Cryptocurrencies

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Historical:

- Stage 1 : barter

Commodity Money

grain

- Stage 2, some goods are elevated into money.

shells

gold

pepper

Standard Coins

- 700 BC, in Greece, first known standardized coins. (~ concurrently India, China)

Athens 10 drachma coin: ~450 BC

Paper money

- Bank issues notes which is representative of value (but has almost no intrinsic value).
- Gold standard: the bank notes are in some direct correspondence with gold stored in the bank.

Plastic Money

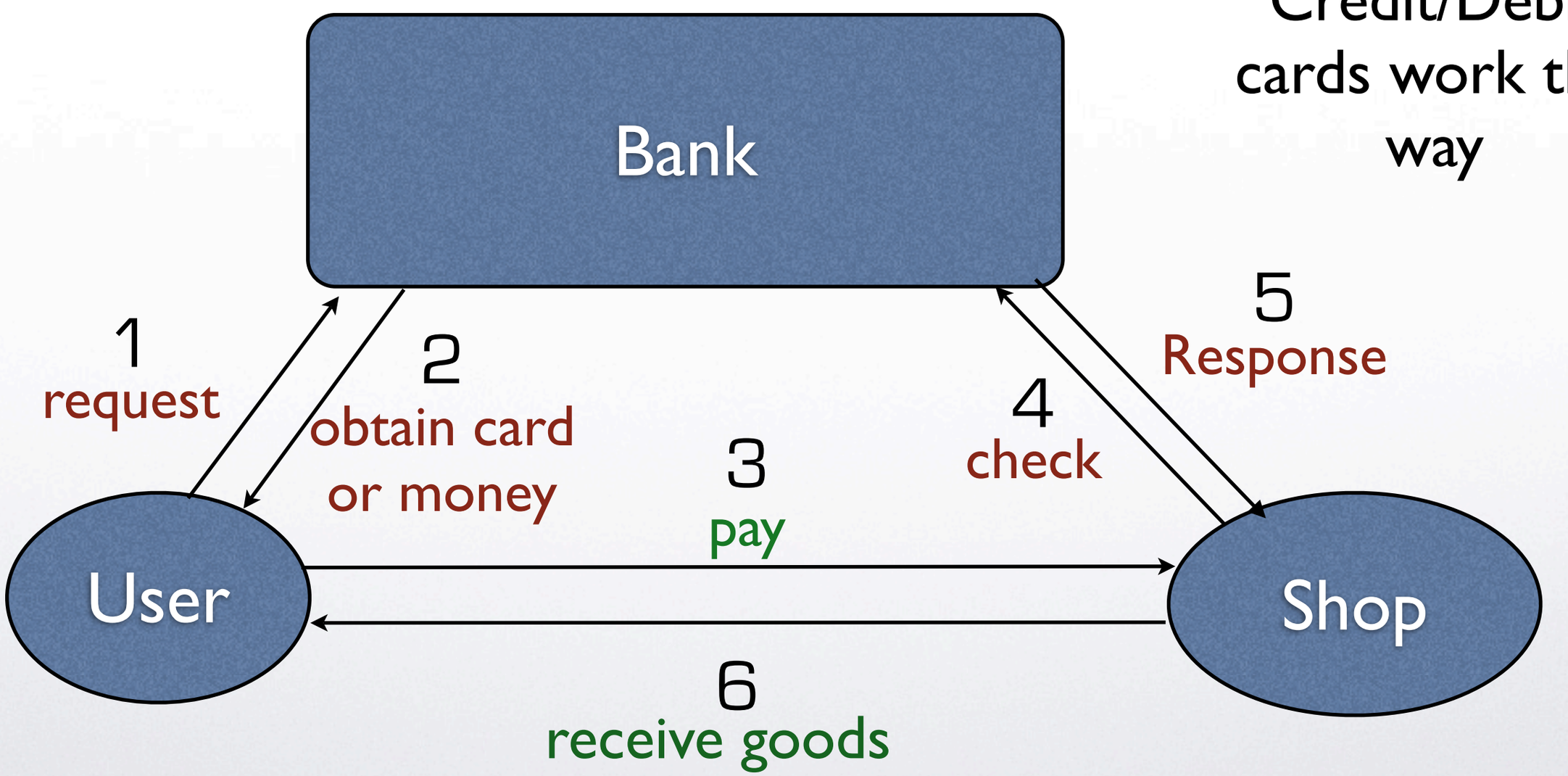
- Bank issues card with account information
- Possible security features:
  - smartcard: integrated circuit that may execute cryptographic operations.
- Card can be used to authorize transactions to/from account.

