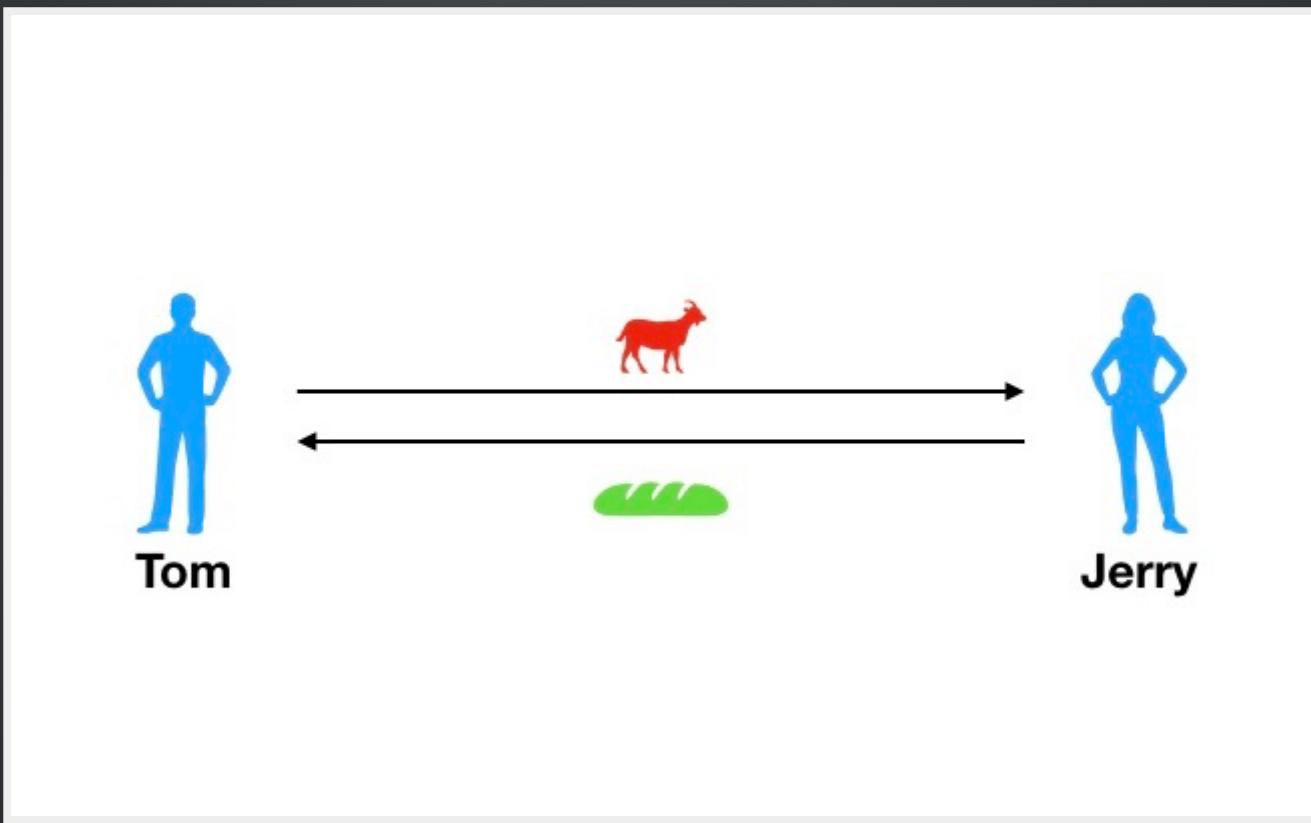
- Evolution of Currency
- What is Bitcoin
- History of Bitcoin
- Transactions
- Blockchain
- Mining and Consensus
- User Security Best Practices

# WHAT WE ARE NOT GOING TO TALK ABOUT?

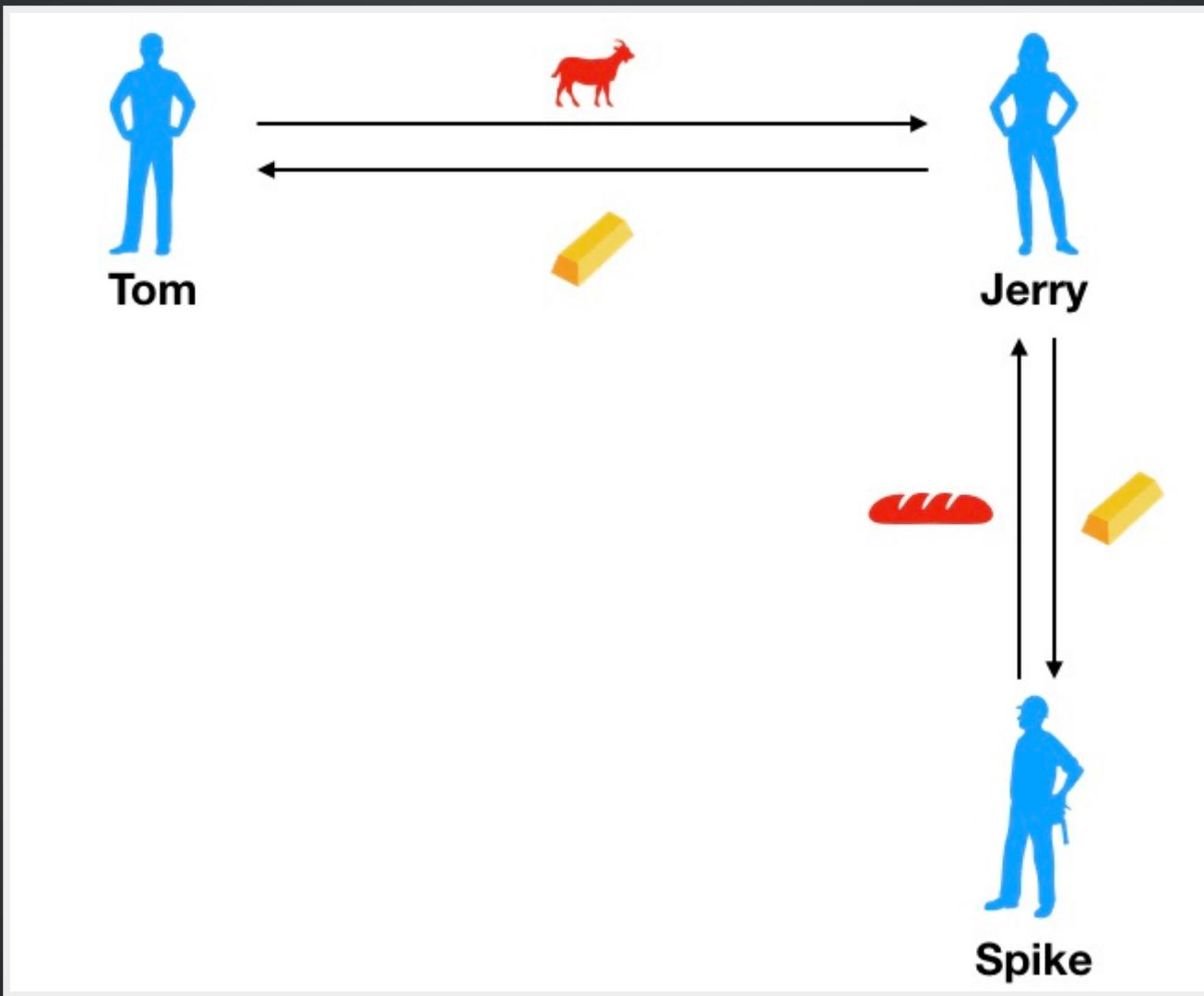
- Alternative Coins
- Ethereum
- Elliptic Curves Cryptography
- Digital Signatures (ECDSA)

