Crypto 6: Passwords & Blockchains

-Lea Kissner

Reminder: Cryptographic Hashes...

- We love ourselves some cryptographic hashes
  - SHA_256, SHA_384, SHA3_256, SHA3_384
- Reminder on the properties:
  - Irreversible:
    Given H(X), it is infeasible to find X short of simply trying all possibilities
  - First preimage resistant:
    Given H(X), it is infeasible to find any X' such that H(X) = H(X')
  - Second preimage resistant:
    It is infeasible to find X and Y such that X != Y and H(X) = H(Y)

A Couple Other Hash Properties...

- They accept arbitrarily large inputs
- They "look" random
  - Change a single bit on the input and each output bit has a 50% chance of flipping
  - And until you change the input, you can't predict which output bits are going to change
- The ones we talked about are ***fast***
  - Can operate at many many MB/s:
    Faster at processing data than block ciphers

A Hash Problem: Proof of work...

- Alice wants Bob to waste a bunch of CPU resources
  - But wants to quickly ***check*** that Bob wasted that much CPU
- Alice -> Bob: "Here is a message ***M*** and a factor ***x***"
  - Make sure ***M*** has a nonce in it
- Now Bob needs to provide ***M'*** such that it starts with ***M*** and H(***M'***) starts with ***x*** zero bits
- Alice computes H(***M'***) and verifies that it starts with ***x*** zero bits
  - Alice now knows that Bob is expected to have had to create 2^x separate M's and hash them until he found one that matched

What this provides

- You can use it in a protocol where the user has to waste something...
  - EG, proposals for sending mail as a way of reducing spam
    - It wouldn't: Bad guys can get lots of CPU resources
- Have other options too
- CAPTCHAs:
  - Those "prove your human" web puzzles:
    It is a proof you wasted a few seconds of a human's time
    (Or that you paid $.01 to waste a few seconds of a human's time)
- Proof of ***wait***
  - Alice has a secret key ***k***
  - Alice to Bob sends "Don't contact me until time ***T***, here is HMAC(***k***,***T***)"
  - When Bob gets back, he says "***T***, HMAC(***k***,***T***)"
  - Alice then verifies ***T*** is in the past and HMAC(***k***,***T***)

Passwords

- The password problem:
  - User Alice authenticates herself with a password ***P***
- How does the site verify later that Alice knows ***P***?
- Classic:
  - Just store {**Alice, *P***} in a file...
- But what happens when the site is hacked?
  - The attacker now knows Alice's password!
- Enter "Password Hashing"

Password Hashing

- Instead of storing {**Alice, *P***}...
  - Store {**Alice, H(*P*)**}
- To verify Alice, when she presents ***P***
  - Compute **H(*P*)** and compare it with the stored value
- Problem: Brute Force tables...
  - Most people chose bad passwords...
    And these passwords are known
  - Bad guy has a huge file...
    - **H(P1), P1**
      H(P2), P2
      H(P3), P3...
  - Ways to make this more efficient ("Rainbow Tables")

A Sprinkle of Salt...

- Instead of storing {**Alice, H(P)**}, also have a user-specific string, the "Salt"
  - Now store {**Alice, Salt, H(P||Salt)**}
  - The salt ideally should be both long and random, but it isn't considered "secret": rather it is a ***nonce***
- As long as the salt is unique...
  - An attacker who captures the password file has to ***brute force*** Alice's password on its own
- Its still an "off-line attack" (Attacker can do all the computation he wants) but...
  - At least the attacker can't ***precompute*** possible solutions

Slower Hashes...

- Most cryptographic hashes are designed to be ***fast***
  - After all, that is the point: they should not only turn **H(🐮)** to hamburger... they need to do it quickly
- But for password hashes, we ***want*** it to be slow!
  - Its OK if it takes a good fraction of a second to ***check*** a password
    - Since you only need to do it once for each legitimate usage of that password
  - But the attacker needs to do it for each password he wants to try
- Slower hashes don't change the ***asymptotic difficulty*** of password cracking but can have huge practical impact
  - Slow rate by a factor of 10,000 or more!

PBKDF2

- "Password Based Key Derivation Function 2"
  - Designed to produce a long "random" bitstream derived from the password
- Used for both a password hash and to generate keys derived from a user's password
  - PBKDF(PRF, P, S, c, len):
    - **PRF** == Pseudo Random Function (e.g. HMAC-SHA256)
    - **P** == Password
    - **S** == Salt
    - **c** == Iteration count
    - **len** == Number of bits/bytes requested
    - **DK** == Derived Key

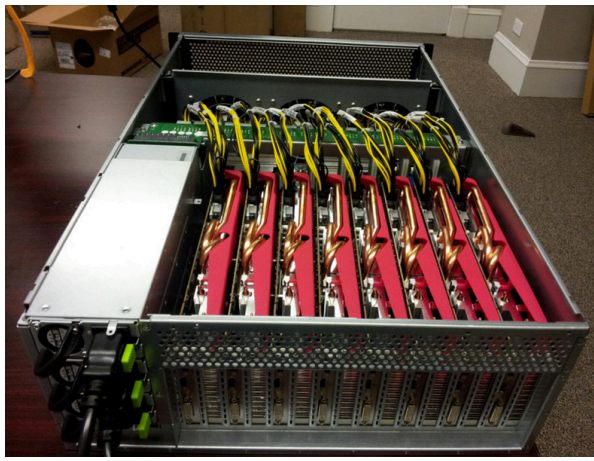
```
PBKDF(PRF,P,S,c,len){
  DK = ""
  for i = 1,range(len/blocksize)+1){
    DK = DK || F(PRF,P,S,c,i)
  }
  return DK[0:len]
}

F(PRF,P,S,c,i){
  UR = U = PRF(P, S||INT_32(i))
  for j = 2; j <= c; ++j {
    U = PRF(P, U)
    UR = UR ^ U
  }
  return UR
}
```

Comments on PBKDF2

- Allows you to get effectively an arbitrary long string from a password
  - ***Assuming*** the user's password is strong/high entropy
- Very good for getting a bunch of symmetric keys from a single password
  - You can also use this to seed a pRNG for generating a "random" public/private key pair
- Designed to be slow in computation...
  - But it does ***not*** require a lot of memory:
    Other functions are also expensive in memory as well, e.g. scrypt & argon2

Passwords...

