Permissionless Innovation

Bitcoin Research Challenges
The Dawn of Decentralized Computing

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Definitions

Definiton of Bitcoin

Bitcoin is a peer-to-peer network that maintains a public distributed ledger of digital math-based assets known as bitcoins.

Definiton of Computer

A computer is a system that takes data in input, elaborate them via a mathematical model and outputs data without interpreting them.

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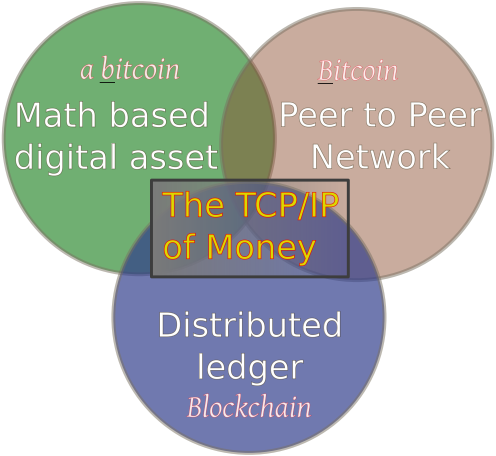
What is “Bitcoin”

The Currency, the Network, the Ledger



a bitcoin

Math based digital asset

Bitcoin

Peer to Peer Network

The TCP/IP of Money

Distributed ledger

Blockchain

The Currency

The Grey Metal Metaphore

“As a thought experiment, imagine there was a base metal as scarce as gold but with the following properties:

- boring grey in colour
- not a good conductor of electricity
- not particularly strong, but not ductile or easily malleable either
- not useful for any practical or ornamental purpose
- and one special, magical property:
  can be transported over a communications channel”

Satoshi Nakamoto – 27 August 2010

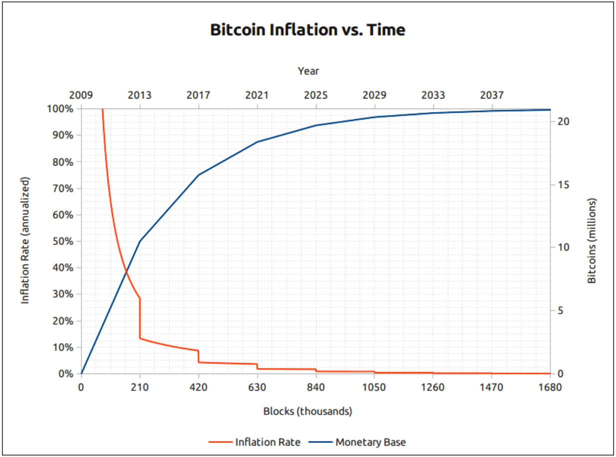
The Currency

Some information

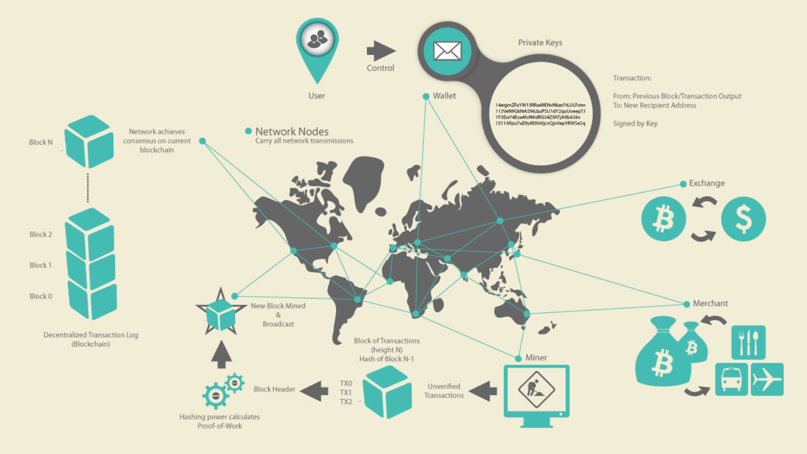
- The supply of bitcoins is fixed at 21 millions, (now ∼13 M)
- Each bitcoin (BTC) can be divided in 10^8 units (1/100 000 000 is called one *satoshi*)
- The network tends to produce 25 new bitcoins every 10 minutes (block reward)
- The block reward is halved every ∼4 years (210 000 blocks)
- We are in the 2^{nd} reward era out of 34 (rewards ends in 2140)
- 1 BTC = 310 € on online exchanges

