Overview of Bitcoin, Blockchain, and Cryptofinancial Technology

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Code Samples and Slides at:
github.com/ryanxcharles/blockchain-university

Datt

Outline

Who am I?

Bitcoin History & Technology

Altcoins & Other Blockchains

Non-Blockchains

Bitcoin Economy

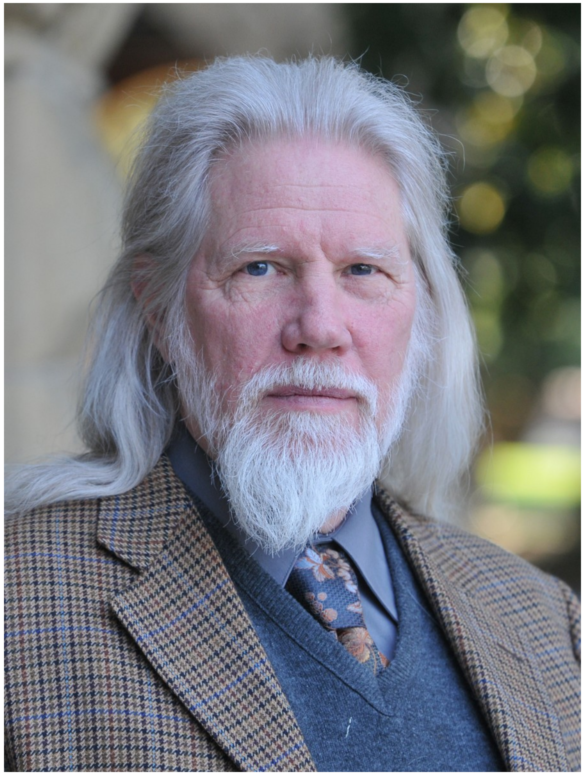
Bitcoin Implementations

Who is Ryan X. Charles?

- Programming since age 10
- Web designer/developer, 1999 – 2005
- Physicist, 2005 – 2013
- Angry at govt/banks, 2008
- Discovered bitcoin, 2011
- Full-time bitcoin, 2013
- BitPay -> reddit -> BitGo -> Datt
- bitcore, Copay, fullnode, Datt

Crypto History of Bitcoin

- Public Key Cryptography, 1976 (Diffie-Hellman)
- DigiCash, 1990 – 1998
- Hashcash, Adam Back, 1997
- b-money, Wei Dai 1998
- Bit Gold, Nick Szabo, 2005? 2008?
- Bitcoin Whitepaper, 2008
- Bitcoin Genesis Block, 2009



Witfield Diffie

Money History of Bitcoin

- Pre-gold*, ~100,000 BC – Today
- Gold*, ~5000 BC
- Fractional Reserve Banking*, ~1000 AD
- Classical Gold Standard, 1870 – ~1915
- Bretton Woods, 1944 – 1971
- Bitcoin, 2009