# EVOLUTION OF CURRENCY

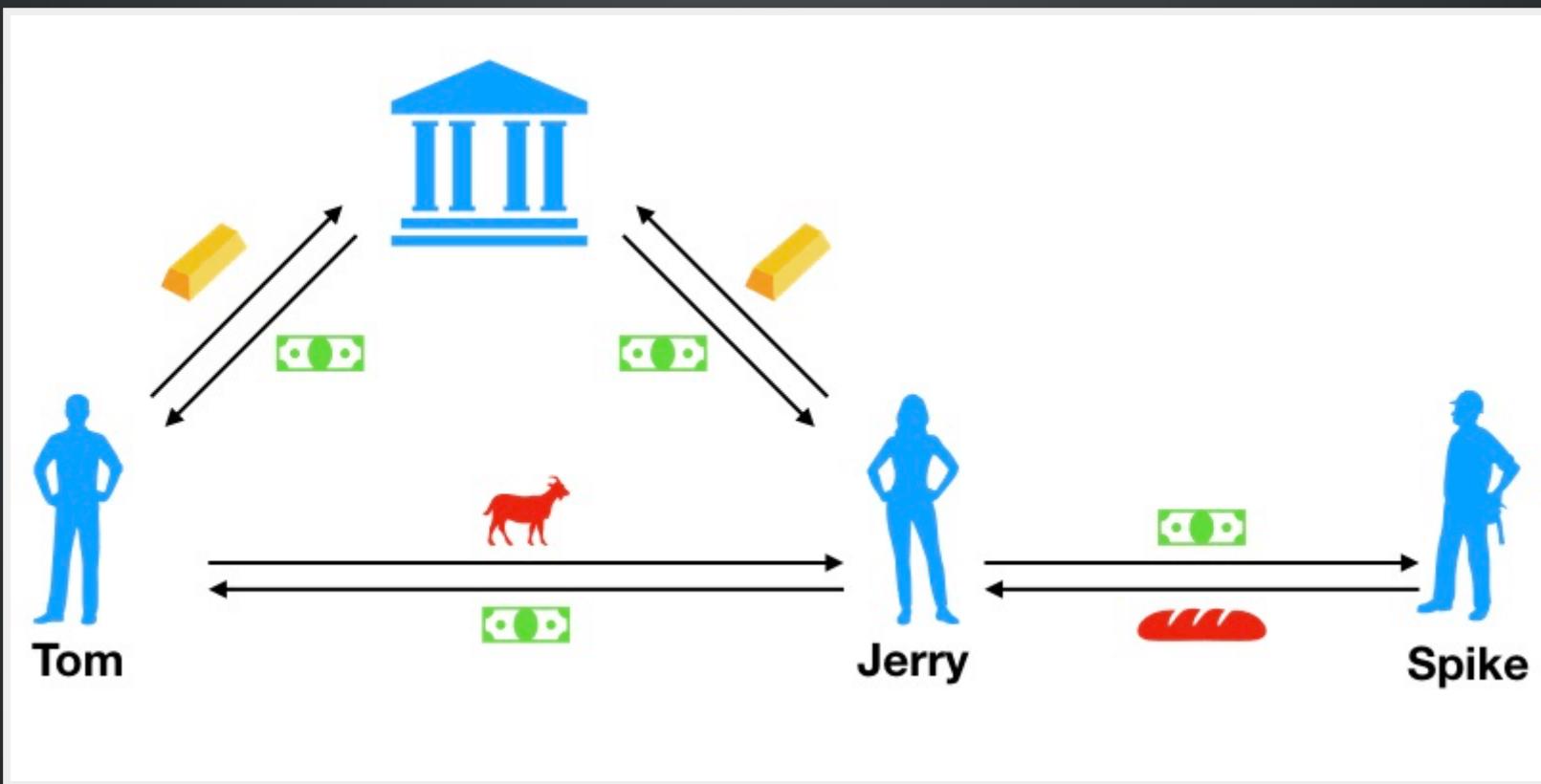
# BARTER ECONOMY



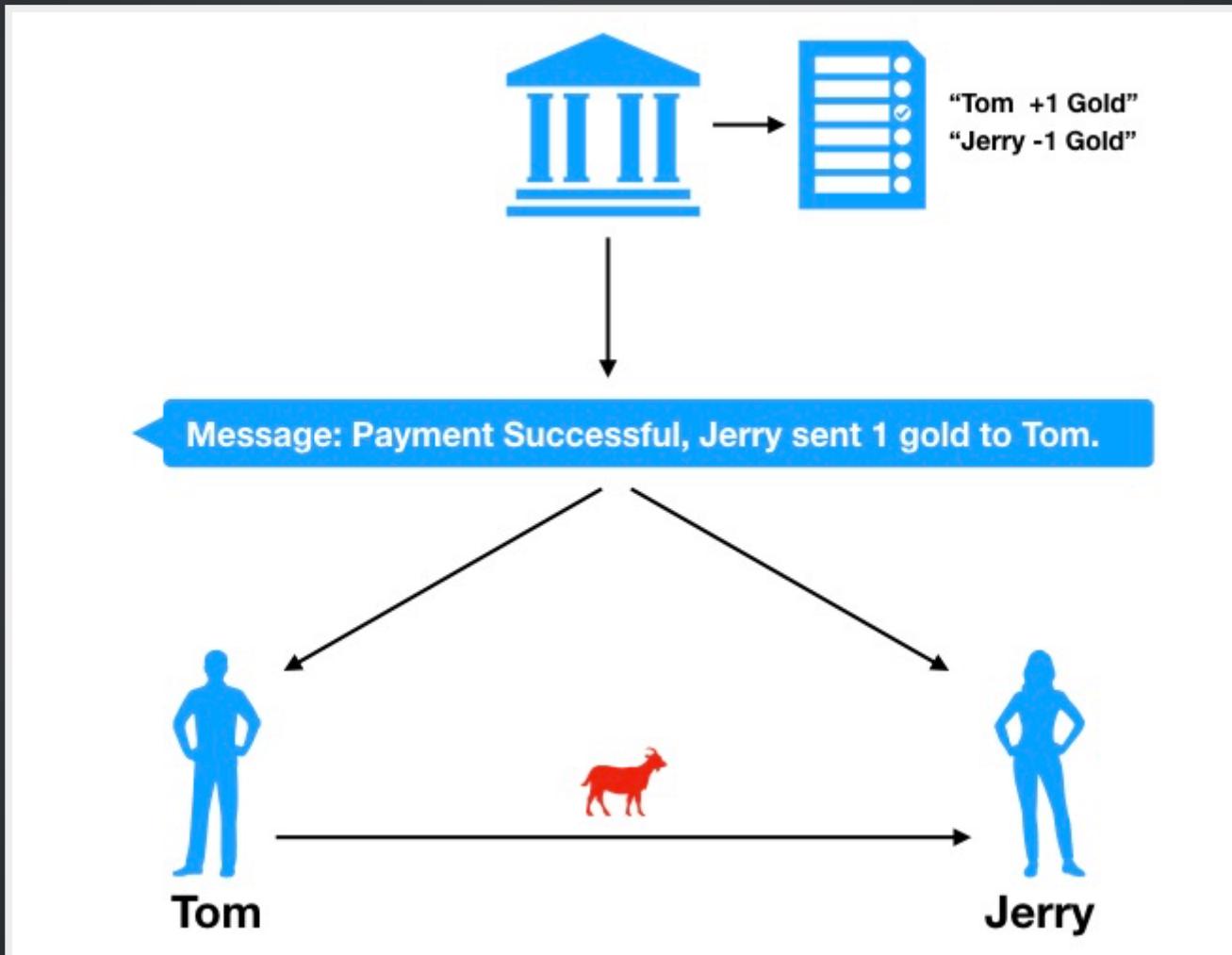
# MATERIAL CURRENCY



# TOKEN MONEY



# CASHLESS SOCIETY



# WHAT IS BITCOIN?

Bitcoin consists of:

- A decentralized P2P network (the bitcoin protocol)
- A public transaction ledger (the blockchain)
- A set of rules for independent transaction validation and currency issuance (consensus rules)
- A mechanism for reaching global decentralized consensus on the valid blockchain (Proof-of-Work algorithm)

# HISTORY OF BITCOIN

- Bitcoin was invented in 2008 with the publication of a paper titled "[Bitcoin: A Peer-to-Peer Electronic Cash System](#)" written under the alias of Satoshi Nakamoto

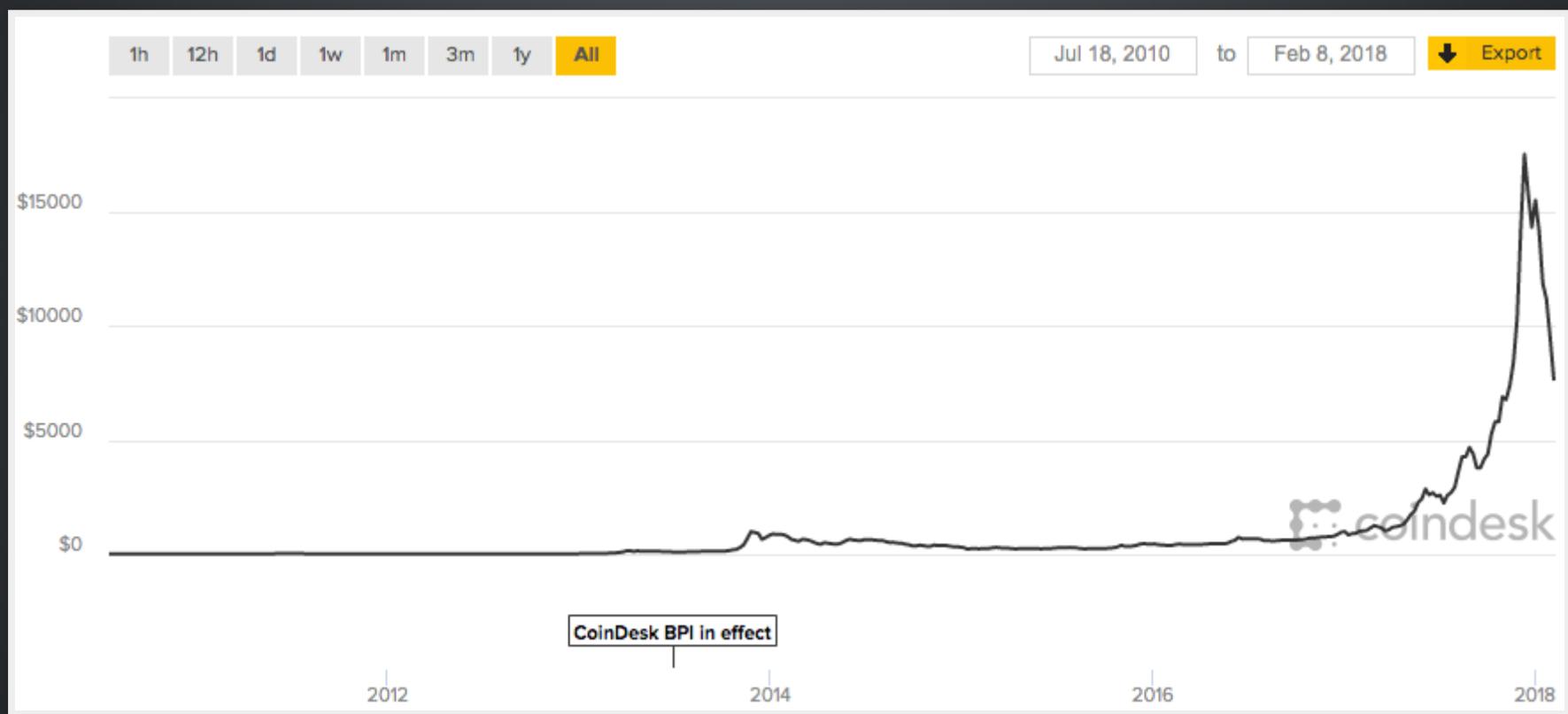
# HISTORY OF BITCOIN

- The bitcoin network started in 2009, based on a reference implementation published by Nakamoto and since revised by many other programmers

