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A Perspective on Bitcoin and Blockchain

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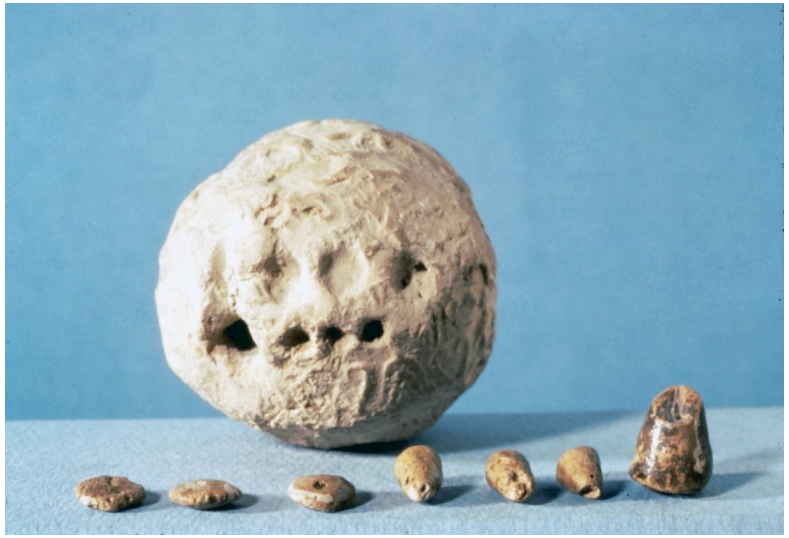
6 JUNE 2017

Currencies = maintaining memory



"Envelope and contents from Susa, Iran, circa **3300 BCE**."
"Each lenticular disc stands for "a flock" (perhaps 10 animals). The large cone represents a very large measure of grain; the small cones designate small measures of grain."

Tensions between centralized and de-centralized ways to remember value exchanges, debts, and what is due

- **Centralization (clay tablet):** economies of scale, high-integrity, vulnerable
- **Decentralized (coins):** high-availability, difficult to destroy as a system, forgery

Image provided courtesy of Denise Schmandt-Besseratand Musée du Louvre, Département des Antiquités Orientales

Slide credit: George Danezis

Hash functions (1975): one-way easy to compute but hard to invert

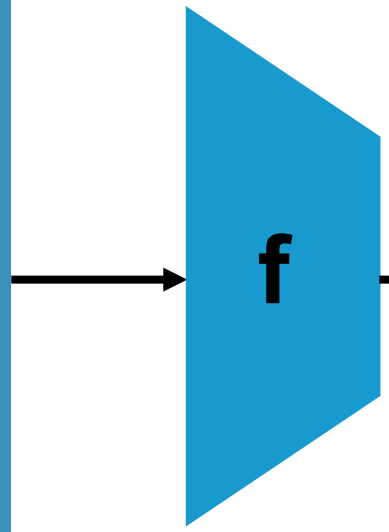
RIPEMD-160

SHA-256

SHA-512

SHA-3

This is an input to a crypto-graphic hash function. The input is a very long string, that is reduced by the hash function to a string of fixed length. There are additional security conditions: it should be very hard to find an input hashing to a given value (a preimage) or to find two colliding inputs (a collision).



1A3FD4128A198FB3CA345932

Digital signatures (1975): “equivalent” to manual signature

Public key

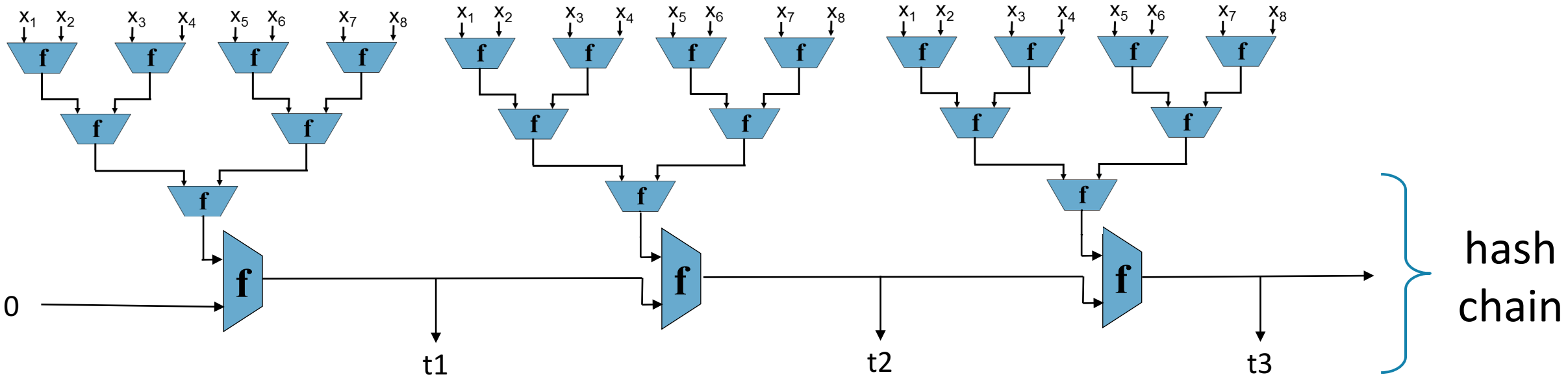
Private key

Timestamping (1990)

