

FS19

BLOCKCHAIN, BITCOIN, ETHEREUM

Introduction

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Agenda

- **Distributed Systems in the News**
- **Bitcoin**
- **Transactions / Blocks**
- **Mining**

■ 19.03.2019: Digitec Galaxus akzeptiert ab sofort Bitcoin und Co. – das musst du wissen

- «Paukenschlag im Schweizer E-Commerce: Der grösste Onlinehändler des Landes führt Kryptowährungen als Zahlungsmittel ein – und macht sie damit massentauglich. Hier sind die wichtigsten Fragen und Antworten.»
 - Bitcoin (BTC), Bitcoin Cash (BCH), Bitcoin SV (BSV), Ethereum (ETH), Ripple (XRP), Binance Coin (BNB), Litecoin (LTC), TRON (TRX), OmiseGo (OMG), NEO (NEO)
- Fixed rate for 15 min, 1.5% fee, [coinify](#)

■ 22.03.2019: You Can Now Donate to the Tor Project in 9 Different Cryptocurrencies

- Augur (REP), Bitcoin (XBT), Bitcoin Cash (BCH), Dash (DASH), Ether (ETH), Litecoin (LTC), Monero (XMR), Stellar Lumen (XLM), Zcash

■ 22.03.2019: Three protocols and a future of the decentralized internet

- “power to be redistributed from the hands of large centralized corporate interests and back into the hands of individual people and small groups”
- Secure ScuttleButt (SSB)
 - P2P, friends of friends, message passing
- ActivityPub (W3C)
 - Federation, web protocol, coordinating messages
- Dat, P2P, sharing large files
- “how can we have a Google Drive style system where a bunch of people can just connect to each other's computers and share files that way, removing the giant tech company in the middle?” → (BT sync) [Resilio](#)

Distributed Systems - In the News

13:03

Digitec Galaxus AG



22690943

 BTC ▾ 0.08921219

Payment address: `3Mng78ozG5DAx9Vc5o4vSXmjB7LwTR4RGv`

 Pay using Bitcoin client

Powered by **Coinify**

- Not payed with crypto, ~10CHF fees (3%, exchange rate)

Goals

- I know the history of Bitcoin
- I have a high level overview over Bitcoin transactions
- I know what a miner does
- I know the pros and cons of public PoW Blockchain (e.g., Bitcoin)

Introduction

■ Bitcoin is an experimental digital currency

- Bitcoin is fully peer-2-peer (no central entity)
- 1st Bitcoin issued on January 3, 2009
- Smallest unit: 0.00000001 BTC (1 satoshi)

■ Key characteristics

- Maximum of ~21 million BTC
- Every transaction broadcast to all peers
 - Every peers knows all transactions (~209 GByte as of today)
- Validation by proof-of-work (partial hash collision)
 - Difficult to fake proof-of-work
 - No double-spending

■ The initiator is unknown so far



```
draft@home: /scratch/bitcoin/blocks
File Edit View Search Terminal Help
blk000000.dat blk000002.dat blk000004.dat blk000006.dat blk000008.dat
blk000001.dat blk000003.dat blk000005.dat blk000007.dat blk000009.dat
draft@home:/scratch/bitcoin/blocks$ head -c 300 blk000000.dat | hexdump -C
00000000 f9 be b4 d9 1d 01 00 00 01 00 00 00 00 00 00 00 | .....|
00000010 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 | .....|
00000020 00 00 00 00 00 00 00 00 00 00 00 00 3b a3 ed fd | .....;...|
00000030 7a 7b 12 b2 7a c7 2c 3e 67 76 8f 61 7f c8 1b c3 | z{..z.,>gv.a...|
00000040 88 8a 51 32 3a 9f b8 aa 4b 1e 5e 4a 29 ab 5f 49 | ..Q2:...K.^J)..I|
00000050 ff ff 00 1d 1d ac 2b 7c 01 01 00 00 00 01 00 00 | .....+|.....|
00000060 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 | .....|
00000070 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ff ff | .....|
00000080 ff ff 4d 04 ff ff 00 1d 01 04 45 54 68 65 20 54 | ..M.....EThe T|
00000090 69 6d 65 73 20 30 33 2f 4a 61 6e 2f 32 30 30 39 | imes 03/Jan/2009|
000000a0 20 43 68 61 6e 63 65 6c 6c 6f 72 20 6f 6e 20 62 | Chancellor on b|
000000b0 72 69 6e 6b 20 6f 66 20 73 65 63 6f 6e 64 20 62 | rnk of second b|
000000c0 61 69 6c 6f 75 74 20 66 6f 72 20 62 61 6e 6b 73 | ailout for banks|
000000d0 ff ff ff ff 01 00 f2 05 2a 01 00 00 00 43 41 04 | .....*....CA.|
000000e0 67 8a fd b0 fe 55 48 27 19 67 f1 a6 71 30 b7 10 | g....UH'.g..q0..|
000000f0 5c d6 a8 28 e0 39 09 a6 79 62 e0 ea 1f 61 de b6 | \..(.9..yb....a..|
00000100 49 f6 bc 3f 4c ef 38 c4 f3 55 04 e5 1e c1 12 de | I..?L8..U.....|
00000110 5c 38 4d f7 ba 0b 8d 57 8a 4c 70 2b 6b f1 1d 5f | \8M....W.Lp+k...|
00000120 ac 00 00 00 00 f9 be b4 d9 d7 00 00 | .....|
0000012c
draft@home:/scratch/bitcoin/blocks$
```

Who is Satoshi Nakamoto?

- [The New Yorker](#) believes that Satoshi Nakamoto was Michael Clear.
 - Analyzed texts from Nakamoto and searching for linguistic clues
 - 2nd possible candidate Vili Lehdonvirta
- [Fast Company](#) argues its either Neal King, Vladimir Oksman, or Charles Bry.
- Other names suggested: [Martii Malmi](#) (involved in Bitcoins since the beginning), [Jed McCaleb](#) (founder of Ripple), [Donal O'Mahony](#), [Michael Peirce](#), [Hitesh Tewari](#) (authors of [Electronic Payment Systems for E-Commerce 2nd edition](#)), [Shinichi Mochizuki](#) (Math Prof. Kyoto University), Hal Finney, Michael Weber, Wei Dai, [Nick Szabo](#), Craig Wright ([wired article](#)),
- [Dorian S Nakamoto](#) (a guy with the same name)
- Satoshi is probably rich, first miner, [may have ~1mio BTC](#)