Online payment systems

- How do you prevent double-spending?

Centralized Systems

Credit/Debit cards work this way



Cryptocurrency Principles

- Trust Distribution: no entity controls the minting of money.
- Scarcity: there may be a limited amount of money.
- Difficulty: minting requires effort. *Cryptographic guarantee.*
- Verifiability: transactions are indisputable.
- Efficiency and Scalability.
- Pseudonymity/Anonymity/Traceability: ability or inability to track or classify transactions.

Bitcoin

- Bitcoin P2P network starts on Jan 2009.
- Relies on proofs of work.
- It distributively maintains a public ledger that keeps track of all transactions.
- Pseudonymous.
- Fixed amount of bitcoin (~21M).

Bitcoin vs. $


BitStamp (USD)
May 22, 2015 – Daily
Op:235, Hi:237.2, Lo:234.8, Cl:234.8
Vol: 3.127K
bitstampUSD
UTC – http://bitcoincharts.com
140K
130K
120K
110K
100K
90K
80K
70K
60K
50K
40K
30K
20K
10K
0K
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Oct 11
Jan 12
Apr
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Jan 13
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Jul
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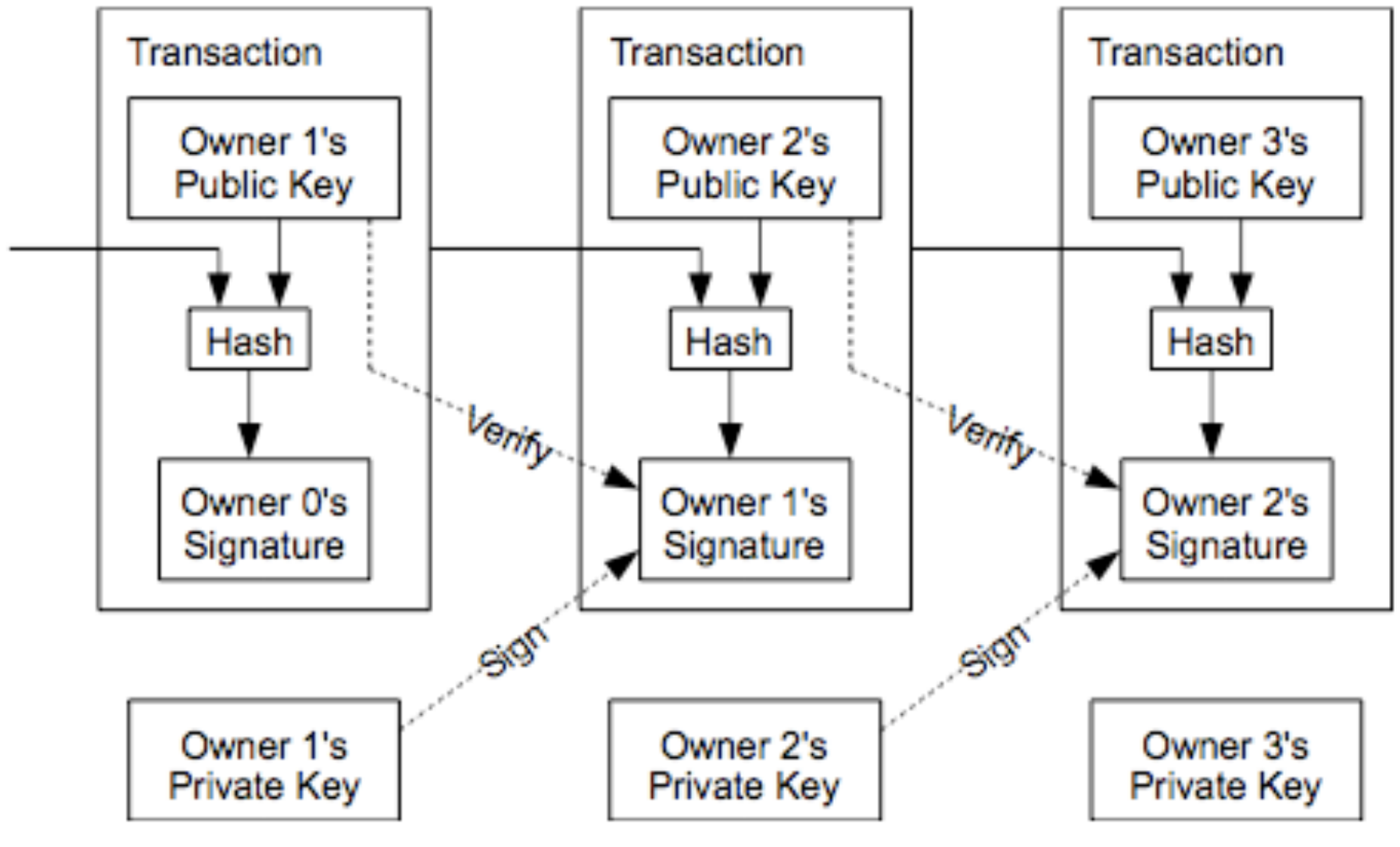
Jan 14
Apr
Jul
Oct
Jan 15
Apr