Collect documents and hash them with a Merkle tree

Chain these trees together with a hash chain

Publish intermediate values on a regular basis



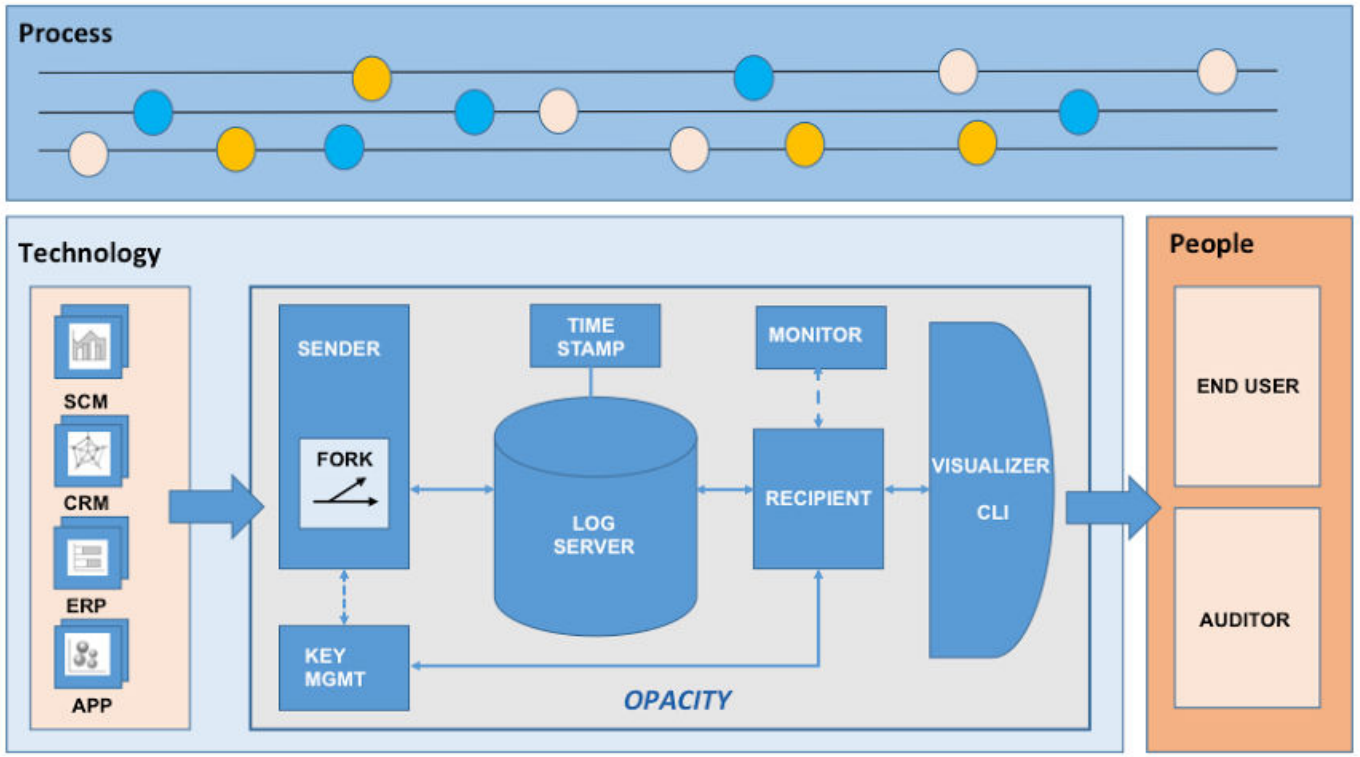
Timestamping: Surety Technologies (°1994)

http://www.surety.com/

Distributed logging + Privacy

OPACITY

http://www.project-opacity.com/



Bitcoin? (2008)

E-currency with distributed generation and verification of money

Transactions

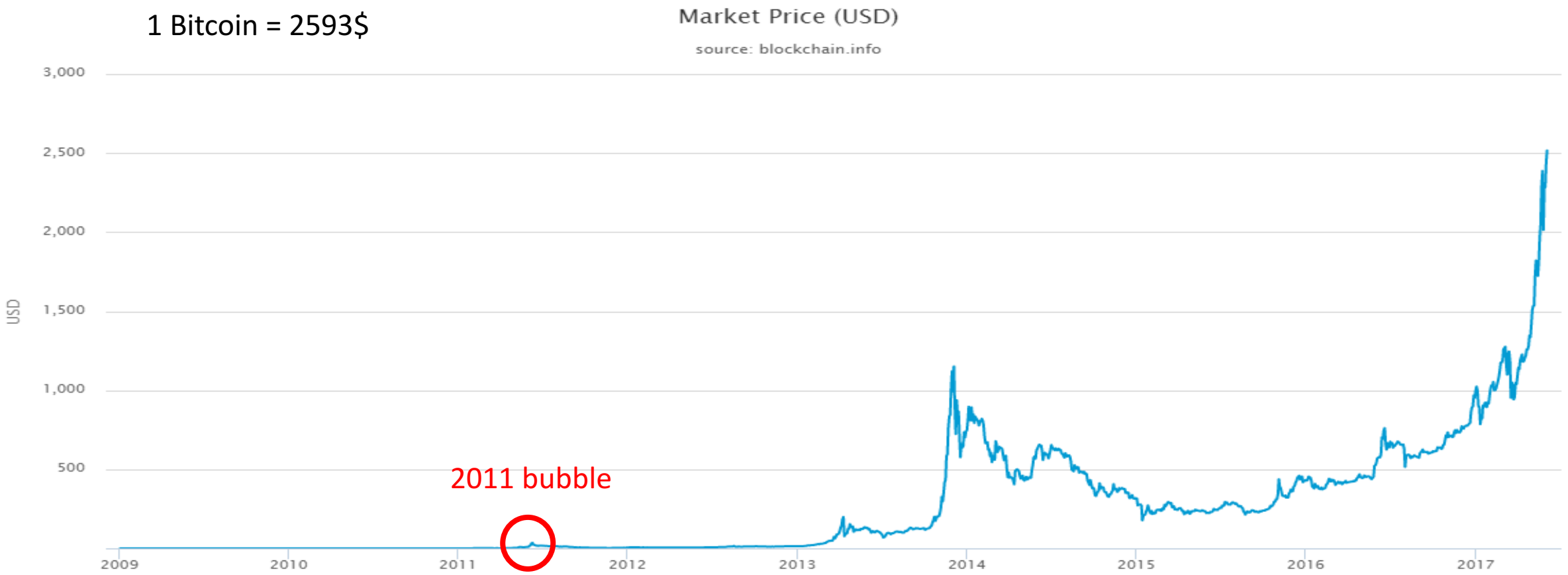
- irreversible
- inexpensive
- over anonymous peer-to-peer network
- broadcast within seconds and verified within 10 to 60 minutes by inclusion in hash chain
- pay using private key (digital signature); verify with public key
- double spending prevention using a public decentralized ledger (chaining mechanism)

