Hardware Specialization

The Age of Dark and Bespoke SIlicon

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Dark Silicon

- What: Silicon that is not used all the time or at its full frequency

- Why: Transistor energy efficiency improves at a slower rate than the improvements of native transistor speeds and transistor density

- Dark Silicon on chip is exponentially increasing
  - PANIC ------- THE APOCALYPSE APPROACHES

The Four Horsemen of the Apocalypse

The Shrinking Horseman

- Building smaller chips
- Price:Size ratio goes higher the smaller the chips get
- Same goes for Temperature
- Most pessimistic Horseman

I

The Dim Horseman

- Manipulates:
  - Voltage
  - Frequency
  - Duty cycles
  To manage power

- Implemented:
  - Turbo Boost 1.0
  - NTV Processors
  - Bigger caches

II

The Specialized Horseman

- Power and clock-gate unused cores
- reduce the amount of capacitance per particular operation

👍 for coprocessors
👎 for general-purpose

The Specialized Horseman

👍 for coprocessors
👎 for general-purpose

=> Tower of Babel Problem

The Deus Ex Machina Horseman

- Hope for a breakthrough in semiconductor devices
    - MOSFET-imposed limits
    - Currently at a bottleneck imposed by the laws of physics
- Alternatives to MOSFET transistors
    - Tunnel Field-Effect Transistors (TFETs)
    - Nanoelectromechanical System (NEMS)
- Beyond-CMOS approaches
    - Electron-Spin Memory (C-SPIN)
    - Statistics Models: Nondeterministic (SONIC)

So what?

- Decrease sharing
  - Expensive control logic
  - Additional energy consumption
- Reduce pipelining
  - Increases duty cycle and increases capacitance
  - Increases gap between processing and memory

Bitcoin

- International Cryptocurrency (Began Jan 3rd, 2009)

- Account that allows you to make or receive payments

- System maintains a global, distributed cryptographic ledger of transactions called the blockchain
  - Maintained by computers running a consensus algorithm across the world
  - Algorithm is called mining- integrates transactions into the blockchain
 - Each transaction becomes the new head block and is posted to the block chain

Why Mine

- Each block the miner adds to the block chain:
  - Block Reward (Started at 50 BTC, halved every 210,000 blocks)
  - BTC cannot exceed 21 million
  - In 2032, 99% will be issues
- Rewarded transaction fees attached to the block
  - The higher the transaction fee the faster the transaction is completed
 - Incentivizes paying to use the service

Why Use Bitcoin

- Can be used internationally

- Known upper limit to amount of BTC that can be mined

- Users are mostly anonymous and transactions are secure but public to everyone
   - Can still be traced and subjected to law enforcement
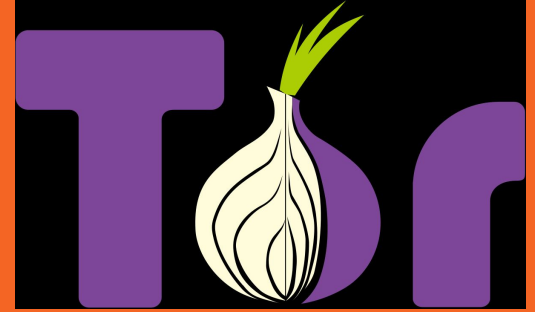
Bitcoin Trend