# HISTORY OF BITCOIN

- Satoshi Nakamoto withdrew from the public in April 2011, leaving the responsibility of developing the code and network to a thriving group of volunteers

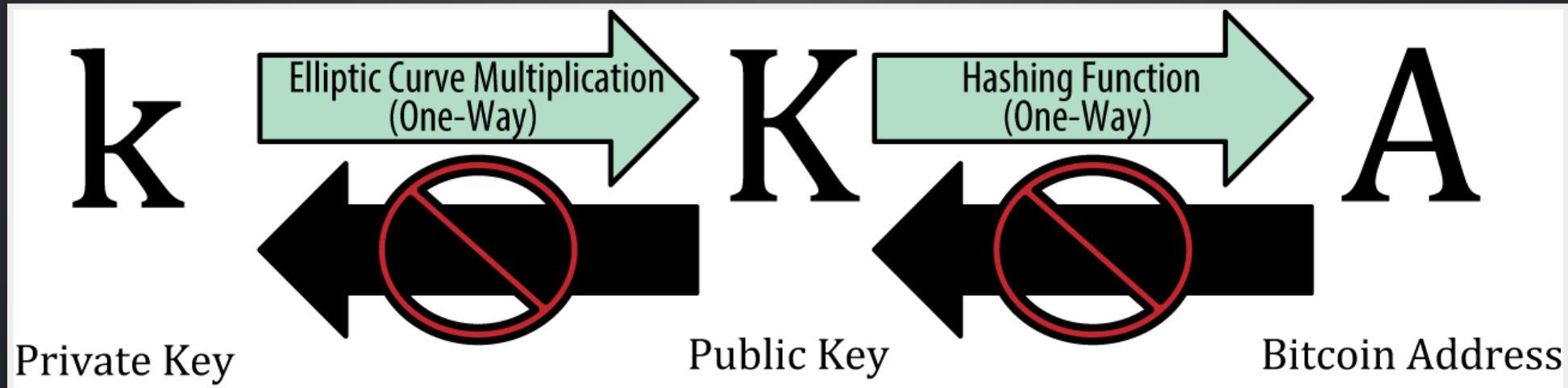
# BITCOIN PRICE 2013 - 2018



# BITCOIN TRANSACTION

# KEYS, ADDRESSES, AND WALLETS

- Ownership of bitcoin is established through digital keys, bitcoin addresses, and digital signatures
- The digital keys created and stored by users in a file, or simple database, called a wallet



# TRANSACTION INPUTS AND OUTPUTS

## Transaction as Double-Entry Bookkeeping

Inputs	Value	Outputs	Value
Input 1	0.10 BTC	Output 1	0.10 BTC
Input 2	0.20 BTC	Output 2	0.20 BTC
Input 3	0.10 BTC	Output 3	0.20 BTC
Input 4	0.15 BTC		
Total Inputs:	0.55 BTC	Total Outputs:	0.50 BTC
-			
<i>Inputs</i>	<i>0.55 BTC</i>		
<i>Outputs</i>	<i>0.50 BTC</i>		
<i>Difference</i>	<i>0.05 BTC (implied transaction fee)</i>		

# A CHAIN OF TRANSACTIONS

**Transaction 7957a35fe64f80d234d76d83a2a8f1a0d8149a41d81de548f0a65a8a999f6f18**

INPUTS From

From (previous transactions Joe has received):  
Joe 0.1005 BTC

OUTPUTS To

Output #0 Alice's Address 0.1000 BTC (spent)  
Transaction Fees: 0.0005 BTC



**Transaction 0627052b6f28912f2703066a912ea577f2ce4da4caa5a5fb8a57286c345c2f2**

INPUTS From

7957a35fe64f80d234d76d83a2a8f1a0d8149a41d81de548f0a65a8a999f6f18:0  
Alice 0.1000 BTC

OUTPUTS To

Output #0 Bob's Address 0.0150 BTC (spent)  
Output #1 Alice's Address (change) 0.0845 BTC (unspent)  
Transaction Fees: 0.0005 BTC



**Transaction 2bbac8bb3a57a2363407ac8c16a67015ed2e88a4388af58cf90299e0744d3de4**

INPUTS From

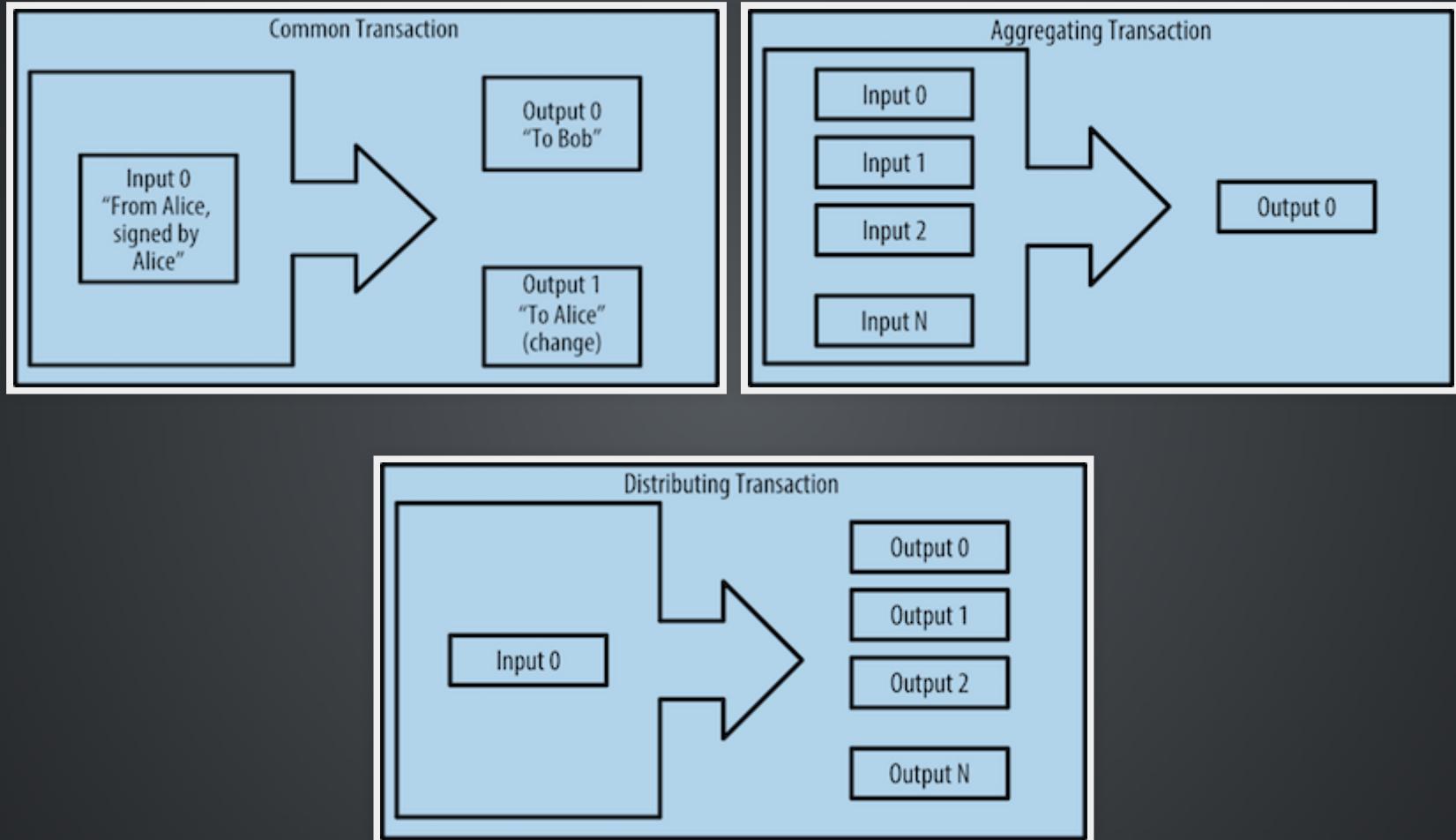
0627052b6f28912f2703066a912ea577f2ce4da4caa5a5fb8a57286c345c2f2:0  
Bob 0.0150 BTC

OUTPUTS To

Output #0 Gopesh's Address 0.0100 BTC (unspent)  
Output #1 Bob's Address (change) 0.0845 BTC (unspent)  
Transaction Fees: 0.0005 BTC



# COMMON TRANSACTION FORMS



# THE BLOCK EXPLORER APPLICATION

## Transaction View information about a bitcoin transaction

0627052b6f28912f2703066a912ea577f2ce4da4caa5a5fb8a57286c345c2f2

[1Cdid9KFAaatwczBwBttQcwXYCpvK8h7FK](#) (0.1 BTC - Output)



[1GdK9UzpHBzqzX2A9JFP3Di4weBwqgmoQA](#)  
- (Unspent) 0.015 BTC  
[1Cdid9KFAaatwczBwBttQcwXYCpvK8h7FK](#) -  
(Unspent) 0.0845 BTC

97 Confirmations

0.0995 BTC

### Summary

Size 258 (bytes)

Received Time 2013-12-27 23:03:05

Included In  
Blocks [277316](#) (2013-12-27 23:11:54 +9  
minutes)