Pseudonymous

- Money is linked to public key – can generate arbitrary key pairs and move money around
  - But in many cases identification is possible

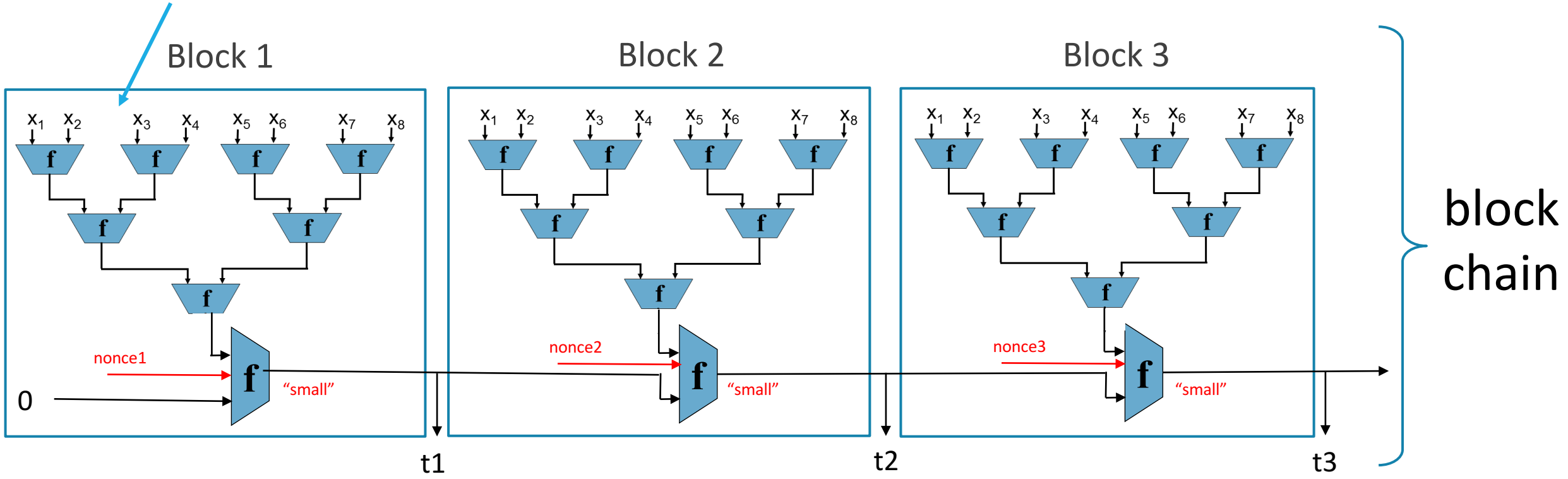
Market price in USD (market cap ≈ 42.5 B$)

