The Mathematics of Bitcoin

Brian Heinold

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- Price as of Saturday 3/28/15 at 7:50 pm

1 Bitcoin equals

253.48 US Dollar

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- 256 bits means $2^{256} \approx 10^{77}$ possible outputs.

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Assuming SHA-256 is secure, you would need around 10^{40} messages before two messages had same hash.

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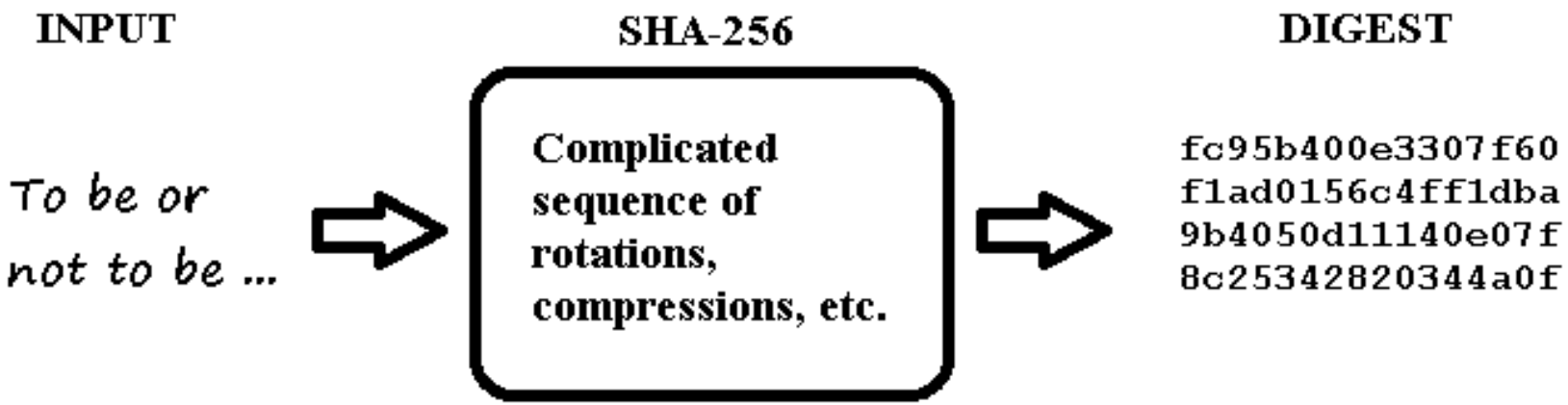

The hash's output (*digest*) serves as a short fingerprint of something.

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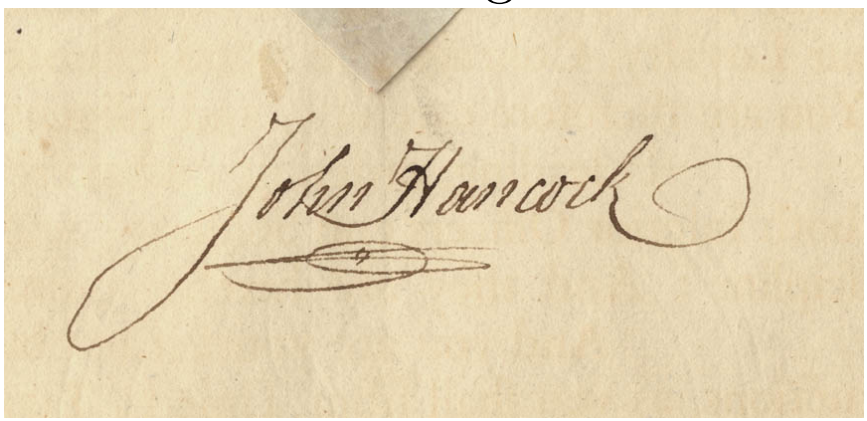