The Currency

Predictable Money Supply



Overview of the Network


User
Control
Wallet
Private Keys
14eqjmZFaYW15RRa49ENvNkze7rLULFotw
113VeN9GkNrkS96JzuPSU1dY2quUoeep7J
1F3EiaY4Exa4fof4KdRGS4ZXhTjA9bAS6v
1511AFpu7uE9y8EthMjcvQjoVepVRWSeSq
Transaction:
From: Previous Block/Transaction Output
To: New Recipient Address
Signed by Key
Block N
Network achieves consensus on current blockchain
Network Nodes
Carry all network transmissions
Exchange
Block 2
Block 1
Block 0
Decentralized Transaction Log (Blockchain)
New Block Mined & Broadcast
Merchant
Block of Transactions (height N) Hash of Block N-1
Miner
TX0
TX1
TX2
Block Header
Unverified Transactions
Hashing power calculates Proof-of-Work

Real time visuals: `http://bitcoinglobe.com/`

Who Invented Bitcoin?

Satoshi Nakamoto

- Satoshi Nakamoto, in 2008 publishes a white paper, “Bitcoin: a Peet-to-Peer Electronic Cash System” via “The Cryptography Mailing List”.
- In 2009–2011 he wrote a lot of posts (80000 words, the size of a novel) in flawless english with British colloquialisms (aside only the first post where he used American spellings).
- Satoshi is probably a pseudonym for a developer or a group, “vanished” from the web in April 2011 because he “moved to other things”
- If he is not a group, he is a world class programmer, with deep knowledge of C++, economics, cryptography and peer-to-peer networking.
- His timestamps speculation are about either east-coast US with a fairly normal sleep schedule or western Europe with a *coder* sleep schedule (probably not Japan)

Trusted third party

> *“What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party.””*
>
> — Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System” – October 31, 2008

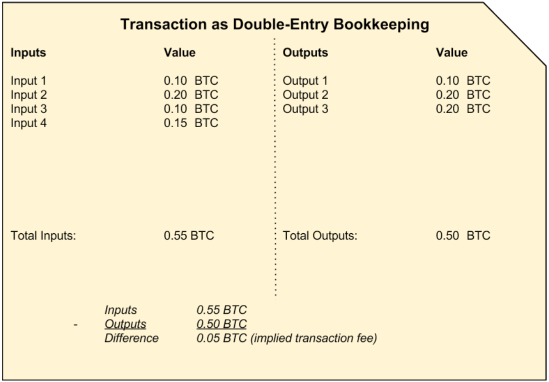
Trustless does not mean that we do not need to trust *anything*, but that we do not need to trust *anyone*.

Consensus in a decentralized system

The Byzantine Generals' problem

> *"A group of generals of the Byzantine army camped with their troops around an enemy city. Communicating only by messenger, the generals must agree upon a common battle plan. However, one or more of them may be traitors who will try to confuse the others. The problem is to find an algorithm to ensure that the loyal generals will reach agreement."*
>
> — Marshall Pease, Robert Shosthak and Leslie Lamport, The Byzantine Generals Problem

Transactions



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

	Inputs	*0.55 BTC*
-	*Outputs*	*0.50 BTC*
	Difference	*0.05 BTC (implied transaction fee)*

> *“**spending** is signing a transaction which transfers value from a previous transaction over to a new owner identified by a bitcoin address”*
>
> — Andreas M. Antonopoulos – Mastering Bitcoin – O’Reilly 2014