1 Bitcoin = 2593$



Block Chain: a public decentralized ledger

Bitcoin transactions



Also include in every block timestamp and difficulty level of puzzle

Mining hash rate of Bitcoin network

5.5 EH/s = 5.5 ExaHash per second = 5.5 10^{18} hash/second = $2^{62.3}$ hash/second

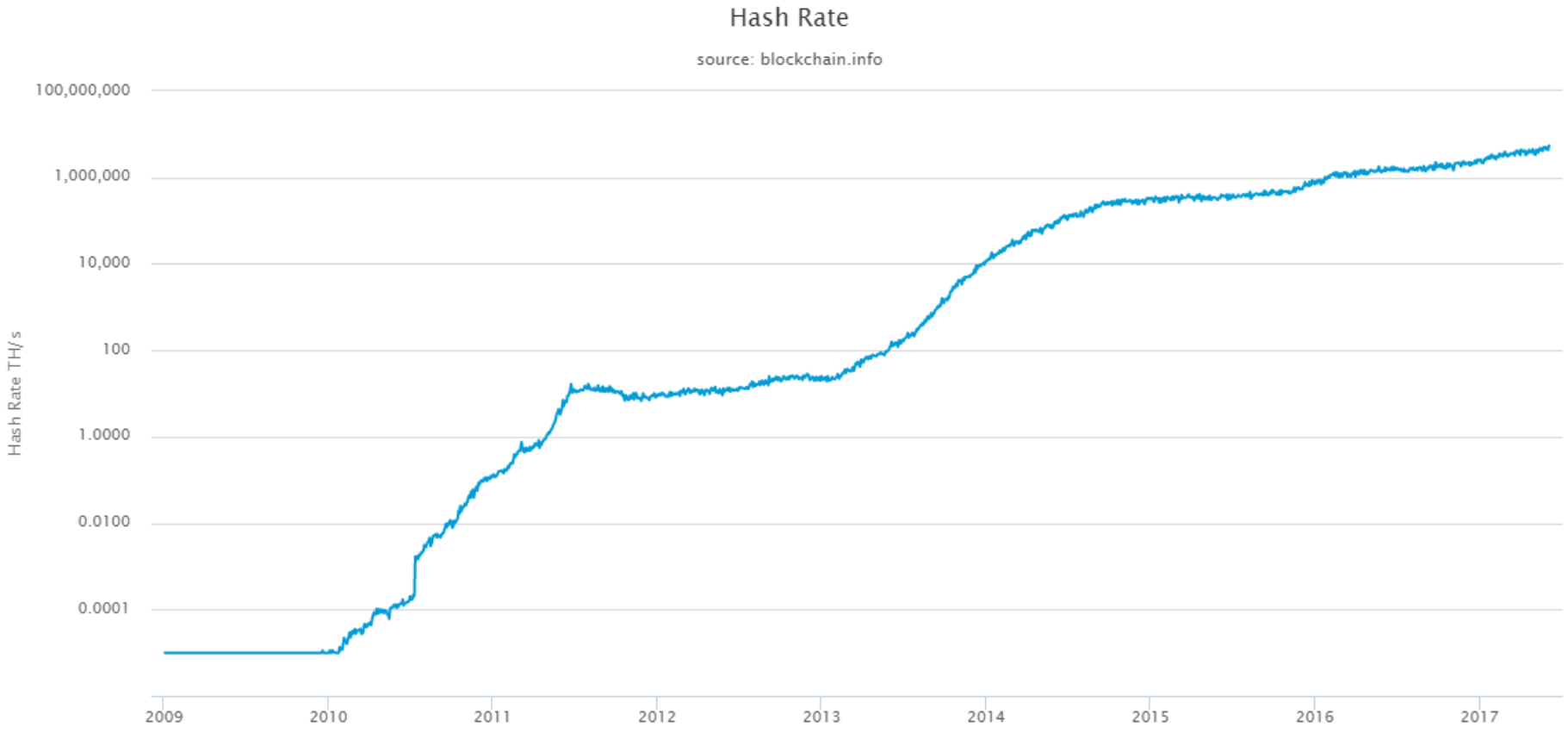
Exa

Peta

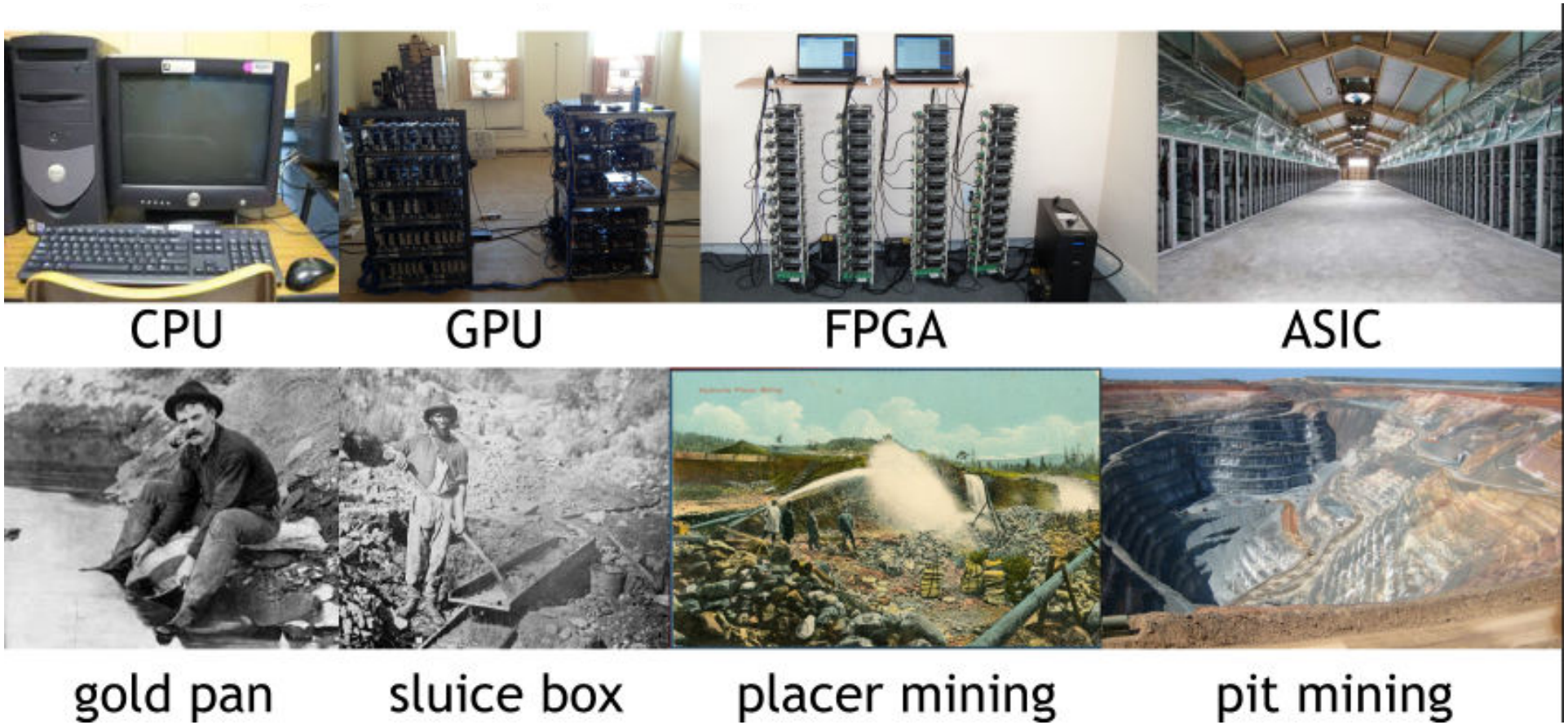
Tera

Giga

Mega



Mining has become industrial



Slide credit: Joseph Bonneau

Mining equipment on Amazon

Sponsored ⓘ

AntMiner S9 ~13.0TH/s @ .098W/GH 16nm ASIC Bitcoin Miner

by AntMiner

$2,199.00

FREE Shipping on eligible orders

In stock on February 27, 2017

9

- Hard Disk Size: **4.0 GB**
- Computer Memory Size: **512.0 MB**
- Hardware Platform: **Linux**
- System Ram Type: **ddr3 sdram**
- Hard Disk Interface: **solid state**

Sponsored ⓘ

Antminer S9 14TH/s 0.10W/GH 16nm ASIC Bitcoin Miner