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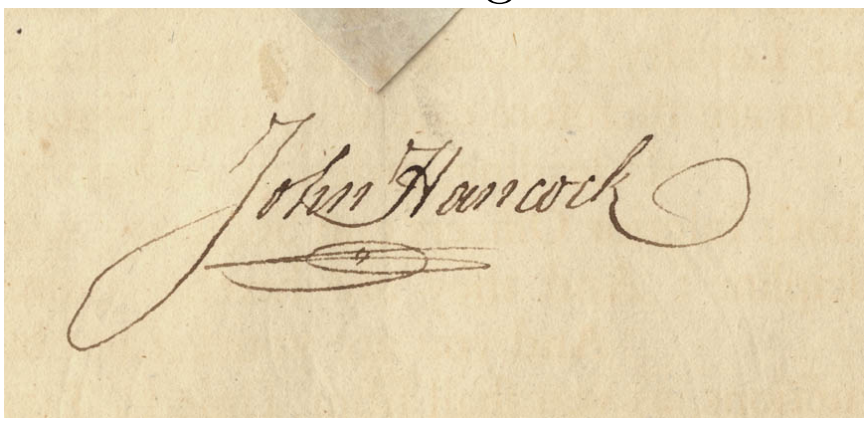

- We want a digital equivalent.
- Ordinary signatures can be forged and don't translate well to the digital world.

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- This is idea of public key cryptography.

  Public key: Fancy light
  Private key: Alice's special pen

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- In Bitcoin, every user has both a public key and a private key. These are large numbers (given in base-58).
- Example public key: `1JHhJuduB86iVzSuubRhwTnV5stimPGQoD`
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  `5JNfwXtrJisnysV84QgkqBr4PwprEX7QPFg6f5jcdDkzT6erXGc`
- Alice signs message by encrypting a hash of it with her private key.
- Other people decrypt it with the public key, and run message through hash function.
- Digest will match decrypted result only if it was sent by Alice.

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- And what is to stop Alice from double-spending?

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- Can store private key in bitcoin wallet software or in "cold storage" (offline)

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- Then she broadcasts it to the whole network.

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- How?

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- It is adjusted every couple of weeks to maintain this average.