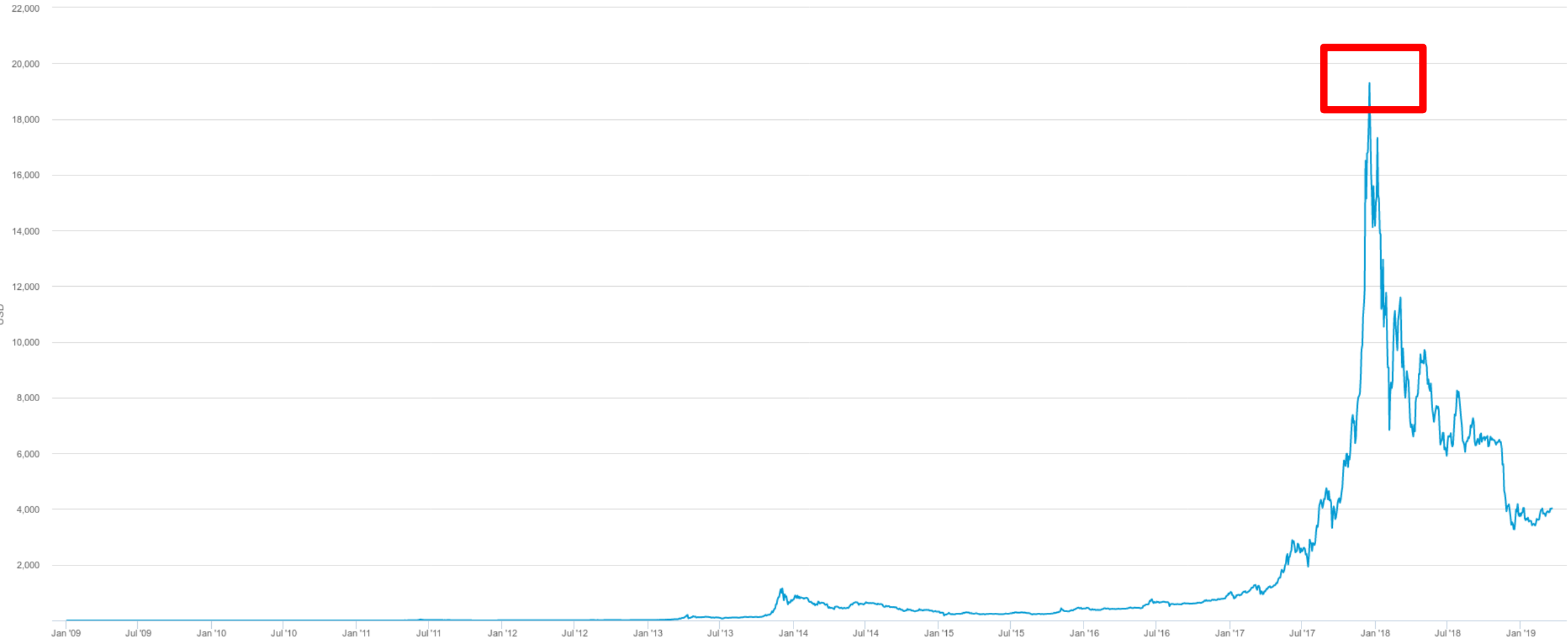
Bitcoin's Market Capitalization in USD

■ Bitcoin boom, started in 2013 – current price



Bitcoin's Market Capitalization in USD

Average USD market price across major bitcoin exchanges.
Source: blockchain.com



Bitcoi

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MAGAZINE

FEATURES 19.12

The Rise and Fall of Bitcoin

By Benjamin Wallace | November 23, 2011 | 2:52 pm | Categories: Wired December 2011

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BITCOIN, DIE DEVISE IM WEB

07. Juni 2011 07:15; Akt: 07.06.2011 09:11

Der gefährliche Cyber-Dollar

von Gérard Moinat - Die Online-Währung Bitcoin wirft hohe Wellen. Es sei das «gefährlichste Open-Source-Projekt aller Zeiten» und «gefährde

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- 20.03.2019, NZZ
«[Nationalrat will Regulierung von Kryptowährungen](#)»
- 25.02.2019, Cash
«[Die Bitcoin-Chilbi läuft wieder](#)»
- 26.02.2019, ARD
«[Welchen Wert haben Kryptowährungen und Token?](#)»
- 07.03.2019, finnews.ch
«[Kryptowährungen: Der Zug fährt ohne UBS und Credit Suisse ab](#)»
- 13.03.2019, Handelsblatt
«[Bankenaufseher warnen vor Risiken durch Kryptowährungen](#)»
- 22.03.2019, BTC Echo
«[Nvidia erwartet Bullenmarkt für Kryptowährungen](#)»

As of 2019

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- **Not relying on trust, but on strong cryptography**
- **Weak anonymity (pseudonymity)**
 - All peers know all transactions
 - [Clustering](#): e.g. if a transaction has multiple input addresses, assume those addresses belong to the same wallet. ([example](#))
- **Not controlled by a single entity**
 - Development community, no central bank – forks – Bitcoin Cash, SV
- **Creation of Bitcoins: reward for validation (partial hash collision SHA-256) of payments**
- **Bitcoins can be exchange for real currencies**
 - Several companies allow to exchange BTC for Dollar, Euro, ...
- **US, CH considered Bitcoin friendly, [China](#) not**

Bitcoin in Numbers

■ 1 BTC ≈ 3920 US\$ (26.03.20189)

■ Total of 17.6 Million BTC mined

■ Market capitalization of 70 Billion US\$

■ Volume fake?

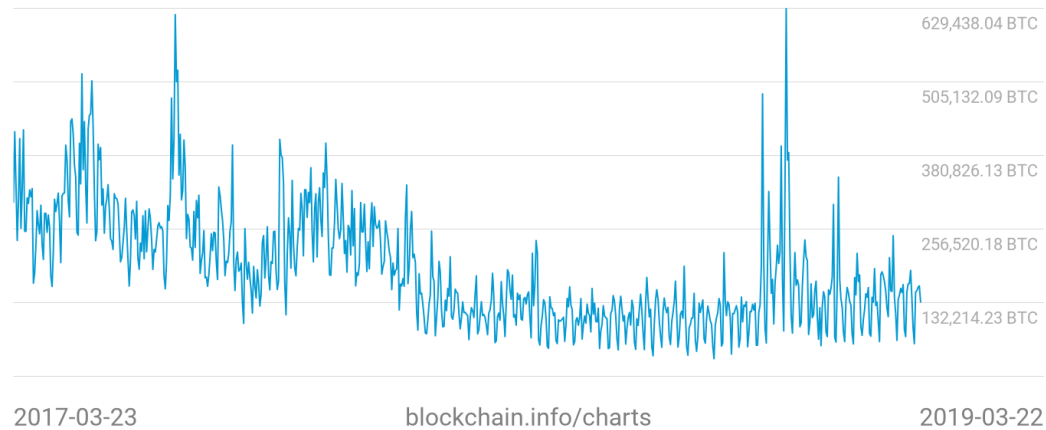
#	Source	Pair	Volume (24h)	Price	Volume (%)	Category	Fee Type	Updated
1	BitMEX	XBT/USD	** \$707,584,195	* \$3,964.50	6.04%	Derivatives	No Fees	Recently
2	CoinBene	BTC/USDT	\$484,258,127	\$4,018.65	4.13%	Spot	Percentage	Recently
3	OEX	BTC/USDT	\$380,845,416	\$4,017.50	3.25%	Spot	Percentage	Recently
4	FCoin	EOS/BTC	** \$360,171,189	\$4,022.61	3.07%	Spot	Transaction Mining	Recently
5	BitForex	BTC/USDT	\$331,667,440	\$4,018.55	2.83%	Spot	Percentage	Recently
6	BW.com	BTC/USDT	\$260,897,136	\$4,019.62	2.23%	Spot	Percentage	Recently
7	Coineal	BTC/USDT	\$240,977,177	\$4,019.54	2.06%	Spot	Percentage	Recently
8	ZBG	BTC/USDT	** \$208,762,113	\$4,019.32	1.78%	Spot	Transaction Mining	Recently
9	Bibox	BTC/USDT	\$207,467,793	\$4,018.67	1.77%	Spot	Percentage	Recently
10	Coinall	LTC/BTC	** \$200,654,712	\$4,019.82	1.71%	Spot	Transaction Mining	Recently
11	FCoin	XRP/BTC	** \$184,730,519	\$4,003.43	1.58%	Spot	Transaction Mining	Recently
12	DOBI Exchange	ETH/BTC	\$180,331,283	\$4,020.72	1.54%	Spot	Percentage	Recently
13	BitMart	BTC/USDT	\$173,520,105	\$4,019.26	1.48%	Spot	Percentage	Recently
14	Bit-Z	BTC/USDT	\$158,942,064	\$4,022.55	1.36%	Spot	Percentage	Recently
15	IDAX	BTC/USDT	\$156,340,983	\$4,019.02	1.33%	Spot	Percentage	Recently

Pair	Volume (24h)	Price	Volume (%)
BTC/USD	\$399,089,000	\$9,727.70	4.08%
BTC/USDT	\$383,736,000	\$9,699.38	3.92%
BTC/USDT	\$312,149,000	\$9,713.49	3.19%
BTC/USDT	\$199,218,000	\$9,698.41	2.04%
ETH/BTC	\$193,109,000	\$9,690.79	1.97%
TRX/BTC	\$180,766,000	\$9,882.97	1.85%
BTC/JPY	\$175,906,000	\$9,675.15	1.80%
BTC/KRW	\$162,262,000	\$9,926.20	1.66%
TRUE/BTC	\$158,638,000	\$9,542.52	1.62%
BTC/USD	\$157,022,000	\$9,691.80	1.60%
EOS/BTC	\$145,699,000	\$9,743.80	1.49%
EOS/BTC	\$144,533,000	\$9,779.96	1.48%
ETH/BTC	\$136,844,000	\$9,689.85	1.40%
BTC/KRW	\$122,001,000	\$9,912.26	1.25%