by AntMiner

$2,299.00

FREE Shipping on eligible orders

In stock on February 27, 2017

4

- Hard Disk Size: **4.0 GB**
- Computer Memory Size: **512.0 MB**
- Hardware Platform: **Web browser**
- System Ram Type: **ddr3 sdram**
- Operating System: **Linux**

AntMiner S5 ~1155Gh/s @ 0.51W/Gh 28nm ASIC Bitcoin Miner

by AntMiner

$350.00 new (1 offer)
$269.99 used (3 offers)

62

- Hardware Platform: **Linux**
- System Ram Type: **dimm**
- Operating System: **Linux**

Sponsored ⓘ

Antminer S7 Version 7 ~5.06TH/s...

$850.95

3

Bitmain Antminer R4 ~8.7TH/s at...

$1,796.00

1

Cost of Leaderless Consensus

Distributed consensus protocol:

- whichever coalition deploys most hash power, has control of the block chain
- 5.5 10^{18} hash/second is a significant cost.
- not performing any useful task!

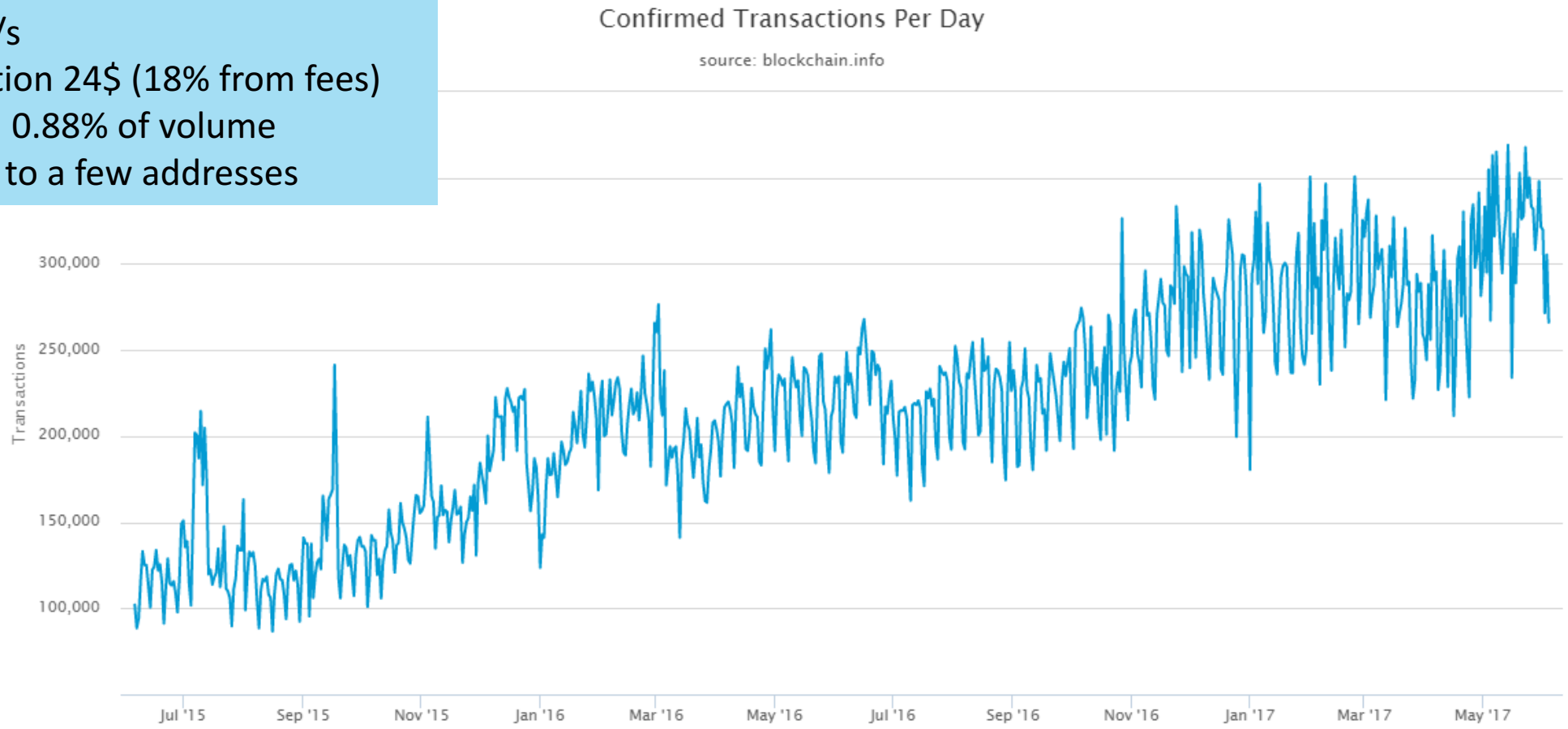
Electricity + Networking costs:

- 0.10 W/GH/s or 550 MWatt (1/2 of a nuclear plant)
- @10 cent per KWh: 1 block costs 9200$ electricity (12.5 BTC = +/-32,400$)

Profit calculator: http://www.vnbitcoin.org/bitcoincalculator.php

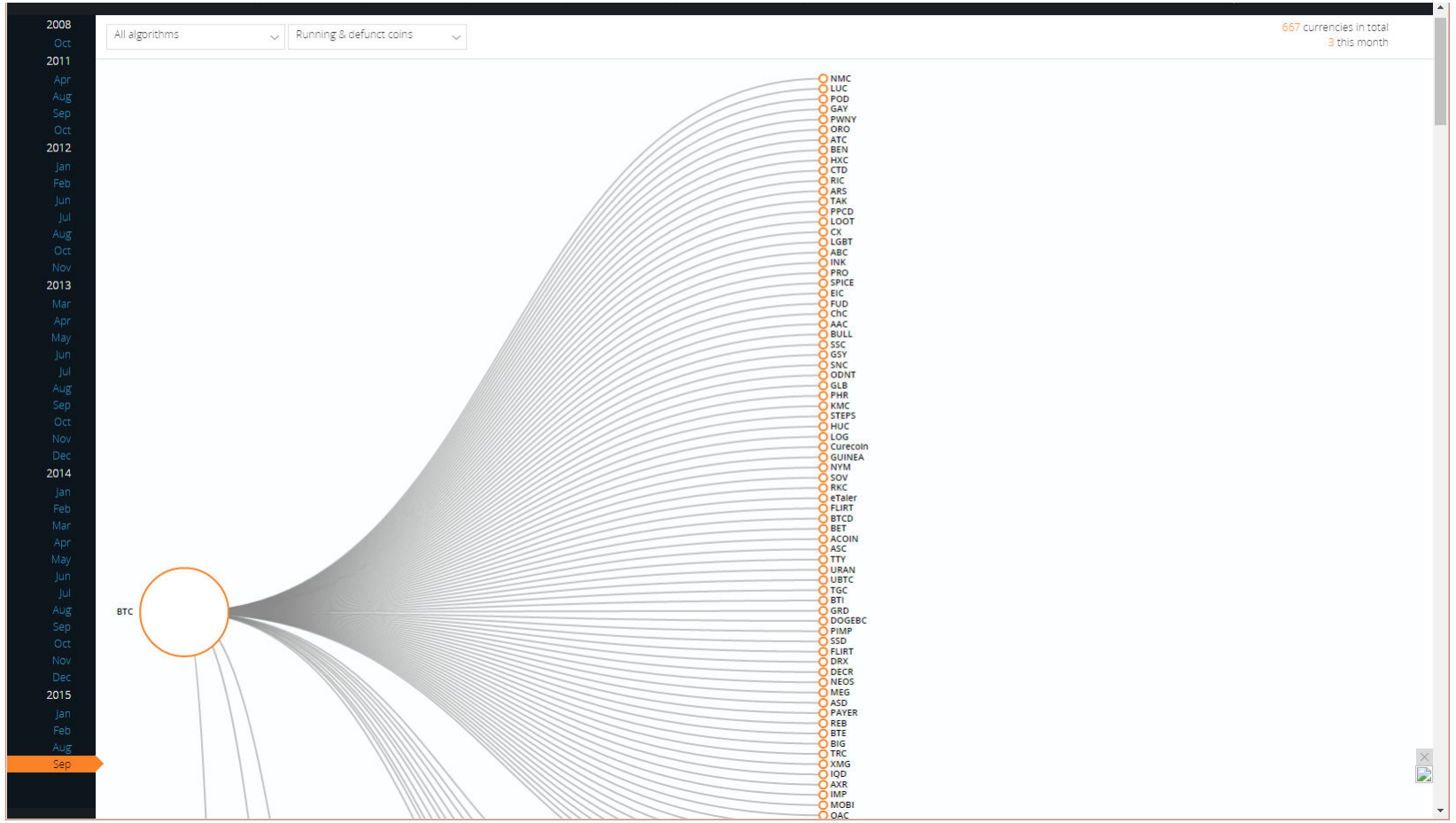
Number of Transactions Per Day

3.5 transactions/s
cost per transaction 24$ (18% from fees)
transaction fees: 0.88% of volume
large share goes to a few addresses



Bank card payments: around 10.000 per second?