- If an attacker can do an ***offline*** attack, your password must be ***really good***
  - Attacker simply tries a huge number of passwords in parallel using a GPU-based computer: buy a bunch of used Nvidia 2080 supers from all those upgrading to 3080s
  - So you need a ***high entropy*** password:
    - Even xkcd-style is only 10b/word with a 1000 word dictionary, so need a 7 or more ***random word*** passphrase to resist a determined attacker
- Life is far better is if the attacker can only do ***online*** attacks:
  - Query the device and see if it works
  - Now limited to a few tries per second and ***no parallelism!***



... and iPhones

- Apple's security philosophy:
  - In your hands, the phone should be everything
  - In anybody else's, it should (ideally) be an inert "brick"
- Apple uses a small co-processor in the phone to handle the cryptography
  - The "Secure Enclave"
- The rest of the phone is untrusted
  - Notably the memory: ***All*** data must be encrypted:
    The CPU requests that the Secure Enclave unencrypt data and some data (e.g., your credit card for ApplePay) is only readable by the Secure Enclave
- They also have an ability to effectively erase a small piece of memory
  - "Effaceable Storage": this takes a good amount of EE trickery

Crypto and the iPhone Filesystem

- A lot of keys encrypted by keys...
  - But there is a random master key, $\mathbf{k_{phone}}$, that is the root of all the other keys
- Need to store $\mathbf{k_{phone}}$ encrypted by the user's password in the flash memory
  - PBKDF2(P,...) = $\mathbf{k_{user}}$
- But how to prevent an off-line brute-force attack?
  - Also have a 256b ***random*** secret burned into the Secure Enclave that you can use for encryption
    - Need to take apart the chip to get this!
  - Even the secure enclave can't ***read*** this secret, only ***use*** this secret as a key for hardware cryptographic engines
- Now the user key is not just a function of $\boldsymbol{P}$, but $\boldsymbol{E(K_{secret}, P)}$
  - Without the secret, ***can not*** do an offline attack
- All ***online*** attacks have to go through the secure enclave
  - After 5 tries, starts to slow down
  - After 10 tries, can (optionally) nuke $\mathbf{k_{phone}}$!
    - Erase just that part of memory -> effectively erases the entire phone!
  - Even compromising the secure enclave limits guessing to 10 per second!

Backups...

- Of course there is a ***necessary*** weakness:
  - Backing up the phone copies all the data off in a form not encrypted using the in-chip secret
    - After all, you need to be able to recover it onto a new phone!
- So someone who can get your phone...
  And can somehow managed to have it unlocked
  - Thief, abusive boyfriend, cop...
    - Hold it up to your face (iPhone X) or Fingerprint (5s or beyond)
    - And then sync it with a new computer
- Change of policy for iOS-11:
  - Now you also need to put in the passcode to trust a new computer:
    Can't create a backup without knowing the passcode

Why Talk About Cryptocurrencies?!?

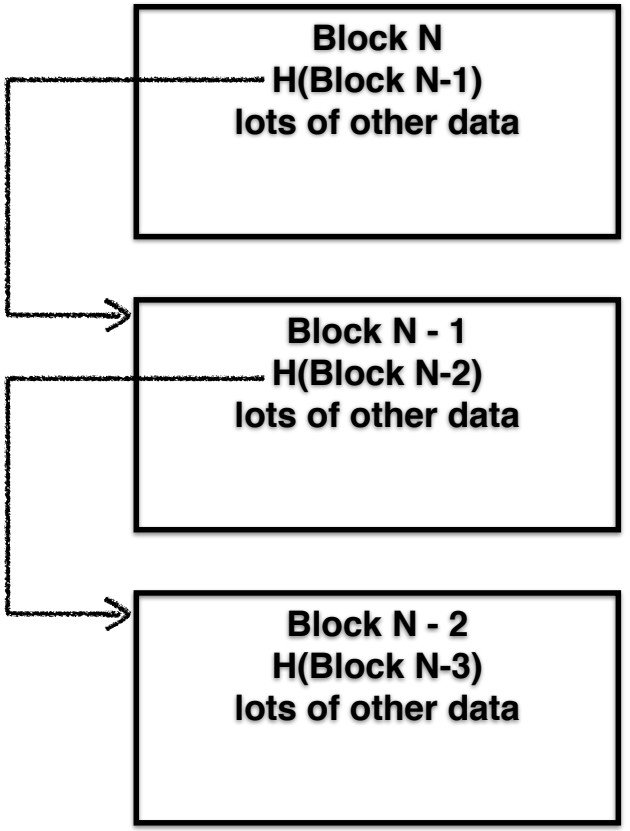
- I am an actual ***expert*** in this area
  - It has been one of my research focuses for the past 8+ years!
- But I want it to die in a fire!
  - There is effectively no value:
    - Private Blockchains are 20+ year old ideas
    - Public Blockchains are grossly inefficient in the name of "decentralization" without actually being decentralized!
      - And don't actually solve any problems other than those required to implement cryptocurrencies!
    - Cryptocurrencies don't work as currency unless you are a criminal!
- Yet it has refused to just go away
- And it touches on a lot of real world "security" issues that often have nothing to do with actual security!