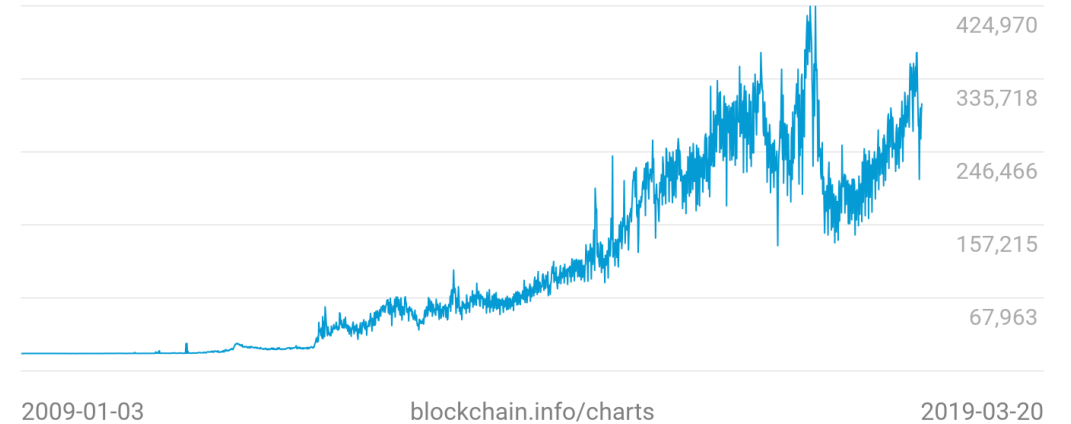
Bitcoin Transactions

- **425,000 transactions per day (highest)**
 - ~5 transactions per second
- **150,000 BTC traded per day**
- **Transaction fees per day ~ 27 BTC**

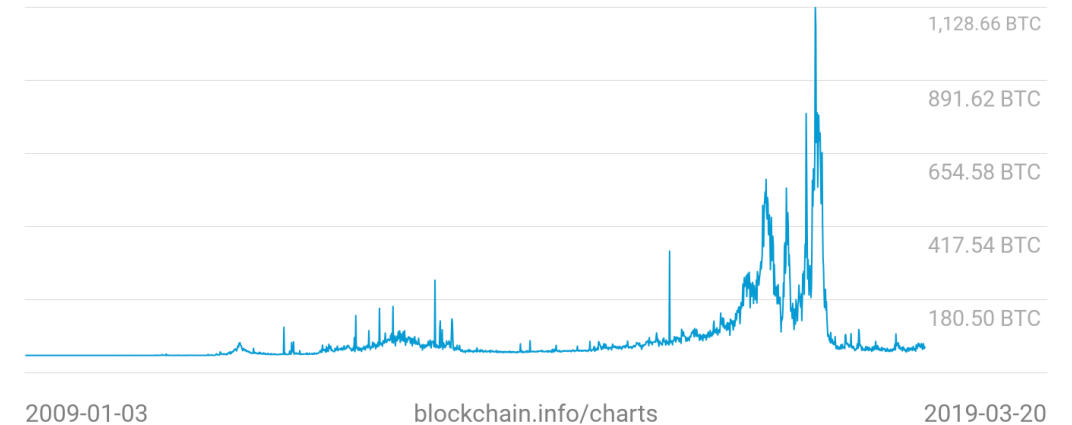
Estimated Transaction Value
133,222.38 BTC



Confirmed Transactions Per Day
304,960



Total Transaction Fees
27.20 BTC



Bitcoin Numbers

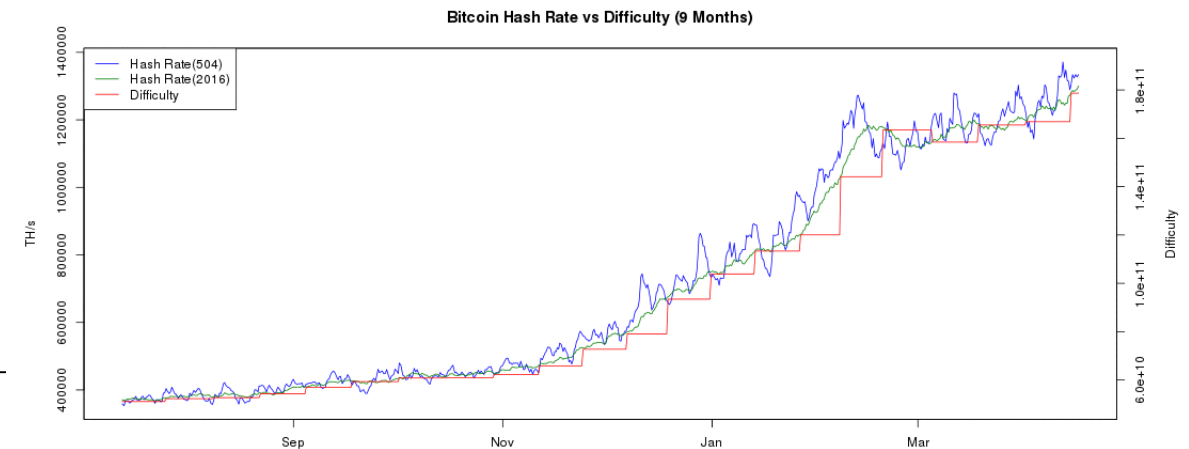
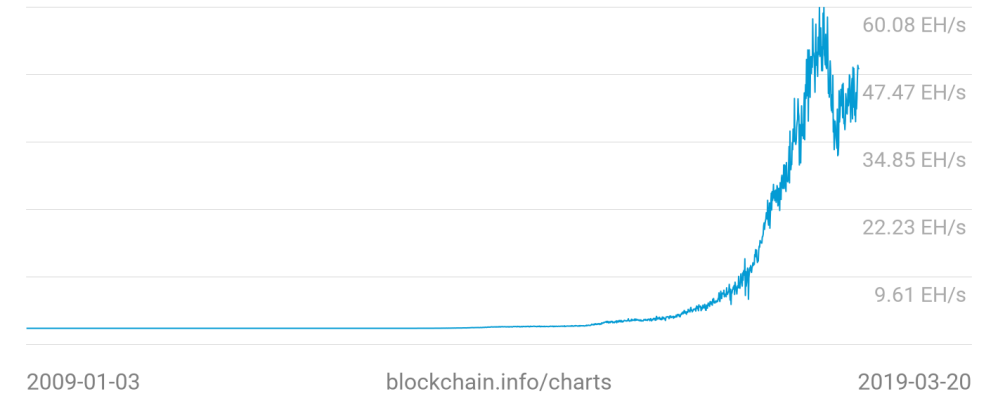
■ Network Hashrate

- ~635 [Zetta](#)FLOPS in 2019
- ~4 ZettaFLOPS in 2015
- ~714 ExaFLOPS in 2014
- ~900 PetaFLOPS in 2013
- ~155 PetaFLOPS in 2012

■ Adjust time: ~14 days

■ Fastest supercomputer ([top500.org](#)) Summit 143 PetaFLOPS (max), all 500 ~910 PetaFLOPS