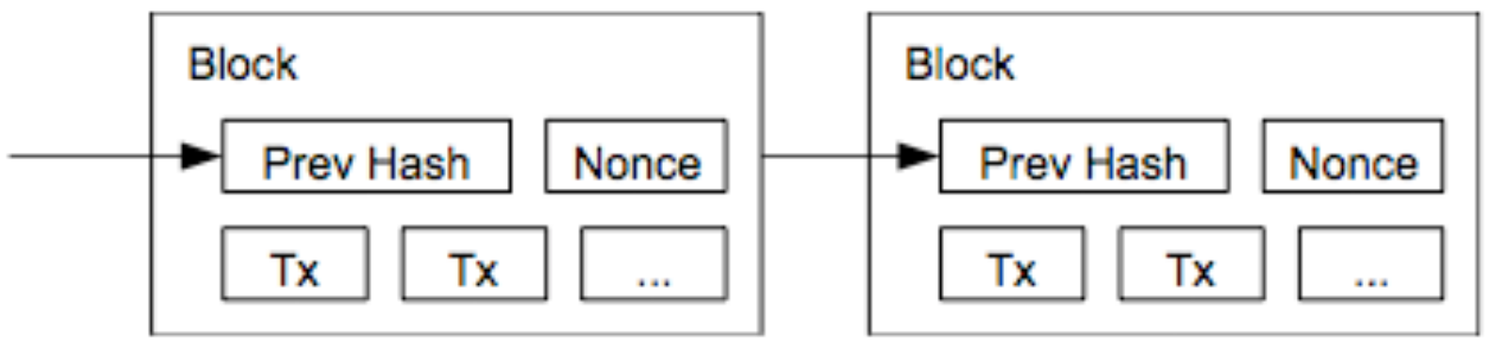
BitCoins



Transferring ownership of an asset

Bitcoin Transaction Blocks

Distributively maintains the transaction history



Generating a valid block requires a *proof of work*.

SHA256(Block) should satisfy a certain constraint
(e.g., starts with 0000000)

Transaction

Short link: http://blockexplorer.com/t/8n65mn2mCM

Hash[?]: cd3b641faa72bab1ea12ef5579dff58d57ee3858a5179bef3e2cc28da826752f
Appeared in block 281220 (2014-01-18 23:28:56)
Number of inputs[?]: 1 (Jump to inputs)
Total BTC in[?]: 0.6874
Number of outputs: 2 (Jump to outputs)
Total BTC out[?]: 0.6374
Size[?]: 226 bytes
Fee[?]: 0.05
Raw transaction[?]

Inputs[?]