• Difficulty of mining is dynamically increased as more machines mine to avoid saturating the amount of currency created per day
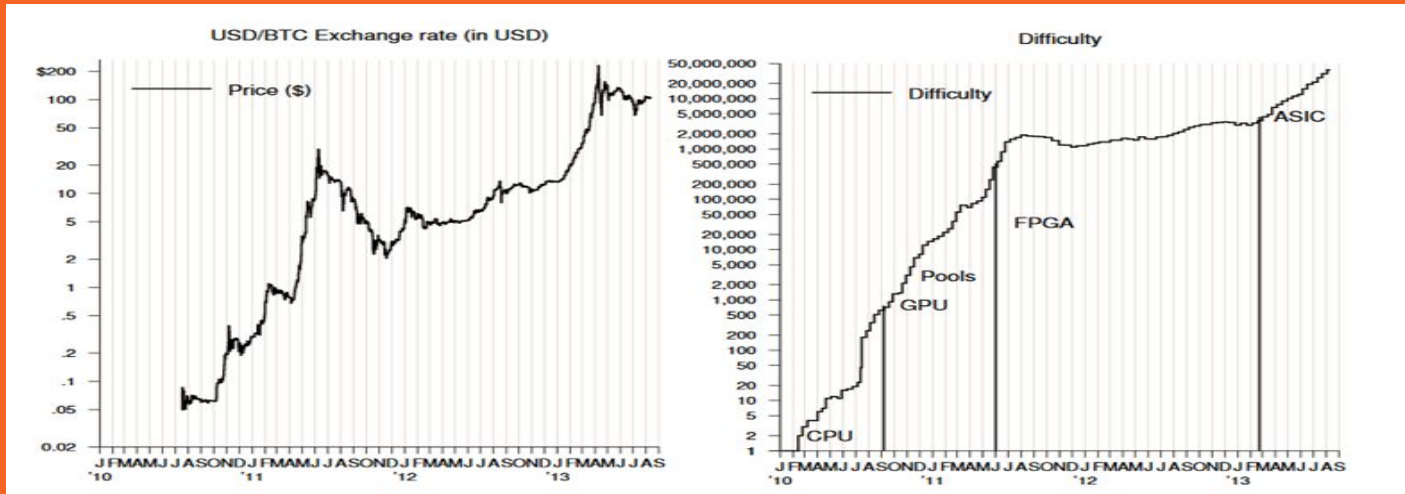
Bitcoin Stats: May 14th 2017

- 1 BTC = 1,825.40 Dollars

- Current Block Reward = 12 BTC = 21,904.80 Dollars

- Bitcoin Mined = 77.76%

- Total BTC in circulation: 16,330,450

- Total BTC left to mine: 4,669,550

- Sources
  - http://www.coindesk.com/price/
  - http://www.bitcoinblockhalf.com/
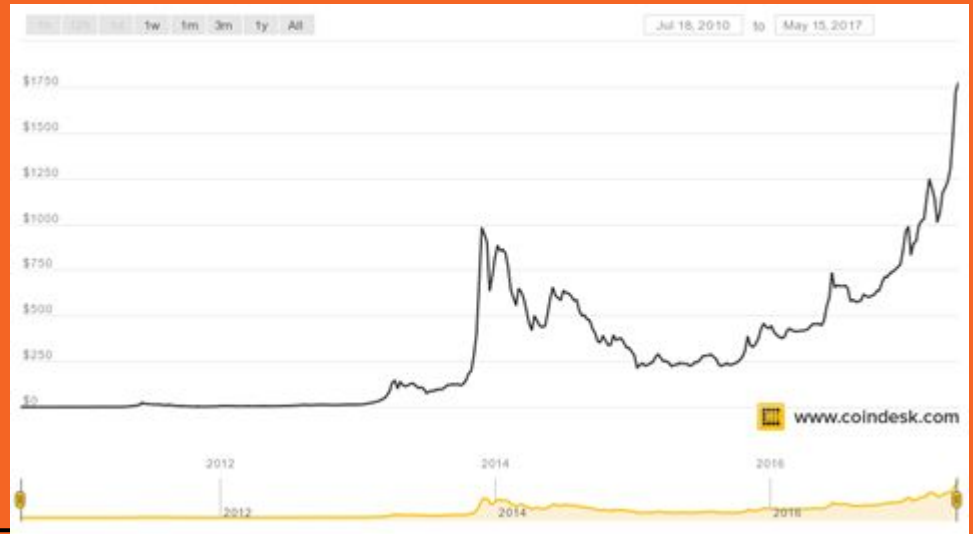
Bitcoin, Bespoke and Dark Silicon

- Cost of cooling and energy is what holds back miners
- Bespoke Silicon
  - Best if the specialized implementation is much smaller than the general purpose case and computation exhibits weak scaling
  - The power of homebrew and crowdsourcing

Thanks for Listening!

Article Sources

- https://cseweb.ucsd.edu/~mbtaylor/papers/bitcoin_taylor_cases_2013.pdf
- http://cseweb.ucsd.edu/~mbtaylor/papers/taylor_landscape_ds_ieee_micro_2013.pdf