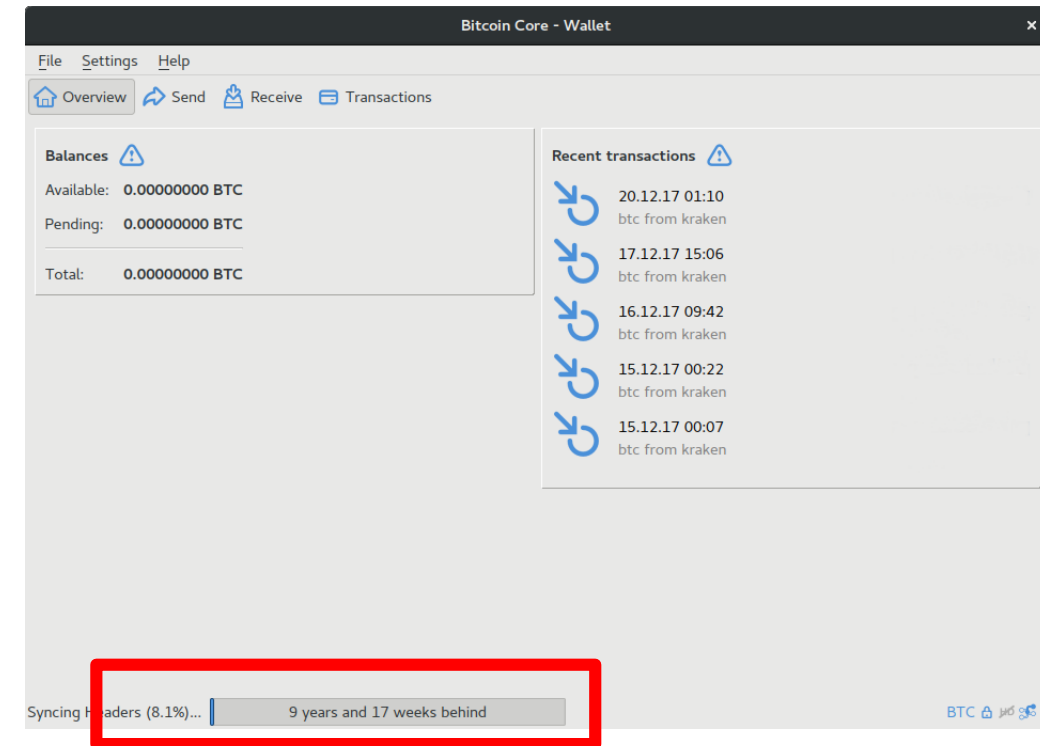
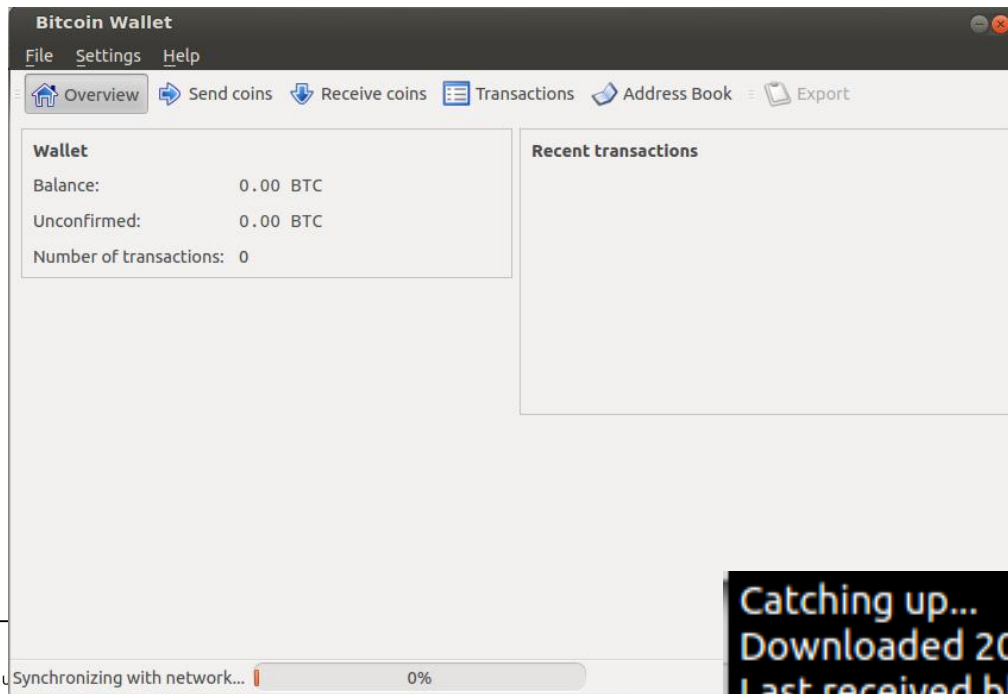
Hash Rate
48.57 EH/s



Bitcoin Example

■ Bitcoin is also the name of the software

- 2012: ~2 hours and 1.8G less disk space later...
- 2013: 8G disk space
- 2014: 19G disk space
- 2015: 36G disk space, 2016: 71G, 2019: 209 GB



Catching up...
Downloaded 2000 of 178717 blocks of transaction history.
Last received block was generated 1194 days ago.

Bitcoin Example

- **Not easy to add funds...**

- Especially with credit cards / paypal / okpay

- **Decided to transfer via bank**

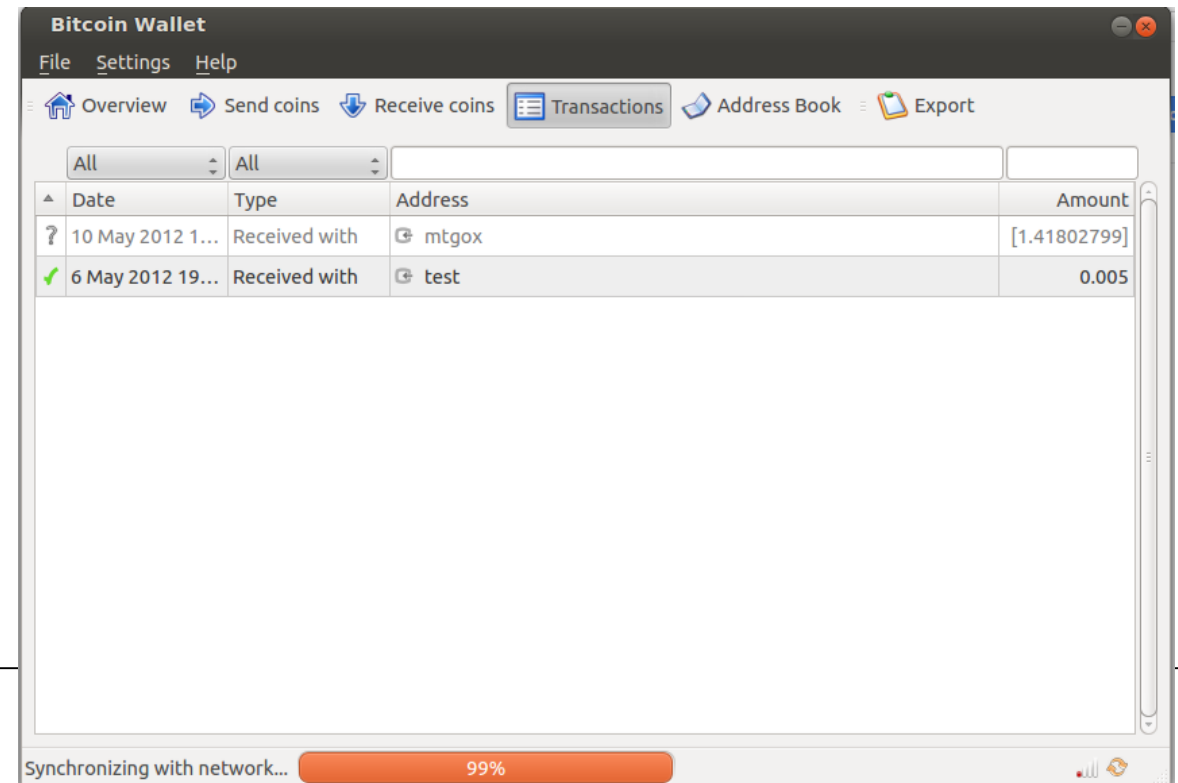
- SWIFT (financial messaging network) fee 25CHF, send 20USD
- Exchange rate 0.94000 → fee of 1,000 Yen → ~7.2USD

- **Spend 43.80 CHF for ~1.42 lousy BTC (2012)**

- **Now, transfer with bitstamp, kraken: register, proof of residency, SEPA bank transfer → easier**