Previous output (index)[?]	Amount[?]	From address[?]	Type[?]	ScriptSig[?]
5a6ac66824cc...:1	0.6874	1DCBnn9NDmY76pj4KhoxKVvCbfq1H5d1vk	Address	3045022100cc8363ab2545232fa99fd63eacfb2c 03e431e7cc0e60896ccba0409e2c68903bd143c

Outputs[?]

Index[?]	Redeemed at input[?]	Amount[?]	To address[?]	Type[?]	ScriptPubKey[?]
0	Not yet redeemed	0.292	1JMnjTW9XAd6kNs27zoPyEyQ2TW2FDabq3	Address	OP_DUP OP_HASH160 be68a1fa3e1e2cf6311c92935e0597ac83bd86b8 OP_EQUALVERIFY OP_CHECKSIG
1	Not yet redeemed	0.3454	16qpcjHx4UsvWsbTrhjREGNHQShACeCUf	Address	OP_DUP OP_HASH160 011ad5602f426e550aaddd8c8cab61f818f34329 OP_EQUALVERIFY OP_CHECKSIG

From http://blockexplorer.com

Block 281220?

Short link: http://blockexplorer.com/b/281220

Hash?: 0000000000000000137167c3a9b843035ad75418bba5f4f3bde661be5a955f6aa

Previous block?: 0000000000000000257a8157e5c2948b5511822640f53e2799a443ad5ec4a94a9

Time?: 2014-01-18 23:28:56

Difficulty?: 1 789 546 951.05324 ("Bits"?: 19026666)

Transactions?: 174

Total BTC?: 1625.59780063

Size?: 89.664 kilobytes

Merkle root?: 9f3efc5d2433864dae18148c88d9c2ab58e094baaa78615845c3641e123c0e3a

Nonce?: 3102274478

Raw block?

Transactions

Transaction?	Fee?	Size (kB)?	From (amount)?	To (amount)?
4197bfa3a6...	0	0.168	Generation: 25 + 0.08187781 total fees	18d3HV2bm94UyY4a9DrPfoZ17sXuiDQq2B: 25.08187781
cd3b641faa...	0.05	0.226	1DCBnn9NDmY76pj4KhoxKVvCbfq1H5d1vk: 0.6874	1JMnjTW9XAd6kNs27zoPyEyQ2TW2FDabq3: 0.292 16qpcjHx4UsvWsbTrhjREGNHQShACeCUf: 0.3454
6c2fcab612...	0.001	0.258	1JVZM5XqDULZce6yGqR9u435YmfWjqbg8w: 1	1GPyn2UfrvnZi3BjBoKSb9byfMbJKx6yeN: 0.97318037 18meAufCoMuLp1wjG7L27oP183odtn3EKL: 0.02581963
ef8118a3ef...	0.0005	0.223	15v1YuQSerr5T27JKCNmDgQRHaNwfUnGn9: 0.01	16NwGDZ4LQzQZQfC25nK4VwGJXXJuDcSn2: 0.0095
2009870a11...	0.0005	0.226	1Hk7t7kqoiA9c2Q3bJBa3JTrsNkQ2AFdDq: 441.8540463	1JnpeePZ7XL9JLEqRh1KpZ7cUZPGSPTx7g: 441.8046463 12o5SgJWUGXuPr1MSeRqSM9s9ijMPKh33b: 0.0489