Mining simulation

```
 >>> f(1)
40 0b918943df0962bc7a1824c0555a389347b4febdc7cf9d1254406d80ce44e3f9
>>> f(2)
287 00328ce57bbc14b33bd6695bc8eb32cdf2fb5f3a7d89ec14a42825e15d39df60
>>> f(3)
887 000f21ac06aceb9cdd0575e82d0d85fc39bed0a7a1d71970ba1641666a44f530
>>> f(4)
88485 0000a456e7b5a5eb059e721fb431436883143101275c4077f83fe70298f5623d
>>> f(5)
596139 00000691457f4f0ce13e187b9ab4fda6d42c8647752909b8f71f9dbd8f6bd4ab
>>> f(6)
665783 0000000399c6aea5ad0c709a9bc331a3ed6494702bd1d129d8c817a0257a1462
>>> f(7)
665783 0000000399c6aea5ad0c709a9bc331a3ed6494702bd1d129d8c817a0257a1462
>>> f(8)
426479725
00000000690ed426ccf17803ebe2bd0884bcd58a1bb5e7477ead3645f356e7a9
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- **It is this massive amount of work that backs all those transactions.**

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- The other miners stop working on whatever they are doing.
- They all start on a new block, building on the just-mined block.
- **It is this massive amount of work that backs all those transactions.**
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More on mining

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- They all start on a new block, building on the just-mined block.
- **It is this massive amount of work that backs all those transactions.**
- If someone wants to add in a fraudulent transaction, they have to mine faster than the whole rest of network.
- Only feasible if you have roughly as much computing power as the rest of the network combined.

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- The miner who successfully solves the challenge gets the transaction fees for all the transactions that make up the block.
- They also get a reward, currently 25 bitcoins.