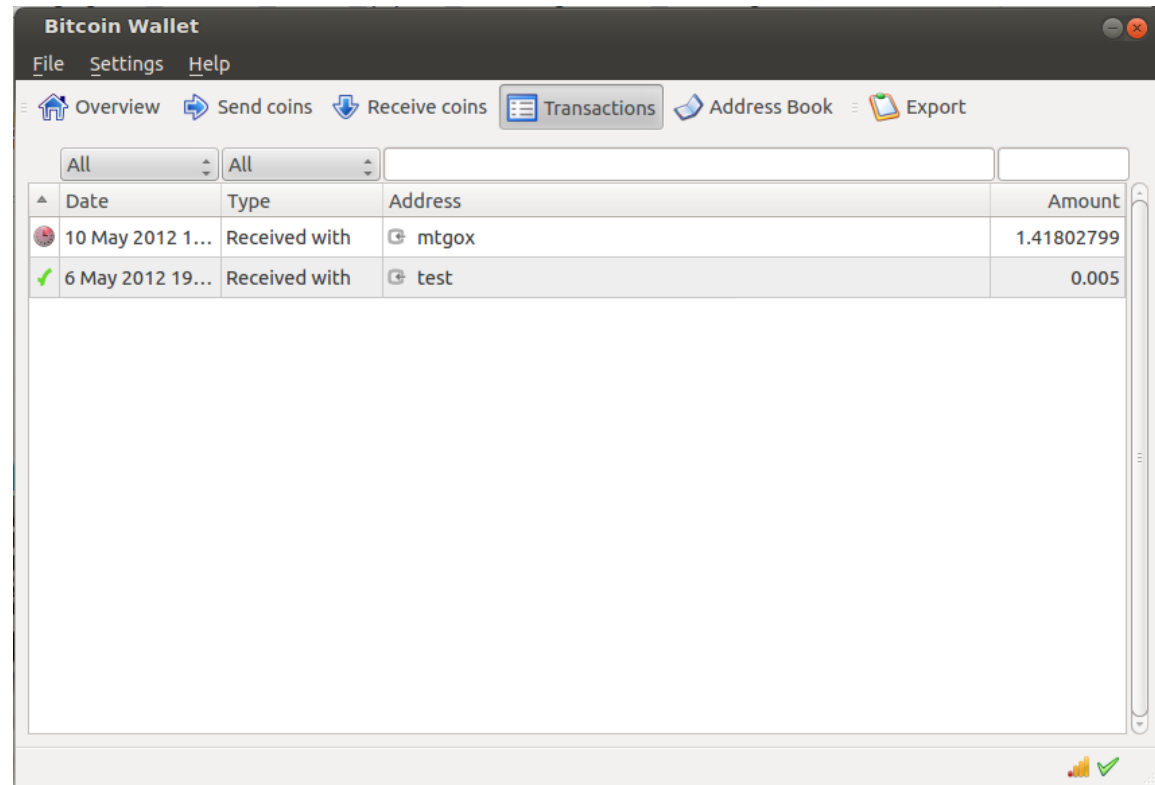
Bitcoin Client

- **2012: not easy to add funds... (credit cards / paypal)**
- **2016: more market places**
 - <http://coinbase.com>, <http://bitstamp.net>, <https://www.kraken.com/>
 - Not operating: <http://mtgox.com>, <http://bitcoin-24.com>, <http://bitfloor.com>, <http://bitcoin-central.net>
- **2019: its getting better**
 - SBB
 - However, credit cards often not working
 - Exachenges: KYC, delays



Bitcoin Client

- Transaction ongoing
 - Waiting for confirmations
- Good idea: don't leave coins in an online wallet



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■ A wallet has public-private keys (wallet.dat)

- Public key, ECDSA 256 bit → Bitcoin address (can receive bitcoins)
- Simple address: `base58(RIPEM160(Sha256(ecdsa public key)))`
 - E.g. 1GCeaKuhDYnNLNR6LGmBtKhPqEJD4KeEtF
- Private key used for signing transactions



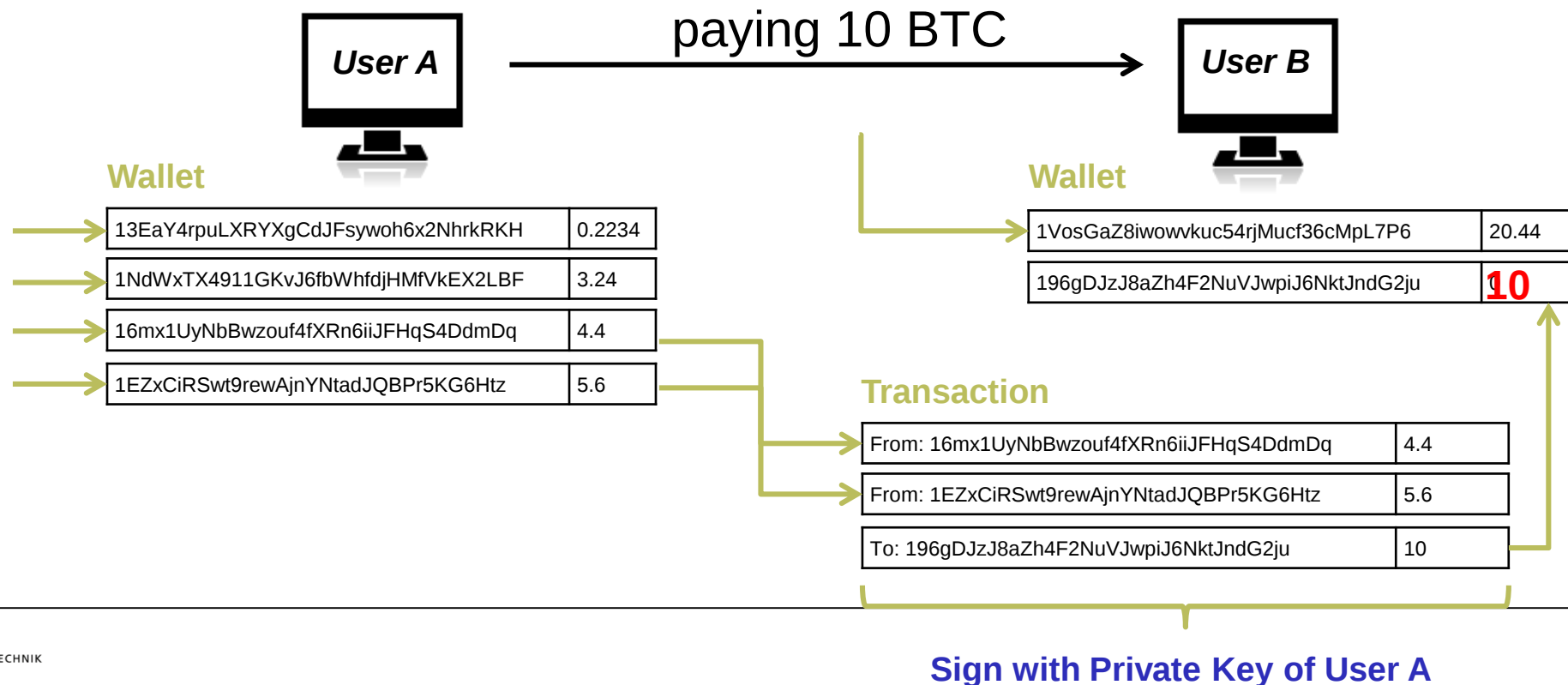
■ Transaction

- Peer A wants to send BTC to peer B → creates transaction message
- Transaction contains input / output
 - where the BTC came from and where it goes
- Peer A broadcasts the transaction to all the peers in the network
- Transaction stored in blocks → block is created / verified ~10min

Key Bitcoin Operations (2)

■ Private key authorizes the transaction (“access“)

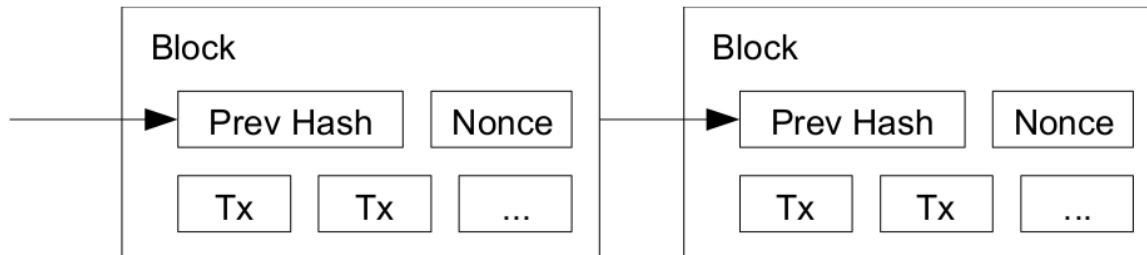
- If keys are stolen, thief may use “your” coins
- If keys are lost, coins are lost