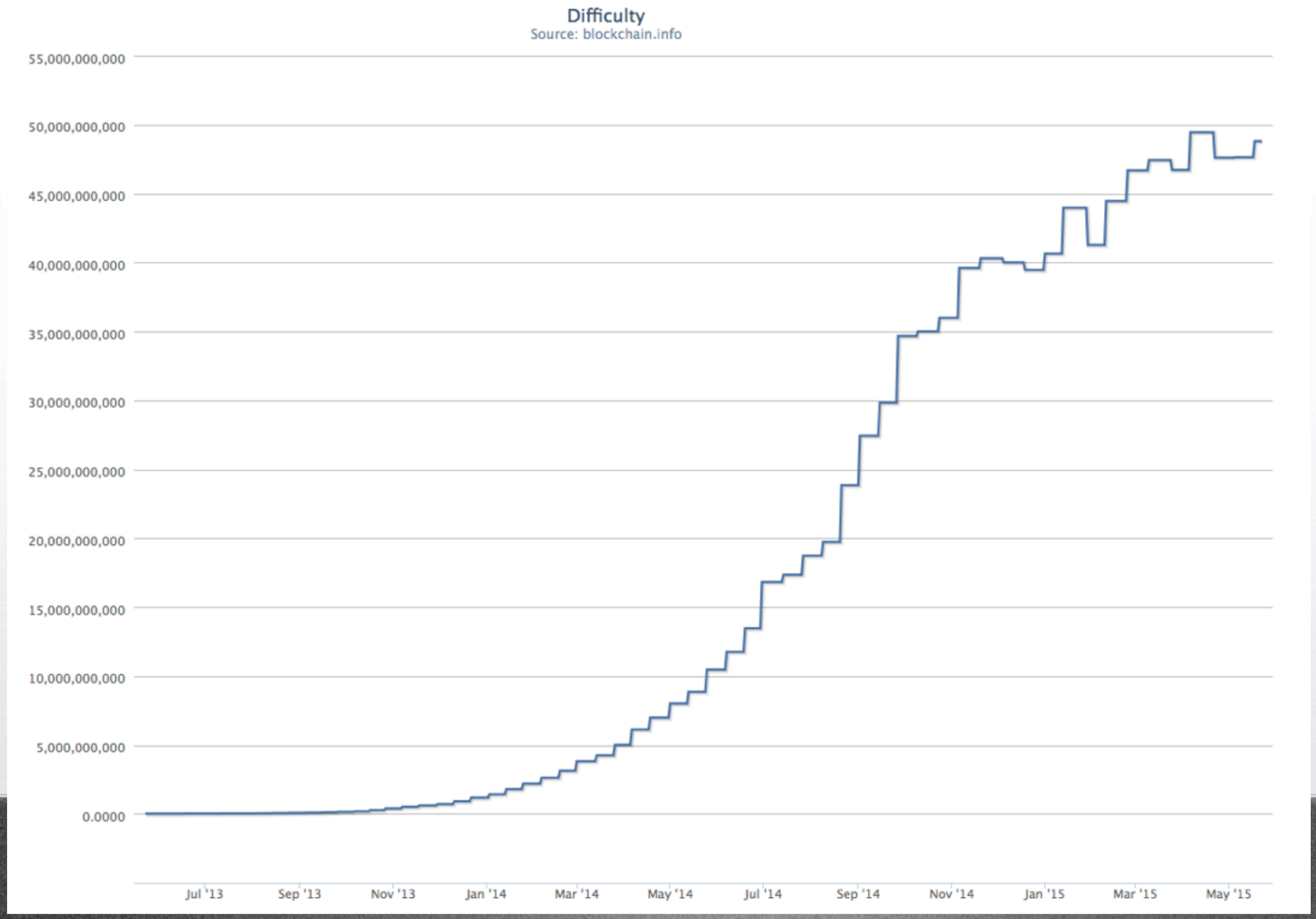
Block Difficulty

- The difficulty level determines how hard it is to mine blocks.
- The difficulty is adjusted every 2016 blocks based on the time it took to find these blocks.
- Desired rate: 1 block per 10 minutes. Therefore 2016 blocks would have to take 2 weeks.
- Difficulty *D* should be calculated as a proportion of how much over or under 2 weeks it took to calculate 2016 blocks.

Adjusting Difficulty

- Difficulty level 1: (<u>32</u> 0's|| <u>16</u> 1's || <u>208</u> 0's) = *A* ← First block has to hash below this
- Difficulty level *D* would have as target (*A*/*D*)
- Expected number of hashes to find a block with difficulty *D* is equal to $$\frac{2^{256}}{A/D} = \frac{D \cdot 2^{48}}{2^{32}-1} = H$$
- Next *D* is calculated: let *H* be the average number of hashes the network computes in 10 min (over the previous 2016 blocks). Solve for D.