~~Linked Lists~~ Blockchains And CryptoCurrencies

- "Blockchain Technology"
  - A fancy word for "Append-Only Data Structure"
    - That causes people's eyes to glaze over and them to throw money at people
  - "Private/Permissioned Blockchain":
    - A setup where only one or a limited number of systems are authorized to append to the log
    - AKA 20 year old, well known techniques
  - "Public/Permissionless Blockchain":
    - Anybody can participate as appenders so there is supposedly no central authority: Difficulty comes in removing "sibyls"
- Cryptocurrencies
  - Things that don't actually work as currencies…

Hash Chains

- If a data structure includes a hash of the previous block of data: This forms a “hash chain”
- So if you have a way of validating the ending block:
  The inclusion of the previous block’s hash validates all the previous blocks
- This also makes it easy to add blocks to data structures
  - Only need to hash block + hash of previous block, rather than rehash everything:
    How you can efficiently hash an "append only" datastructure
- Now just validate the head (e.g. with signatures) and voila!
  - All a “blockchain” is is a renamed hashchain!
    Linked timestamping services used this structure and were proposed back in 1990!
  - Certificate Revocation Lists are signed hash-chains



Merkle Trees

- Lets say you have a lot of elements
  - And you want to add or modify elements
- And you want to make the hash of the set easy to update
- Enter hash trees/merkle trees
  - Elements 0, 1, 2, 3, 4, 5...
  - H(0), H(1), H(2)...
  - H(H(0) + H(1)), H(H(2)+H(3))...
  - The final hash is the root of the top of the tree.
- And so on until you get to the root
  - Allows you to add an element and update lg(n) hashes Rather than having to rehash all the data
  - Patented in 1979!!

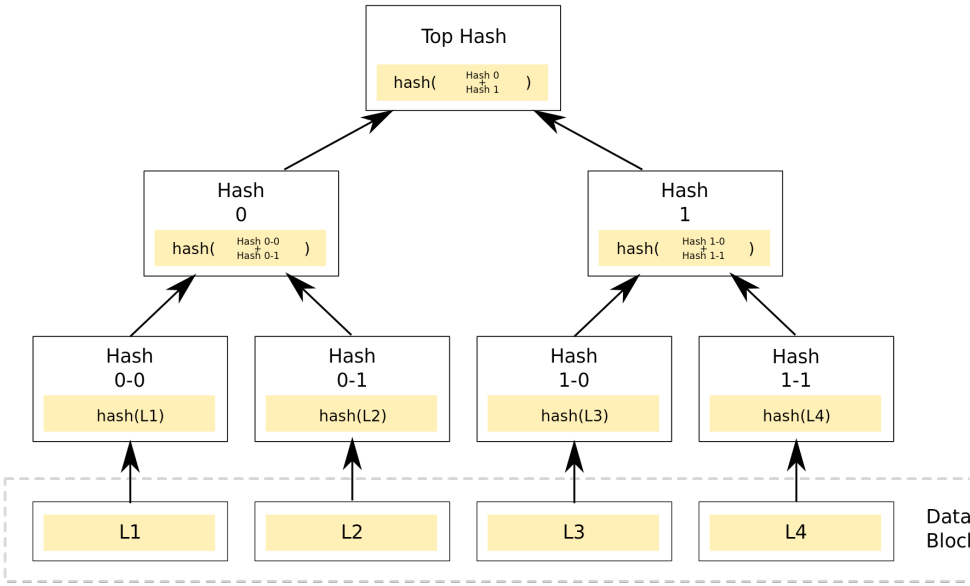


Image Stolen from Wikipedia

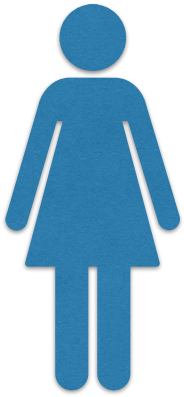
A Trivial Private Blockchain…

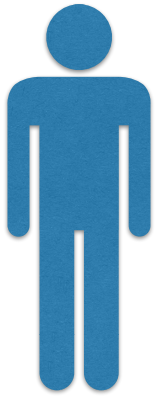
- We have a single server ***s***, with keys K_{pub} and K_{priv}…
  - And a git archive ***g***… (in which we fix git to use SHA-256)
- Whenever we issue a pull request…
  - The server validates that the pull request meets the allowed criteria
  - Accepts the pull request
  - Signs the hash of the head…
- And that is it!
  - Git is an append only data structure, and by signing the new head, we have the server authenticating the ***entire archive!***
- This is why "private" blockchain is ***not*** a revolution!!!
  - Anything that would benefit from an append-only, limited writer database already has one!

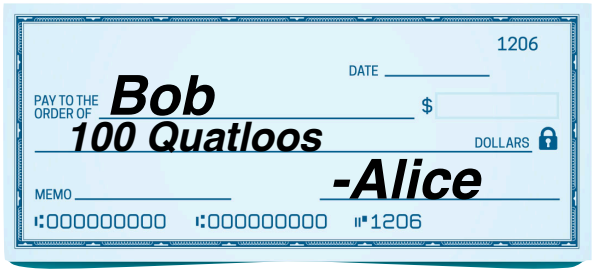
What Is A "Cryptocurrency"?

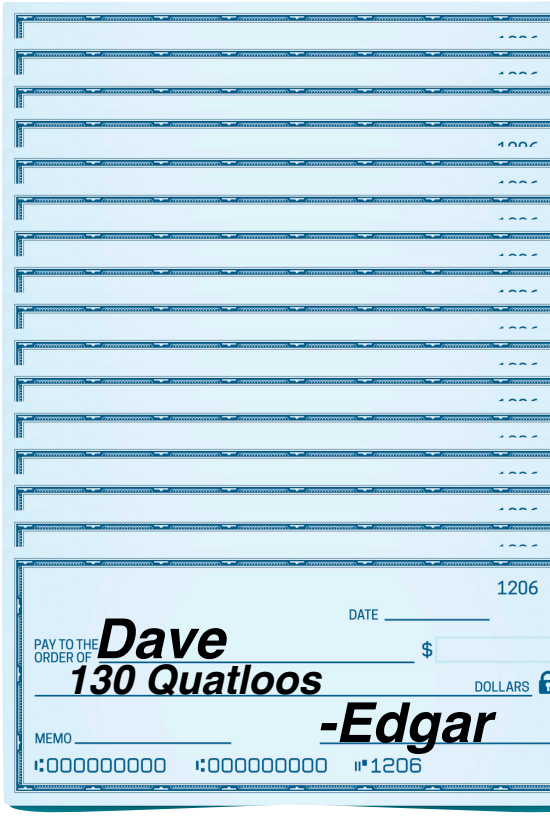
- A cryptocurrency is a tradable cryptographic token
  - The goal is to create irreversible electronic cash with no centralized trust: If Alice wants to pay Bob 200 Quatloos to pay off her losing bet on the Green thrall, there should be ***nobody else who can block or reverse this transfer***
- Based on the notion of a public ledger (the "Blockchain")
  - A public shared document that says "Alice has 3021.1141 Quatloos, Bob has 21.13710 Quatloos, Carol has 1028.8120 Quatloos..."
  - People can ***only*** add items to the ledger ("append-only"), never remove items
- Big Idea: Alice writes and signs a check to Bob saying "I, Alice, Pay Bob 200 Quatloos"
  - This check then gets added to the public ledger so now everyone knows Alice now has 2821.1141 Quatloos and Bob has 221.13710 Quatloos

What Is A "Cryptocurrency"?