### Inputs and Outputs

Total Input 0.1 BTC

Total Output 0.0995 BTC

Fees 0.0005 BTC

Estimated BTC Transacted 0.015 BTC

blockchain.info

# UTXO

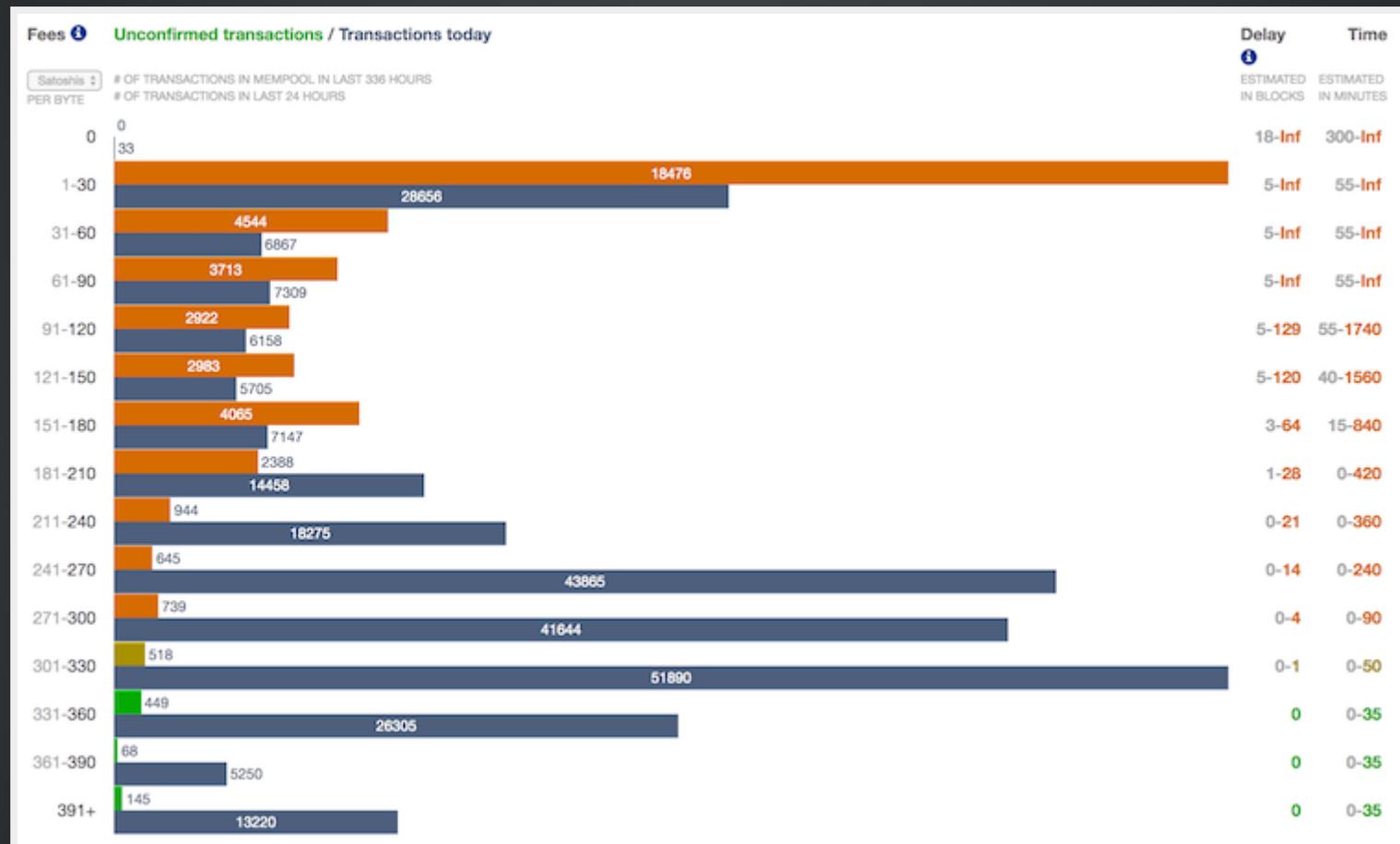
- UTXO means "Unspent Transaction Outputs"
- UTXO can be spent as an Input in a transaction
- Every transaction represents a change in the UTXO set
- Bitcoin "balance" is the sum of all UTXO that user's wallet can spend and which may be scattered among hundreds of transactions and hundreds of blocks

# TRANSACTION FEES

Fees = Sum( Inputs ) – Sum( Outputs )

- Calculated based on the size of the transaction in Kbytes, not the value of the transaction in bitcoin
- Transaction fees affect the processing priority
- Most wallets calculate and include transaction fees automatically