Mechanism

■ Avoiding double spending

- Transactions in blocks are confirmed.
- guessing value that results in zero bits
(00000000000001805ff174586
b6acf100f733aaf634e92f9580b4fac9272ed97)
- Chained proofs of work

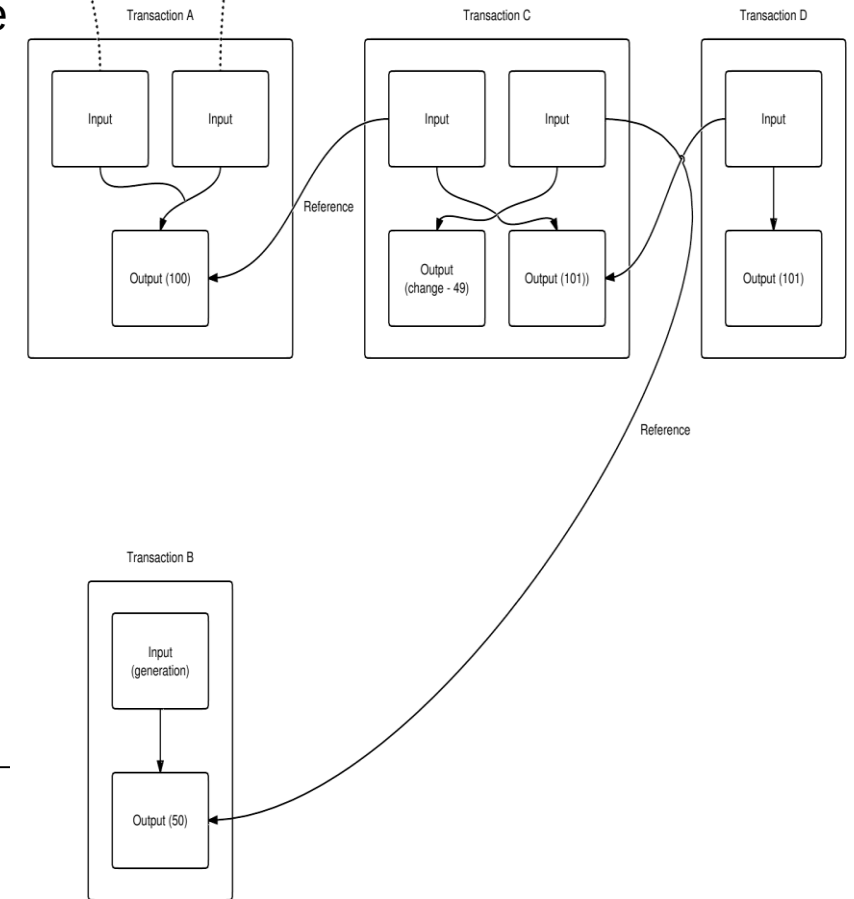


■ Generation of coins

- Mining / creating blocks → Miner get currently 12.5 BTC per creation
 - [adjustable difficulty](#) 6 blocks / h
 - Sometime in 2020 reward will be 6.25

■ Transactions have one or more inputs

- A sends 100 BTC to C, C generates 50 BTC. C sends 101 BTC to D, and send himself some change. D sends the 101 BTC to someone



Bitcoin - Protocol

■ TX in details

version		01 00 00 00
input count		01
input	previous output hash (reversed)	48 4d 40 d4 5b 9e a0 d6 52 fc a8 25 8a b7 ca a4 25 41 eb 52 97 58 57 f9 6f b5 0c d7 32 c8 b4 81
	previous output index	00 00 00 00
	script length	8a
	scriptSig	47 30 44 02 20 2c b2 65 bf 10 70 7b f4 93 46 c3 51 5d d3 d1 6f c4 54 61 8c 58 ec 0a 0f f4 48 a6 76 c5 4f f7 13 02 20 6c 66 24 d7 62 a1 fc ef 46 18 28 4e ad 8f 08 67 8a c0 5b 13 c8 42 35 f1 65 4e 6a d1 68 23 3e 82 01 41 04 14 e3 01 b2 32 8f 17 44 2c 0b 83 10 d7 87 bf 3d 8a 40 4c fb d0 70 4f 13 5b 6a d4 b2 d3 ee 75 13 10 f9 81 92 6e 53 a6 e8 c3 9b d7 d3 fe fd 57 6c 54 3c ce 49 3c ba c0 63 88 f2 65 1d 1a ac bf cd
	sequence	ff ff ff ff
output count		01
output	value	62 64 01 00 00 00 00 00
	script length	19
	scriptPubKey	76 a9 14 c8 e9 09 96 c7 c6 08 0e e0 62 84 60 0c 68 4e d9 04 d1 4c 5c 88 ac
block lock time		00 00 00 00

■ ScriptSig

PUSHDATA

signature data and SIGHASH_ALL

PUSHDATA

public key data

■ ScriptPubKey

OP_DUP

OP_HASH160

PUSHDATA

Bitcoin address (public key hash)

OP_EQUALVERIFY

OP_CHECKSIG

■ Non-turing complete (e.g. No loops)

■ With scripts

- Multisig, n-of-m, escrow and dispute mediation
- Micropayment channel, refund tx in future

■ Opcodes – [all codes](#)

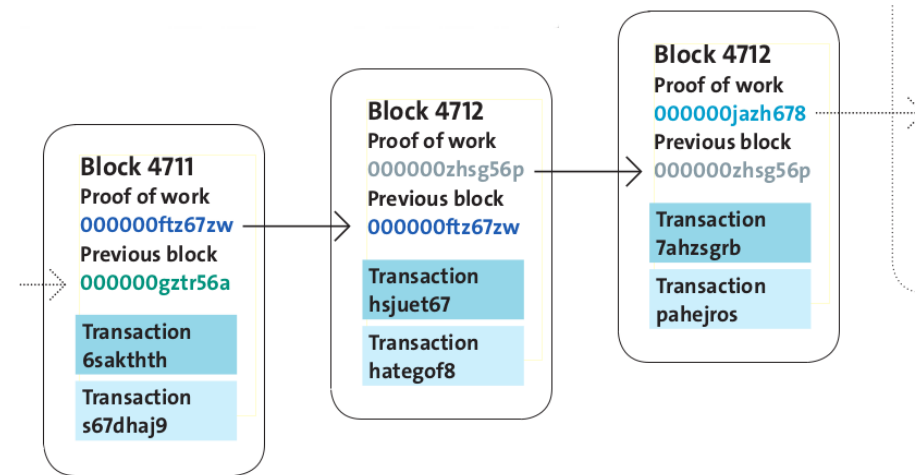
- Data operations
 - OP_PUSHDATA1, OP_PUSHDATA4,...
- Flow control
 - OP_IF, OP_ELSE, ...
- Stack
 - OP_DUP, OP_SWAP, ...
- Arithmetic
 - OP_ADD, OP_ABS, ...
- Crypto
 - OP_SHA256, OP_CHECKSIGVERIFY

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Blockchain (repetition)