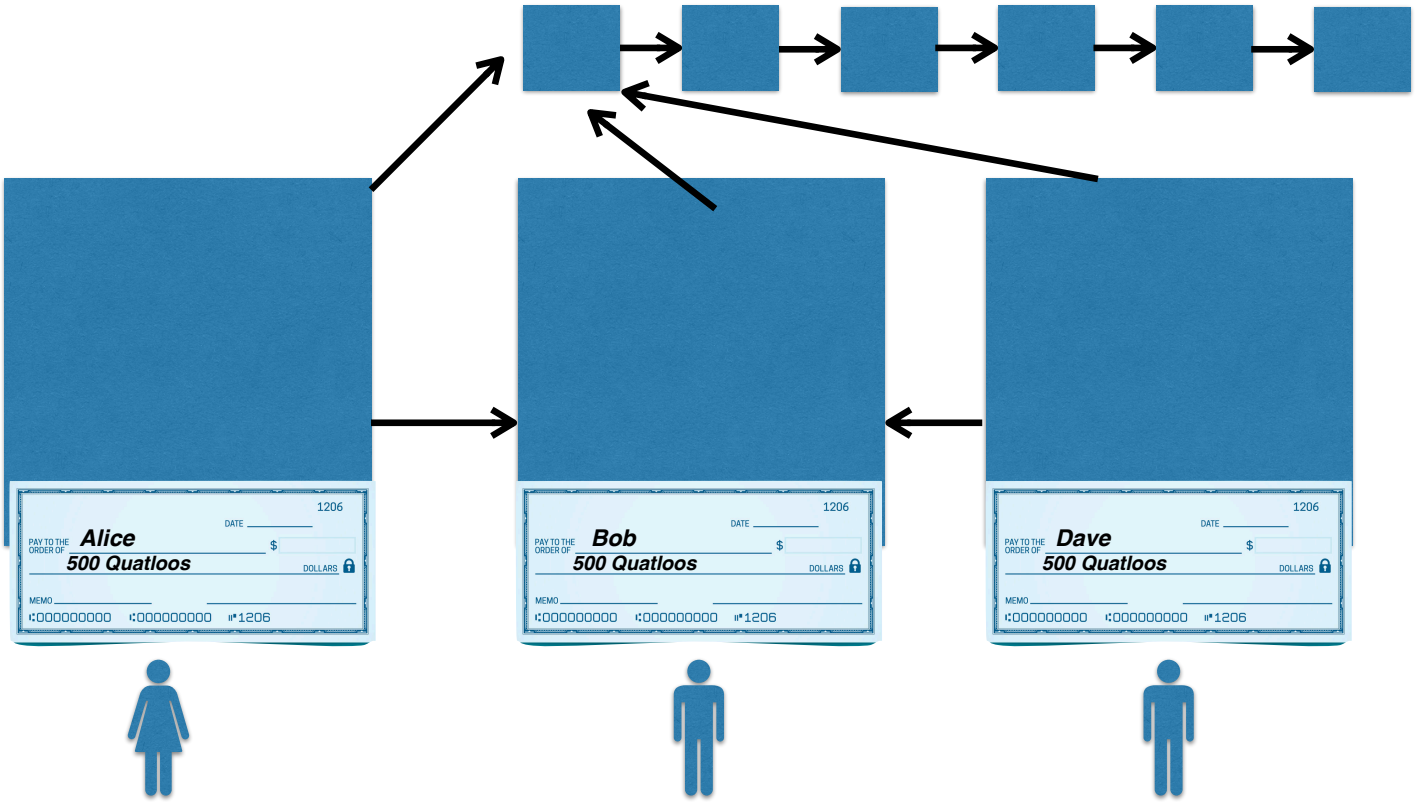




What Is A "Blockchain" (well, "Public" or "Permissionless" Blockchains)

- Everyone involved gathers up copies of the loose checks
  - For each check, validate that there are sufficient funds
  - Bundle all the checks up into a "block" and staple them together, with a pointer to the previous pile
- Everybody now does a lot of useless "work" that may eventually get lucky
  - The one that gets lucky staples this (which is in the form of a check saying "The system pays to ME the reward for success" and the staple that binds everything together) to the block as well, publishes this, and gets the reward
- Now everybody else knows this stapled pile of checks is now verified
  - So everybody starts on a new block, pointing to the previous block and gathers up the new checks that haven't yet been processed
- Result is an ***append only*** data structure

What Is A "Blockchain"
(well, "Public" or "Permissionless" Blockchains)



What Is Bitcoin?

- Simply the first widespread development of this idea
  - A "Bitcoin wallet" is simply a collection of cryptographic keys
    - Private key K_{priv}: A secret value stored in the wallet
    - Public key K_{pub}: A public value that anybody is allowed to see, derived from the private key
  - The "Bitcoin Blockchain" is Bitcoin's particular implementation of the shared ledger
- Spending Bitcoin is simply writing a check and broadcasting it:
  - "Pay K_{pub}=1Ross5Np5doy4ajF9iGXzgKaC2Q3Pwwxv the value 0.05212115 Bitcoin...
    And whoever validates this transaction gets 0.0005 Bitcoin"
    - Signed 1FuckBTCqwBQexxs9jiuWTiZeoKfSo9Vyi:
    - This is Bitcoin transaction
      `d6b24ab29fa8e8f2c43bb07a3437538507776a671d9301368b1a7a32107b7139`

What Is Bitcoin?