- Rewards are enough that it's more profitable to put your resources toward mining than towards trying to create fraudulent transactions.

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- It is currently 25.
- It halves after every 210,000 blocks (about 4 years since 10 minutes per block).
- Last one will be created around year 2140 (though by exponential decay most will be generated well before).
- Bitcoins can be broken down. Minimum unit is 1/100,000,000 of a bitcoin, a *satoshi*.

Mining

- Bitcoin mining has become so popular that it's not feasible for individual to mine without special hardware and/or joining a mining pool.
- Total processing consumed by mining exceeds that of the world's top 500+ supercomputers combined.
- Some people are worried about all the power consumed by bitcoin mining.

From https://www.coinbase.com/network

Bitcoin Node

Our connection to the bitcoin network

349,950 Blocks

Last block created 3 minutes ago

67,008,441 Transactions

Last transaction created less than a minute ago

1,608 unconfirmed transactions

35 Peers Connected

8360 available

From https://www.coinbase.com/network

Network › Transactions

Transaction Hash	Pool	Net Amount	Created
df321b40f89ffa9a1b818dc48229e1dc3caee5c2d52e08d5855e1d3bbedba4fb	Transaction Pool	0.41453829	less than a minute ago
2433246261342d91641ee7a8235f704b558e75a9ee0f7faf256f13d594860879	Transaction Pool	1.90085498	less than a minute ago
f3a5e73b5cb2717dbd6098d34dcfaff650fb2e92a566c430ea6fcbc28b0b32eb	Transaction Pool	0.00100000	less than a minute ago
7847e3b08456d28a2587167f686a4bd08407b257661abe5efa9b165a9e97e21e	Transaction Pool	0.49999000	less than a minute ago