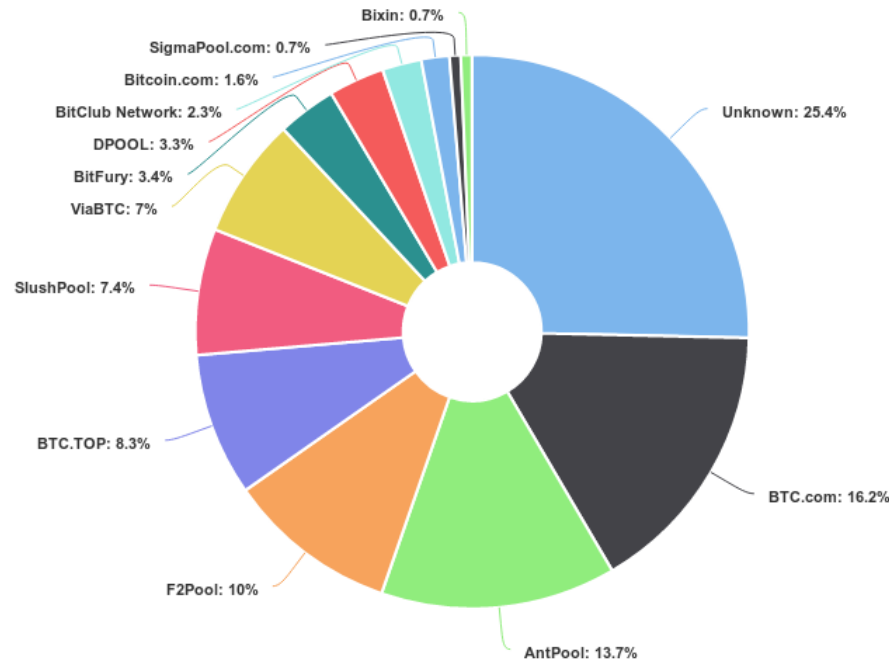
- **Transactions are collected in blocks**
 - New block created approximately every 10 min
- **Blocks contain solved crypto puzzles**
 - In the form of partial [hash collisions](#) (SHA256)
- **A block has a pointer to previous [block](#) → [Blockchain](#)**
- **Creation of blocks is called mining (reward)**
 - Miners use highly specialized hardware!



Mechanism - Mining

■ Couple of big miners

- Miners specialized, AMD GPUs, FPGA, ASIC (application-specific integrated circuit) [1][2][3]



<http://blockchain.info/pools>

■ Mining = creating valid blocks

■ Blocks are linked to previous blocks

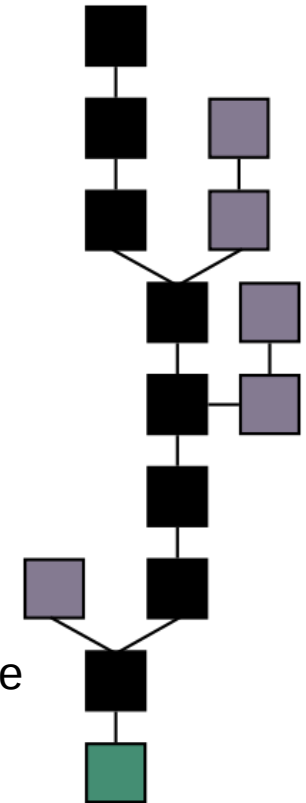
- Longest block survive (most difficult)

■ Different level of confirmations

- 6 block conf. is considered secure

■ Dangerous if someone has more than 50% computing power

- Can exclude and modify the ordering of transactions



Mining Evolution – CPU



Source: <https://99bitcoins.com/20-insane-bitcoin-mining-rigs/>

Mining Evolution – GPU



<https://bitcointalk.org/index.php?topic=7216.560>

Mining Evolution – FPGA



<http://www.openmobilefree.net/?p=1308>

Mining Evolution – ASIC Farms

■ Life Inside a Secret Chinese Bitcoin Mine

- 4,000 BTC per month
- <https://www.youtube.com/watch?v=K8kua5B5K3I>

■ KnCMiner

- Operator of the giant mining facility in Boden, Sweden
- Former maker of mining computers
- [Bankruptcy](#)



Mining: Evolution ASIC

■ Scenario: old ASIC miner

- Example: Avalon Batch #2
- 70GHash/s

■ Generates ~~2.11CHF~~ per day

■ Generates ~~~0.17CHF~~ per day

■ Generates ~0.01CHF per day in 2019

■ Uses 500-600W

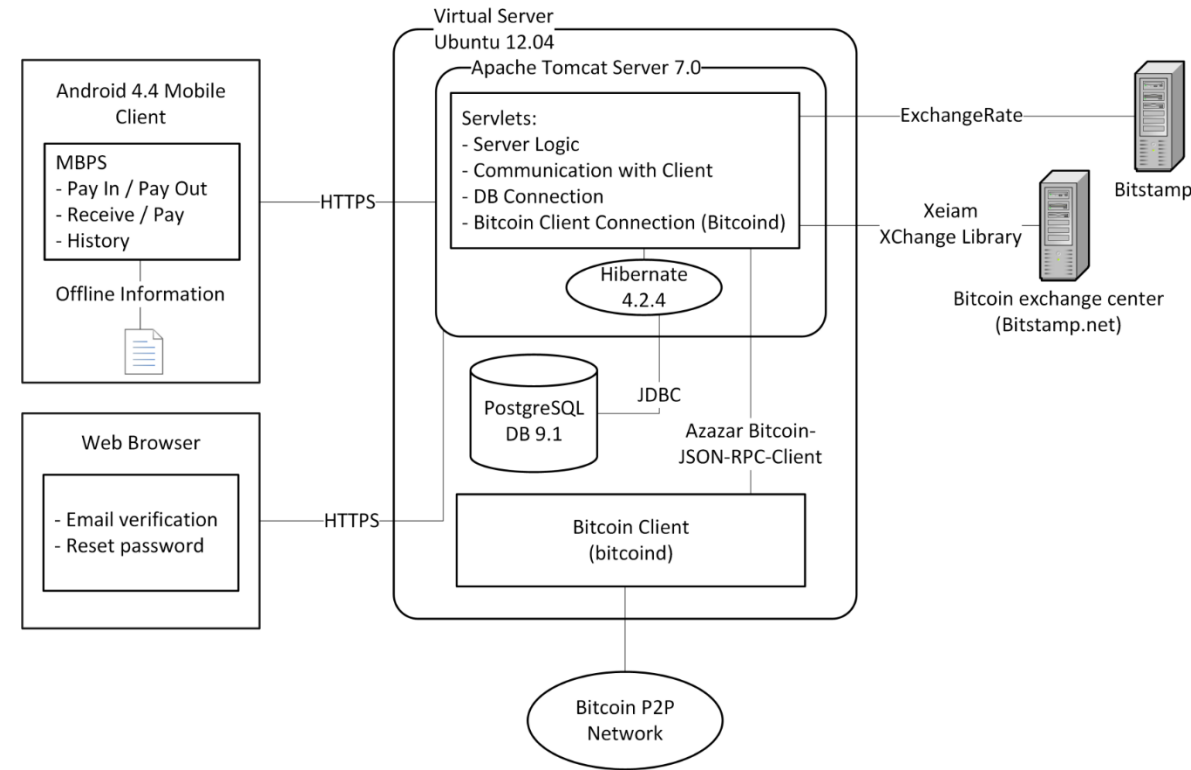
- 0.6KWh with 0.08 / 0.04CHF
- Cost per day 2.59 CHF
(Hochtarif, Mo-Sa 06:00-22:00)
- Cost per day 1.30 CHF
(Niedertarif, rest)