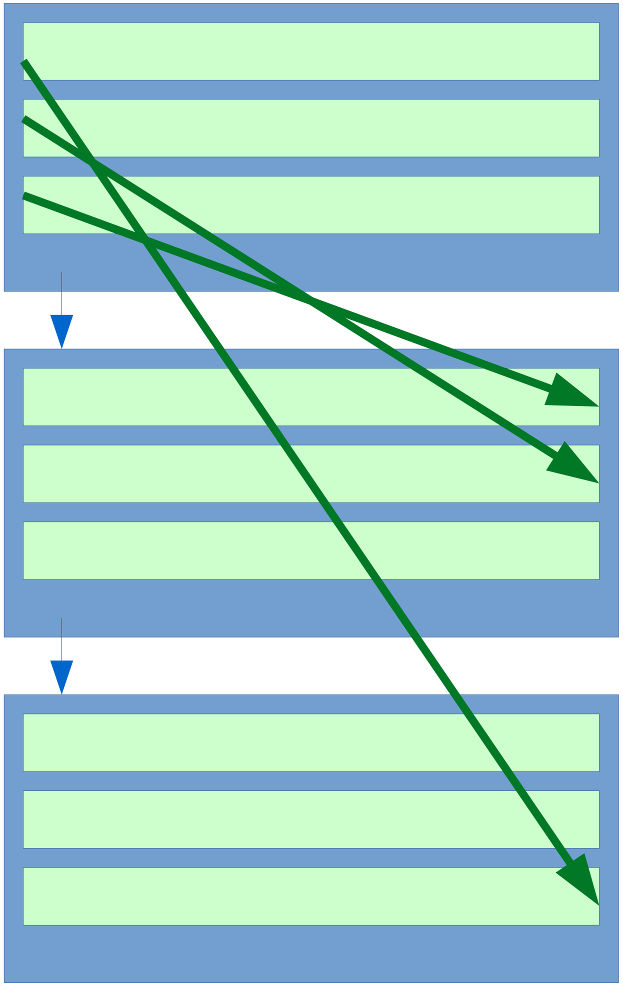
* Caveat: Rough estimate

Rai Stones: Physical Bitcoin

- Quarried in Micronesia & Guam
- Used as money on Yap
- Stones do not move – rely on oral history to track ownership
- Really difficult to make new ones – can't just print them (without modern tech)
- Just like bitcoin: value comes from proof-of-work, history of ownership is shared information

Bitcoin Blockchain Overview

- Blocks contain transactions and a proof-of-work hash
- Each block links to previous block
- Each transaction links to outputs of earlier transactions



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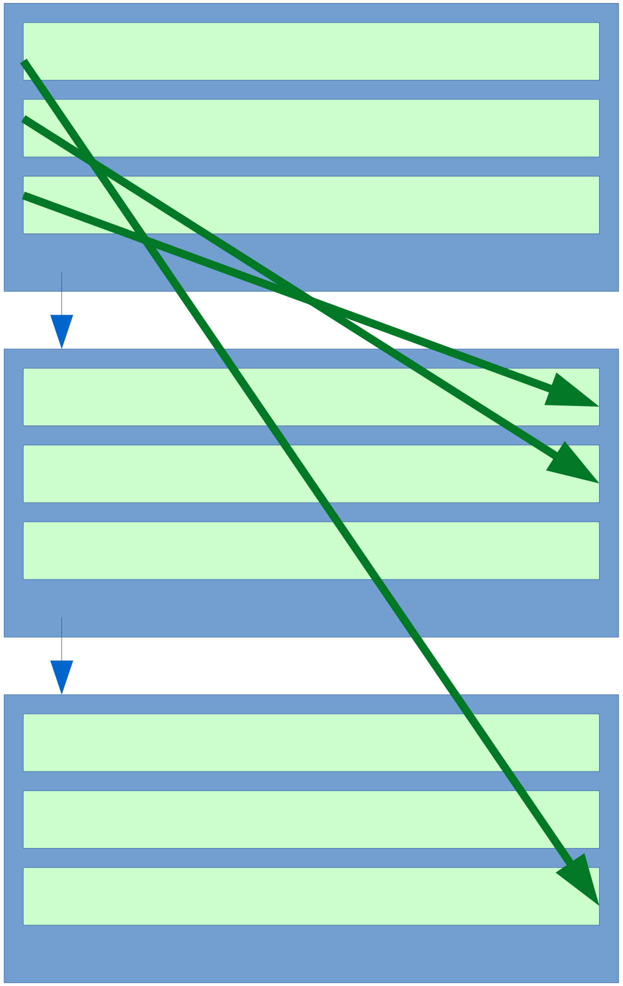
Bitcoin Blockchain Overview

- Genesis Block:
  - The First Block
- Coinbase Transaction:
  - First transaction in a block
  - Mining reward
  - Has “null” inputs



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Bitcoin Blockchain Overview

- Each block has:
  - Proof-of-Work Hash (PoW)
  - Nonce
  - Meta data and transactions
- Example PoW with data “test data”
  - Nonce: 0, Hash: `df59bb7272f144dc7d3620e6f9e14234`
  - Nonce: 1, Hash: `460142d2a0349c13a48b422261d708eb`
  - Nonce: 2, Hash: `71be158053f58c9e1f094fb3f7da282e`
  - …
  - Nonce: 146, Hash: `00f82186722b46b2adb57f321793e44f`

Bitcoin Blockchain Summary

- Transactions are digitally signed (public key cryptography).
  - Cannot fake a transaction – must have private key to produce valid signature
- Hash functions used for proof-of-work on each block.
- “Encryption” has nothing to do with it – just digital signatures and hash functions.
- Transactions grouped in blocks, one big chain back to the genesis block.
- Each transaction links to earlier transaction(s) back to Coinbase transaction(s).