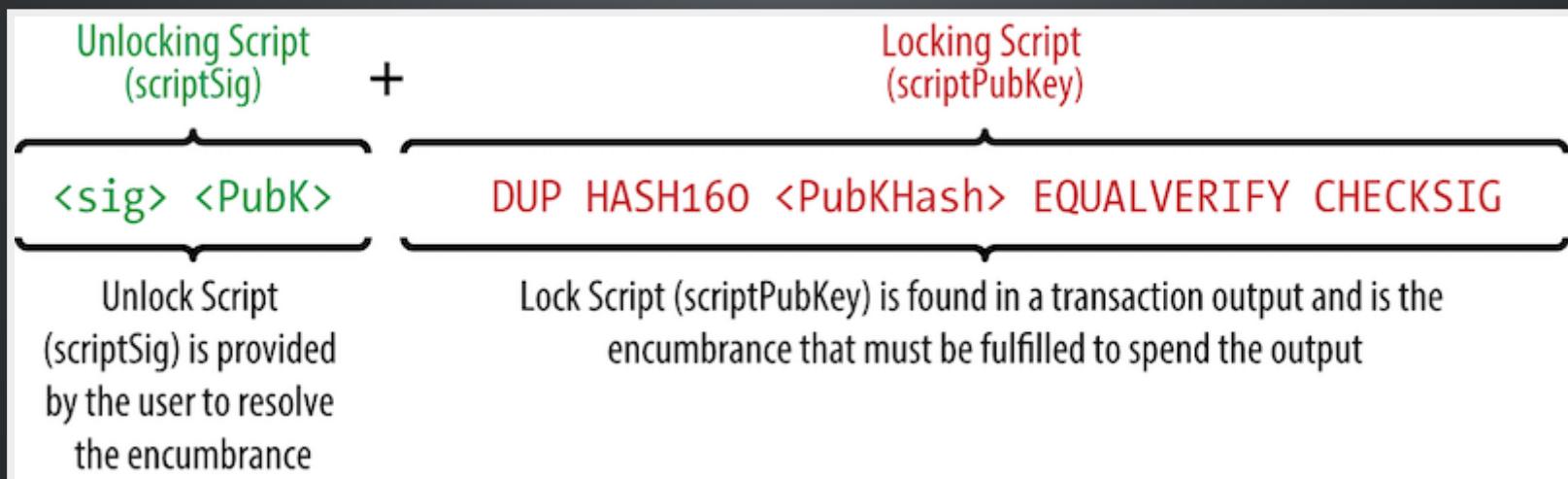
# FEE ESTIMATION



<https://bitcoinfees.21.co/>

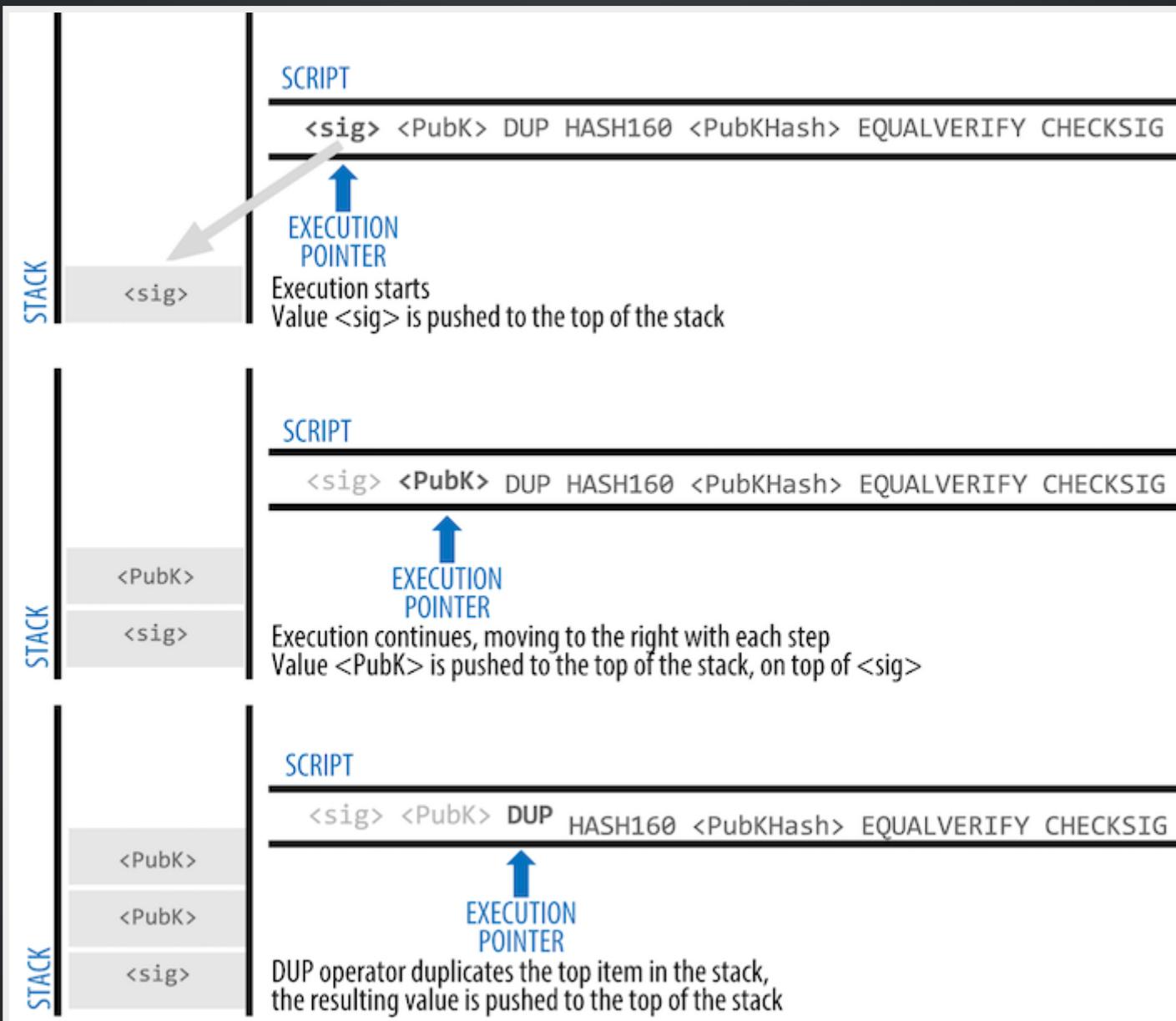
# TRANSACTION SCRIPTS

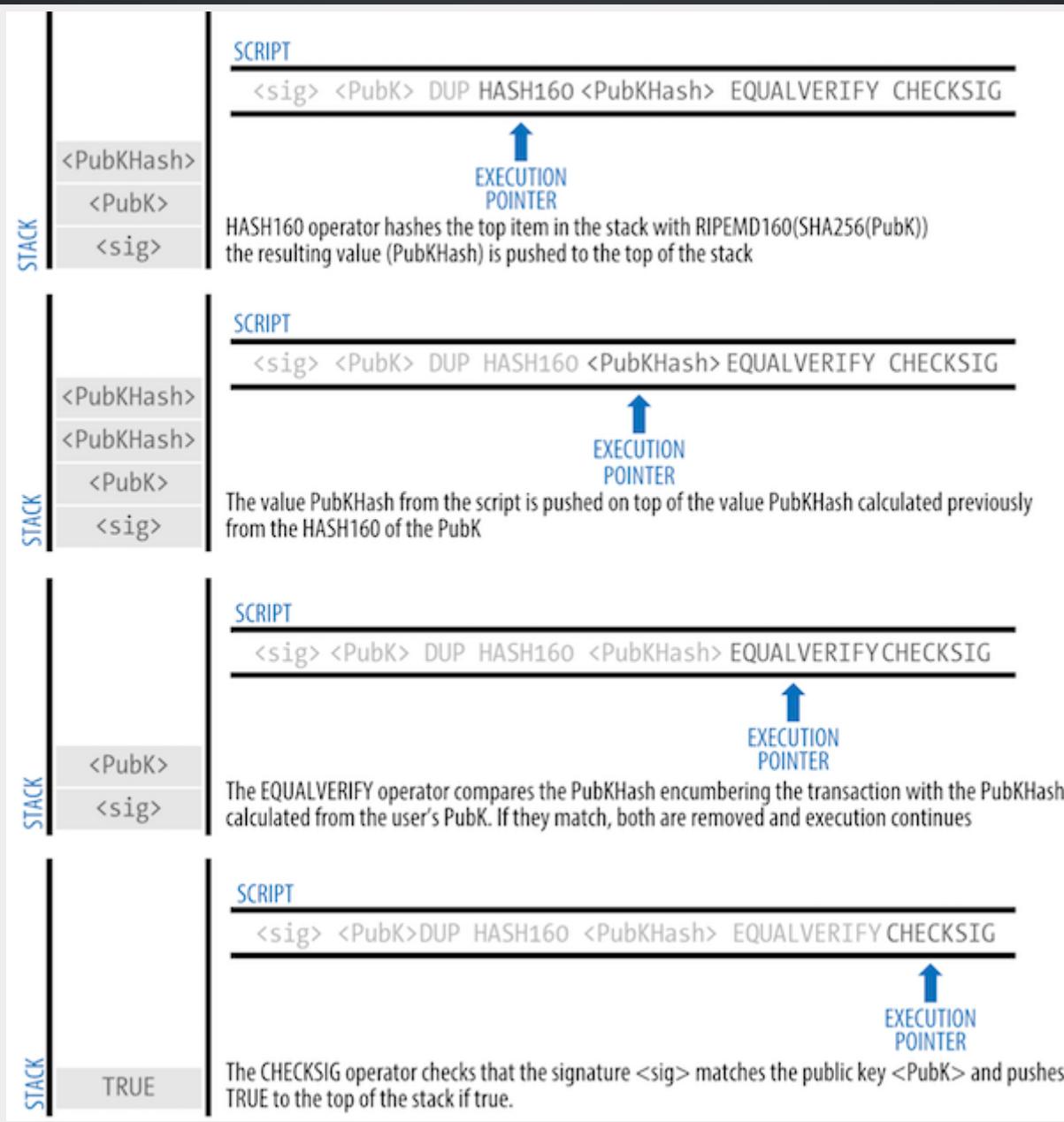
- Bitcoin's scripting language is a stack-based, turing completeness, and stateless verification language
- Bitcoin's transaction validation relies on two types of scripts: a locking script and an unlocking script



# EVALUATING A SCRIPT FOR A P2PKH TRANSACTION

The vast majority of transactions processed on the bitcoin network spend outputs locked with a Pay-to-Public-Key-Hash or "P2PKH" script





# BLOCKCHAIN

# BLOCK AND BLOCKCHAIN

- Block is a container data structure that aggregates transactions
- The blockchain data structure is an ordered, back-linked list of blocks, serves as the public ledger for all transactions

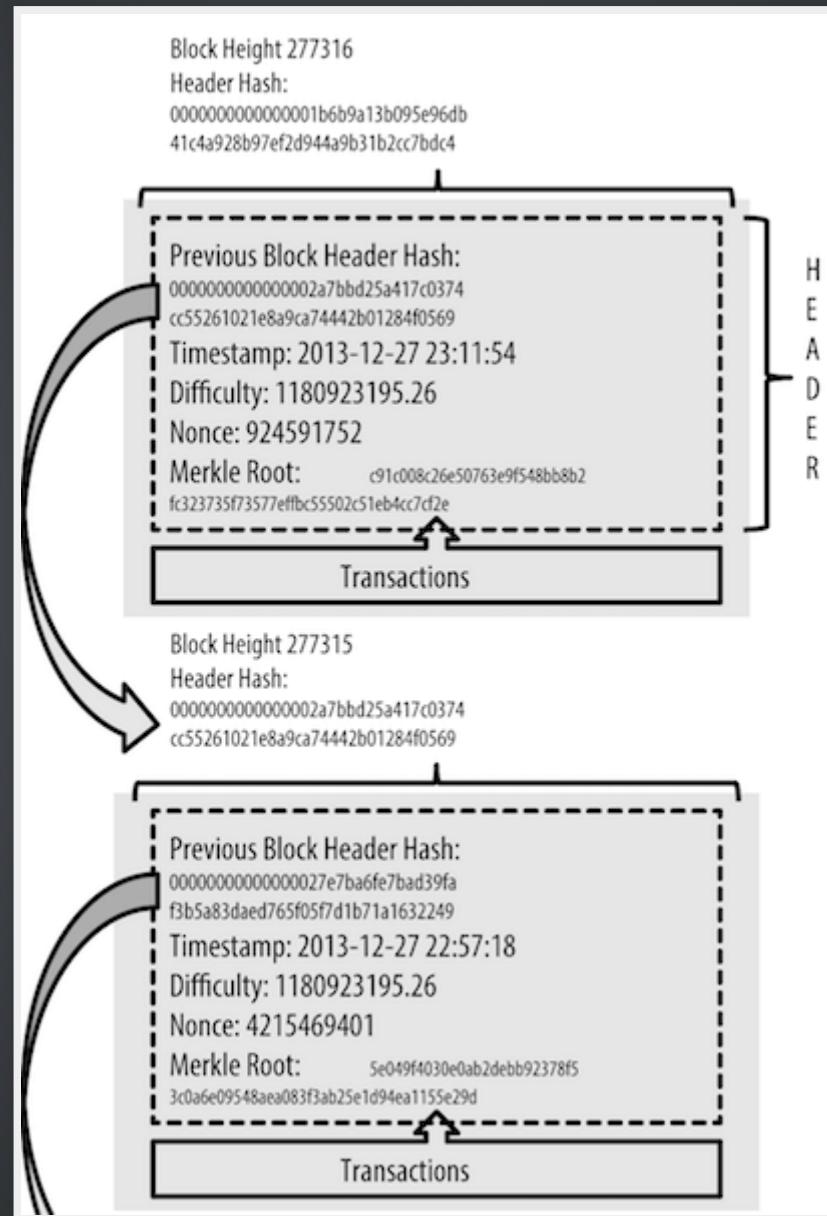
# STRUCTURE OF A BLOCK

Size	Field	Description
4 bytes	Block Size	The size of the block, in bytes, following this field
80 bytes	Block Header	Several fields form the block header
VarInt	Transaction Counter	How many transactions follow
Variable	Transactions	The transactions recorded in this block

# BLOCK HEADER

Size	Field	Description
4 bytes	Version	A version number to track software/protocol upgrades
32 bytes	Previous Block Hash	A reference to the hash of the previous block in the chain
32 bytes	Merkle Root	A hash of the root of the merkle tree of this block's transactions
4 bytes	Timestamp	The approximate creation time of this block
4 bytes	Difficulty	The Proof-of-Work algorithm difficulty target for this block
4 bytes	Nonce	A counter used for the Proof-of-Work algorithm