b5a31252d83ead1ed3b2de2aaaa5e53ad979b04b741b8384195cdf3a61aa1bf6	Transaction Pool	0.14321780	less than a minute ago
8c4fa57b87e23d116bdcb0bd868211493ec14a6ba1d1baf113ecc42f4a3007d2	Transaction Pool	0.01926981	less than a minute ago
79613d9c3389625e35327ec112922fbcfd331fac9ecbc5dd272afed7d66d7605	Transaction Pool	0.61214489	less than a minute ago
7b8139e4a738ff5e64e0eb3d8462e1b6d0c9722796375b0413993e21a24ef3e6	Transaction Pool	5.01930000	less than a minute ago

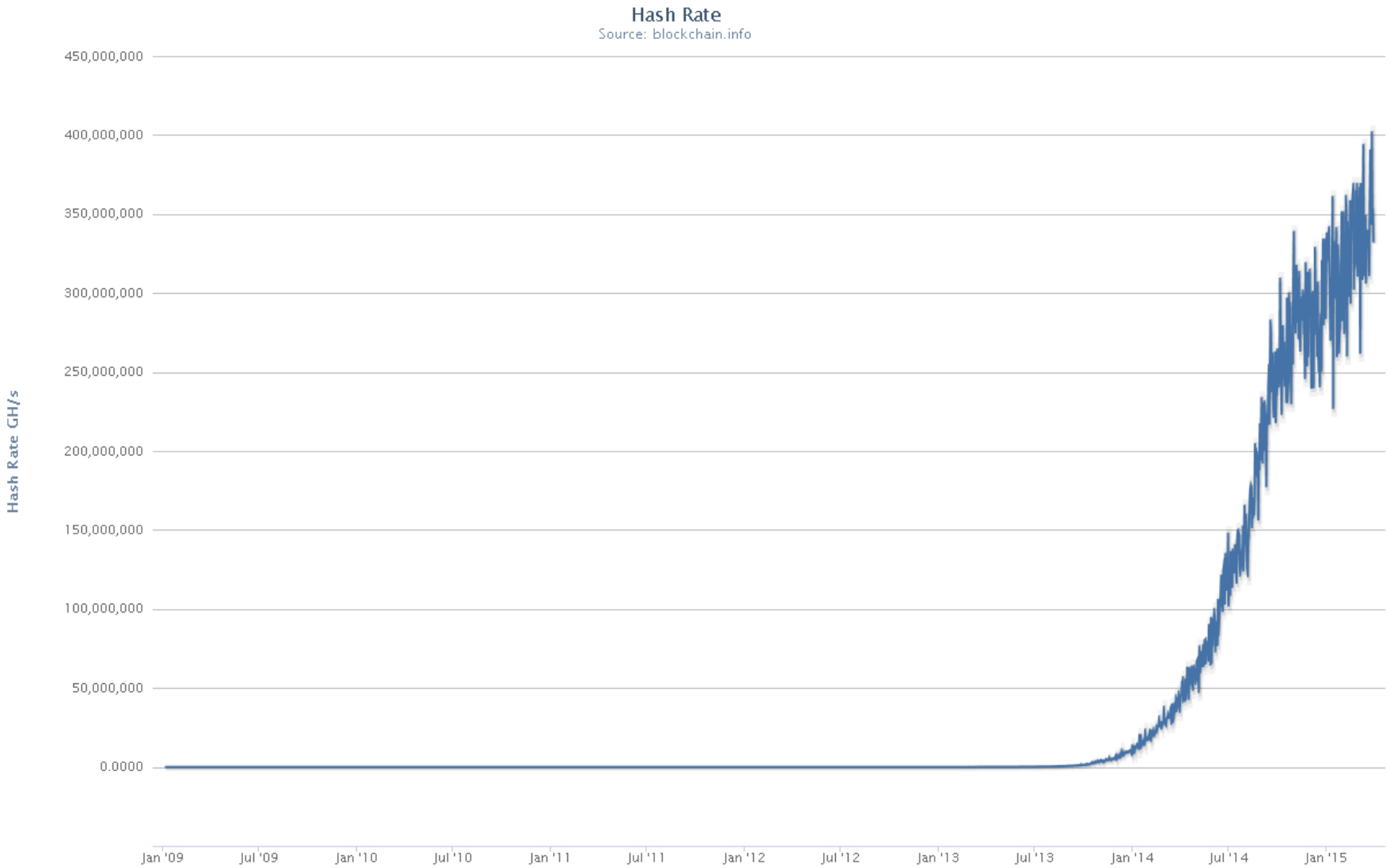
From https://www.coinbase.com/network

Network › Blocks

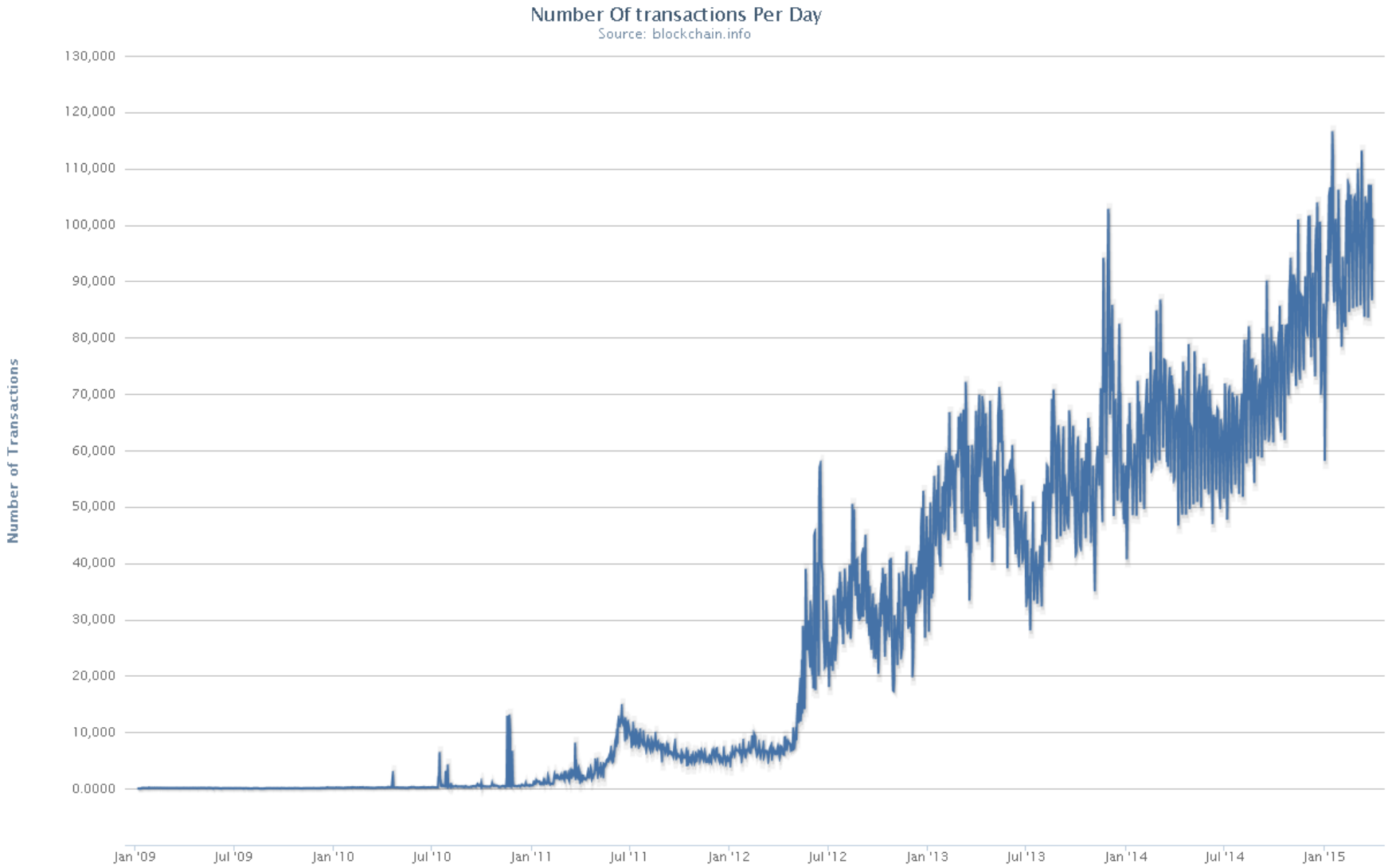
Block Hash	Branch	Height	Transactions	Timestamp
00000000000000000116fc83685867b561f6b0566999ff502cb5d296844847fc8	main	349951	356	2 minutes ago
000000000000000001055564896d474580b19b18bab2448a7978e6972b59b4111b	main	349950	1050	6 minutes ago
00000000000000000001a7f5b11d35183c7a0d9d9c5e4803d5705865ad8a0cd89d	main	349949	1723	15 minutes ago
000000000000000000001453922aff3e7ca334f070920f081ae9de129870b69fd47	main	349948	85	40 minutes ago
00000000000000000001d9c1e745d1c091d8012ab87942a8335583b7357d6d7be3	main	349947	1039	39 minutes ago
0000000000000000064f4270c6878fdf555c1c3cdf6223f8810fafed500616bf	main	349946	706	about 1 hour ago
00000000000000000006cbec774c2acf7c595bc3a3f3010124592a147f8a670ec7	main	349945	1410	about 1 hour ago

From https://blockchain.info/charts

From https://blockchain.info/charts



From https://blockchain.info/charts



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- chrispacia.wordpress.com/?s=Explained+Like+You%27re+Five&submit=Search
- bitcoin.org/bitcoin.pdf (Nakomoto's original whitepaper.)
- bitcoin.org/en/faq
- www.coinbase.com/network (Current info about blocks/transactions)
- blockchain.info/charts (Historical and recent graphs)