d6b24ab29fa8e8f2c43bb07a3437538507776a671d9301368b1a7a32107b7139

1FuckBTCqwBQexxs9jiuWTiZeoKfSo9Vyi (0.05 BTC - Output)
1FuckBTCqwBQexxs9jiuWTiZeoKfSo9Vyi (0.000016 BTC - Output)
1FuckBTCqwBQexxs9jiuWTiZeoKfSo9Vyi (0.00235018 BTC - Output)
1FuckBTCqwBQexxs9jiuWTiZeoKfSo9Vyi (0.00025497 BTC - Output)

1Ross5Np5doy4… (Free Ross Ulbricht) - (Spent) 0.05212115 BTC

0.05212115 BTC

Summary	
Size	763 (bytes)
Weight	3052
Received Time	2015-02-04 21:15:16
Included In Blocks	341974 (2015-02-04 21:16:58 + 2 minutes)
Confirmations	180240 Confirmations
Visualize	View Tree Chart

Inputs and Outputs	
Total Input	0.05262115 BTC
Total Output	0.05212115 BTC
Fees	0.0005 BTC
Fee per byte	65.531 sat/B
Fee per weight unit	16.383 sat/WU
Estimated BTC Transacted	0.05212115 BTC
Scripts	Hide scripts & coinbase

d6b24ab29fa8e8f2c43bb07a3437538507776a671d9301368b1a7a32107b7139

What Is Bitcoin Mining?

- It is the particular instance used to protect the transaction history for Bitcoin
  - Based on SHA-256
- Every miner takes all the unconfirmed transactions and puts them into a block
  - The block has fixed capacity (currently 1MB), limiting the global rate to ~3-7 transactions per second, and also includes a timestamp
  - Also attaches the "pay me the block reward and all fees" check to the front (the "coinbase")
  - Also attaches the hash of the previous block (including by reference everything in the past)
- Then performs the "Proof of work" calculation
  - Just hashes the block, changing it trivially until the hash starts with enough 0s.
    - This is the "difficulty factor", which automatically adjusts to ensure that, worldwide, a new block is discovered roughly every 10 minutes
- On success it broadcasts the new block

So Proof of Work...

- Remember, SHA256 looks random...
  - So just tweak one bit and the output looks totally different
- So if I present to you a string and the corresponding hash that starts with ***n*** 0-bits...
  - I probably had to do 2^n hashes
- So you can trivially verify that I did a ton of useless work with just a single hash

The Blockchain Size Problem

- In order to verify that Alice has a balance...
  - You have to potentially check ***every transaction*** back to the beginning of the chain
- Results in amazingly inefficient storage
  - Every full Bitcoin node needs access to the ***entire*** transaction history
    - Because the entire history is needed to validate the transaction
  - A "lightweight" node still needs to keep the headers for all history
    - And still has to ask for suitable information to verify each transaction it needs to verify
- So if we have 10,000 nodes, this means 10,000 copies of the Bitcoin Blockchain!

Corollary:
The Blockchain Capacity Problem...

- To limit the blockchain growth to "just" 1 MB a block...
  - An early defense against possible spam
  - The resulting design for Bitcoin can only process 3-7 transactions per second ***worldwide!***
- Which means any "Bitcoin takes over money" requires trusted, centralized entities that maintain databases...
  - Oh, yeah, those are called banks! We have "electronic money" as a result, and have had it for decades!
- Also results in price shocks
  - When desired transactions < block capacity, transactions are cheap
  - When desired transactions > block capacity, prices spiral up because of an inelastic supply
  - Unknown attacks have cause transaction price shocks ***for the lulz***!

The Blockchain Power Problem

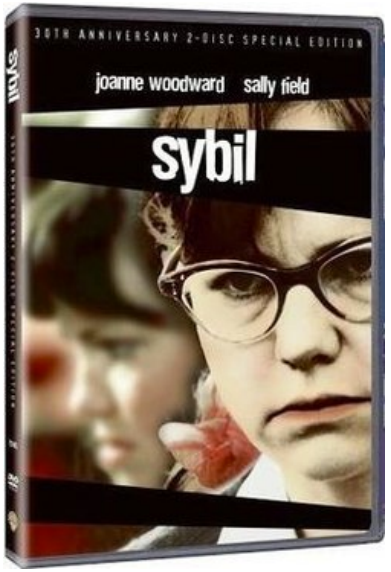
- The Bitcoin system consumes roughly 8 GW of power right now (or basically Austria!)
- This is because Proof of Work creates a Red Queen's Race
  - As long as there is potential profit to be had you get an increase in capability
  - Efficiency gains get translated into more effort, not less power consumption: 10x the hashes doesn't mean 10x the bitcoin but just 10x the difficulty factor
- There is ***no way*** to reduce Bitcoin's power consumption without reducing Bitcoin's price or the block reward
  - It is this waste of energy that protects Bitcoin!

The Bitcoin Folks ***lie*** about the power consumption...

- Claim this rescues "stranded power"
  - But this is the point of a power ***grid***: We ship electricity half-way across the country
    (Well, not to Texas because they have a separate grid so they can ignore federal regulations)
- Claim this incentivizes "green power"
  - But bitcoin mining wants 24/7/365 power ("base load")
    Base load power is only hydroelectric, fossil-fuel, or nuclear
  - And there really are no new spots for dams
- Oh, but other things burn power too...
  - Yeah, ALL data centers together is probably 2x-3x Bitcoin...
    But Bitcoin can only do 3-7 transactions per second on a WORLDWIDE BASIS!
  - And unlike Bitcoin, data centers try to reduce the power consumption
- Tesla's $1.5B is really a $1.5B in "Destroy the Planet Inc"
  Annual Bitcoin CO_2 emission of ~35 Mt of CO2 is equivalent to driving an F150 Raptor for >60 billion miles!

The Sybil Problem...

- There is a lot of talk about "consensus" algorithms in cryptocurrencies
  - How the system agrees on a common view of history
  - Bitcoin's is simple: "Longest Chain Wins"
- But Proof of Work is ***not*** about consensus:
  - It is about solving the sybil (fake node) problem...
    How do you prevent someone from just spinning up a gazillion "nodes"
    - Have each node have to contribute some resource!
  - "Proof of stake" is just another solution...
    Which requires your money to be easy to steal!
    Plus enshrines "he who has the gold, rules!"
- But there is an easier one: "Articulated Trust!"
  - Like the CAs: Use human-based agreements to agree on ***M*** trusted parties
    - Only ½***M***+1 need to actually be trustworthy!