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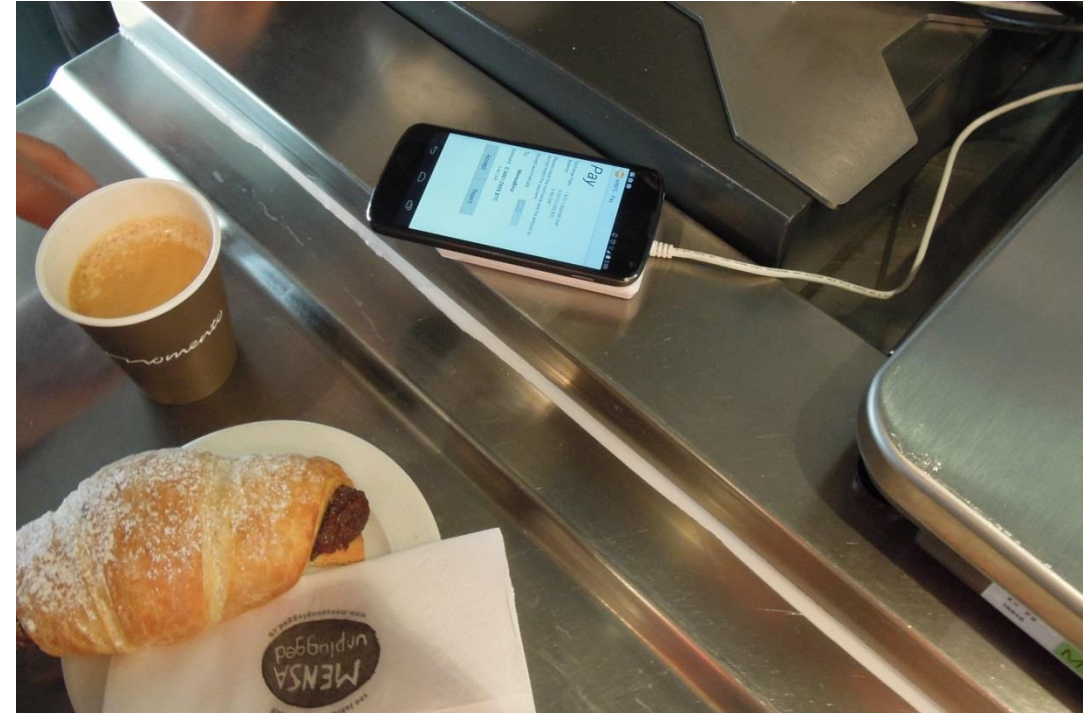
- Bitcoin Mensa Project ([MBPS/CoinBlesk](#))
- 4 Testruns
- Why - transactions should be considered as verified after 3-6 block confirmations
 - Currently ~10-60 minutes
 - Not applicable for everyday transactions
- Goal - instant exchange of bitcoins (below 1sec)
 - By means of mobile devices (Android)
 - Use two-way Near Field Communication (NFC)
- Introduce a “clearing center” to reduce the number of Bitcoin core transactions
 - Reduce transaction fees



System Architecture

Bitcoins at UZH: Evaluation: Mensa Test Run

- One week test run from 10th to 14th of February 2014
- In collaboration with the Mensa Binzmühle
- Pay all consumptions in Mensa with Bitcoins
- Reduce Bitcoin volatility risk by immediate trades on Bitstamp.net
 - After selling Bitcoins at the exchange point → Buy the same amount of Bitcoins
 - Keep the balance of the exchange point constant
 - After the Mensa receives Bitcoins → Sell these Bitcoins
 - Since the Mensa wants to receive CHF at the end, the equivalent amount is assured in this way



Example payment at Mensa Binzmühle

Bitcoins at UZH: Evaluation: Conclusions

- NFC handling caused many problems because users are inexperienced with NFC
- Android 4.4 restriction → too big entry barrier at the moment / below 4.4 no two-way NFC possible



USD/mBTC Exchange Rate Drop – February 10, 2014

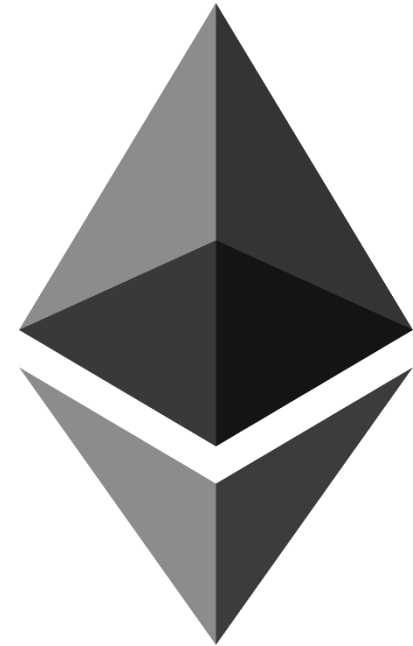
URL: b.socrative.com/student/

Room: HSR

Many Coins – Similar Mechanism

■ All electronic backed by scarce resource - avoid: double spending

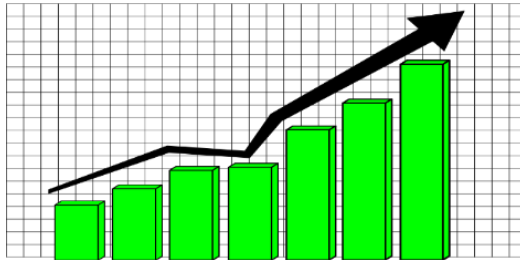
- Bitcoin: SHA256 partial hash collision: time, CPU, electricity
- Ethereum: variant of Dagger-Hashimoto, time, CPU, memory, electricity, miner store dataset: 1GB, verification only needs 16MB
- Ethereum: Opcodes in Bitcoin, smart contracts in Ethereum
- Litecoin: scrypt partial hash collision: time, CPU, memory, electricity
- Ripple XRP: Unique node list (trusted validators, 1000): web of trust
- [PPCoin](#)/Peercoin: proof of stake / (proof of work):
 - holding 1% will generate 1% of coins
 - 1% inflation per year
 - Energy efficient / proof of stake
- [Cardano/EOS/...many more](#)



Discussion (1)

■ Advantages

- Low (fixed) tx fees
 - ~10 satoshi per byte
- Scalable
 - Hardware/storage gets faster



- Anonymity
 - No privacy concerns/ datamining difficult

■ Disadvantages

- Power consumption
 - ~ 6 times AKW Leibstadt
- Not scalable
 - Bitcoin with 5 tps vs. VISA 57,000 tps (23.12)
[tps: transactions per sec]

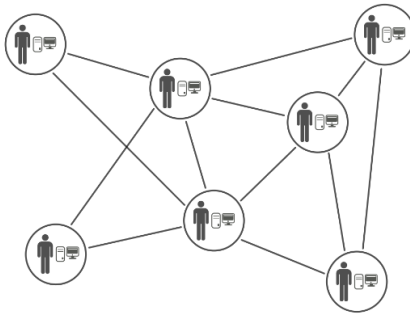


- Anonymity
 - Can be used for illegal activities

Discussion (2)

■ Advantages

- No major “crashes”
 - Mt.Gox was exchange site!
- Decentralized
 - Open protocol
 - Forks

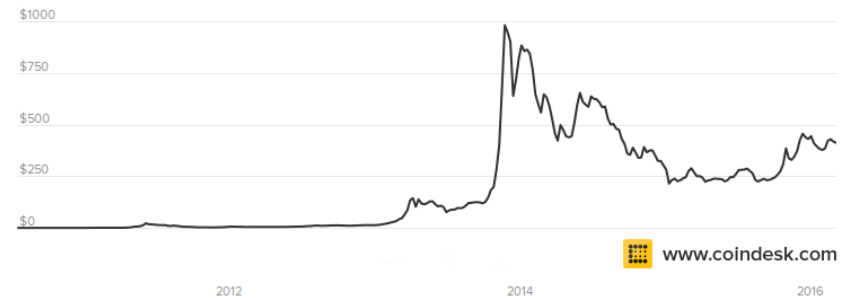


- Other blockchain usage
 - Smart contracts

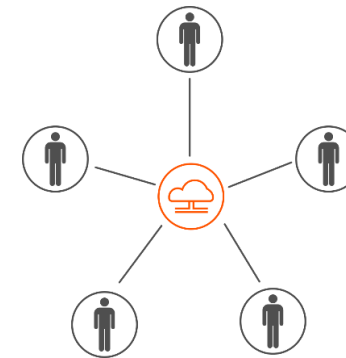


■ Disadvantages

- Volatile exchange rate



- Core developers



- But! [wrt ASIC](#) – *“It shows that Bitcoin is considered stable enough for a company to invest a LOT of money on design and production on it, which is very good. ASICs were bound to happen if Bitcoin survived long enough.”*
- But! Bitcoin does not intend to replace VISA
 - Still affordable by (some) individuals
 - Better comparable to wire transfers
- But! Moore’s, Nielson’s law, and other laws
 - [Moore’s law](#): number of transistors doubles every two years
 - [Nielson’s law](#): Bandwidth grows 50% per year
 - [Kryder's Law](#): Space per unit cost has doubled roughly every 14 months
- But! [Lightning](#)
 - TX fees up to 30 USD → micro payments
 - Multisig, hashed timelock → fast and cheap transactions

Questions?

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