Important Concepts

- Bitcoins are mined. 50 new bitcoins per block for first four years, 25 per block for next four years, etc. Total of 21 million.
- Miners perform proof-of-work hashing. CPUs → Graphics cards → FPGAs → ASICs.
- “full node” - a fully-validating node. “light node”, or “SPV” - only validates block headers.
- **Bitcoin has no central authority.** The only way to change the rules is to change the software the miners, full nodes, and wallets run. Democratic by CPU power and economic power.
- Do you control your private keys?

The Creator: Satoshi Nakamoto

- Active on cryptography mailing list 2008
- Active on bitcoin forum 2009 – 2010
- Last known message late 2010
- Writings recorded at: http://nakamotoinstitute.org/
- Highly recommended to read his writings!

Byzantine Consensus

- **Byzantine Generals Problem** – a well-known computer science problem.
- If generals want to attack a city, when no one is in charge, how do they arrive at consensus about what particular time to attack?
- **Bitcoin is a solution to this problem** (use proof-of-work on times – most proof-of-work wins) https://bitcointalk.org/oldSiteFiles/byzantine.html

“The Blockchain”

- “**Bitcoin: A Peer-to-Peer Electronic Cash System**” https://bitcoin.org/bitcoin.pdf
- The word “blockchain” does not appear in whitepaper or original source code. (“block chain”, two separate words, does appear in original source code, but not whitepaper)
- “Blockchains,” distributed consensus of transactions grouped into blocks, have become popular for reasons other than money, particularly other financial services & identity.
- Bitcoin was invented for one purpose: decentralized electronic cash. Other uses of blockchain are nice bonus.

Altcoins

(The First Non-Bitcoin Blockchains)

- First appeared ~2012.
- Litecoin first popular altcoin.
- Dogecoin second popular altcoin.
- Almost all are forks of bitcoin, or a fork of a fork. Some, like NXT, are complete rewrites.
- Most do not have novel features. Some do.
- Bitcoin market cap: ~$6.5 billion
- All alts put together: < $1 billion

Alternative Uses of Blockchain

(besides money)

- Stocks, bonds, fiat currencies, commodities – decentralized ownership, but centralized backing
- Identity, names, rotating keys, revoking keys
- Smart contracts (money or other assets change hands according to complex conditions executed automatically)
- Smart property & Internet of Things (property perform actions, can be owned by cryptographically)
- Proof-of-existence, patents, trademarks, copyright
- DACs and DAOs (distributed autonomous corporations & organizations)
- **If it involves distributed consensus, consider blockchain**

Permissioned Blockchains

- Bitcoin is **permissionless**. Anyone can use it. Anyone can mine it. No one owns it. (Although some actors have more power than others – more bitcoin, more hash power, commit access, etc.)
- Banks are creating **permissioned** blockchains. Based on the same principles, but not open to the public. They are owned by the banks.
- Exploring **monetary and non-monetary** uses of blockchain technology.
- **R3**: http://www.coindesk.com/bitcoin-headlines-r3-blockchain-dream-team/

Blockchains in a Box

- OpenChain – easily produce a blockchain that is optionally attached to bitcoin https://www.openchain.org/
- MultiChain – easily produce a blockchain with custom features as a fork of Bitcoin Core http://www.multichain.com/
- Can be permissionless (open, anyone can use) or permissioned (closed, only used by select parties)

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Ethereum

- Bitcoin script is not Turing complete (there are some programs that cannot be written with it)
- **Ethereum script is Turing complete** – can program any conceivable contract
- **Bitcoin is designed to solve the problem of digital cash. Ethereum is designed to solve everything else.**
- Bitcoin infrastructure better developed (companies, software, capital), but Ethereum potentially more useful
- See Gav Wood's recent article, “So Ethereum is released.” https://medium.com/@gavofyork/so-ethereum-is-released-4291da46b770