A Paper Wallet

Vires in numeris

Private Key

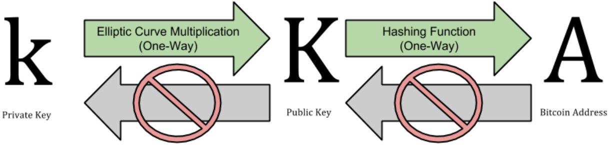
BIP38 Encrypted

6PRNsJqabLoT73aWNWfSa3hMcX6ML
mx779TPHbKzht4apwqsngkwFcBuKQ

Bitcoin Address

1fbk5AYjA7wLdwbru2CunWEuToBu1USsX

`https://blockchain.info/address/1fbk5AYjA7wLdwbru2CunWEuToBu1USsX`

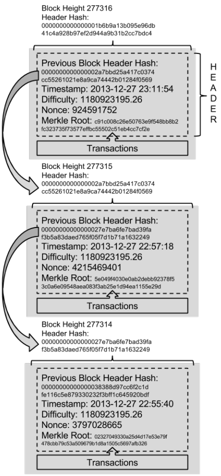


Elliptic Curve Digital Signature Algorithm – secp256k1

Hash = RIPEMD160(SHA256(pubkey))

Chain of Blocks

A Distributed Ledger



Block Height 277316
Header Hash:
0000000000000001b6b9a13b095e96db
41c4a928b97ef2d944a9b31b2cc7bdc4

Previous Block Header Hash:
0000000000000002a7bbd25a417c0374
cc55261021e8a9ca74442b01284f0569
Timestamp: 2013-12-27 23:11:54
Difficulty: 1180923195.26
Nonce: 924591752
Merkle Root: c91c008c26e50763e9f548bb8b2
fc323735f73577effbc55502c51eb4cc7cf2e

HEADER

Transactions

Block Height 277315
Header Hash:
0000000000000002a7bbd25a417c0374
cc55261021e8a9ca74442b01284f0569

Previous Block Header Hash:
00000000000000027e7ba6fe7bad39fa
f3b5a83daed765f05f7d1b71a1632249
Timestamp: 2013-12-27 22:57:18
Difficulty: 1180923195.26
Nonce: 4215469401
Merkle Root: 5e049f4030e0ab2debb92378f5
3c0a6e09548aea083f3ab25e1d94ea1155e29d

Transactions

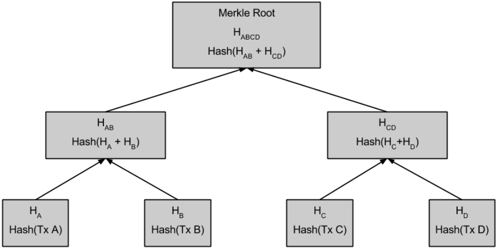
Block Height 277314
Header Hash:
00000000000000027e7ba6fe7bad39fa
f3b5a83daed765f05f7d1b71a1632249

Previous Block Header Hash:
0000000000000000038388d97cc6f2c1d
fe116c5e879330232f3bff1c645920bdf
Timestamp: 2013-12-27 22:55:40
Difficulty: 1180923195.26
Nonce: 3797028665
Merkle Root: 02327049330a25d4d17e53e79f
478cbb79c53a509679b1d8a1505c5697afb326

Transactions

Secure Hash Algorithm – SHA256

The proof of work used in Bitcoin takes advantage of the apparently random nature of cryptographic hashes. A good cryptographic hash algorithm converts arbitrary data into a seemingly-random number.



Merkle Root
H_{ABCD}
Hash(H_{AB} + H_{CD})

H_{AB}
Hash(H_A + H_B)

H_{CD}
Hash(H_C+H_D)

H_A
Hash(Tx A)

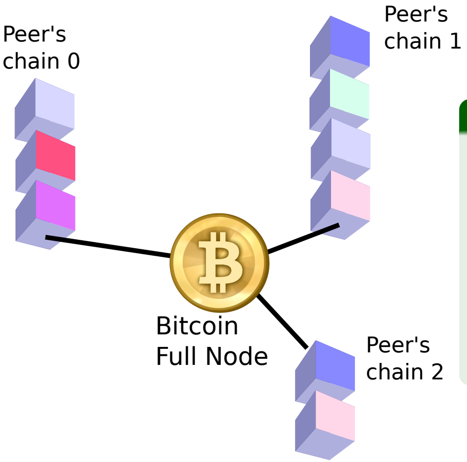
H_B
Hash(Tx B)

H_C
Hash(Tx C)

H_D
Hash(Tx D)