The Irreversibility Problem

- A challenge: Buy $1500 worth of Bitcoin ***now***, without:
  - Needing $1500 cash in hand, transferring money to an individual, or having a preexisting relationship with an exchange
- You ***can't***!:
  Everything electronic in modern banking is by design reversible except for cryptocurrencies
  - This is designed for fraud mitigation: Ooops, something bad, undo undo...
- So the seller of a Bitcoin either must...
  - Take another irreversible payment ("Cash Only")
  - Have an established relationship so they can safely extend the buyer credit
  - Take a deposit from the buyer and wait a couple days

The Theft Problem...

- Irreversibility also makes things ***very*** easy to steal
  - Compromise the private key & that is all it takes!
  - See "How to make money with Bitcoin in 10 easy steps" by your's truly
- Result: ***You can't store cryptocurrency on an Internet Connected Computer!***
  - The best host-based IDS is an unsecured Bitcoin wallet
  - So instead you have hardware devices, paper wallets, and other schemes intended to safeguard cryptocurrency
    - It is worse than money under the mattress:
      Stealing money under the mattress requires ***physical access!***

The Decentralization Dream...

- "Trust Nobody"
  - The entire ***system*** is trustworthy but each actor is not
- Requires that there never be a small group that can change things...
- It is basically an article of faith that this is a good & necessary idea
  - But about the only thing it really buys is censorship-resistance

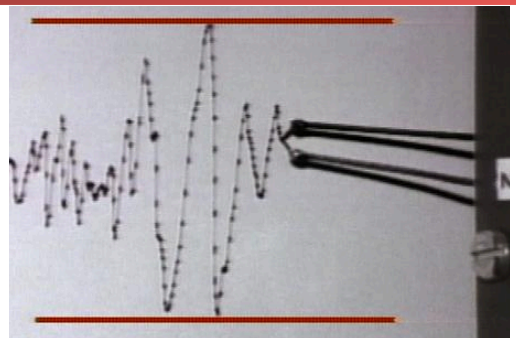
The Decentralization Reality

- Code is inevitably developed by only one or a few groups
  - And they can ***and do*** change it capriciously if it affects their money:
    When the Ethereum "DAO" theft occurred, the developers changed things to take ***their*** money back from the thief
    - Current debate to unlock another smart contract...
- Rewarded mining centralizes
  - Especially with ASICs and "Stealth ASICs" for proof of work mining
  - And the miners can ***and do cheat***, such as enable "double spending" attacks against gambling sites
- Several just aren't decentralized at all
  - Trusted coordinator or seed nodes
  - Ability to override/freeze assets

The True Value of Cryptocurrencies: Censorship Resistance...

- There is (purportedly) no central authority to say "thou shalt not" or "thou shouldn't have"
  - Well, they exist but they don't care about your drug deals...
- If you believe there should be no central authorities...
  - Cryptocurrencies are the only solution for electronic payments
- But know this enables
  - Drug dealing, money laundering, crim2crim payments, gambling, attempts to hire hitmen etc...
  - Ease of theft of the cryptocurrencies themselves
  - Ransomware and extortion: estimates of half a ***billion dollars a year!***
- And some minor "good" uses
  - Payments to Wikileaks and Backpage when they were under financial restrictions

Cryptocurrencies don't work unless you ***need*** censorship resistance



- ***Any*** volatile cryptocurrency transaction for real-world payments requires two currency conversion steps
  - It is the only way to remove the volatility risk
    - Which is why companies selling stuff aren't actually using Bitcoin, but a service that turns BTC into Actual Money™
    - And thanks to the irreversibility problem, buying is expensive
  - But if you believe in the cryptocurrency, you ***must hodl!***

- Result is that the promised financial applications (cheap remittances etc) can ***never apply*** in volatile currencies like Bitcoin
  - Really Bitcoin et al are ***only*** appropriate for buying drugs, paying ransoms, hiring fake hitmen, money laundering...
  - Otherwise, use PayPal, Venmo, Zelle, MPasa, Square, etc etc etc...

Worse:
Censorship Resistance Enables Crime

- Before the cybercrooks had Liberty Reserve and still have Webmoney...
  - But Liberty Reserve got shut down by the feds (a shutdown that ***really*** screwed up the black market hackers), and WebMoney is Russia-only
- So the only censorship alternative is cash
  - Which requires mass ($1M ≅ 10 kg) and physical proximity
- So the cryptocurrencies are the only game in town!
  - The drug dealers hated Bitcoin in 2013, and hate them all still, but it is the only thing that works
  - Ransomware used to be Green Dot & Bitcoin, but Green Dot was forced to clean up its act

And "Stablecoins" are no better...

- Removing the two currency conversion steps requires ***eliminating*** volatility
- Building a stable cryptocurrency requires an entity to convert dollars to tokens and vice versa ***at par***.
  AKA a "Bank" and "Banknotes"
  - Thus a centralized entity, so why bother with a "decentralized" blockchain? 🤔
  - All other "algorithmic stablecoins" are snake oil that implode spectacularly
- There is now a choice for the bank
  - Either you become as regulated as PayPal & Visa
  - Or you have a "wildcat bank": This is banking in the 1800s
  - Or you have "Liberty Reserve" and the principals end up in jail

Liberty Reserve

Department of Justice
Office of Public Affairs

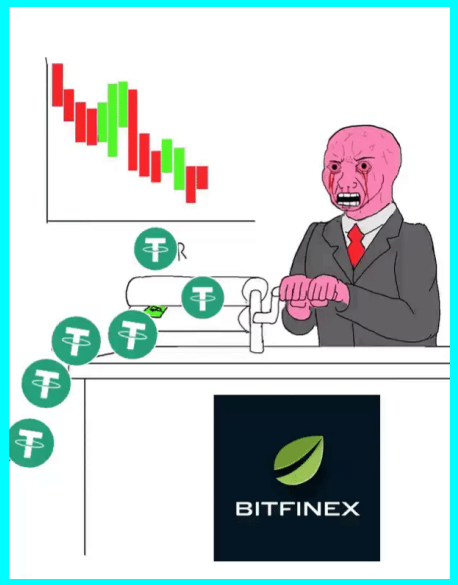
FOR IMMEDIATE RELEASE — Friday, May 6, 2016

Liberty Reserve Founder Sentenced to 20 Years For Laundering Hundreds of Millions of Dollars

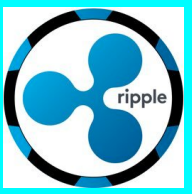
Arthur Budovsky, 42, was sentenced today in the Southern District of New York to 20 years imprisonment for running a massive money laundering enterprise through his company Liberty Reserve S.A. ("Liberty Reserve"), a virtual currency once used by cybercriminals around the world to launder the proceeds of their illegal activity.