Non-Blockchains

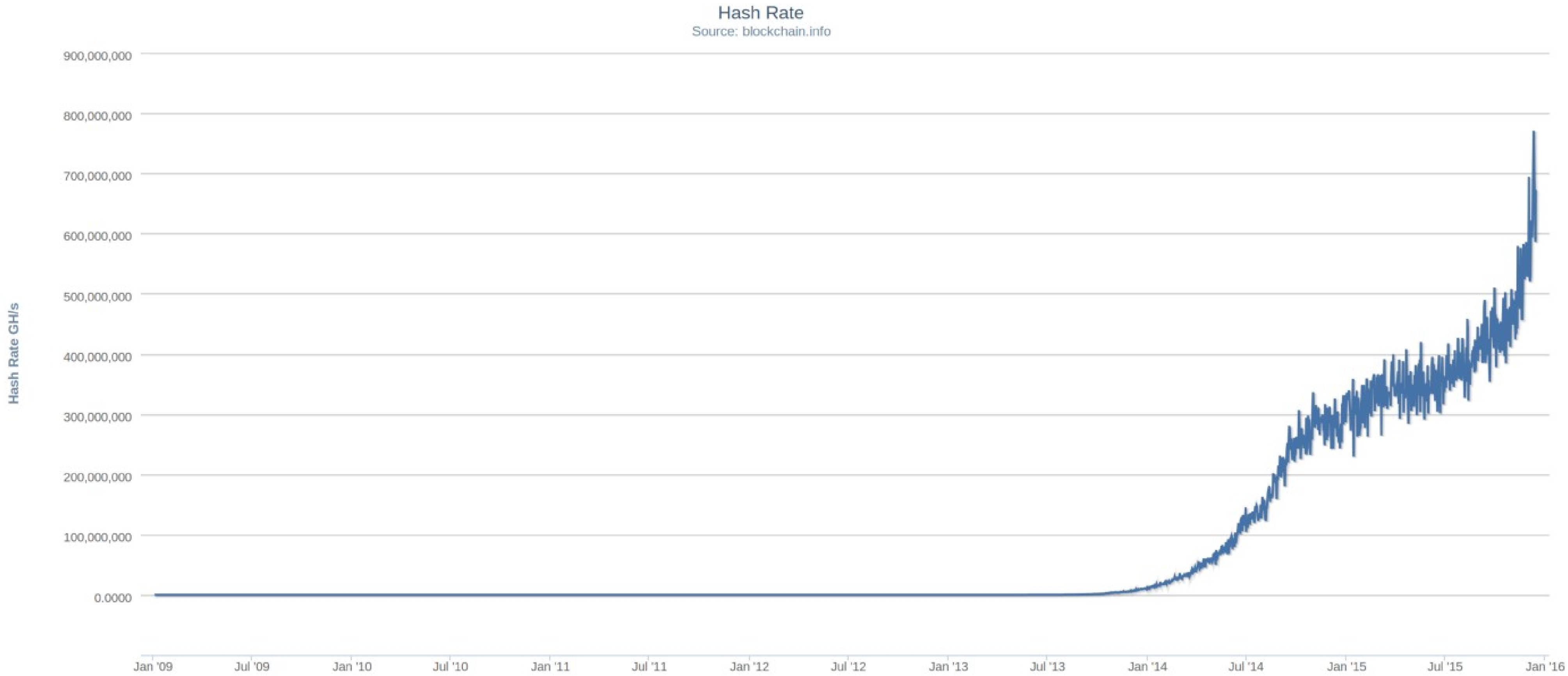
- **Ripple** – a distributed ledger, based on similar cryptography to bitcoin, but NOT proof-of-work or proof-of-stake
- **Stellar** – a fork of Ripple
- Both of them can track arbitrary assets and rely on third parties to exchange for “real” assets, e.g. withdrawing dollars or bitcoin
- Fall under “cryptofinance” category, but they DO NOT have blockchains!

A Note on Security

- Bitcoin miners are the world's most powerful supercomputer. (5 billion teraflops vs. 54 thousand teraflops*)
- Reversing bitcoin transactions requires having an enormous amount of computing power, only achievable by a State actor.
- Reversing a small, private blockchain requires far less computing power and is achievable by small actors. Beware.

* Conversion info: https://www.quora.com/How-to-convert-mflop-s-to-mhash-s ...
I calculated assuming 700 million Ghash/s current hash rate, and 700 Mhash/s to 5340 Gflop/s
Current top super computers: http://www.top500.org/lists/2015/06/

Bitcoin's All-Time Hash Rate



Colored Coins

- Put meta data on bitcoin transactions to track assets (stock, bonds, whatever) on the bitcoin blockchain.
- Protocols: Open Assets, CoinSpark, Chromaway, Colu, others.
- Upside: Security of bitcoin.
- Downside: Limited block size and thus transaction count. Rules are not enforced by miners.