Consensus via Proof of work

Longest chain wins



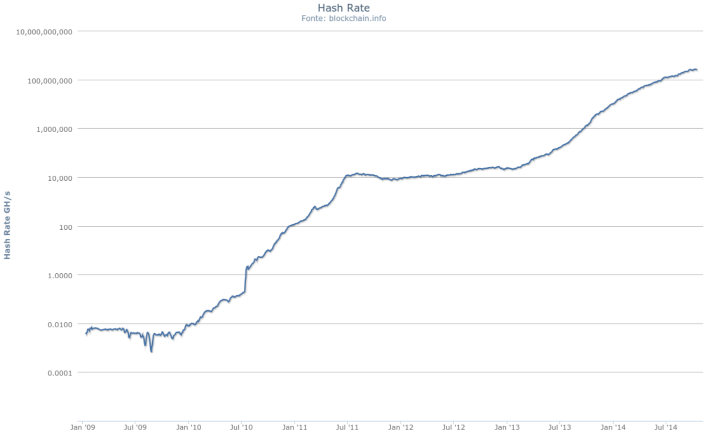
The "Work" is called "mining"

1. SHA256(SHA256(block header) + nonce) < *target* ?
2. The Bitcoin Network will rewards me (25 BTC)

Difficulty ("inverse" of target) will adapt to global hashrate every ~ 2 weeks (2016 blocks)

Historycal Hashrate

Logarithmic Scale



Random Quotes

Taking Breath

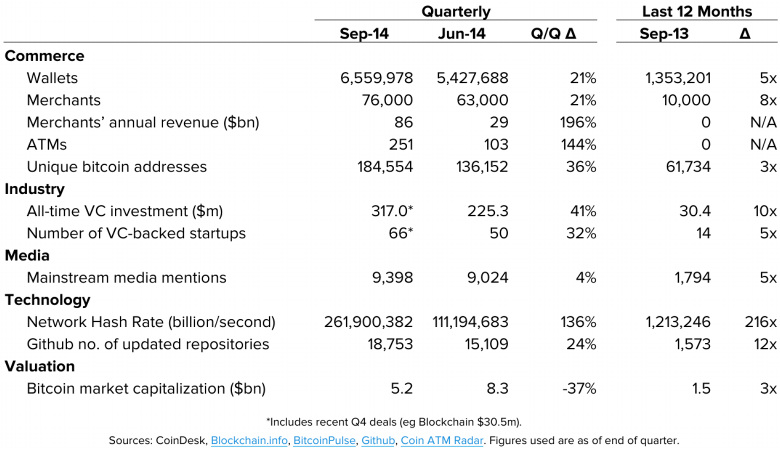
> *"Bitcoin is a remarkable cryptographic achievement and the ability to create something that is not duplicable in the digital world has enormous value."*
>
> — Eric Schmidt (Google's former CEO)

> *"Not having an internet strategy in 1995 is the equivalent of not having a bitcoin strategy now."*
>
> — Moe Levin (Bitpay CEO)

> *"By 2005 or so, it will become clear that the Internet's impact on the economy has been no greater than the fax machine's."*
>
> — Paul Robin Krugman – Nobel Memorial Prize in Economic Sciences (1998)

Usage Metrics

Latest quarter



	Quarterly			Last 12 Months	
	Sep-14	Jun-14	Q/Q Δ	Sep-13	Δ
Commerce					
Wallets	6,559,978	5,427,688	21%	1,353,201	5x
Merchants	76,000	63,000	21%	10,000	8x
Merchants' annual revenue ($bn)	86	29	196%	0	N/A
ATMs	251	103	144%	0	N/A
Unique bitcoin addresses	184,554	136,152	36%	61,734	3x
Industry					
All-time VC investment ($m)	317.0*	225.3	41%	30.4	10x
Number of VC-backed startups	66*	50	32%	14	5x
Media					
Mainstream media mentions	9,398	9,024	4%	1,794	5x
Technology					
Network Hash Rate (billion/second)	261,900,382	111,194,683	136%	1,213,246	216x
Github no. of updated repositories	18,753	15,109	24%	1,573	12x
Valuation					
Bitcoin market capitalization ($bn)	5.2	8.3	-37%	1.5	3x