Bitcoin difficulty



current difficulty $\approx 2^{67}$

LiteCoin

- Similar to bitcoin but
  - block is mined every ~ 2.5 minutes
  - it employs *scrypt* as the proof of work scheme (rather than "SHA256 <")
- scrypt is designed to be much harder to optimize in ASIC / FPGA (contrary to SHA256).

ZeroCoin

- In bitcoin/*coin it is possible to link all transactions and “follow the money”
- Zerocoin uses more complex cryptographic techniques than bitcoin to make transactions unlinkable.
- It still maintains the integrity of the ledger through the use of zero-knowledge proofs.

From http://coinmarketcap.com

4.07.14

#	Name	Market Cap	Price	Available Supply	Volume (24h)	% Change (24h)	Market Cap Graph (7d)
1	Bitcoin	$ 8,193,829,645	$ 631.31	12,979,050 BTC	$ 22,725,573	-2.91 %	
2	Litecoin	$ 235,225,979	$ 7.87	29,888,304 LTC	$ 1,803,307	-2.55 %	
3	Nxt	$ 58,277,169	$ 0.058277	999,996,993 NXT*	$ 216,563	-6.00 %	
4	Darkcoin	$ 34,369,317	$ 7.74	4,439,097 DRK	$ 498,320	+4.23 %	
5	Peercoin	$ 32,997,592	$ 1.53	21,532,213 PPC	$ 184,192	-6.52 %	
6	Ripple	$ 25,442,200	$ 0.003254	7,817,888,647 XRP*	$ 220,676	-4.60 %	
7	Dogecoin	$ 19,861,471	$ 0.000232	85,680,831,277 DOGE	$ 446,985	+5.53 %	
8	Namecoin	$ 17,495,607	$ 1.91	9,183,032 NMC	$ 181,992	-4.82 %	
9	Mastercoin	$ 11,100,923	$ 19.71	563,162 MSC*	$ 362	+7.19 %	
10	BlackCoin	$ 9,640,912	$ 0.129263	74,583,439 BC*	$ 42,749	-1.99 %	

22.05.15

#	Name	Market Cap	Price	Available Supply	Volume (24h)	% Change (24h)	Price Graph (7d)
1	Bitcoin	$ 3,349,186,008	$ 236.05	14,188,400 BTC	$ 16,084,100	0.41 %	
2	Ripple	$ 210,567,404	$ 0.006599	31,908,551,587 XRP *	$ 198,354	0.24 %	
3	Litecoin	$ 61,554,304	$ 1.57	39,239,054 LTC	$ 1,766,290	7.25 %	
4	Dash	$ 15,369,081	$ 2.85	5,387,745 DASH	$ 45,793	-1.64 %	
5	Stellar	$ 13,890,789	$ 0.002872	4,837,097,306 STR *	$ 18,666	2.86 %	
6	Dogecoin	$ 13,677,392	$ 0.000137	99,498,716,423 DOGE	$ 184,472	5.07 %	
7	BitShares	$ 13,327,218	$ 0.005306	2,511,953,117 BTS *	$ 330,042	30.24 %	
8	Nxt	$ 11,357,267	$ 0.011357	999,997,096 NXT *	$ 59,742	2.62 %	
9	BanxShares	$ 8,231,356	$ 1.44	5,708,331 BANX *	$ 13,793	0.55 %	
10	MaidSafeCoin	$ 8,076,793	$ 0.017847	452,552,412 MAID *	$ 6,746	4.68 %	

Bitcoin can be more than a payment system

- Distributed consensus mechanism that works without identity infrastructure. May be used for:
  - Any kind of registry (e.g., land registry - case of Honduras land title registry http://in.reuters.com/article/2015/05/15/usa-honduras-technology-idINKBN0O01V720150515)
  - Document time stamping services.
  - Any computation between parties that requires some accountability.

Ethereum

- A ledger where *smart contracts* can also receive and generate transactions.

Here is the implementation of a "Bank" in Ethereum:

```
def init():
    self.storage[msg.sender] = 10000
def code():
    to = msg.data[0]
    from = msg.sender
    value = msg.data[1]
    if self.storage[from] >= value:
        self.storage[from] = self.storage[from]  - value
        self.storage[to] = self.storage[to] + value
```