Two-Way Pegged Sidechains

- Invented by Blockstream, theoretically allows transfer of bitcoin to other blockchains by “pegging” - proof-of-peg lets you spend bitcoin on the sidechain, proof-of-unpeg lets you retrieve bitcoin back on normal chain
- Upside: Security of bitcoin, network effect of bitcoin, unlimited advanced uses of blockchain.
- Downside: Not yet implemented.

Technology Summary

- Bitcoin
- Altcoins
- Ethereum
- Non-Blockchain (Ripple, Stellar)
- Permissioned Blockchains (banks)
- Bitcoin-dependent: Colored Coins; Sidechains
- ...hard to beat bitcoin's security and network effect

Bitcoin Economy

- Wallets
- Exchanges
- APIs and Developer Tools
- Payment Gateways
- Miners
- Storage
- Merchants
- Investment
- Non-Monetary Advanced Uses
- Financial Services

Miners

BLOCK C
BLOCK C
BitFury
KnCMiner
KnCMiner
Genesis Mining
BITMAIN
spondoolies-tech
MINERS

"Bitcoin opens up an entire world of opportunities. We are just now starting to realize how impactful this can be and we are very excited about the future."

Marco Streng
CEO, Genesis Mining

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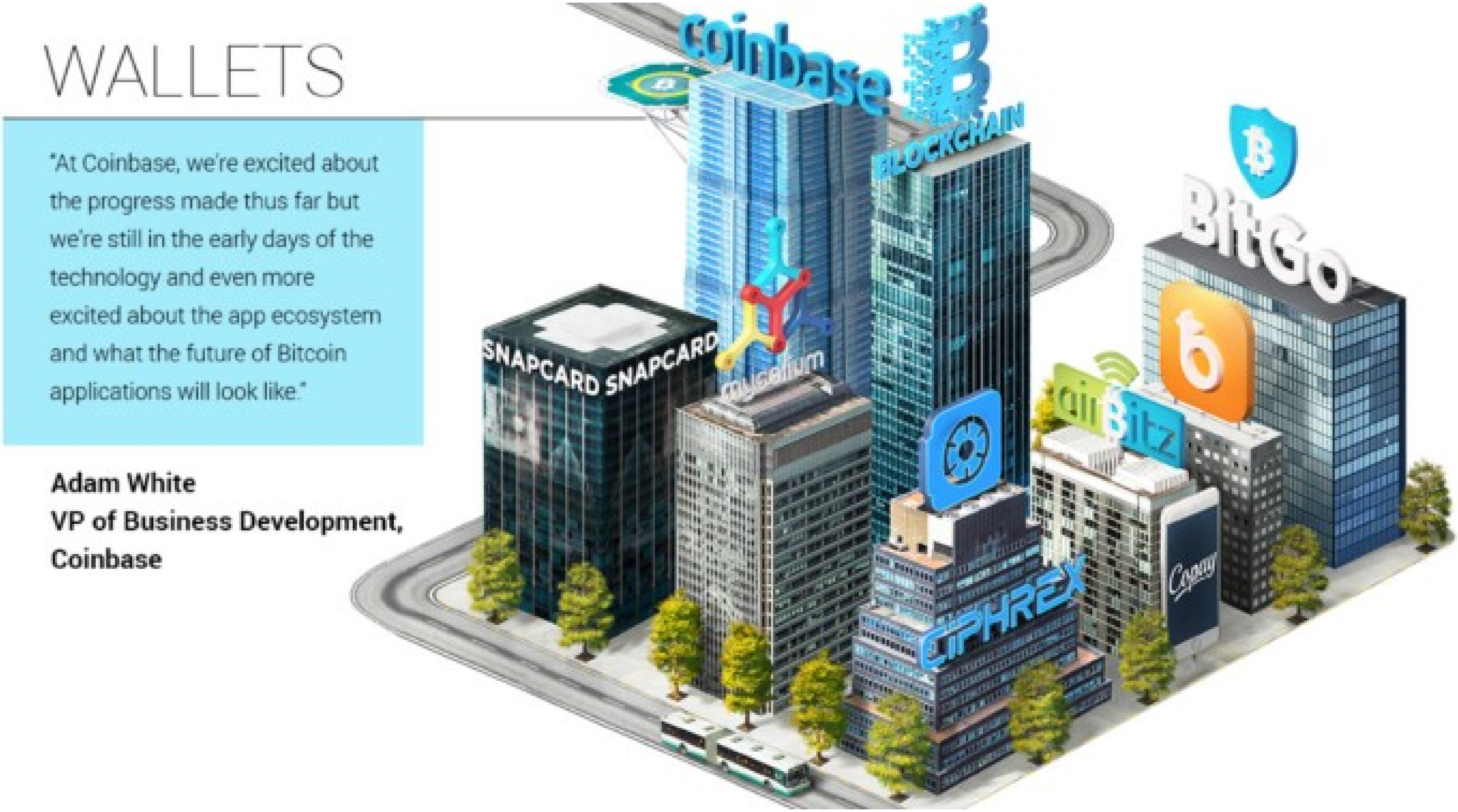
Wallets