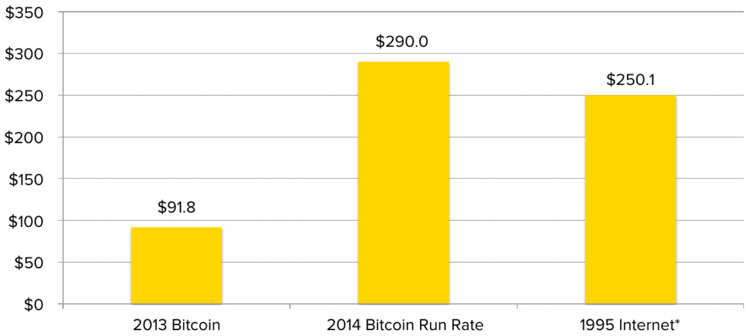
*Includes recent Q4 deals (eg Blockchain $30.5m).

Sources: CoinDesk, Blockchain.info, BitcoinPulse, Github, Coin ATM Radar. Figures used are as of end of quarter.

- http://coinmap.org/

What is happening?

Status of Venture Capitals



Bitcoin vs Early Internet VC Investment (millions)

*Includes first sequence venture deals but excludes late-stage 1995 internet investments ($257.6m). For additional disclosure on methodology see http://www.coindesk.com/following-money-trends-bitcoin-venture-capital-investment/

Source: CoinDesk, PricewaterhouseCoopers

Permissionless Innovation

Bitcoin and Internet

- Before Internet point to point communication between computers was available
- You needed a contract or permission from a Telco inorder to innovate
- Low level of Innovation, fax-machine, poor video conferences, not much more
- Bitcoin opens an era of financial Innovation (programmable money)
- The Blockchain permits Decentralized Computing
- Internet of Things: IBM’s “Adept” will use the Blockchain

Blockchain as DB

Permanent Storage

- You could write important data in the Blockchain (for free or for a small fee)
- What is written in the Blockchain is “forever”
- No one can remove or alter Blockchain information
- Example Application: Proof of Existence, Decentralization of Notary services

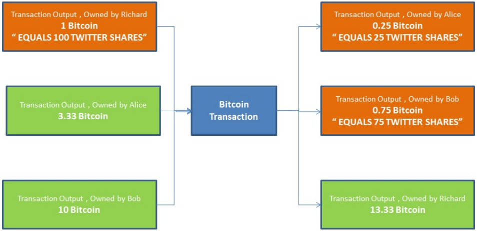
`http://www.proofofexistence.com/detail/`

`e3c21569e6ba5b488d5c416e8fc6ea166551cf64076f8f337ddc8cc8f9936bc0`

Generic Asset Ledger

Coloring Coins

- Tracking bitcoin transaction to permits generic asset trading
- “coloring coins” enables distributed exchanges
- anyone can issue a colored coin


Transaction Output , Owned by Richard
1 Bitcoin
“ EQUALS 100 TWITTER SHARES”
Transaction Output , Owned by Alice
3.33 Bitcoin
Transaction Output , Owned by Bob
10 Bitcoin
Bitcoin Transaction
Transaction Output , Owned by Alice
0.25 Bitcoin
“ EQUALS 25 TWITTER SHARES”
Transaction Output , Owned by Bob
0.75 Bitcoin
“ EQUALS 75 TWITTER SHARES”
Transaction Output , Owned by Richard
13.33 Bitcoin

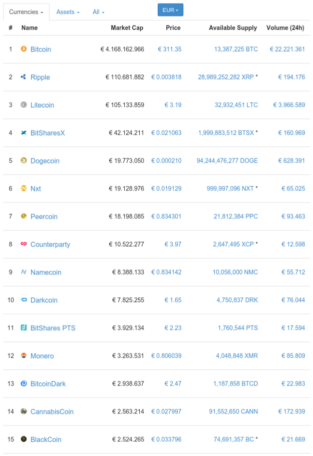
Multisignatures

Enabling Smart Contracts

- Wallets needs more that one signature to send a transaction
- k/n multisignatures are available in Bitcoin since 2012
- Smart Contracts are Trustless Unbreakable agreements
- Example: micro and nanopayments trustless channels
- Example: decentralized escrow (OpenBazaar is a decentralized Ebay)
- Example: Smart Properties