Alt CoinsToday: 700+ currencies derived from Bitcoin (see http://mapofcoins.com/bitcoin)



Slide credit: F. Vercauteren

Some observations on Bitcoin

Bitcoin community aspires to be mainstream but behaves as rebels
- this is not sustainable

Volatile

Paying and secure storage somewhat complex

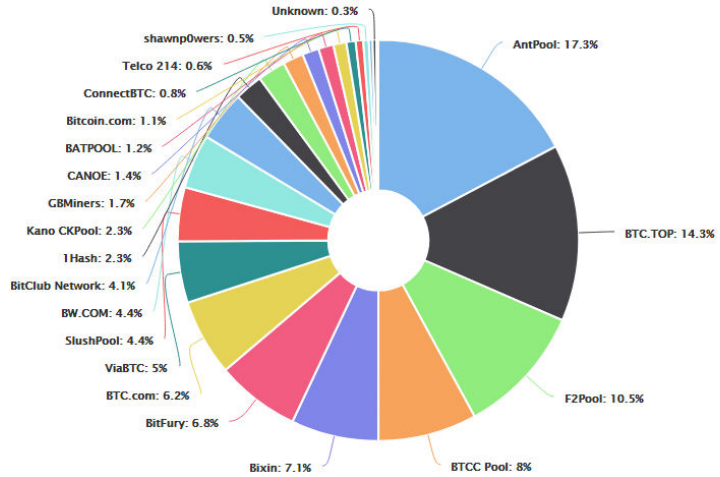
No peace of mind for users: if you are hacked, tough luck

Most miners are in China (70%)

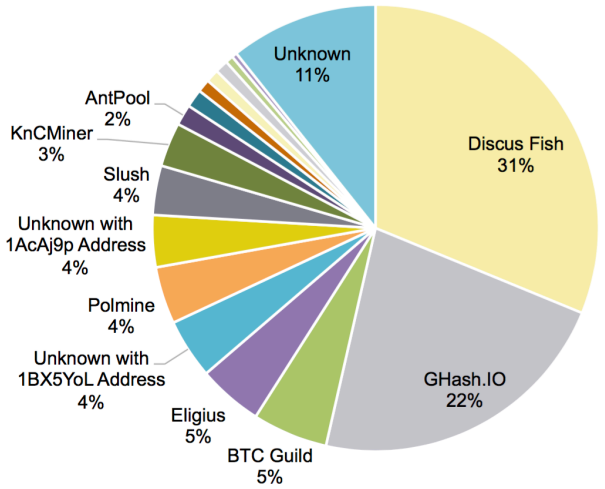
Incentives system complex

Not clear that the system will survive, but some ideas will for sure

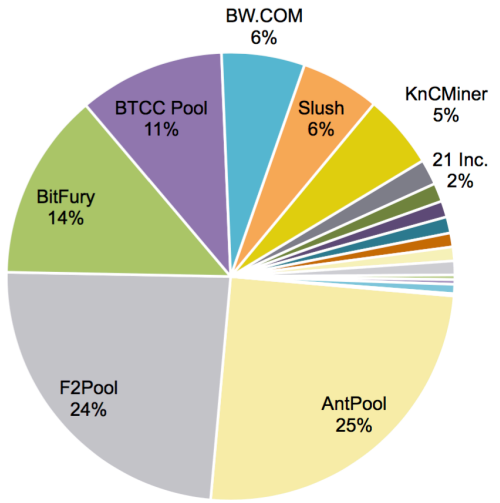
2017



2014



2015



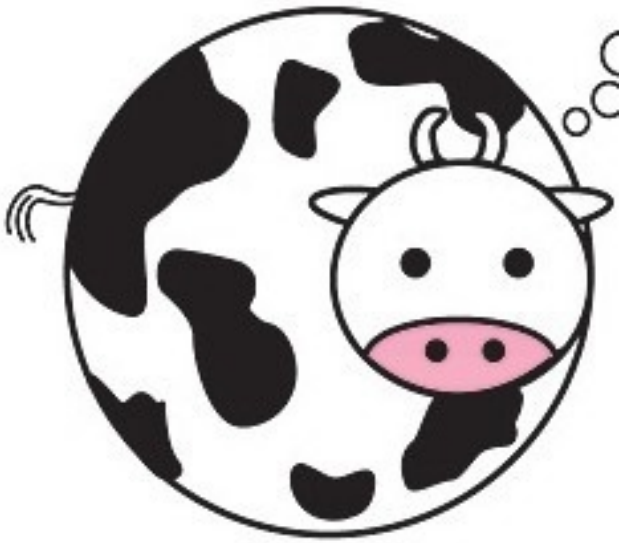
Open issues: Bitcoin

Is Bitcoin incentive compatible?

- Convergence
- Fairness
- Liveliness

- Sybil attack: attacker controls many nodes in network, can refuse relaying or favouring his own blocks
- Selfish mining attack
- Bribery

Some proof exist in simplified models



Open issues: cryptocurrencies

Design of contracts (e.g. trading digital art)

Block chain technology for non-currency applications:

- typical applications: decentralized consensus required
- Namecoin: key-value registration and transfer platform, used for domain names etc…
- Ethereum: contract processing and execution platform using Turing-complete language

Can we avoid the enormous computational cost? (proof of stake)

Is a zero-governance currency possible?

Bitcoin needs governance for “hard” upgrades

Business

Financial world dislikes

- distributed control
- full transparency
- unclear governance (or anarchy)
- uncontrolled money supply

Restrict: write, verify or read (fully private block chain)

Distributed Ledger: a range of solutions

Public Blockchain

- No central point of control by individuals, corporations or governments
- Permissionless to participate
- Concensus based on “proof ow work”
- Examples:
  - *Bitcoin*
  - *Ethereum*

Consortium/Hybrid Blockchain

- Controlled by > 2 individuals, corporations or governments
- Permission on participation from consortium necessary
- Arbitrary consensus mechanism
- Readability of the blockchain can be public or restricted to the consortium
- Example: *RSCOIN (UC London)*

Full private Blockchain

- Controlled by one individual, corporation or government (no consensus needed)
- Permission on participation from owner necessary
- Readability of the blockchain can be public or restricted to one

Distributed Ledger

distributed database - only needed if

- multiple mutually distrustful writers
- no intermediate party that is trusted by all players
- interactions or dependencies between the transactions

Financial sector: disintermediation?