And The Big Stable-Coin, Tether, IS A FRAUD!!!

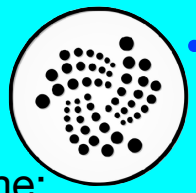
- Bitcoin's value is purely a speculative bubble
  - Somebody in the future will pay more than you paid today
- Bitcoin has a price equation based on supply/demand
  - New Bitcoin = (New $ + New Fake $s)
- Bubbles have been drive by fake $
  - 2013: Willy-Bot on MtGox:
    Created fake $ in deposit in the
    Magic The Gathering Online Exchange Bitcoin exchange, bought Bitcoin
  - 2017: Tether:
    A stablecoin which unbanked Bitcoin exchanges use since they can't access the banking system.
    Roughly 1/3rd of the price runup then
  - 2020-21: Tether AGAIN:
    The Tether Printer go BRRRRR. Now in a situation where real new $ is ***deeply negative*** as they are adding billions of "dollars" a week in Tether to buy Bitcoin to back the Tether...



Practically Every Cryptocurrency is "Me Too" with some riff...



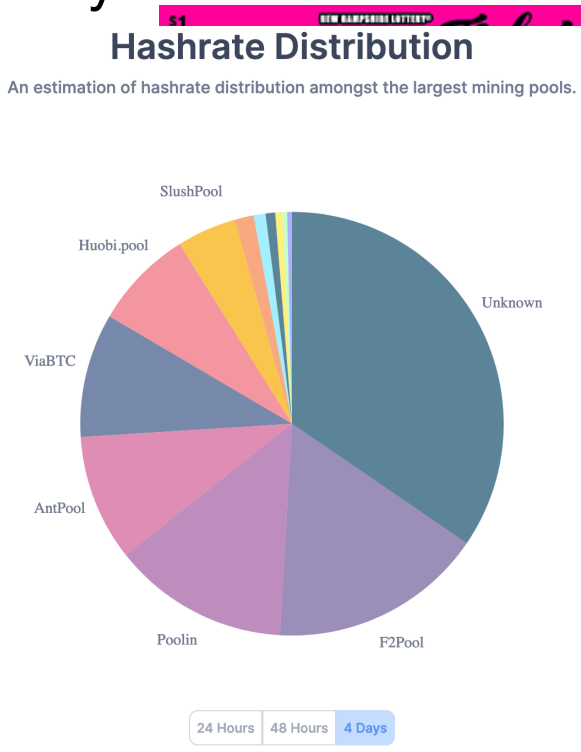
- There are lots of cryptocurrencies...
  - But in many ways they act the same: A public ledger structure and (perhaps) a purported decentralized nature
- Litecoin:
  - Bitcoin with a catchy slogan
- Dogecoin:
  - Bitcoin with a cool joke
- Ripple:
  - (Centralized) Bitcoin with an ***unrelated*** settlement structure



- IOTA:
  - (Centralized) Bitcoin but with trinary math 🤷 and roll-thy-own cryptography 🤦?!?!
- Monero:
  - Bitcoin with some better pseudonymity
- Zcash:
  - Bitcoin with ***real*** anonymity, err, "money laundering built in!"
- Ethereum:
  - Bitcoin with "~~smart contracts~~", unlicensed securities and million dollar bug bounties

Public Blockchain's Weak Security Guarantees

- "Public blockchains" protected by proof-of-whatever promise a "no central authorities" & "fully distributed trust" append-only data structure.
  - But this isn't the case!
- Any lottery-based reward creates mining pools
  - Which means a few entities ***can and do*** control things:
    5 entities effectively control Bitcoin with >50% of the hashrate
- The code developers also ***can and do*** act as central authorities
  - When ~10% of Ethereum was stolen from the "DAO",
    the developers rolled out a fork to undo the theft
- ***And worse...***



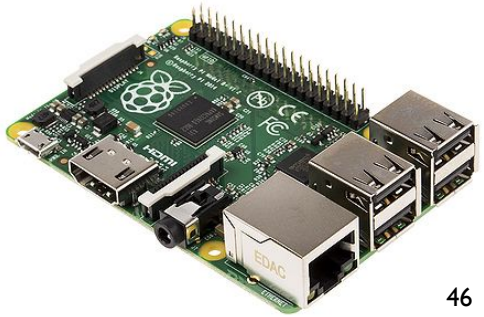
Proof of Work's Economic Unsoundness

- Idea: The system wastes $***x*** per hour to defend against potential attackers
- If an attacker needs to change the last ***n*** hours of history...
  - They will need to spend at least $***nx***, which acts as a floor
- This puts a ceiling on security as well: an attacker doesn't need to spend much more than $***nx***
  - If an attacker can make more than $***nx*** for an attack, they will!
- And its grossly inefficient:
  - The system is wasting $***x*** per hour ***whether or not it is under attack***
- Oh, and there are services!

niceHash

So The Security Must Be Either Weak or Inefficient

- Proof of work is provably wasteful
  - It ***may*** be possible to make "proof of stake" work, but that has different problems
- And there is no way to make proof of work cheap!
  - Proof of "whatever" protects up to the amount that "whatever" costs, ***but not more!***
- So "articulated trust" is vastly cheaper
  - Take 10 trustworthy entities, each one has a Raspberry Pi that validates and signs transaction independently
    - In the end, 6 need to prove to be honest, but could easily process every Bitcoin transaction
  - This requires 100W of power and $500 worth of computers!, or 9 ***orders of magnitude less power***



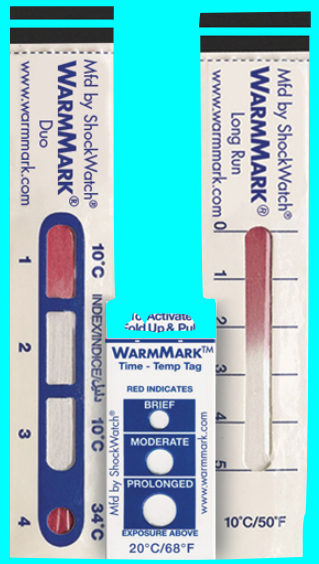
The Worm Problem....