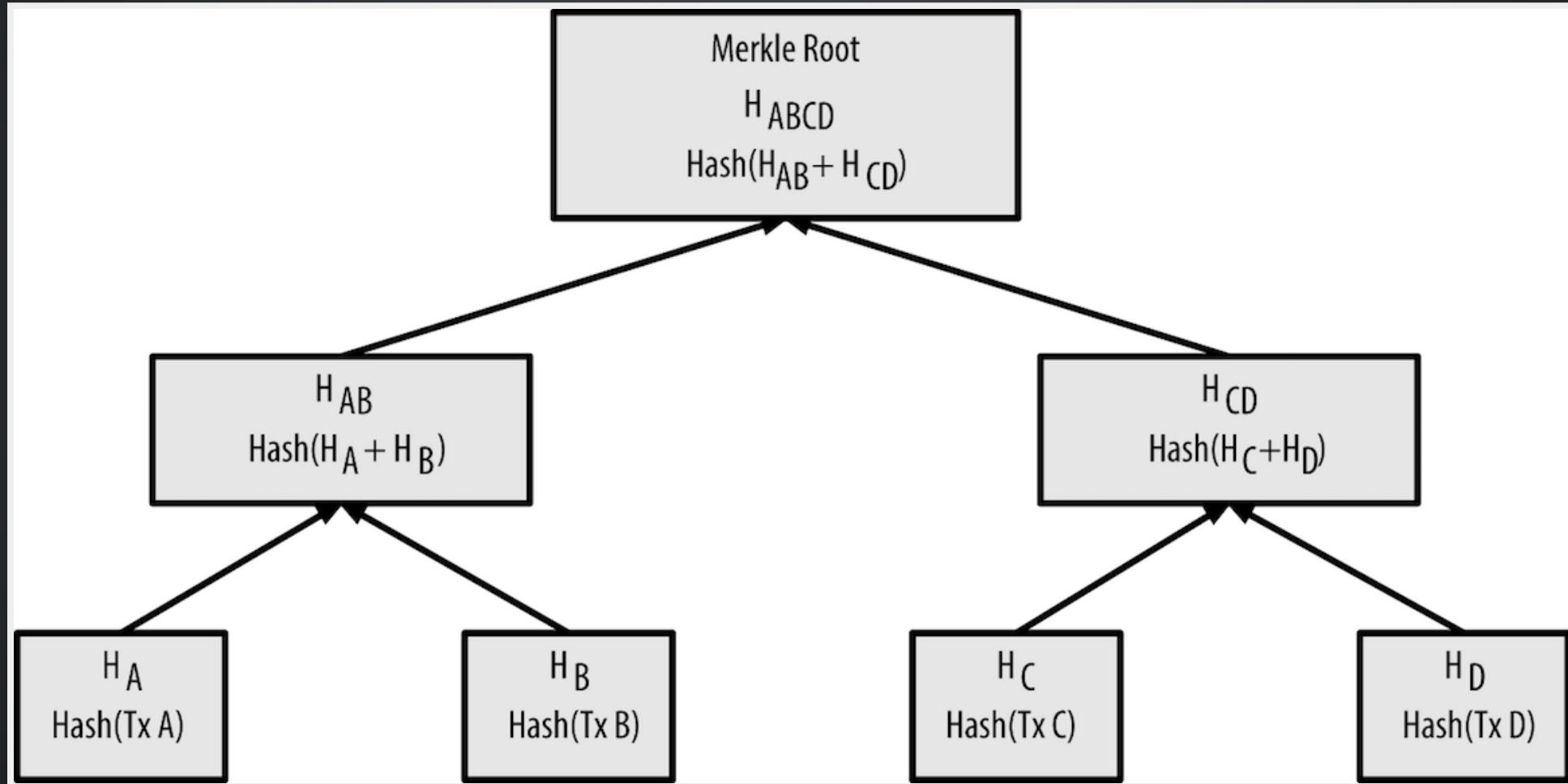
# LINKING BLOCKS



# THE GENESIS BLOCK

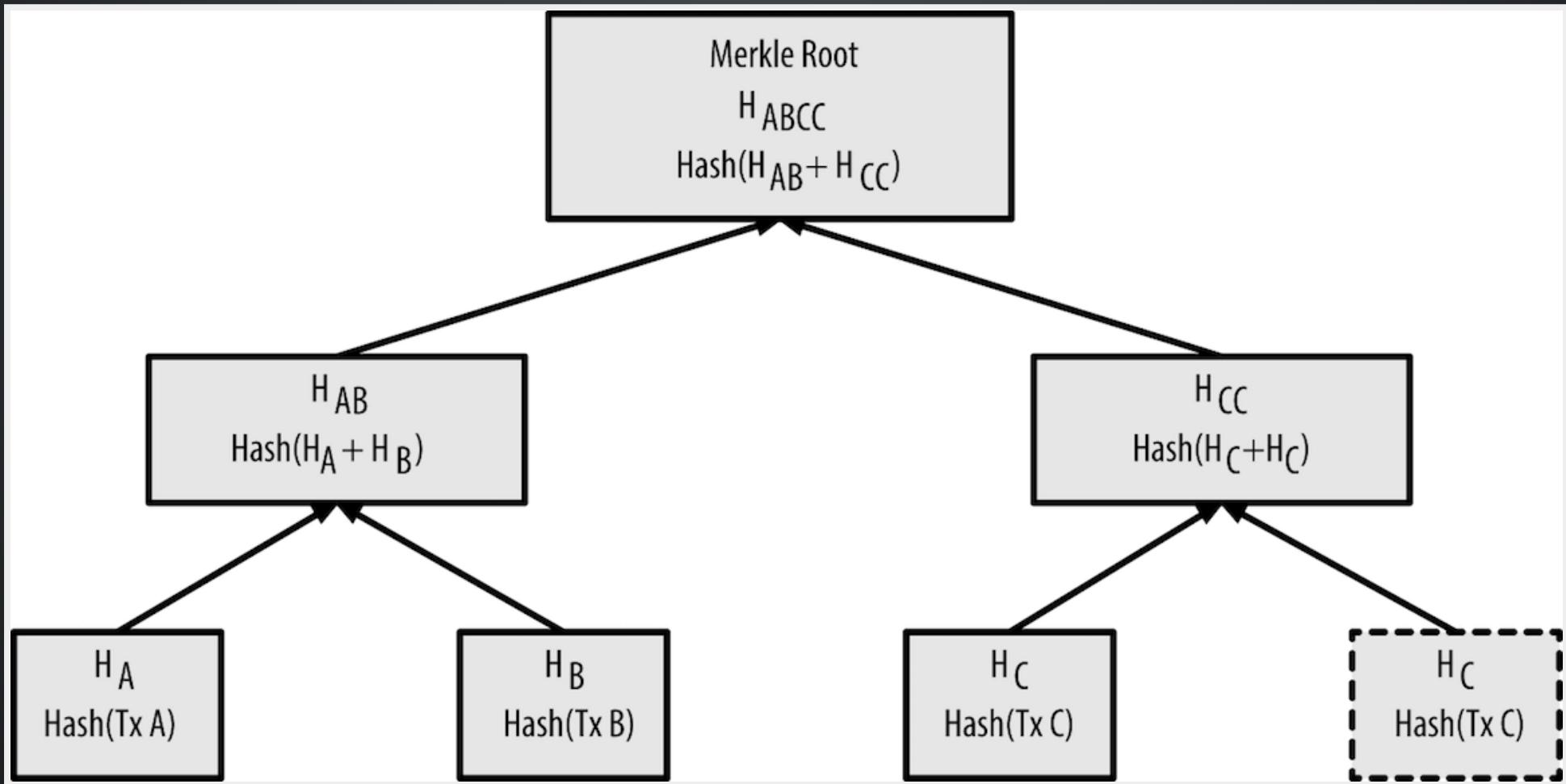
The first block in the blockchain is called the genesis block and was created in 2009. The genesis block contains a hidden message within it. The coinbase transaction input contains the text "The Times 03/Jan/2009 Chancellor on brink of second bailout for banks," by referencing the headline of the British newspaper The Times.

# MERKLE TREE

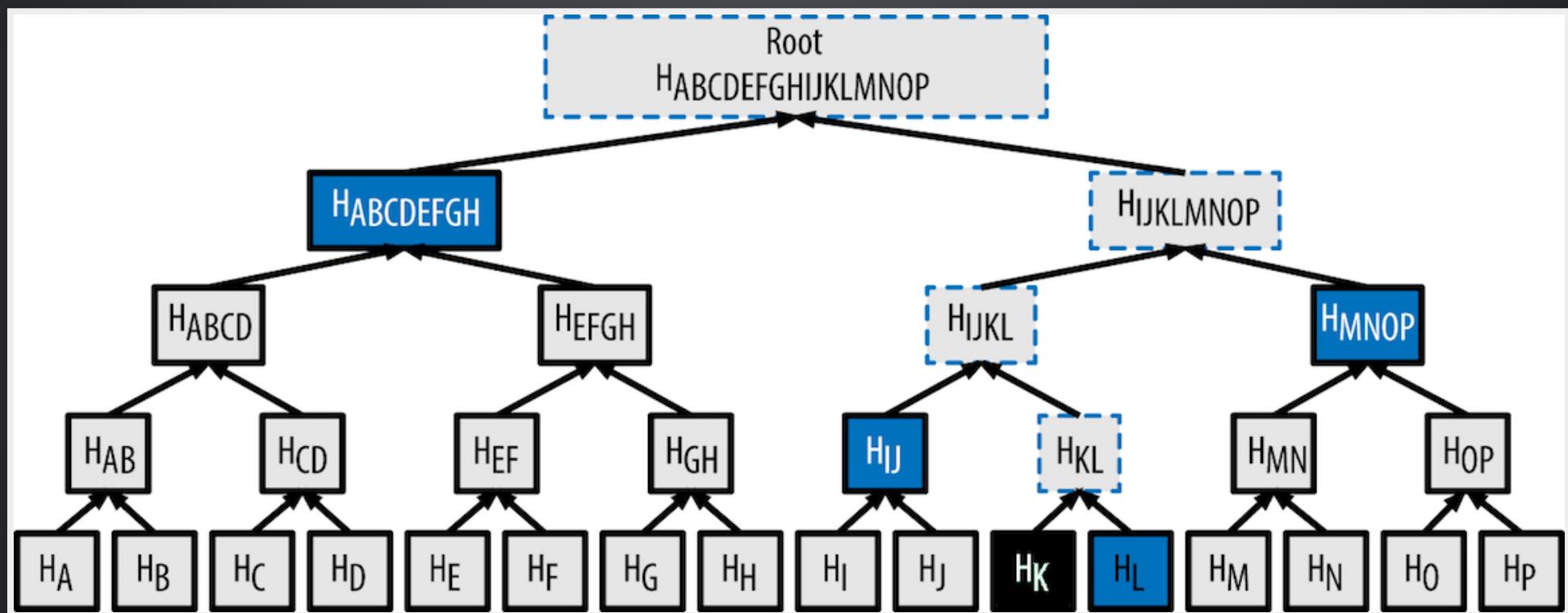


# MERKLE TREE

Even number of nodes



# MERKLE PATH



# MERKLE TREE EFFICIENCY

Number of Txns	Approx. size of block	Path size (hashes)	Path size (bytes)
16 txs	4 KB	4 hashes	128 bytes
512 txs	128 KB	9 hashes	288 bytes
2048 txs	512 KB	11 hashes	352 bytes
65535 txs	16 MB	16 hashes	512 bytes