- 20% seriously investing
- 20% planning to invest
- 20% watching the space very closely

Aite Group: blockchain market could be worth as much as $400m in annual business by 2019

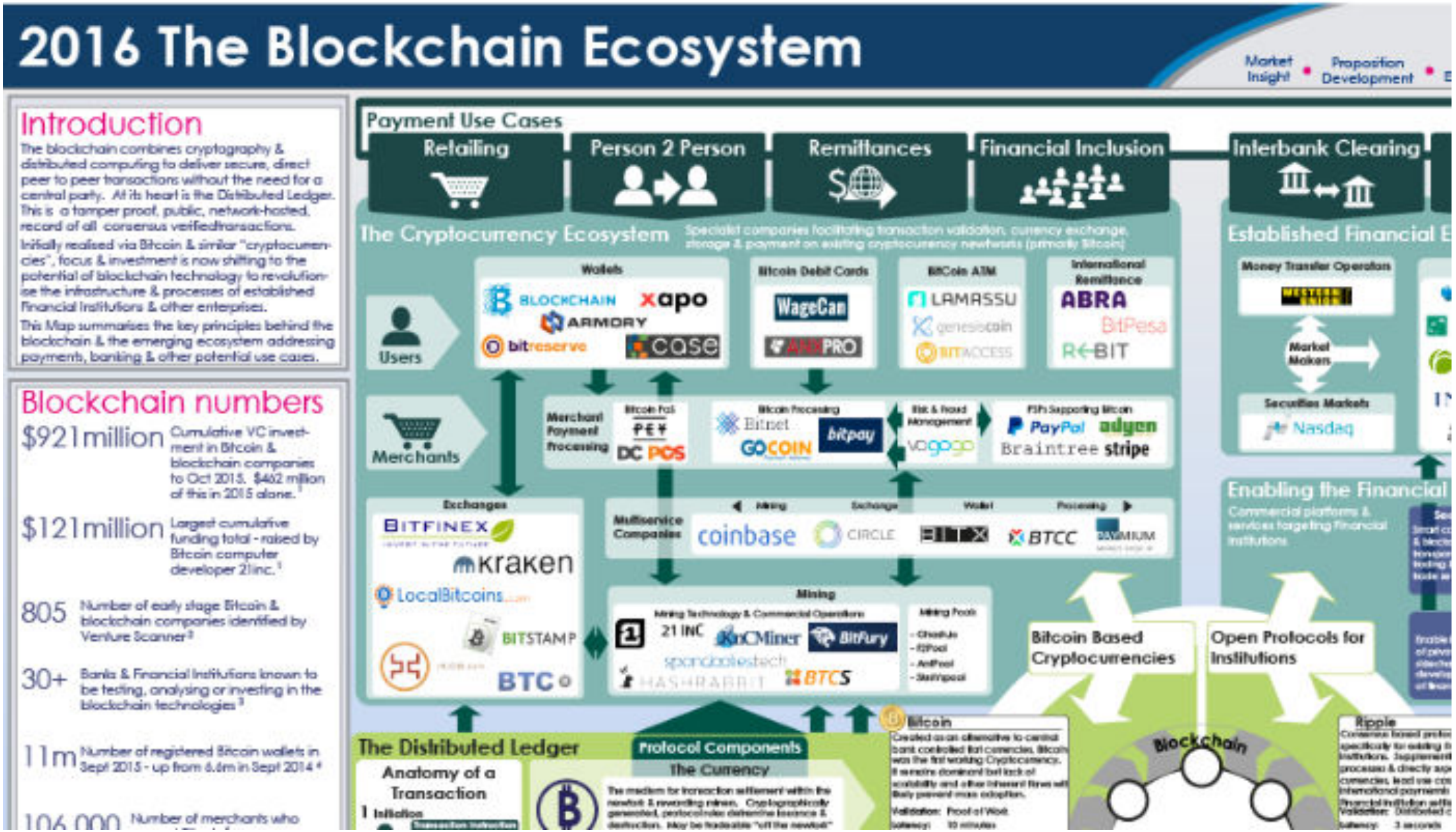
Distributed Ledger: open questions

Explore the continuum between fully open and fully restricted ledgers?

Develop a methodology to design restricted distributed ledgers as a function of the business requirements

Which advanced cryptographic and scripting techniques can be used in private or permissioned ledgers to improve privacy and to allow for complex transactions such as smart contracts?

2016 The Blockchain Ecosystem



http://www.ecrypt.eu.org/csa/documents/D3.2-Cryptocurrencies.pdf

ECRYPT CSA

H2020-ICT-2014 – Project 645421

ECRYPT – CSA

ECRYPT – Coordination & Support Action

D3.2

Cryptocurrencies
– Challenges and Research Directions

Pointers

http:www/ecrypt.eu.org

http://www.bitcoin.org

http://www.blockchain.com

http://www.vnbitcoin.org/bitcoincalculator.php

http://randomwalker.info/bitcoin/

http://www.coindesk.com/

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Financial Cryptography conference series

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