WALLETS

"At Coinbase, we're excited about the progress made thus far but we're still in the early days of the technology and even more excited about the app ecosystem and what the future of Bitcoin applications will look like."

Adam White
VP of Business Development, Coinbase

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Storage

STORAGE

"Bitcoin paved the way to decentralized security, and will jumpstart the usage of personal privacy devices."

Eric Larchevêque
CEO, Ledger

"Today there are more than 100,000 Bitcoin transactions per day for more than $100 million and there are more than 5,000 servers acting as nodes of the network: Bitcoin is a lot less likely to disappear today than it was 2 years ago when the price was over $1,000 per Bitcoin."

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Exchanges

EXCHANGES

"Bitcoin startups like Gemini are ushering in a new chapter of legitimacy and integrity that will allow Bitcoin to go mainstream and fulfill its ultimate promise."

Tyler Winklevoss
Co-Founder and CEO, Gemini

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Payment Processors

adyen
bitpay
NETELLER
GOCOIN
bitpay
Coinify
BitPay
Copay
Bitnet
bitcoin
PAYMENT
PROCESSORS

"The original vision for Bitcoin was the creation of a peer to peer payment system for the Internet. We believe in that vision. The consistent growth we've seen in Bitcoin transactions over the last year shows that our customers are beginning to share that belief.

Bitcoin has put online payments into the hands of merchants and consumers. That change is going to be hard to ignore. This technology is on track to become a part of every major payment system in the coming five years."

Stephen Pair
CEO, BitPay

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Merchants

TigerDirect
WordPress
newegg.com
Dell
Microsoft
Expedia
overstock.com
Time Inc
gyft
namecheap
REEDS
dish
MERCHANTS

"Bitcoin affords our customers an easy checkout process, while protecting us against fraud and chargebacks. We could not be happier with the results"

Steven Leeds
CMO, TigerDirect

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Investment

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Media & Advocacy

MEDIA & ADVOCACY

> "We are privileged to be at the nexus where information meets technology, using a multimedia platform to support the adoption and innovation of Bitcoin and the blockchain. In only two years, the audience for digital currency news has exploded from Fintech specialists to the man on the street. This is now a mainstream media topic, and what happens in Bitcoin happens to the world."

David Bailey
CEO, BTC Media

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Advanced Uses of Blockchain

"Bitcoin will serve a purpose and Ethereum will serve a different one. The ideas I see coming out of it are immense and are the most adventurous in years. The opportunity is huge and I hope a lot of the investment types understand that real, long term money is happening on the fringes."

Tony Sakich
Director of Marketing, Augur

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Financial Services

t0
symbiont
COINALYTICS
vogogo
ascribe
bitWAGE
TradeBlock
SolidX PARTNERS INC.

FINANCIAL SERVICES

"Bitcoin use is continuing to grow across borders. 12% of our users, all of whom are international receiving wages from US employers, encompass over 50% of our volume. While we continue to see growth with domestic employees receiving wages from the like of Google, Microsoft or even the U.S. Navy, we foresee the international use-case growing significantly over the next few years until the value of Bitcoin stabilizes."

Jonathan Chester,
Founder & President, BitWage

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Implementations of Bitcoin

- Bitcoin Core – Original C++ implementation, maintained by “Core” developers
- BitcoinJ – The first re-implementation
- Btcd – A full implementation in Go
- bitcore, bitcoinjs, fullnode – Javascript & Node.js
- rust-bitcoin – Rust
- python-bitcoinlib, caesure – Python