# MINING AND CONSENSUS

# MINER

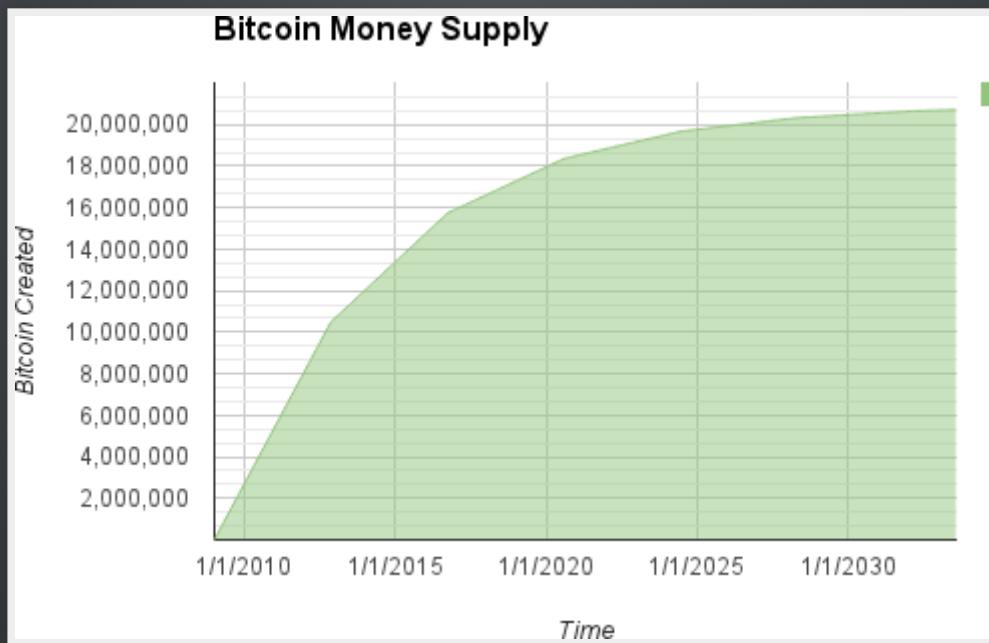
- Miners validate new transactions and record them on the global ledger
- Miners receive two types of rewards by mining: new coins created with each new block, and transaction fees from all the transactions included in the block

# BITCOIN ECONOMICS AND CURRENCY CREATION

Each block, generated on average every 10 minutes, contains entirely new bitcoin, created from nothing

# BITCOIN MONEY SUPPLY

- Every 210,000 blocks, or approximately every 4 years, the currency issuance rate is decreased by 50%
- Finally, in approximately 2140, almost 21 million bitcoin will be issued. Thereafter, blocks will contain no new bitcoin, and miners will be rewarded solely through the transaction fees



# THE COINBASE TRANSACTION

- The first transaction in any block is a special transaction, called a coinbase transaction
- Coinbase transaction does not consume UTXO as inputs. Instead, it has only one input, called the "coinbase", which creates bitcoin from nothing

# PROOF OF WORK

The Difficulty target and Nonce in block header

Size	Field	Description
4 bytes	Difficulty	The Proof-of-Work algorithm difficulty target for this block
4 bytes	Nonce	A counter used for the Proof-of-Work algorithm

# PROOF OF WORK

The Proof-of-Work must produce a hash (Nonce) that is less than the difficulty target

```
# example of proof-of-work algorithm
max_nonce = 2 ** 32 # 4 billion

def proof_of_work(header, difficulty_bits):

    difficulty_target = 2 ** (256-difficulty_bits)

    for nonce in xrange(max_nonce):
        block_hash = hashlib.sha256(str(header)+str(nonce)).hexdigest()

        if long(block_hash, 16) < difficulty_target:
            print "Success with nonce %d" % nonce
            return (block_hash, nonce)
```

# RETARGETING TO ADJUST DIFFICULTY

- Blocks are generated every 10 minutes, on average. This is bitcoin's heartbeat and underpins the frequency of currency issuance and the speed of transaction settlement
- Retargeting occurs automatically and on every node independently

```
New Difficulty = Old Difficulty *  
(Actual Time of Last 2016 Blocks / 20160 minutes)
```

# MINER COMPETITION

When one miner solves and transmits a block, other miners receive, validate, and then propagate the new block, they abandon their efforts to find a block at the same height and immediately start computing the next block in the chain

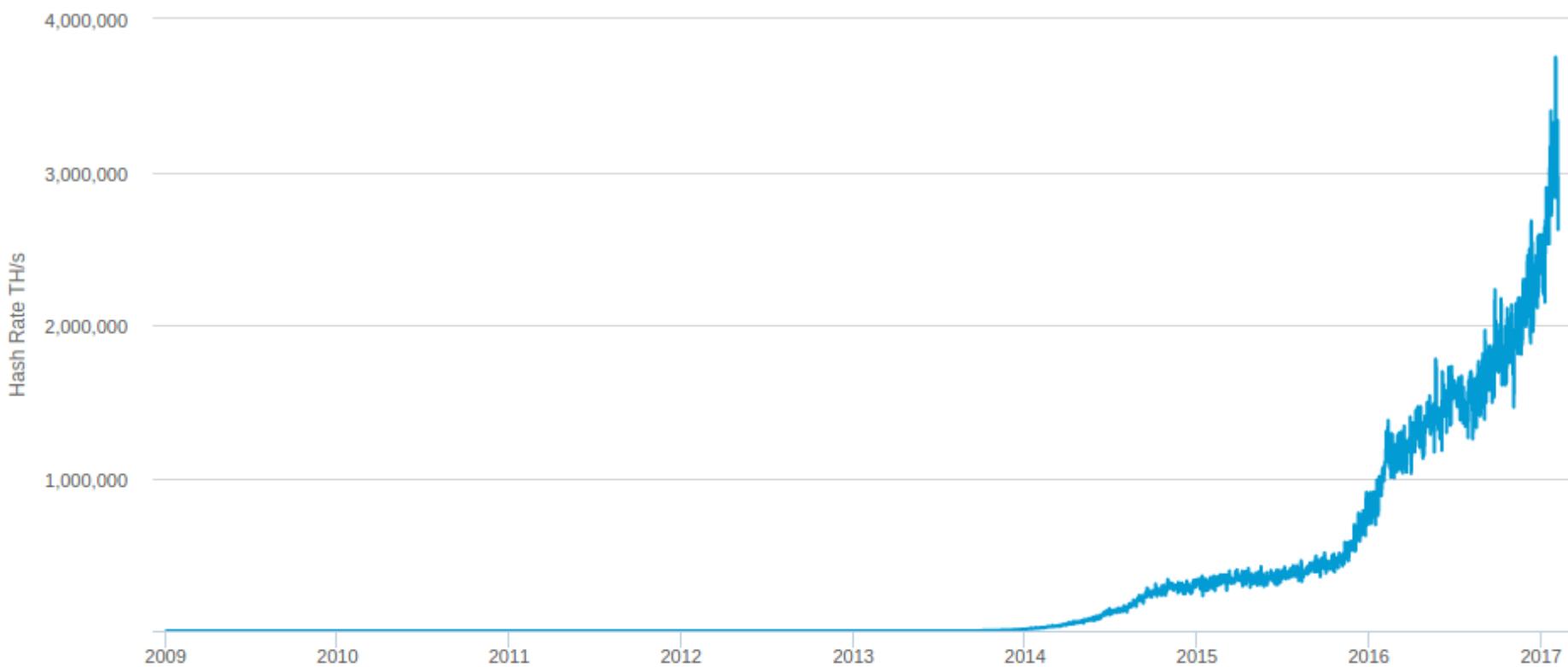
# TOTAL HASHING POWER

## Hash Rate

The estimated number of tera hashes per second (trillions of hashes per second) the Bitcoin network is performing.