- These cryptocurrencies form a closely connected peer-to-peer network
  - If you have an exploit that can compromise other nodes...
    You can make a self propagating attack (a "worm"), but do NOT DO SO
- Would be able to compromise ***every node*** in the P2P network in ***seconds***
  - And you know that thing about "don't keep your cryptocurrency on an internet connected system"? Yeah, how many actually do that!
- Target a secondary cryptocurrency...
  - EG, Dogecoin is a fork of Luckycoin is a fork of Litecoin is a fork of Bitcoin....
  - With half a decade of ***NO UPDATES!***
  - So search the post-fork Bitcoin code for indications of memory vulnerabilities
  - And write a worm that steals all the OTHER cryptocurrencies!

What About Non-Currency Blockchain Applications?

- Put A ~~Bird~~ Blockchain On It!
- "Private" or "Permissioned" Blockchain
  - Simply a cryptographically signed hashchain:
    Techniques known for ***20+ years***!
  - The only value gained is you say "Blockchain" and idiots respond with "Take My Money!"
- "Public" Blockchains are grossly inefficient and can't actually deliver on what they promise
- And those proposing "blockchain" don't actually understand the problem space!
  - Solve (Voting, electronic medical records, food security, name your hard problem) by putting {what data exactly? How? What formats? What honesty? What enforcement?} in an append-only data structure

A Concrete Example...

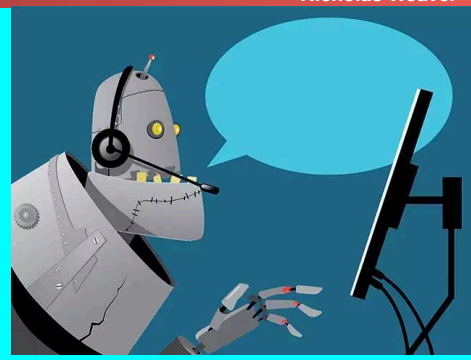


- A couple years ago there was a "Blockchain" class here at Berkeley
  - Yes, I screamed inside
  - I attended one session to give a short rebuttal...
    - But the two outside "experts" also present were delusional
- Concrete example: Vaccine supply chains...
  - You need to keep a vaccine supply chain suitably cold, if it gets too hot that is a problem...
  - One expert: "You can solve this in India with Blockchain!"
- BULLSHIT! You solve this with temperature-sensitive labels! At $1.50 each
- Proof of Nick's Iron Law of Blockchain: Blockchain solves exactly one problem: When someone says "you can solve X with Blockchain", they clearly don't know anything about X and should be ignored

But There Is One Innovative New Stupidity: "Smart Contracts"

- Idea! "Contracts are expensive!" 🤔
  - So lets take standard things written in a formal language ("Legaleze")
  - And replace them with things written in a horrid language (that looks vaguely like JavaScript)
    - By default these "smart contracts" are fixed once released!
    - And this makes things cheaper ***how***?
- And ditch the exception handling mechanism
  - If you can steal from a Smart Contract, are you actually violating the contract?

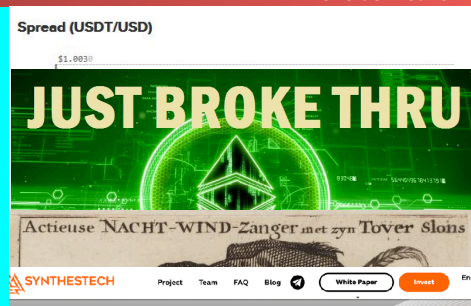
"Smart Contract" Reality: Public Finance-Bots



- They are really Public Finance-Bots
  - Small programs that perform money transfers
    - Finance bots are ***not new***:
      The novelty is these finance bots are public and publicly accessible
    - Oh, and these aren't "distributed apps"
- Predictable Result: Million Dollar Bugs
  - The "DAO", a "voted distributed mutual fund as smart contract":
    Got ~10% of Ethereum before someone stole all the money!
  - The "Parity Multi-Signature Wallet" (an arrangement to add multiple-signature control to reduce theft probability)
  - The "Proof of Weak Hands 1.0" explicit Ponzi Scheme

The Rest Is Speedrunning
500 years of bad economics...

- Almost every cryptocurrency exchange is full of frauds banned in the 1930s
- Ponzi schemes without postal reply coupons, including explicit ponzies as "Smart Contracts"
- Tether, a "stablecoin" is almost certainly a wildcat bank from the 1800s
- Every tradable ICO is really an unregulated security just like the plagues in the South Sea Bubble of 1720
- Replicated rare tulips with rare cats on the Ethereum Blockchain as a "Smart Contract"! Time to party like it is 1637!
- And don't forget the goldbug-ism...



Smart Contracts and "Decentralized Finance": Speed Running the Speed Run

- "Hey, only Wall Street has previously benefitted from super-whiz-bangie techno innovations"
  - So lets instead build them as "Smart Contracts"?
- ONLY applications end up being:
  - Fraudulent stocks (ERC20 tokens)
  - Tulip Manias
  - Implicit ponzi schemes ("Yield Farming")
  - Explicit ponzi schemes
  - Front-running bots and fraudulent miners
  - And million dollar thefts seemingly on a near-daily basis
    - Not sure which is more, the thefts or the frauds ("Rugpulls")?

So The Space is Dismal

- The value is nonexistent
- The harms are great
- So avoid it...
- Or work on making it die in a fire