Crypto currencies

640 currencies should be enough for everyone



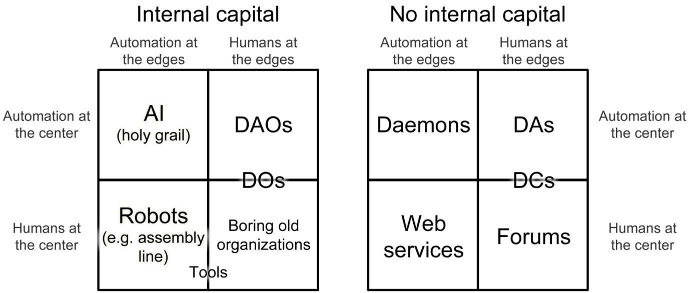
#	Name	Market Cap	Price	Available Supply	Volume (24h)
1	Bitcoin	€ 4.168.162.966	€ 311.35	13,387,225 BTC	€ 22.221.361
2	Ripple	€ 110.681.882	€ 0.003818	28,989,252,282 XRP *	€ 194.176
3	Litecoin	€ 105.133.859	€ 3.19	32,932,451 LTC	€ 3.966.589
4	BitSharesX	€ 42.124.211	€ 0.021063	1,999,883,512 BTSX *	€ 160.969
5	Dogecoin	€ 19.773.050	€ 0.000210	94,244,476,277 DOGE	€ 628.391
6	Nxt	€ 19.128.976	€ 0.019129	999,997,096 NXT *	€ 65.025
7	Peercoin	€ 18.198.085	€ 0.834301	21,812,384 PPC	€ 93.463
8	Counterparty	€ 10.522.277	€ 3.97	2,647,495 XCP *	€ 12.598
9	Namecoin	€ 8.388.133	€ 0.834142	10,056,000 NMC	€ 55.712
10	Darkcoin	€ 7.825.255	€ 1.65	4,750,837 DRK	€ 76.044
11	BitShares PTS	€ 3.929.134	€ 2.23	1,760,544 PTS	€ 17.594
12	Monero	€ 3.263.531	€ 0.806039	4,048,848 XMR	€ 85.809
13	BitcoinDark	€ 2.938.637	€ 2.47	1,187,858 BTCD	€ 22.983
14	CannabisCoin	€ 2.563.214	€ 0.027997	91,552,650 CANN	€ 172.939
15	BlackCoin	€ 2.524.265	€ 0.033796	74,691,357 BC *	€ 21.669

- Initially forks of bitcoin codebase
- Purpose Specific or Experimental testbed
- Different parameters or hash Algorithm
- Tied to bitcoin in the exchanges they become real too
- Less network effect, no real threat to bitcoin

Appcoins

Ethereum example

- Bitcoin full nodes execute a non Turing Complete script (handling of transactions, signatures)
- What is the script is Turing Complete?
- Distributed Applications
- Distributed Autonomous Corporations



Internal capital

	Automation at the edges	Humans at the edges
Automation at the center	AI (holy grail)	DAOs
Humans at the center	Robots (e.g. assembly line)	Boring old organizations

DOs

Tools

No internal capital

Automation at the edges	Humans at the edges	
Daemons	DAs	Automation at the center
Web services	Forums	Humans at the center

DCs

Bitcoin for good

Payment system for developing countries

- 50 % of the world is unbanked
- Kenya: 50 % of gdp is transacted via Mpesa, SMS money
- Remittances: ∼400 B$ market, 8% average fee
- Microcredits

Bitcoin is difficult

Why FBK?

- ICT is about data, communication and technologies
- Money is Data, Data is Money (Big Data, Secure computing)
- Cryptography is hard
- Peer-to-peer is hard
- Enterprenuer needs Technology partners

What Next?

- FBKcoin – The “Kessler”®
- PATcoin – meal vouchers, *glocal* social credits
- Trentino as the new “Bitcoin Valley”
- Deep social and economic impact papers
- Becoming The Bitcoin Research Center ;-)
- ~~A new Research Unit~~

These slides

`http://goo.gl/BbzhTT` [github: mammadori]