Source: blockchain.info

Export ▾



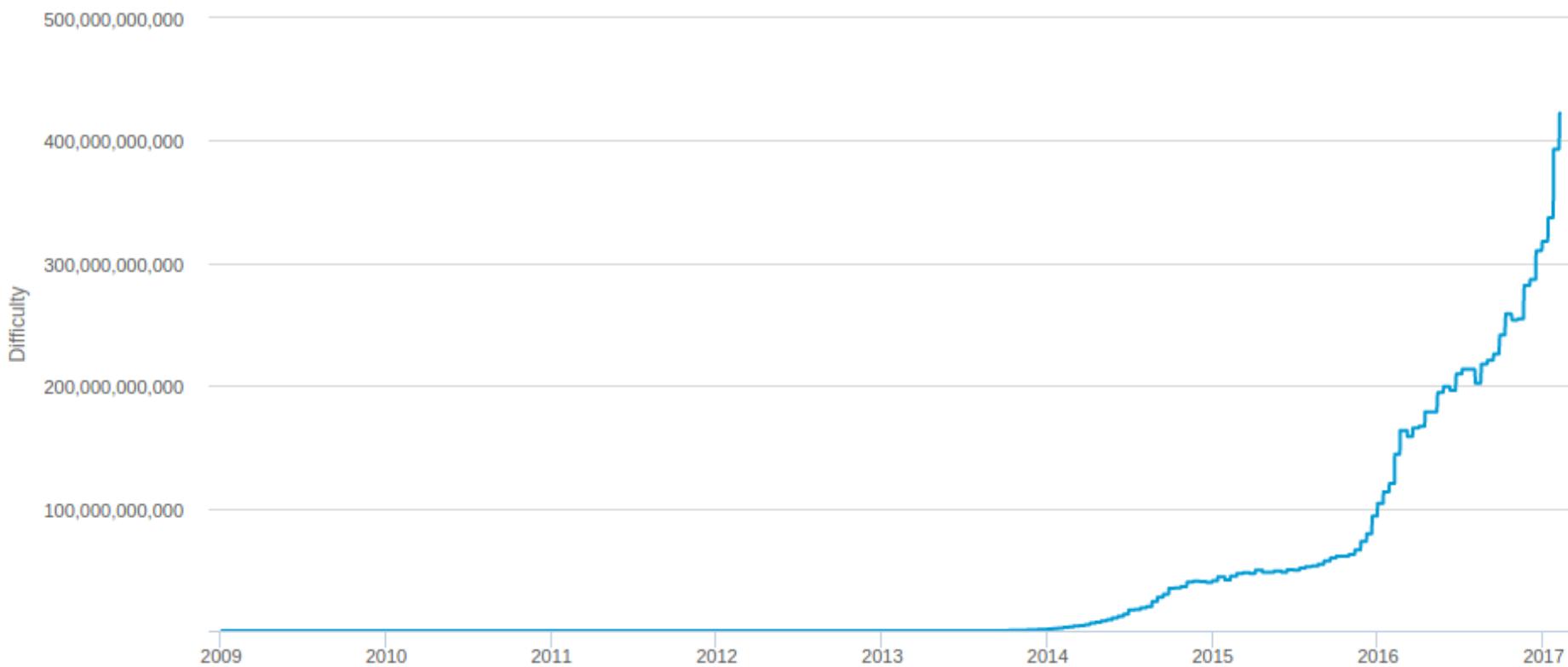
# MINING DIFFICULTY

## Difficulty

A relative measure of how difficult it is to find a new block. The difficulty is adjusted periodically as a function of how much hashing power has been deployed by the network of miners.

Export ▾

Source: blockchain.info

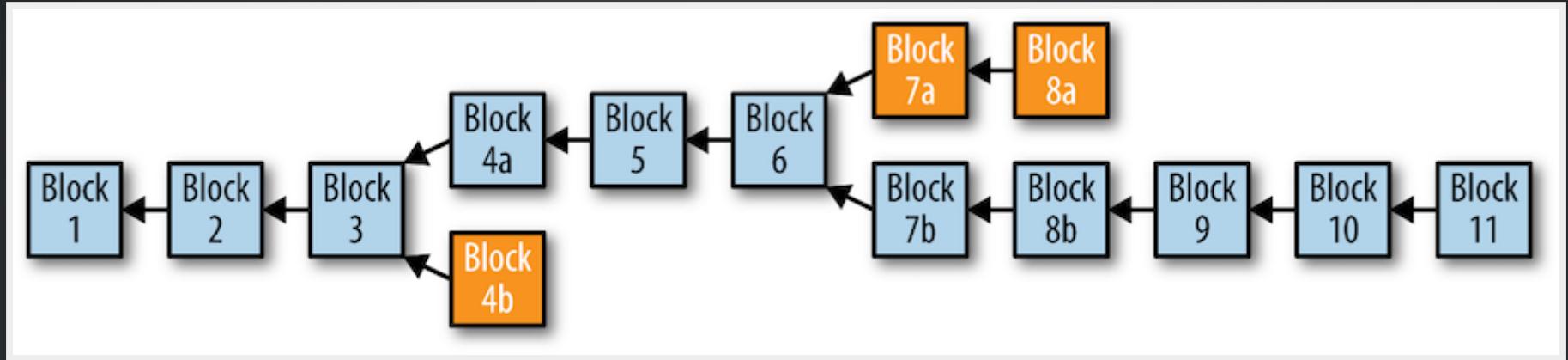


# DECENTRALIZED CONSENSUS

Bitcoin's decentralized consensus emerges from the interplay of four processes that occur independently on nodes across the network:

- Independent verification of each transaction, by every full node, based on a comprehensive list of criteria
- Independent aggregation of those transactions into new blocks by mining nodes, coupled with demonstrated computation through a Proof-of-Work algorithm
- Independent verification of the new blocks by every node and assembly into a chain
- Independent selection, by every node, of the chain with the most cumulative computation demonstrated through Proof-of-Work

# BLOCKCHAIN FORKS



- Because the blockchain is a decentralized data structure, different copies of it are not always consistent
- As long as all nodes select the greatest-cumulative-work chain, the global bitcoin network eventually converges to a consistent state

# HARD FORK

A permanent divergence in the blockchain, commonly occurs when non-upgraded nodes can't validate blocks created by upgraded nodes that follow newer consensus rules

# 51% CONSENSUS ATTACKS

If we controlled a majority (51%) of the total network's hashing power, we can:

- Cause deliberate "forks" in the blockchain and double-spend transactions
- Execute DoS attacks against specific transactions or addresses

**IS IT TOO LATE TO START MINING?**

# GPU MINER



Nvidia GTX1080 GPU = 2.83GH/s for 200w

# ASIC: Application-Specific Integrated Circuit

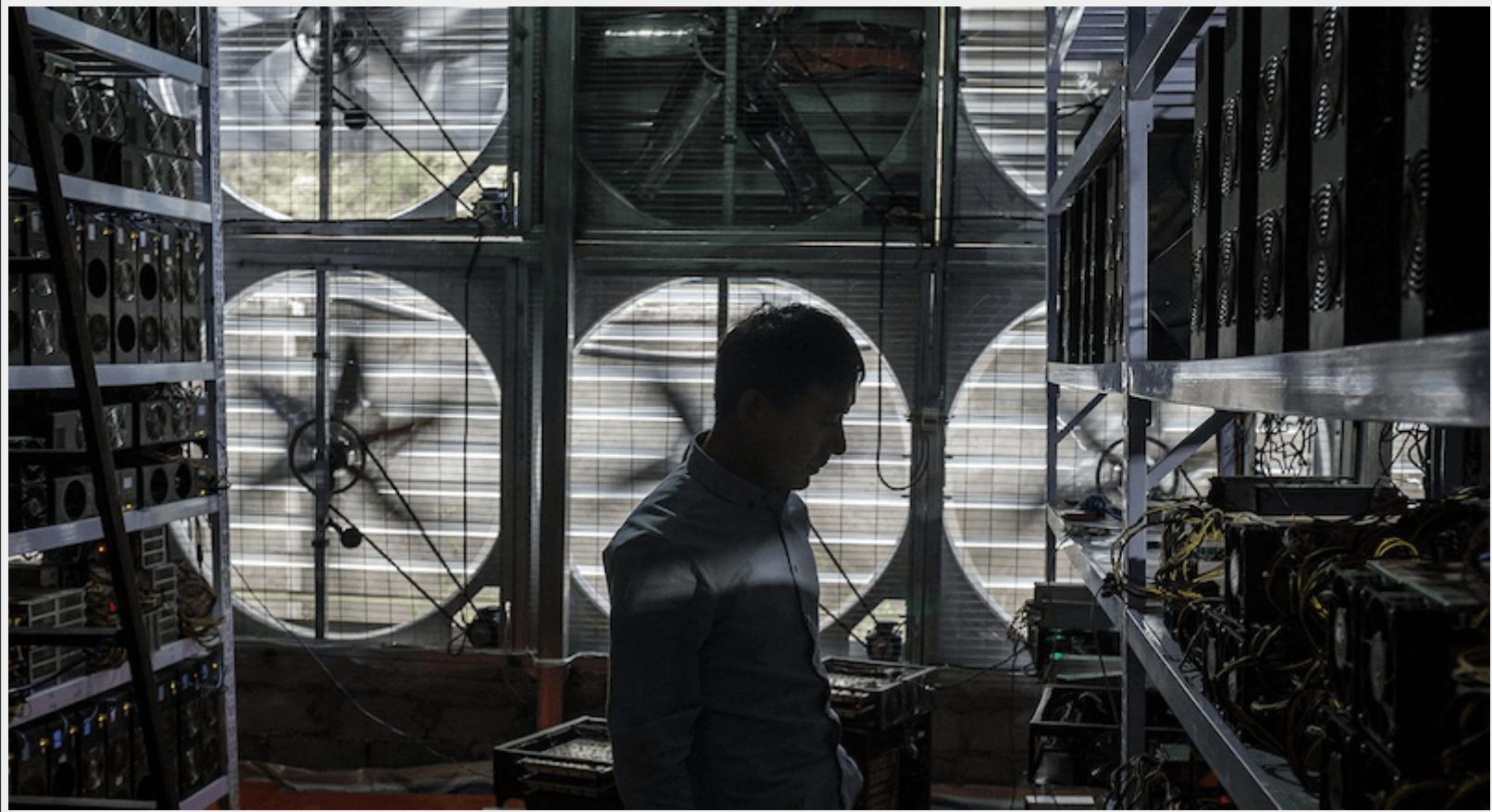


AntMiner S2 ASIC = 1000GH/s for 120w

# RETURN ON INVESTMENT

ROI = Miner costs / (Income per day - Power costs)

# YOUR COMPETITORS: INSIDE A SECRET CHINESE BITCOIN MINE



In this highly competitive environment, miners collaborate to form mining pools

# USER SECURITY BEST PRACTICES

- Physical Bitcoin Storage
- Hardware Wallets
- Balancing Risk
- Diversifying Risk
- Multisig and Governance
- Survivability

# BLOCKCHAIN APPLICATIONS

- Digital Identity
- Proof-of-Existence (Digital Notary)
- Kickstarter
- Smart Contracts
- Distributed Cloud Storage

# REFERENCES

- Mastering Bitcoin
- CoinDesk

# THE END

Q&A